2.0 SITE CHARACTERISTICS

Chapter 2, “Site Characteristics,” of the Fermi 3 Combined Operating License (COL) Final Safety Analysis Report (FSAR) addresses the geological, seismological, hydrological, and meteorological characteristics of the site and vicinity, in conjunction with present and projected population distribution and land use, and site activities and controls.

2.0.1 Introduction

The site characteristics are reviewed by the U.S. Nuclear Regulatory Commission (NRC) staff to determine whether the applicant has accurately described the site characteristics and site parameters together with site-related design parameters and design characteristics in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, “Licenses, certifications, and approvals for nuclear power plants.” The review is focused on the site characteristics and site-related design characteristics needed to enable the NRC staff to reach a conclusion on all safety matters related to siting of Fermi 3. Because this COL application references the Economic Simplified Boiling-Water Reactor (ESBWR) Design Control Document (DCD) Revision 9, this section focuses on the applicant’s demonstration that the characteristics of the site fall within the site parameters specified in the design certification (DC) rule or, if outside the site parameters, that the design satisfies the requirements imposed by the specific site characteristics and conforms to the design commitments and acceptance criteria described in the ESBWR DCD.

2.0.2 Summary of Application

Section 2.0 of the Fermi 3 COL FSAR, Revision 4, incorporates by reference Section 2.0 of the ESBWR DCD, Revision 9. In addition, the applicant provides the following:

COL Items

- EF3 COL 2.0-1-A DCD Site Parameter Values

  Table 2.0-201 of the Fermi 3 COL FSAR, Revision 4 identifies each DCD site parameter value and the corresponding Fermi 3 site characteristic values, and evaluates, as applicable, whether the Fermi 3 site characteristic values fall within the DCD values.

- EF3 COL 2.0-2-A through
  EF3 COL 2.0-30-A Site Characteristics

  Information in Sections 2.1 through 2.5 of the Fermi 3 COL FSAR, Revision 4 identifies site characteristics and addresses NRC guidance in NUREG-0800.

Supplemental Information

- EF3 SUP 2.0-1 Site Specific Input Values

  Appendix 2A provides site specific input values used in the analysis of on-site atmospheric dispersion factors (χ/Q values).

2.0.3 **Regulatory Basis**

The regulatory basis of the information incorporated by reference is in NUREG–1966, the Final Safety Evaluation Report (FSER) related to the certified ESBWR DCD.

In addition, the acceptance criteria associated with the relevant requirements of the Commission regulations for the site characteristics are given in Section 2.0 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)."

The applicable regulatory requirements for site characteristics are as follows:

- 10 CFR 52.79(a)(1)(i) - (vi) provides the site-related contents of the application.

- 10 CFR 52.79(d)(1), as it relates to information sufficient to demonstrate that the characteristics of the site fall within the site parameters specified in the DC.

- 10 CFR Part 100, "Reactor Site Criteria," as it relates to the siting factors and criteria for determining an acceptable site.

- The acceptance criteria associated with specific site characteristics/parameters and site-related design characteristics/parameters are addressed in the related Chapter 2 or other referenced sections of NUREG-0800.

2.0.4 **Technical Evaluation**

As documented in NUREG–1966, NRC staff reviewed and approved Section 2.0 of the certified ESBWR DCD. The staff reviewed Section 2.0 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 4, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirmed that the information contained in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 4, as follows:

<u>*COL Items*</u>

- EF3 COL 2.0-1-A

  DCD site parameter values for the ESBWR standard plant are identified in DCD Table 2.0-1 and DCD Tier 1, Table 5.1-1.

- EF3 COL 2.0-2-A through EF3 COL 2.0-30-A

  Information on Fermi 3 site characteristics is provided in Section 2.1 through Section 2.5. This information addresses NRC guidance in NUREG-0800 as

---

1 See "*Finality of Referenced NRC Approvals*," in SER Section 1.2.2, for a discussion on the staff's review related to verification of the scope of information to be included in a COL application that references a design certification.

identified in Table 2.0-2R. In the "COL Information" column, the COL item from the DCD is replaced with information responding to the COL item and identifying the FSAR section which addresses the SRP section invoked by the COL item.

The NRC staff reviewed the COL information in Fermi 3 COL FSAR Section 2.0, "Site Characteristics", describing the characteristics and site-related design parameters for the Fermi site. The appropriateness of the site characteristic values presented by the applicant for the Fermi 3 site is reviewed by the staff in Section 2.1 through 2.5 of this SER. The applicant compared its site specific characteristics to the DCD site parameters from DCD Tier 2, Table 2.0-1 and DCD Tier 1, Table 5.1-1 in Fermi 3 COL FSAR Table 2.0-2R and Table 2.0-201.

In Fermi 3 FSAR, Revision 2, Table 2.0-201, the applicant listed Fermi 3 long term dispersion estimate site characteristic values that do not fall within the corresponding ESBWR DCD site parameter values. The staff issued **RAI 02-1** and requested the applicant justify why this is not listed as a departure in Part 7 of the Fermi 3 COL application. In a letter Agency wide Documents Access and Management System (ML102570700) dated September 2, 2010, the applicant provided the response discussed below.

The applicant stated that the Fermi 3 long term atmospheric dispersion estimates are not referenced as a departure from the ESBWR DCD for the following reasons:

- The departure definition of Regulatory Guide (RG) 1.206 is not applicable to the Fermi 3 long term atmospheric dispersion estimates presented in FSAR Chapter 2 because the site specific atmospheric dispersion estimates do not constitute a deviation from DCD design information. The χ/Q and D/Q estimates presented in the DCD are not utilized as bounding analysis to determine or demonstrate site suitability, as each COL applicant is responsible to perform site specific analysis.

- The departure definitions of current design certification rules are not applicable to ESBWR DCD long term atmospheric dispersion estimates. Although the GEH ESBWR design certification rule has not yet been finalized, a previous design certification rule has stated that a departure from a method of evaluation described in the plant-specific DCD used in establishing the design bases or in the safety analyses means (1) changing any of the elements of the method described in the plant-specific DCD unless the results of the analysis are conservative or essentially the same, or (2) changing from one method described in the plant-specific DCD to another method unless that method has been approved by the NRC for the intended application. The applicant contends that the Fermi 3 COL application has not changed the method of evaluation described in the DCD; instead, it presents the required site specific atmospheric dispersion estimates and associated dose analysis utilizing methods specified in the DCD.

- The 10 CFR 52.79(d)(1) and NUREG-0800 discussions of design certification site parameters that must be met by COL applicants are not applicable to ESBWR DCD long term atmospheric dispersion estimates. According to NUREG-0800, site parameters used in bounding evaluations of the certified design define the requirements for the design that must be met by a site. The ESBWR DCD χ/Q and D/Q estimates are not utilized in any bounding evaluations of the certified design, as each COL applicant is required to present a site specific evaluation.

- Footnote 12 of the ESBWR DCD Tier 2, Table 2.0-1 requires the Fermi 3 analysis of site parameters associated with long term atmospheric dispersion estimates to be extended to the dose analysis of Chapter 12. In other words, the Fermi 3 COL application demonstrates that the estimated atmospheric dispersion site characteristics fall within the site parameters specified in the DCD by presenting a site specific dose analysis as required in Chapter 12 of the Fermi 3 FSAR.

The staff evaluated the applicant's response to Request for Additional Information (**RAI) 02-1** (ML102570700) and found the response to be acceptable because the ESBWR DCD long term χ/Q and D/Q estimates are not utilized in any bounding evaluations of the certified design as each COL applicant is required to present a site specific evaluation.

The NRC staff reviewed the applicant's comparison of site specific characteristics against the ESBWR DCD site parameters and found the comparison to be acceptable. The staff review confirmed that the DCD values enveloped site specific values, except for the long term atmospheric dispersion estimates discussed above.

Supplemental Information

- EF3 SUP 2.0-1

  Appendix 2A provides site specific input values used in ARCON96 analysis of on-site χ/Q values.

The site specific input to the ARCON96 analysis which is provided in Appendix 2A is reviewed in SER Subsection 2.3.4.

The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

2.0.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.0.6 Conclusion

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference has been resolved.

In addition, the staff compared the additional COL information in the application, and the applicants response to **RAI 02-1** (ML102570700) to the relevant NRC regulations, the guidance in Section 2.0 of NUREG–0800, and other NRC RGs. The staff's safety evaluation (SE) of Fermi 3 COL FSAR, Section 2.0 is provided in Section 2.0 of this SER, and concluded that Fermi 3 COL FSAR, Revision 4, Section 2.0 is acceptable and meets NRC regulatory requirements in 10 CFR 52.79(a)(1)(i) - (vi), 10 CFR 52.79(d)(1), 10 CFR Part 100 and Section 2.0 of NUREG-0800.

2.1 <u>Geography and Demography</u>

Section 2.1 of the Fermi 3 FSAR, Revision 4, discusses the site characteristics that could affect the safe design and siting of the plant and includes information about the site boundaries and location of the site with respect to prominent natural and man-made features.

The descriptions of the site area and reactor location are used to assess the acceptability of the reactor site. The review covers the following specific areas: (1) specification of reactor location with respect to latitude and longitude, political subdivisions; and prominent natural and manmade features of the area, (2) site area map to determine the distance from the reactor to the boundary lines of the exclusion area, including consideration of the location, distance, and orientation of plant structures with respect to highways, railroads, and waterways that traverse or lie adjacent to the exclusion area, and (3) any additional information requirements prescribed within the "Contents of Application" sections of the applicable Subparts to 10 CFR Part 52. The purpose of the review is to ascertain the accuracy of the applicant's description for use in independent evaluations of the exclusion area authority and control, the surrounding population, and nearby manmade hazards.

2.1.1 Introduction

Section 2.1, "Geography and Demography" of the Fermi 3 COL FSAR addresses site-specific information related to site location and description, exclusion area authority and control, and population distribution.

2.1.2 Summary of Application

Section 2.1 of the Fermi 3 COL FSAR, Revision 4, describes the geography and demography of the Fermi 3 site. In addition, the applicant provides the following:

<u>COL Items</u>

- EF3 COL 2.0-2-A Site Location and Description

  The proposed location for Fermi 3 is on the same site as Fermi 2. The Fermi 3 FSAR, Revision 4, specifies the latitude, longitude and coordinates for the Fermi 3 site.

- EF3 COL 2.0-3-A Exclusion Area Authority and Control

  The Fermi 3 Exclusion Area Boundary (EAB) is designated as the area encompassed by an 892.45 m (2928 ft) radius circle around the reactor center.

- EF3 COL 2.0-4-A Population Distribution

  The permanent population data presented in this section are primarily derived from the 2000 U.S. Census.

2.1.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the site characteristics are given in Section 2.0 of NUREG-0800.

The applicable regulatory requirements for site characteristics are as follows:

10 CFR Parts 50 and 52, as they relate to the inclusion in the SAR of a detailed description and safety assessment of the site on which the facility is to be located, with appropriate attention to features affecting facility design 10 CFR 52.79(a)(1).

10 CFR Part 100, as it relates to the following: (1) defining an exclusion area and setting forth requirements regarding activities in that area (10 CFR 100.3); (2) addressing and evaluating factors that are used in determining the acceptability of the site as identified in 10 CFR100.20(a) and 10 CFR100.20(b); (3) determining an exclusion area such that certain dose limits would not be exceeded in the event of a postulated fission product release as identified in 10 CFR 52.79(a)(1) as it relates to site evaluation factors identified in 10 CFR 100; and (4) requiring that the site location and the engineered features included as safeguards against the hazardous consequences of an accident, should one occur, should ensure a low risk of public exposure.

10 CFR 100.20(a) and 10 CFR 100.20(b) as they relate to population densities.

The related acceptance criteria are:

Specification of Location: The information submitted by the applicant is adequate and meets the requirements of 10 CFR 52.79(a)(1) if it describes highways, railroads, and waterways that traverse the exclusion area in sufficient detail to allow the reviewer to determine that the applicant has met the requirements in 10 CFR 100.3.

2.1.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Section 2.1 of the certified ESBWR DCD. The staff reviewed Section 2.1 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 4, appropriately represents the complete scope of information relating to this review topic.[1]

The staff's review confirmed that the information contained in the application address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 4, as follows:

<u>*COL Items*</u>

- EF3 COL 2.0-2-A Site Location and Description

---

[1] See "*Finality of Referenced NRC Approvals,*" in SER Section 1.2.2, for a discussion on the staff's review related to verification of the scope of information to be included in a COL application that references a design certification.

The proposed reactor is designated as Fermi 3. It is located on the same site as Fermi 2. The location of each reactor at the Fermi site is specified by latitude, longitude and Universal Transverse Mercator (UTM) coordinates.

- EF3 COL 2.0-3-A Exclusion Area Authority and Control

  As shown in Figure 2.1-204, the Fermi 3 Exclusion Area Boundary (EAB) is designated as the area encompassed by an 892.45 m (2928 ft) radius circle around the reactor center. The Fermi 2 and Fermi 3 exclusion areas overlap a significant amount of the same area and are entirely within the 509.9 hectares (1260 acres) owned by Detroit Edison with the exception of a few small areas in Lake Erie to the east. Detroit Edison owns a 16.2 hectare (40 acre) parcel of submerged land in Lake Erie expressly for protection and maintenance of the intake channel. Detroit Edison has fee simple absolute ownership of all the land within the Fermi site property boundary, and therefore the applicant has the authority to determine all activities, including exclusion and removal of personnel and property from the EAB, as specified by 10 CFR 100.21(a). All points of personnel and vehicle access to the site are strictly controlled utilizing methods such as searches, escorts for visitors, and ensuring individuals are evacuated in the event of an emergency.

- EF3 COL 2.0-4-A Population Distribution

  The permanent population data presented in this section are primarily derived from the 2000 U.S. Census information contained in LandView® 62. This software is a flexible tool capable of identifying economic and demographic information in a selected geographic area. Sources for population data and projections, as well as information on seasonal variations (transient) population in the area around the Fermi site are identified and referenced in this section, as appropriate. The population data and general descriptions of human activity and seasonal variations are provided to comply with RG 1.206. In general, the Fermi 3 Environmental Report was the basis for the information included in this section. This information was updated with data obtained by research, as cited.

The NRC staff reviewed the resolution to the site-specific items related to the site location and description included under Section 2.1 of the Fermi 3 COL and independently estimated and verified the site latitude and longitude coordinates, and the UTM coordinate system coordinates provided by the applicant in the Fermi 3 COLA.

Using maps readily available in most libraries and the internet, the NRC verified the political subdivisions and prominent manmade features of the area provided by the applicant.

The NRC staff verified that the site area map, Figure 2.1-1 provided by the applicant, showed the distance from the reactor to the boundary lines of the Fermi 3 exclusion area. The NRC staff verified that no public roads, commercial railroads, or commercial waterways cross or lie adjacent to the exclusion area. The exclusion area does extend into Lake Erie to the east of Fermi 3. Lake Erie is too shallow for commercial shipping in this area. The nearest commercial shipping channel is 4.5 miles east of Fermi 3.

The site area map submitted by the applicant is adequate and meets the requirements of 10 CFR 52.79(a)(1) if it describes the site location, including the exclusion area and the location

of the plant within the area, in sufficient detail to enable the reviewer to evaluate the applicant's analysis of a postulated fission product release, thereby allowing the reviewer to determine (in SRP Sections 2.1.2 and 2.1.3 and Chapter 15) that the applicant has met the requirements of 10 CFR Part 100.

On the basis of a NRC staff's review of the information addressed in the Fermi 3 COL, and also the NRC staff's confirmatory review of pertinent information generally available in literature and on the internet, the information provided by the applicant with regard to the site location and description is considered adequate and acceptable.

The NRC staff reviewed the resolution to the Fermi 3 COLA related to the exclusion area authority and control including size of the area, and activities that may be permitted within the designated exclusion area included under Section 2.1 of the COL using the review procedures described in Section 2.1.2 of NUREG-0800.

The applicant provided the information concerning the following:

- Complete legal authority to regulate access and activity within the exclusion area boundary (EAB).

- Identification of any facilities within the EAB that have activities unrelated to plant operation being controlled and considered for emergency planning (EP).

The NRC staff verified the applicant's ownership of all property within the EAB, including mineral rights, Absolute ownership of all lands within the exclusion area, including mineral rights, is considered to carry with it the required authority to determine all activities on this land and is acceptable to meet the requirements of 10 CFR Part 100. The NRC staff verified the applicant's description of the exclusion area as well as the authority under which all activities within the exclusion area can be controlled. The NRC staff also verified for consistency that the EAB is the same as that being considered for the radiological consequences in Chapters 15 and 13.3 of the FSAR by the applicant. The staff concludes that the applicant has acquired authority to control all activities within the designated exclusion area.

The property is clearly posted and includes actions to be taken in the event of emergency conditions at the plant. The Fermi 3 EAB is greater than 0.5 mile from the potential release points.

The NRC staff reviewed the resolution to the COL specific items related to the population distribution around the site environs included under Section 2.1.3 of the Fermi 3 COL.

The staff reviewed the data on the population in the site environs, as presented in the applicant's FSAR, to determine whether the exclusion area, Low Population Zone (LPZ), and population center distance for the proposed site comply with the requirements of 10 CFR Part 100. The staff also evaluated whether, consistent with Regulatory Position C.4 of RG 4.7, the applicant should consider alternative sites with lower population densities.

The staff also reviewed whether appropriate protective measures could be taken on behalf of the enclosed populace within the emergency planning zone, which encompasses the LPZ, in the event of a serious accident.

The staff compared and verified the applicant's population data estimates against U.S. Census Bureau Internet data. The staff reviewed the projected population data provided by the applicant, including the weighted transient population for 2013, 2018, 2020, 2030, 2040, 2050, and 2060. Based on the comparison of the applicant's data to Census Bureau data, the staff finds that the applicant's estimate of the population, including transients, is reasonable.

The staff verified that the distances to the nearest population centers are well in excess of the minimum population center distance of 4 miles (1 1/3 times the distance from center point to the outer boundary of the LPZ). The Fermi 3 LPZ is defined as a circle with a 3 mile radius from the Unit 3 site center point. The nearest population center, as defined by 10 CFR 100.3, is Monroe, Michigan. The distance to Monroe's urban boundary, as defined by US Census files, is 5.5 miles from the Unit 3 center point. This distance is approximately 1 mile greater than the calculated minimum distance of 4 miles to population center as required by 10 CFR Part 100, and satisfies the acceptance criteria of NUREG-0800 and the guidance provided in RG 4.7. Therefore, the NRC staff concludes that the proposed site meets the population center distance requirement set forth in 10 CFR Part 100, Subpart B.

The NRC staff evaluated the site population density against the criterion in Regulatory Position C.4 of RG 4.7, Revision 2, regarding whether it is necessary to consider alternative sites with lower population densities. The NRC staff's evaluation confirmed the applicant's conclusion that the population densities at the time of initial site approval (assumed 2013), and 5 years thereafter, would not exceed the criteria of 500 persons per square mile averaged over any radial distance out to 20 miles (cumulative population within a distance of up to 20 miles divided by the area of the same radius circle), and thus is acceptable.

The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Therefore, the NRC staff concludes that the applicant's Fermi 3 site density estimates conform with Regulatory Position C.4 of RG 4.7, Revision 2, as well as the requirements in 10 CFR Part 100, Subpart B, and 10 CFR 50.34(a)(1)(ii)(D)(1).

2.1.5 Post Combined License Activities

There are no post COL activities related to this section.

2.1.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference has been resolved.

In addition, the staff compared the additional COL information in the application to the guidance in Section 2.1 of NUREG–0800, and to the regulatory requirements in 10 CFR 52.79(a)(1), 10 CFR 100.3 and 10 CFR 100.2(b).

As set forth above, the applicant has presented and substantiated information to establish the site location and description. The staff has reviewed the information provided and, for the reasons given above, concludes that it is sufficient for the staff to evaluate compliance with the

siting evaluation factors in 10 CFR Part 100.3, as well as with the radiological consequence evaluation factors in 10 CFR 52.79(a)(1).

The staff further concludes that the applicant provided sufficient details about the site location and site description to allow the staff to evaluate, as documented in Sections 2.1.2, 2.1.3, and 13.3 and Chapters 11 and 15 of this SER, whether the applicant has met the relevant requirements of 10 CFR 52.79(a)(1) and 10 CFR Part 100 with respect to determining the acceptability of the site. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Parts 50, 52, and 100.

As set forth above, the applicant has provided and substantiated information concerning its legal authority and control of all activities within the designated exclusion area.

The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant's exclusion area is acceptable to meet the requirements of 10 CFR 52.79(a)(1), 10 CFR Part 100, and 10 CFR 100.3 with respect to determining the acceptability of the site. This conclusion is based on the applicant having appropriately described the plant exclusion area, the authority under which all activities within the exclusion area can be controlled, and the methods by which access and occupancy of the exclusion area can be controlled during normal operation and in the event of an emergency situation. In addition, the applicant has the required authority to control activities within the designated exclusion area, including the exclusion and removal of persons and property, and has established acceptable methods for control of the designated exclusion area. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Parts 50, 52, and 100.

As set forth above, the applicant has provided an acceptable description of current and projected population densities in and around the site. The staff has reviewed the information provided and, for the reasons given above, concludes that the population data provided is acceptable to meet the requirements of 10 CFR 52.79(a)(1), 10 CFR 100.20(a), 10 CFR 100.20(b), 10 CFR 100, and 10 CFR 100.3. This conclusion is based on the applicant having provided an acceptable description and safety assessment of the site, which contains present and projected population densities that are within the guidelines of Regulatory Position C.4 of RG 4.7, and properly specified the low-population zone and population center distance. In addition, the staff has reviewed and confirmed, by comparison with independently obtained population data, the applicant's estimates of the present and projected populations surrounding the site, including transients. The applicant also has calculated the radiological consequences of design-basis accidents at the outer boundary of the low-population zone (SRP Chapter 15) and has provided reasonable assurance that appropriate protective measures can be taken within the low-population zone to protect the population in the event of a radiological emergency. This addresses COL Section 2.1 specific items. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Parts 50, 52, and 100.

2.2 Nearby Industrial, Transportation, and Military Facilities

Section 2.2, "Nearby Industrial, Transportation, and Military Facilities" of the Fermi 3 COL FSAR provides information on the site characteristics that could affect the safe design and siting of the plant. The information consists of three subsections: Subsection 2.2.1 provides information on locations and routes; Subsection 2.2.2 describes nearby industrial transportation facilities (airports, airways, roadways, railways, etc.) and military facilities; and Subsection 2.2.3 evaluates potential hazards.

2.2.1 Locations and Routes

The locations of and separation distances from transportation facilities and routes, including airports and airways, roadways, railways, and navigable bodies of water are addressed as information item EF3 COL 2.0-5-A in Fermi 3 FSAR Sections 2.2.1 and 2.2.2. The staff's review of this information is in the following Safety Evaluation Report (SER) Section 2.2.2.

2.2.2 Descriptions

2.2.2.1 Introduction

The description of locations and routes refers to potential external hazards or hazardous materials that are present or may reasonably be expected to be present during the projected lifetime of the proposed plant. The purpose is to evaluate the sufficiency of information concerning the presence and magnitude of potential external hazards so that the reviews and evaluations described in standard review plan Sections 2.2.3, 3.5.1.5, and 3.5.1.6 can be performed. The review covers the following specific areas: (1) the locations of and separation distances to transportation facilities and routes, including airports and airways, roadways, railways, pipelines, and navigable bodies of water; (2) the presence of military and industrial facilities such as fixed manufacturing, processing, and storage facilities; and (3) any additional information requirements prescribed within the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.2.2.2 Summary of Application

Subsection 2.2.2 of the FSAR addresses the need for locations and route descriptions and descriptions of nearby industrial and military facilities. The applicant addressed the information as follows:

COL Items

- EF3 COL 2.0-5-A

  EF3 COL 2.0-5-A resolves DCD COL Item 2.0-5-A by providing information about industrial, military, and transportation facilities and routes to establish the presence and magnitude of potential external hazards. The site-specific information needed to address DCD COL Item 2.0-5-A in the Fermi 3 FSAR is addressed by EF3 COL 2.0-5-A in Fermi 3 FSAR Sections 2.2.1 and 2.2.2 in accordance with RG 1.206 and relevant sections of 10 CFR Parts 52 and 100.

Locations and Routes

The significant manufacturing plants, storage facilities, quarrying operations, and transportation routes within 8 km (5 mi) of Fermi 3 are presented in Fermi 3 COL FSAR Figure 2.2-201. There are no chemical plants, refineries, mining operations, drilling operations, active oil or gas wells, military bases, or missile sites within the vicinity of Fermi 3. The Fermi 2 reactor is located approximately 0.42 km (0.26 mi) northeast of the Fermi 3 centerline.

The western basin of Lake Erie is adjacent to the eastern property boundary of the Fermi site. The Port of Monroe is the closest waterway shipping facility at the mouth of River Raisin approximately 11.2 km (7 mi) southwest. The West Outer Channel and the East Outer Channel

connect in Lake Erie approximately 11.2 km (7 mi) northeast of the plant as shown in Fermi 3 FSAR Figure 2.2-201. The West Outer Channel provides the closest shipping approach in Lake Erie at over 8 km (5 mi) away from Fermi 3.

The nearest major highways are Interstate 75 and Interstate 275. These to highways intersect at 6.6 km (4.1 mi) northwest of Fermi 3. State Route 24 runs parallel to Interstate 75 approximately 9.3 km (5.8 mi) northwest of Fermi 3. Interstate 75 has heavy commercial traffic since it is a major access route to industries in the Detroit area.

Two railroad companies transport freight in the vicinity of Fermi 3 as shown in FSAR Figure 2.2-201. Canadian National Railway operates the closest rail line within 5.6 km (3.5 mi) of Fermi 3, and also provides service to the single spur track onto the site. Norfolk Southern Railway has two parallel rail lines at distances of 5.6 km (3.5 mi) and 6.1 km (3.8 mi) from Fermi 3 and operates the nearest railroad yard in Monroe over 9.6 km (6 mi) away. Nearby airports and air routes are shown in FSAR Figure 2.2-202.

Industrial Facilities

Industrial facilities which use, store, or transport significant quantities of hazardous materials in the vicinity of 8 km (5 mi) of Fermi 3 are presented in FSAR Table 2.2-201, including primary function, major products, and number of persons employed. No hazardous materials are manufactured within 8 km (5 mi) of Fermi 3.

Hazardous materials identified, including toxic chemicals, flammable materials, explosive substances, and shipment information reported by nearby industrial facilities, are summarized in FSAR Table 2.2-202.

There are two extractive industries within 8 km (5 mi) of Fermi 3. However, explosive materials are not stored overnight. For both Stone Co. of Michigan's Newport Quarry and Rockwood Quarry LLC, a blasting company truck delivers the required quantity of ammonium nitrate fuel oil only on the days that blasting occurs. The chemicals are mixed with explosive components immediately prior to use for blasting, and unused explosives are removed from the quarries by the end of the day.

Onsite chemical storage for Fermi 3 and Fermi 2 is shown in FSAR Table 2.2-203.

Pipelines

There are no pipelines carrying potential hazardous materials (e.g., propane, chlorine, toxic chemicals) within 8 km (5 mi) of the site. Even though there are local, residential and commercial natural gas distribution pipelines and service lines near the site, there is no large diameter natural gas or oil transmission pipelines in the vicinity of Fermi 3.

Waterways

The station water intake structure at Fermi 3 is located inside the water intake bay (groin area) and does not extend out into Lake Erie. Additional protection for the intake structure is provided by the designation of all waters and adjacent shoreline of Fermi 2 as a security zone as set forth by 33 CFR 165.915. Entry into this zone is prohibited unless authorized by the U.S. Coast Guard. The station intake structure is located over 8 km (5 mi) from the West Outer Channel as shown in FSAR Figure 2.2-201.

The depths of the shipping channels that extend from the Port of Monroe and from the Detroit River range between 6.4 m (21 ft) to 8.8 m (29 ft). The types of ships using Lake Erie in these channels include self-propelled vessels and integrated tug/barge units ranging in length from 116.7 m to 209 m (383 ft to 1014 ft).

Small amounts of fuel are stored and used near the boat docks at Swan Boat Club and Swan Yacht Basin on Swan Creek about 2.4 km (1.5 mi) north of Fermi 3 and at the Brest Bay Marina approximately 4.8 km (3 mi) southwest. The closest maritime facility is the Port of Monroe located approximately 11.3 km (7 mi) southwest of Fermi 3, where the principal imports and exports are asphalt, asphalt flux, coal, equipment, petroleum coke, and armor stone. On Lake Erie in general, and likely to be shipped on the West Outer Channel about 8 km (5 mi) east of the site, are Great Lakes fleet vessels such as dry-bulk carriers, cement carriers, and tankers which transport cargo primarily consisting of iron ore, coal, limestone, cement, salt, sand and gravel, grain, potash, liquid bulk, and general cargo.

Highways

Nearby industries reported receiving shipments of hazardous material primarily by truck. Trucks deliver freight along Interstates 75 and 275 which pass approximately 6.4 km (4 mi) northwest of the plant. Petroleum products are delivered to the site from Dixie Highway via Fermi Drive in transport trucks.

Railroads

Canadian National Railway operates the closest rail line within 5.6 km (3.5 mi) of Fermi 3, and also provides service to the single spur track onto the site. The rail spur is used infrequently and primarily for the transportation of non-hazardous heavy items and large equipment. Norfolk Southern Railway has 2 parallel rail lines at distances of about 5.6 km (3.5 mi) and 6.1 km (3.8 mi) from the plant running in a northeast to southwest direction, basically paralleling Interstate 75.

Airports

Nearby airports, runway descriptions, types of aircraft, number of operations per year, and accident statistics are provided in FSAR Table 2.2-204. The Fermi helipad is located approximately 1.2 km (0.75 mi) southwest of the Fermi 3 reactor and is available for emergency MediVac air ambulance service.

Mills Field (MI53), a private turf runway, is the only operational airport within 8 km (5 mi) of Fermi 3. The National Transportation Safety Board aviation accident database lists no reported accidents/incidents in the last 40 years at Mills Field. Detroit Metropolitan Wayne County Airport located 30.6 km (19 mi) to the northwest is the only airport in the region which has annual flight operations greater than the 1000 D^2 criteria (where D= Statute miles from the site) per RG 1.206. As shown in FSAR Figure 2.2-202, the closest edges of V 383 and V 10 176-188 airways fall within the proximity criteria provided in RG 1.206 and NUREG-0800. Federal airway V 383 passes 8 km (5 statute miles) west of Fermi 3 oriented in a north-south direction. Federal airway V 10-176-188 passes 8 km (5 statute miles) north of Fermi oriented in an east-west direction.

Outside the vicinity, Airway V 133 is located approximately 10.46 km (6.5 mi) to the northeast, Airway V 426 runs about 11.26 km (7 mi) to the southwest, Airway 26 is located approximately 12.1 km (7.5 mi) to the northeast, and Airway V 467 passes over 14.5 km (9 mi) to the west at its closest point.

Projections of Industrial Growth

Very limited long-term growth of industrial facilities is expected in the vicinity, which is predominantly rural, agricultural and residential. According to the Monroe County Industrial Development Corporation, future plans call mainly for prime agricultural uses and open space in the areas surrounding the Fermi site. Most of the anticipated industrial growth for facilities using hazardous materials will take place outside the 8 km (5 mi) vicinity near the Port of Monroe about 11.3 km (7 mi) to the southwest near Interstate 275/Telegraph Road intersection area, or in the city of Monroe. Overall, the region is continuing to experience a decline in manufacturing and industrial processes that are the most likely candidates to use hazardous materials.

2.2.2.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the site characteristics are given in Section 2.2 of NUREG-0800.

The applicable regulatory requirements for identifying locations and routes are:

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

- 10 CFR 52.79(a)(1)(iv), as it relates to the factors to be considered in the evaluation of sites that require the location and description of industrial, military, or transportation facilities and routes.

- 10 CFR 52.79(a)(1)(vi), as it relates to compliance with 10 CFR Part 100.

The related acceptance criteria are:

- Data in the FSAR adequately describe the locations of and distances from the plant of nearby industrial, military, and transportation facilities; and the data are in agreement with data obtained from other sources, when available.

- Descriptions of the nature and extent of activities conducted at the site and in its vicinity, including the products and materials likely to be processed, stored, used, or transported; and that they are adequate to permit identification of the possible hazards cited in Subsection III of Section 2.2.1-2.2.2 of NUREG-0800.

- Sufficient statistical data with respect to hazardous materials that establish a basis for evaluating the potential hazards to the plant or plants considered at the site.

2.2.2.4 *Technical Evaluation*

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 4, as follows:

<u>COL Item</u>

- EF3 COL 2.0-5-A Locations and Routes

  The significant manufacturing plants, storage facilities, quarrying operations, and transportation routes within 8 km (5 mi) of Fermi 3 are presented in Figure 2.2-201. There are no chemical plants, refineries, mining operations, drilling operations, active oil or gas wells, military bases, or missile sites within the vicinity of Fermi 3. The Fermi 2 reactor is located approximately 0.42 km (0.26 mi) northeast of the Fermi 3 centerline. The Davis-Besse Nuclear Power Station is located about 42 km (26 mi) south-southeast of the Fermi site. The nearest military facilities are Camp Perry Military Reservation near Port Clinton, Ohio, approximately 48 km (30 mi) southeast and Selfridge Michigan Air National Guard Base about 80 km (50 mi) northeast of Fermi 3.

NRC staff reviewed Section 2.2 of the Fermi 3 COL FSAR to ensure that the required information is presented in the COL. The staff's review confirmed that the information contained in the application addresses the relevant information related to identification of potential hazards in the vicinity of the site.

The staff reviewed EF3 COL 2.0-5-A as a resolution to DCD COL Item 2.0-5-A related to identification of potential hazards in the vicinity of the site, including nearby industrial, transportation, and military facilities addressed in summary of application in Subsection 2.2.2.2.

As set forth above, the applicant presented and substantiated information that identified potential hazards in the site vicinity. The staff reviewed the information in the FSAR and, for the reasons given above, concluded that the applicant had provided information that identified potential hazards in accordance with the requirements of 10 CFR 52.79(a)(1)(iv) and 10 CFR 52.79(a)(1)(vi) for compliance evaluation.

2.2.2.5 *Post Combined License Activities*

There are no post-COL activities related to this section.

2.2.2.6 *Conclusion*

NRC staff reviewed the information provided by the applicant in the Fermi 3 COL application Part 2 FSAR. The staff's review confirmed that the applicant addressed the relevant information, and there is no outstanding information expected to be addressed in the COL FSAR related to this subsection.

As set forth above, the applicant presented and substantiated information that identified potential hazards in the site vicinity. The staff reviewed the information in the FSAR and, for the reasons given above, concluded that the applicant had provided information that identified potential hazards in accordance with the requirements of 10 CFR 52.79(a)(1)(iv) and 10 CFR 52.79(a)(1)(vi) for compliance evaluation. The nature and extent of activities involving potentially hazardous materials that are conducted at nearby industrial, military, and

transportation facilities have been evaluated to identify those activities that have the potential for adversely affecting plant safety-related structures. Based on information in the FSAR, as well as information that the staff had independently obtained, the staff concluded that all potentially hazardous activities on the site and in the vicinity of the plant have been identified. The hazards associated with these activities have been reviewed and are discussed in Sections 2.2.3, 3.5.1.5, and 3.5.1.6 of this SER. In conclusion, the applicant has provided sufficient information to satisfy 10 CFR Part 50, 10 CFR 52.79(a)(1)(iv), 10 CFR 52.79(a)(1)(vi),10 CFR 100.20, and 10 CFR 100.21.

2.2.3 Evaluation of Potential Accidents

2.2.3.1 Introduction

The evaluation of potential accidents considers the applicant's probability analyses of potential accidents involving hazardous materials or activities on the site and in the vicinity of the proposed site to confirm that appropriate data and analytical models have been used. This review covers the following specific areas: (1) hazards associated with nearby industrial activities such as manufacturing, processing, or storage facilities; (2) hazards associated with nearby military activities such as military bases, training areas, or aircraft flights; and (3) hazards associated with nearby transportation routes (aircraft routes, highways, railways, navigable waters, and pipelines). Each hazard review area includes consideration of the following principal types of hazards: (1) toxic vapors or gases and their potential for incapacitating nuclear plant control room operators; (2) overpressure resulting from explosions or detonations involving materials such as munitions, industrial explosives, or explosive vapor clouds resulting from the atmospheric release of gases (such as propane and natural gas or any other gas) with a potential for ignition and explosion; (3) missile effects attributable to mechanical impacts such as aircraft impacts, explosion debris, and impacts from waterborne items such as barges; and (4) thermal effects attributable to fires.

2.2.3.2 Summary of Application

This section of the COL FSAR addresses the need to evaluate potential accidents. The applicant addressed the information as follows:

<u>COL Item</u>

- EF3 COL 2.0-6-A Evaluation of Potential Accidents

  EF3 COL 2.0-6-A resolves DCD COL Item 2.0-6-A by addressing the provision for evaluating potential accidents. The site-specific information needed to address DCD COL Item 2.0-6-A in Fermi 3 FSAR is incorporated in Fermi 3 COLA Part 2 FSAR Section 2.2.3.

2.2.3.3 Regulatory Basis

The applicable regulatory requirements for identifying and evaluating potential accidents are: 10 CFR 52.79(a)(1)(iv) as it relates to the factors to be considered in the evaluation of sites, which require the location and description of industrial, military, or transportation facilities and routes.

- 10 CFR 52.79(a)(1)(vi) as it relates to compliance with 10 CFR Part 100.

The acceptance criteria presented in the Fermi 3 COLA Part 2 FSAR are based on meeting the relevant requirements of 10 CFR Parts 52 and 100.

The related acceptance criteria are:

- Event Probability: The identification of design-basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant or plants of specified type is acceptable if all postulated types of accidents are included for which the expected rate of occurrence of potential exposures resulting in radiological dose in excess of the 10 CFR 50.34(a)(1) limits, as it relates to the requirements of 10 CFR Part 100, is estimated to exceed the NRC staff objective of an order of magnitude of 10^{-7} per year.

- Design-Basis Events: The effects of design-basis events have been adequately considered, in accordance with 10 CFR 100.20(b), if analyses of the effects of those accidents on the safety-related features of the plant or plants of specified type have been performed and measures have been taken (e.g., hardening, fire protection) to mitigate the consequences of such events.

2.2.3.4 Technical Evaluation

NRC staff reviewed Subsection 2.2.3 of the Fermi 3 COL FSAR and performed independent checks of the information presented. The staff's review confirmed that the information contained in the application addresses the relevant information related to the evaluation of potential accidents. Where the information or analyses lack sufficient details, the staff requested additional information from the applicant. The review of that information will be pending until the receipt of adequate response from the applicant.

The staff's technical evaluation of this application is based on reviewing the information pertaining to EF3 COL Item 2.0-6-A, related to the evaluation of potential accidents to be covered under resolving the DCD COL Item 2.0-6-A.

Explosions

The applicant addressed potential explosions from the transportation of explosive materials from Interstates 75 and 275 at a minimum distance of 4 mi, the nearest railway at a minimum distance of 3.5 mi, and the nearest waterway (West Outer Channel) at a minimum distance of 5 mi from the Fermi site. According to RG 1.91, the separation distance between the interstate highways, railway and waterway and the Fermi site are within the respective safe distance criteria, and therefore, explosion events from these transportation routes are not considered design basis events.

The applicant listed propane in Fermi 3 FSAR Table 2.2-202, but did not evaluate for the potential as an explosion hazard. The staff requested the applicant for additional information (**RAI 2.2.3-1**) on the basis for not evaluating this potentially explosive material.

In letter (ML092750405) dated September 30, 2009, the applicant responded to **RAI 2.2.3-1** and provided the following information:

The propane explosion scenario was analyzed using the methodology of RG 1.91. RG 1.91 provides guidance for evaluations of explosions postulated to occur on transportation routes near nuclear power plants. As described in Section B, fifth paragraph, of RG 1.91, a TNT mass equivalence is used to determine the safe separation distance.

For determining the safe stand-off distance for the off-site propane storage, the reasonable upper bound of 240 percent is used.

The applicant included in the response a table, “Determination of Safe Stand-Off Distances For Off-Site Propane Storage Locations”, which lists the quantities, TNT equivalents and safe stand-off distances for the Meijer Distribution facility (4 miles distance), the TWB Company (4.5 miles distance) and the Rockwood Landfill (4.5 miles distance). The applicant stated the propane quantities stored at the three facilities are located much farther away than the calculated minimum safe stand-off distance determined using the guidance in RG 1.91. Based on the staff’s review of the applicant provided information, and confirmatory calculations, the staff considers the information adequate and acceptable, therefore **RAI 2.2.3-1** is closed.

The applicant evaluated hydrogen and oxygen from the nearest storage tank farm for potential explosions resulting in blast overpressure using 1 psi overpressure as a criterion for adversely affecting plant operations or preventing the safe shutdown of the plant. The applicant determined the safe separation distance of 229 ft between the hydrogen and oxygen storage area and the nearest safety-related structures. The applicant did not provide sufficient details for determining this safe separation distance. Therefore, the staff requested the applicant for additional information (**RAI 2.2.3-2**).

In letter (ML092750405) dated September 30, 2009, the applicant responded to **RAI 2.2.3-2** and provided the following information:

> In Fermi FSAR Section 2.2.3.1.1, the safe separation distance between the hydrogen and oxygen storage area and nearest safety-related structure is calculated using methods based on EPRI Document No. NP-5283-SR-A, “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations - 1987 Revision”. Appendix B of the guidelines in EPRI Document No. NP-5283-SR-A provides an evaluation report recommending separation distances based on stored quantities and building design factors.
>
> The method in EPRI Document No. NP-5283-SR-A is based on a reinforced concrete wall at least 18 inches thick; a tensile steel factor between 0.12 ksi and 0.3 ksi, and the minimum static lateral load capacities for the tornado region the plant is located in per RG 1.76.
>
> The ESBWR DCD shows that the outer walls for the ESBWR safety-related structures are at least 18 inches thick. The analysis assumes a tensile steel factor of 0.12 ksi (lower end of range in EPRI Document No. NP-5283-SR-A). The lower value for the tensile steel factor results in a larger safe separation distance. RG 1.76, “Design -Basis Tornado and Tornado Missiles for Nuclear Power Plants,” Revision 1, Figure 1, indicates that the Fermi site is located within Tornado Intensity Region I. NUREG/CR-2642, “Capacity of Nuclear Power Plant Structures to Resist Blast Loadings,” dated September 1983, Section 6, states:

> "A conservative static capacity can be based upon the required design pressure drop for the tornado zone in which the plant is sited."
>
> For Tornado Region I, the design pressure drop is 3.0 psi. Therefore, a static capacity of 3.0 psi is used in the analysis.
>
> Based on these input values, the minimum safe separation distance for the hydrogen and oxygen storage area is 229 m (750.ft) from the nearest safety-related structure.

The staff reviewed the applicant provided information and the reference material. Based on independent determination, staff considers the applicant response reasonable, adequate and acceptable as it satisfies the NRC provided guidance, therefore, **RAI 2.2.3-2** is closed.

It is shown in Fermi 3 FSAR Table 2.2-202, that the nearest storage location of flammable liquids, diesel fuel and gasoline, is 3.4 mi away from the site. The applicant stated that the potential formation and detonation of a flammable vapor is not a design basis event due to the size and distance of the tanks.

The staff noted that Fermi 3 FSAR Table 2.2-203 lists two 8,000 gallon underground gasoline storage tanks adjacent to the southeast corner of building 24. The staff requested additional information from the applicant (**RAI 2.2.3-3**) to address potential explosion hazard of tanker truck for onsite delivery of gasoline to these tanks.

In letter (ML092750405) dated September 30, 2009, the applicant responded to **RAI 2.2.3-3** and provided the following information:

> The Fermi 3 FSAR Table 2.2-203 indicates that there are two 8,000 gallon gasoline underground storage tanks. In further review there is only one 8,000 gallon underground gasoline storage tank, with two dispensing islands (gas pumps). The underground storage tank is currently located adjacent to the holding pond, one dispensing island is located adjacent to the south of the underground storage tank, and the second dispensing island is located adjacent to southeast corner of Fermi 2 Building No. 24. Fermi 3 FSAR Table 2.2-203 will be revised to reflect the single tank and its location.
>
> Fermi 3 FSAR Section 2.2.2.5 Description of Highways states:
>
> "Petroleum products are delivered to the site from Dixie Highway via Fermi Drive in transport trucks."
>
> The current location of the gasoline storage tank will be moved when Fermi 3 is constructed because the current location creates interference with Fermi 3 construction activities. The gasoline storage tank and tanker truck access will be relocated to a safe distance from Fermi 3. The safe separation distance for the gasoline storage tank and tanker truck access is determined using the methodology of RG 1.91 for explosions postulated to occur on transportation routes near nuclear power plants. RG 1.91 uses a TNT mass to determine the safe separation distance.

The minimum safe separation distance is determined by assuming a 10,000 gallon gasoline tanker truck delivering to underground storage tank. The underground gasoline storage tank will be located such that the tank and the gasoline tanker truck access are a minimum of 721.4 m (2367 ft) from the nearest Fermi 3 safety related structure.

NRC staff considers the applicant's response reasonable and the conclusion acceptable because it meets the requirements in 10 CFR 52.79(a)(1)(i) - (vi), 10 CFR 52.79(d)(1), 10 CFR Part 100 and Section 2.0 of NUREG-0800, therefore **RAI 2.2.3-3** is closed.

Aircraft Hazards

The applicant addressed the potential risks due to aircraft hazards associated with airports and airways. The safety evalution of these impact analyses are performed as a part of the NRC staff's review in SER Section 3.5.1.6 based on the guidance provided in RG 1.206 and NUREG-0800.

Toxic Chemicals

The applicant identified the onsite storage of chemicals for Unit 3 and Unit 2 in Fermi 3 FSAR Table 2.2-203 and the toxic chemicals considered for the potential impact for the control room habitability are identified in Fermi 3 FSAR Table 2.2-205. However, there is no detailed information on the methodology for screening out chemicals or the analyses demonstrating that determined concentrations of chemicals are lower than their respective limiting concentrations. The staff requested the applicant for additional information (**RAI 02.02.03-4**) to provide its toxic chemicals analyses. The applicant also identified toxic chemicals from offsite stationary sources in Fermi 3 FSAR Table 2.2-202. The applicant stated that the chemicals were evaluated and screened out using criteria in RG 1.78. But no details were provided. Therefore, the staff requested the applicant for additional information (**RAI 02.02.03-5**) to provide the rationale and methodology used for the toxic chemical analyses. The applicant provided the response for these RAIs with adequate information. The NRC staff reviewed the applicant's response (ML092750405, dated September 30, 2009) information and concluded that the information is reasonable and acceptable because the applicant provided the details and results of analyses except for on-site storage of propane. The applicant stated in the response that the current onsite location of propane will be relocated prior to the operation of Fermi 3. The NRC staff has developed License Condition 2.2.3-1 that will require the applicant to use tanks with a maximum capacity of 1000 gallons for the on-site storage of propane and ensure that no more than 1000 gallons of propane will be stored in any single location, and no storage location will be located closer than the minimum safe distance of 854 meters (2800 ft) from any Fermi 3 safety-related structure and the Main Control Room (MCR). In addition, the applicant proposed revision to Fermi 3 FSAR Sections 2.2.3.1.4.1 and 2.2.3.1.4.2. In the Fermi 3 FSAR Section 2.2.3.1.4.3, the applicant stated that the transportation of toxic chemicals in the vicinity is not a concern for the Fermi 3 control room habitability analysis. There is no discussion to support this statement. Therefore, the staff requested the applicant for additional information (**RAI 02.02.03-6**) to provide the rationale and methodology applied for making this statement. The applicant provided the response with adequate information. The NRC staff reviewed the applicant's responses (ML092750405), dated September 30, 2009 for **RAIs 02.02.03-4, 02.02.03-5** and **02.02.03-6** and concluded that the information is reasonable and acceptable.

The staff evaluated the information pertaining to toxic chemicals from onsite and offsite stationary and mobile sources identified by the applicant in Fermi 3 FSAR Section 2.2.1-2.2.2 and addressed in Section 2.2.3, for the applicant's analysis of control room habitability in Section 6.4.

The staff reviewed the applicant's inventory of chemicals from the above sources, and screening out of toxic chemicals that do not pose a threat to control room habitability. Based on

evaluation of the information presented in above sections of the application, confirmatory analyses, and review of the responses (ML092750405), dated September 30, 2009 to the RAIs, the staff accepts with the applicant's identified toxic chemicals liquid nitrogen and carbon dioxide for the control room habitability analysis. The staff concluded that these two applicant listed chemicals should be further evaluated in Section 6.4 for control room habitability.

Potential fires due to accidents from the transportation routes do not jeopardize the safe operation of Fermi 3 due to the separation distance of potential fires from Fermi 3. A detailed description of the fire protection system is addressed in FSAR Section 9.5.1. NRC staff considers the applicant's response reasonable and the conclusion acceptable because it meets the requirements in 10 CFR 52.79(a)(1)(i) - (vi), 10 CFR 52.79(d)(1), 10 CFR Part 100 and Section 2.0 of NUREG-0800.

Collision with Unit 3 Intake Structure

The Fermi 3 intake structure is adjacent to the Fermi 2 intake structure, located on the Lake Erie shoreline within the intake bay. This bay is protected by two rock groins that extend into the lake. The water in the vicinity of the intake structure is very shallow, and therefore, a large ship would not easily reach the intake structure. In addition, the Fermi 3 intake structure is not a safety-related structure, and therefore, any such collision, although unlikely, would not affect the safe operation or shutdown of Fermi 3. Based on the review of the information, the staff considers the applicant's conclusion acceptable.

Liquid Spills near the Intake Structure

No liquid hazardous materials are stored at, delivered to or transported through the intake bay, and an accidental liquid spill in the intake bay is considered very unlikely. No shipping lanes pass within 5 mi of Fermi 3, therefore waterway traffic unrelated to the plant is not likely to cause a spill near the intake bay. The staff considers that the liquid spills would not affect the safe operation of Fermi 3.

2.2.3.5 Post Combined License Activities

License Condition 2.2.3-1: The applicant shall use tanks with a maximum capacity of 1000 gallons for the on-site storage of propane. No more than 1000 gallons of propane will be stored in any single location, and no storage location will be located closer than the minimum safe distance of 854 meters (2800 ft) from any Fermi 3 safety-related structure and the Main Control Room.

2.2.3.6 Conclusion

As set forth above, the applicant has identified potential accidents related to the presence of hazardous materials or activities in the site vicinity that could affect a nuclear power plant or plants of the specified type that might be constructed on the proposed site, has appropriately determined those that should be considered as design-basis events, and has demonstrated that the plant is adequately protected and can be operated with an acceptable degree of safety with regard to the design-basis accidents. The staff has reviewed the information provided in Fermi 3 FSAR and, for the reasons given above, concludes that the applicant has established that the construction and operation of a nuclear Unit 3 of the specified type on the proposed site location is acceptable to meet the requirements of 10 CFR 52.79(a)(1)(iv) and 10 CFR

52.79(a)(1)(vi) for compliance with respect to determining the acceptability of the site. This addresses EF3 COL Information Item 2.0.6-A. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1)(iv), 10 CFR 52.79(a)(1)(vi), 10 CFR 100.20, and 10 CFR 100.21.

2.3 Meteorology and Air Quality

To ensure that a nuclear power plant or plants can be designed, constructed, and operated on an applicant's proposed site in compliance with the Commission's regulations, NRC staff evaluates regional and local climatological information, including climate extremes and severe weather occurrences that may affect the design and siting of a nuclear plant. The staff also reviews the applicant's onsite meteorological monitoring program and information on the atmospheric dispersion characteristics of a nuclear power plant site to determine whether the radioactive effluents from postulated accidental releases, as well as routine operational releases, are within Commission guidelines.

The staff has prepared Subsections 2.3.1 through 2.3.5 of this SER in accordance with the review procedures described in NUREG-0800, using information presented in Sections 2.0 and 2.3 of the Fermi 3 COL FSAR, Revision 4, which references ESBWR DCD, Revision 9, responses to staff RAIs, and applicable sections of NUREG-0800.

2.3.1 General Regional Climate

2.3.1.1 Introduction

Subsection 2.3.1, "General Regional Climate," of the Fermi Unit 3 COL application addresses observed averages and measured and probabilistic extremes of climatic conditions and regional meteorological phenomena that could affect the safe design and siting of the plant, including information describing the general climate of the region, seasonal and annual frequencies of severe weather phenomena, and other meteorological conditions to be used for design- and operating-basis considerations.

2.3.1.2 Summary of Application

Section 2.3 of the Fermi 3 COL FSAR, Revision 4, addresses characteristics of the regional climate considered by the applicant to be reasonably representative of conditions that may be expected to occur at the Fermi Unit 3 site. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-7-A Regional Climatology

  The meteorological data presented were published by the National Oceanic and Atmospheric Administration (NOAA), and included in industry standards and RGs.

2.3.1.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the site characteristics are given in Section 2.3.1 of NUREG-0800.

The acceptance criteria for identifying regional climatological characteristics are based on meeting the relevant requirements of 10 CFR Parts 52 and 100. The staff considered the following regulatory requirements in reviewing the applicant's discussion of the regional climatology:

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated.

- 10 CFR 100.20(c)(2) and 10 CFR 100.21(d), with respect to the consideration given to the regional meteorological characteristics of the site.

NUREG-0800, Section 2.3.1, specifies that an application meets the above requirements, if the application satisfies the following criteria:

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

- Data on severe weather phenomena should be based on 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 applicability of these data to represent site conditions during the expected period of reactor operation should be substantiated.

- The tornado parameters should be based on RG 1.76; alternatively, an applicant may specify any tornado parameters that are appropriately justified, provided that a technical evaluation of site-specific data is conducted.

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

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

- The 100-year ground-level snowpack or snowfall, whichever is greater, should be based on data recorded at nearby representative climatic stations or obtained from appropriate standards with suitable corrections for local conditions. The 48-hour probable maximum winter precipitation (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.

Generally, the information should be presented and substantiated in accordance with acceptable practice and data as promulgated by the NOAA, industry standards, and RGs.

Subsequent to the publication of SRP Section 2.3.1, the staff issued interim staff guidance document DC/COL-ISG-7, "Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures," (74 FR 31470) (ML091490565) to clarify the staff's position on identifying winter precipitation events as site characteristics and site parameters for determining normal and extreme winter precipitation loads on the roofs of seismic Category I structures.

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

- RG 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants," which provides criteria for an acceptable onsite meteorological measurements program, which can be used to monitor regional meteorology site characteristics.

- RG 1.76, which provides criteria for selecting the design-basis tornado parameters.

- RG 1.206, "Combined License Applications for Nuclear Power Plants," which describes the type of regional meteorological data that should be presented in FSAR 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 acceptability of the information presented by the applicant in FSAR Chapter 2.3.1, the NRC staff applied the same methodologies and techniques cited above.

2.3.1.4 Technical Evaluation

The staff reviewed Section 2.3 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 4, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirmed that the information contained in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 4, as follows:

---

[1] See "*Finality of Referenced NRC Approvals*," in SER Section 1.2.2, for a discussion on the staff's review related to verification of the scope of information to be included in a COL application that references a design certification.

COL Item

- EF3 COL 2.0-7-A Regional Climatology

  This COL information item requires that the COL applicant supply site-specific information in accordance with SRP Section 2.3.1; that is, the COL applicant should describe averages and extremes of climatic conditions and regional meteorological phenomena that could affect the safe design and siting of the plant.

In response to this COL information item, the applicant describes (1) data sources used to characterize the regional climatological conditions pertinent to the proposed site, (2) 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 atmospheric moisture, and precipitation (rain, snow, and ice), (3) the frequencies of severe weather phenomena that have affected the proposed site, including thunderstorms and lightning, extreme wind, tornadoes and waterspouts, hail, drought, dust (sand) storms, freezing rain, and winter precipitation (snow and ice), (4) design-basis dry- and wet-bulb temperatures for the proposed site, and (5) regional air quality and the potentiality for restrictive air dispersion conditions and high air pollution at the proposed site.

NRC staff reviewed the applicant's resolution to EF3 COL 2.0-7-A related to averages and extremes of climatic conditions and regional meteorological phenomena that could affect the safe design and siting of the plant and found the information to be acceptable and to meet the regulatory requirements.

General Climate

In Subsection 2.3.1.1 of the FSAR, the applicant characterizes the regional climatology of the proposed Fermi Unit 3 site using data from the National Climatic Data Center (NCDC), including the first-order NWS stations at Detroit Metropolitan Airport; Toledo, Ohio; and Flint, Michigan, as well as four NWS Cooperative Observation Program (COOP) stations located within 80 km (50 mi) of the Fermi site (Monroe, Michigan; Windsor, Ontario; Ann Arbor, Michigan; and Adrian, Michigan). The regional climatic observation stations used by the applicant are included in the list presented in FSAR Table 2.3-201.

The applicant addresses relevant information related to regional climatology. The applicant states that the meteorological data obtained for the climatology were collected and processed by the NOAA Midwestern Regional Climate Center and the NCDC. The applicant states that the meteorological stations it chose have long-term data (30 years or greater) that are representative of the short- and long-term climate characteristics of the region surrounding the Fermi site.

The applicant describes the general climate of the Fermi site and the surrounding region as humid continental, characterized by warm and humid summers and severe winters. Lake Erie adjacent to the Fermi site has a large influence on temperature, wind, and precipitation patterns at the site and surrounding region. The thermal capacity of the lake moderates the daily temperature extremes from those found farther inland. Lake and land breezes are common during the late spring through late fall. During late December, ice typically forms on the lake, decreasing the lake's influence on the climate in the coastal areas; the ice cover usually thaws by the middle of March, prolonging cooler temperatures into early spring. Annually, the region

experiences approximately six days below –17.8 degrees C (0 degrees F) and twelve days above 32.2 degrees C (90 degrees F).

The applicant states that monthly values of precipitation vary slightly throughout the year in the region surrounding the Fermi site. The meteorological conditions in the Fermi region are also affected by the mean storm track, which brings a high frequency of storm systems and cloudiness to the region. During the late spring and summer, the storm track migrates north of the region, and the Fermi region experiences increased sunshine and warmer temperatures. Monthly rainfall is highest in summer due to frequent thunderstorms that occur about six days per month, higher than other months throughout the year. During the winter, the storm track is situated near the Fermi region, and storm systems come from the southwest, west, and northwest, which could bring wintery precipitation, including rain, freezing rain, sleet, and snow, into the region. Heavy snowfalls are possible throughout the winter and can cause significant accumulations.

The staff verified that the applicant's description of the general climate of the region in FSAR Section 2.3.1.1, is consistent with the NCDC narrative, "2006 Local Climatological Data, Annual Summary with Comparative Data for Detroit, Michigan (KDTW)."

Normal, Mean, and Extreme Climatological Conditions

In Subsection 2.3.1.2 of the FSAR, the applicant states that the monthly prevailing winds at the nearest first-order NWS station, Detroit Metropolitan Airport, are generally from the southwest, except during spring when the prevailing wind is from the northwest. Annual prevailing wind directions at two other first-order NWS stations (Toledo, Ohio, and Flint, Michigan) are also from the southwest, but there are differences in monthly prevailing winds among the three stations in late winter and spring months which can be attributable to the relative position of the storm track and general weakening of the jet stream. The annual mean wind speed at the Detroit Metropolitan Airport is 15.9 km/hr (9.9 mph), with the highest speeds occurring during the winter and spring months and the lowest during summer months. Wind speed patterns at two other first-order NWS stations are almost the same, but wind speeds are generally lower than those at Detroit because of the relative position of the storm track near the Fermi region.

The applicant states that stations that are closer to Lake Erie, such as Monroe, Michigan and Windsor, Ontario, have slightly higher daily minimum and lower daily maximum temperatures than other stations located farther inland due to the heat content of the Lake. One exception is that daily minimum temperature at Detroit Metropolitan Airport is slightly higher than Monroe or Windsor due to the heat island effect caused by the Detroit metropolitan area.

During the summer months of June through August, the daily mean maximum and minimum temperatures average 27.2 degrees C (81 degrees F) and 15.5 degrees C (60 degrees F), respectively. The highest daily maximum temperature recorded at Detroit Metropolitan Airport was 40 degrees C (104 degrees F) in June 1988; a higher temperature, 40.5 degrees C (105 degrees F), was recorded in July 1934 at nearby Detroit City Airport. The highest temperature around the Fermi site was 42.2 degrees C (108 degrees F), recorded at the Adrian 2 NNE COOP station in July 1934.

Mean daily maximum and minimum temperatures at the Detroit Metropolitan Airport during the winter months of December through February are 1.1 degrees C (34 degrees F) and –6.7 degrees C (20 degrees F), respectively. The lowest daily minimum temperature recorded at Detroit Metropolitan Airport was –29.4 degrees C (–21 degrees F) in January 1984. The lowest

temperature recorded around the Fermi site was –32.2 degrees C (–26 degrees F) at the Adrian 2 NNE COOP station in January 1892. During the winter, arctic air masses pass over Lake Michigan, which provides heat and moisture to the air masses. The region experiences increasing cloudiness and moderation of extreme arctic temperatures due to the lake effect caused by the Great Lakes.

The applicant states that mean annual relative humidity values at the three first-order NWS stations range from about 71 to 73 percent, with the highest relative humidity occurring around early morning (7 a.m.) and the lowest relative humidity occurring around early and mid-afternoon. The highest nighttime relative humidity occurs during late summer and early fall, while the highest daytime relative humidity occurs during late fall and winter.

The applicant states that the mean annual wet-bulb temperature at Detroit Metropolitan Airport is 7.2 degrees C (45.0 degrees F), with the highest monthly average of 18.8 degrees C (65.9 degrees F) in July and the lowest monthly average of –4.6 degrees C (23.7 degrees F) in January. Because they are closer to Lake Erie, Detroit and Toledo have somewhat higher mean annual wet-bulb temperatures than Flint.

The applicant states that the mean annual dew-point temperature at Detroit Metropolitan Airport is 4.6 degrees C (40.3 degrees F), with the highest dew-point temperatures in July and the lowest dew-point temperatures in January when the mean monthly temperature is the lowest. Dew point temperatures at Detroit Metropolitan Airport are higher than those at Flint but lower than those at Toledo, Ohio. It appears that atmospheric moisture content could be directly correlated to the latitude of the station and, to lesser extent, its distance to Lake Erie.

The applicant states that annual precipitation, which ranges from 80.3 cm (31.6 in.) in Flint, Michigan, to 91.9 cm (36.2 in.) in Winsor, Ontario, is uniformly distributed across the region and fairly consistent throughout the year. Annual precipitation at the Detroit Metropolitan Airport averaged about 83.5 cm (32.89 in.), with the highest monthly average of 9.0 cm (3.55 in.) occurring in June and the lowest monthly average of 4.8 cm (1.88 in.) occurring in February. The highest 24-hour and monthly precipitation values occurred at the Flint station, with a maximum 24-hour precipitation of 15.3 cm (6.04 in.) in September 1950, and a maximum monthly precipitation of 28.0 cm (11.04 in.) in August 1975. Although the frequency of weather systems decreases in summer, the highest precipitation is recorded during the summer months due to the intensity of precipitation associated with thunderstorms. The annual snowfall amount at the Detroit Metropolitan Airport is about 111.8 cm (44.0 in.), falling mostly during winter months. The highest snowfall amount in a 24-hour period was 62.2 cm (24.5 in.) near what is now the Detroit City Airport in April 1886, while the highest monthly snowfall 148.6 cm (58.5 in.) at the Ann Arbor COOP station in February 1923.

The staff compared the applicant’s statements about the normal, mean, and extreme climatological conditions in the region surrounding the Fermi site in FSAR Section 2.3.1.2, and verified those statements, based on the NCDC narrative, “2006 Local Climatological Data, Annual Summary with Comparative Data,” for three first-order meteorological stations (Detroit and Flint, Michigan, and Toledo, Ohio), “Climatology of the United States No. 20 1971-2000” and “DS 3200-Surface Summary of the Day for Monroe, Ann Arbor (University of Michigan), and Adrian (2 NNE)-1880-2007,” and Environment Canada publication “Canadian Climate Normals 1971-2000” for a COOP station in Windsor, Ontario.

The NRC staff issued **RAI 02.03.01-1** requesting the applicant to be more specific when using the term “storm” because “storm” could be interpreted as a thunderstorm, tropical depression,

tropical storm, or hurricane. The applicant's response (ML093570220) to **RAI 02.03.01-1** (letter dated February 8, 2010) states that "storm" will be replaced with "surface low pressure systems." The applicant has incorporated this into the Fermi 3 FSAR, Revision 2, and thus **RAI 02.03.01-1** is considered resolved.

Regional Meteorological Conditions for Design and Operating Bases

a. Severe Weather Phenomena

i. Thunderstorms and Lightning

Subsection 2.3.1.3.1.1 of the FSAR provides a discussion of severe weather phenomena, thunderstorms and lighting.

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

The applicant states that, on average, thunderstorms occur 33 days of the year at the Detroit Metropolitan Airport. About 54 percent of these thunderstorm days occur between June and August, reaching a maximum of 6.3 days in July. Thunderstorm days are least frequent during the late fall and winter, reaching a minimum of 0.2 days in January. The applicant calculated the average number of lightning strikes as 10 per square mile per year or nearly four strikes per square kilometer per year for the Fermi region. Further, the applicant estimates that 1.13 lightning strikes per year occur near the planned location of the Fermi Unit 3 reactor (within 305 m [1000 ft]).

The staff confirmed that the statistics provided by the applicant for thunderstorms are correct based on the NCDC narrative, "2006 Local Climatological Data, Annual Summary with Comparative Data for Detroit, Michigan (KDTW)." The staff finds the applicant's estimate of the frequency of lightning strikes acceptable because "Vaisala's National Lightning Detection Network (NLDN) Cloud-to-Ground Lightning Incidence in the Continental U.S. (1997-2007)" (http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf, accessed July 8, 2010) shows that the annual average flash density around the Fermi site is 3 to 4 flashes per square kilometer.

ii. Extreme Winds and High Wind Events

FSAR Subsection 2.3.1.3.1.2 states that the Fermi 3 site characteristic value for the 3-second gust 50-year return period wind speed is 144.8 km/hr (90 mph). The applicant derived this site characteristic value from engineering weather data statistics published by NCDC for the Detroit City Airport. The applicant applied a multiplier of 1.07 to convert the 50-year return period wind speed value to its 100-year return period wind speed site characteristic value of 155 km/hr (96.3 mph). The applicant obtained the 1.07 conversion factor from the American Society of Civil Engineers (ASCE) Standard ASCE/SEI 7-05.

The staff reviewed the basic wind speed map in ASCE/SEI 7-05 (which is a plot of 50-year return period 3-second gust wind speeds) for the portion of the United States that includes the Fermi Unit 3 site and obtained the same 144.8 km/hr (90 mph) 3-second gust wind speed value. Because the applicant's extreme wind site characteristic values are consistent with

ASCE/SEI 7-05, the staff finds the applicant's extreme wind site characteristic values to be acceptable.

The applicant states in Revision 1 of FSAR Subsection 2.3.1.3.1.2 that 770 high wind events (50 knots [92.6 km/hr or 57.5 mph] or greater) were reported in the 5-county area surrounding the Fermi Unit 3 site (Lenawee, Monroe, Washtenaw, and Wayne counties in Michigan; Lucas county in Ohio) between January 1, 1955, and December 31, 2007, based on the NCDC online storm database. The highest wind speed was 83 knots (153.7 km/hr or 95.5 mph) in Monroe County on May 21, 2004. The highest wind speeds for the surrounding counties were 90 knots (166.7 km/hr or 103.6 mph), occurring in Wayne and Lucas Counties on July 22, 1960, and July 4, 1969, respectively. For comparison, a maximum 2-minute wind speed of 98.2 km/hr (61 mph) and a corresponding 125.5 km/hr (78 mph) 5-second wind gust were recorded at the Detroit Metropolitan Airport in May of 2004.

The applicant states that local and regional records of maximum wind speeds occurring from thunderstorms and other high wind events present values higher than the 100-year site characteristic extreme wind speed of 155.0 km/hr (96.3 mph) for seismic Category I, II, and radwaste building (RWB) structures. However, these reported maximum wind speed values are below the ESBWR seismic Category I and II structures extreme wind site parameter value of 242 km/hr (150 mph) for a 3-second gust wind speed, and therefore do not represent a threat to these structures.

The NRC staff issued **RAI 02.03.01-2** requesting that the applicant (1) revise its incorrect counting of the number of high wind events and (2) address the possibility of underestimating high wind events, considering that the first year reported in the NCDC online storm database is later than 1955.

The staff counted 816 high wind (50 knots [92.6 km/hr or 57.5 mph] or greater) event reports for the 5-county area in the NCDC online storm database, not 770 as reported in Revision 1 to FSAR Section 2.3.1.3.1.2. The number of high wind events may be under-reported in the FSAR or it may be that only 770 unique high wind events occurred, as some of the events counted by the staff may have occurred concurrently in several of the five counties. In response (ML093570220, dated February 8, 2010) to **RAI 02.03.01-2**, the applicant found a counting error and has revised the number of high wind events in Revision 2 of the Fermi 3 COL FSAR to 816.

The FSAR states that the NCDC online storm database does not cover the entire 1955–2007 period, but in Revision 1 to Section 2.3.1.3.1.2, "Extreme Winds and High Wind Events," the FSAR does not estimate the increase in the number of high wind events that would result from a complete record. The number of high wind events is probably underestimated by virtue of the reporting periods of some of the stations used having begun much later than 1955. Therefore, the number of reported high wind events during the 53-year period considered may be underestimated. In response (ML093570220) to **RAI 02.03.01-2**, the applicant analyzed the storm database on a decade-by-decade basis and concluded that annual-average high wind events in five counties do not show a significant deviation over the first four decades, as compared with the two most recent decades. Lower high wind events reported during the first four decades might be attributable to the sparseness and precision of instrumentation. The applicant has incorporated the results of its analysis into Revision 2 of the FSAR, and thus **RAI 02.03.01-2** is considered resolved.

Revision 1 of FSAR Table 2.0-201, Sheet 1 of 28, stated under the evaluation for extreme wind exposure category that "the Fermi 3 site characteristic is Exposure Category C as this value

cannot be exceeded." The NRC staff requested that the applicant explain this statement in **RAI 02.03.01-3**. In its response (ML093570220) to **RAI 02.03.01-3** (dated February 8, 2010), the applicant identified the Fermi region as being classified as Exposure Category C in accordance with ASCE/SEI 7-05 and agreed that the statement "as the value cannot be exceeded" is incorrect. The applicant removed this statement from Revision 2 of the FSAR. Thus, RAI **02.03.01-3** is considered resolved.

Because the applicant's extreme wind site characteristic values are consistent with ASCE/SEI 7-05, the staff finds the applicant's extreme wind site characteristic values to be acceptable.

iii. Tornadoes and Waterspouts

Subsection 2.3.1.3.1.3 of the FSAR discusses tornadoes and waterspouts. The applicant's report of the number of waterspouts and tornadoes in Revision 1 of FSAR Subsections 2.3.1.3.1.2 and 2.3.1.3.1.3 was based on the NCDC online storm database. Revision 1 to the FSAR stated that eight waterspouts were reported to have occurred off the shoreline of Lucas and Monroe Counties between 1993 and 2007, while 92 tornadoes were reported to have occurred in the 5-county area during the 53-year period January 1, 1955, through December 31, 2007. However, the staff counted 110 tornado reports in the NCDC online storm database for the same 53 year period. The NCDC online database indicated that several tornadoes and a waterspout have occurred in the vicinity of the Fermi site.

The staff issued **RAI 02.03.01-4** to clarify the following two issues. First, some of the tornadoes counted by the staff may have spanned multiple counties, so the number of unique tornadoes in the 5-county area may have been 92, as reported by the applicant. If so, the FSAR should state that there were 92 unique tornadoes and that some of the 110 tornadoes counted by the staff spanned multiple counties. However, if the 110 tornadoes counted by the staff are unique, the statistics on tornadoes per year and strike probabilities presented in the FSAR should be revised. Second, the first year of tornado reports for each of the five counties began later than 1955. The applicant should therefore assess whether the number of tornado events that occurred during the 53-year reporting period (January 1, 1955, through December 31, 2007) could be underestimated.

In response (ML093570220) to **RAI 02.03.01-4** (dated February 8, 2010), the applicant stated it combined tornado occurrences if the tornado reports indicated that the tornado tracked in a traceable direction between different counties or within the same county during a narrow time period and occurred within 45 minutes of one another. Therefore, the applicant concluded that the 92 tornadoes reported in Revision 1 to FSAR Section 2.3.1.3.1.2 is a valid count of tornadoes within the 5-county area between January 1, 1950, and December 31, 2007. The applicant also stated it analyzed the storm data on a decade-by-decade basis and concluded that the annual-average high wind events in five counties do not show a significant deviation over the first four decades. The staff reviewed the response (ML093570220) to **RAI 02.03.01-4** and determined that the question is closed but that two issues remained unresolved. To address these issues, the staff issued follow-up question **RAI 02.03.01-15**.

The staff issued **RAI 02.03.01-15** to clarify the following two issues. First, contrary to the information provided in response to **RAI 02.03.01-4,** in which the applicant stated 92 tornadoes are a valid count in the 5-county area between January 1, 1950, and December 31, 2007, Revision 2 to FSAR Section 2.3.1.3.1.2 states that 92 tornadoes were reported between January 1, 1955, and December 31, 2007. The staff requested the applicant to clarify this

apparent discrepancy in the reporting period and revise the FSAR accordingly. Second, two tornadoes occurring in different counties at almost the same time cannot necessarily be counted as one tornado. The staff requested the applicant provide a list of the tornadoes occurring within the 5-county area indicating which tornado reports were considered unique and which tornado reports were combined.

In response (ML102570700, dated September 2, 2010) to **RAI 02.03.01-15**, the applicant stated that the tornado reporting period begins in January 1, 1950, and revised the reporting period accordingly in Revision 4 of the FSAR. The applicant also performed an updated tornado evaluation for the 5-county area and the 2-degree latitude/longitude box around the Fermi 3 site, where the applicant combined tornadoes with matching coordinates or tornadoes within eight km (five mi) of one another over a time period of 30 minutes or less. The applicant concluded that 110 tornadoes out of 117 reported tornado occurrences in the 5-county area for the period between January 1, 1950, and December 31, 2007 were unique. The applicant's updated analysis resulted in an increase in the overall number of separate tornadoes, tornado area, and strike probability. The applicant revised Revision 4 of the FSAR accordingly. The staff reviewed the applicant's response and found the revised tornado analysis to be reasonable. Therefore, **RAI 02.03.01-15** is considered to be resolved.

The staff conducted an independent analysis to determine whether any tornadoes are unique, based on begin/end times, direction of tornado path, length/width, and relative locations (plotted on the map). Although some tornadoes are uncertain as to a determination of uniqueness, the staff arrived at a conclusion that was similar to the applicant's analysis.

Around 2:33 a.m. on June 6, 2010, a tornado hit the Fermi site and Unit 2 sustained damage due to this severe storm. The tornado touched down in Detroit Beach, Michigan, traveled about 10.5 km (6.5 mi) northeast, and entered Lake Erie at Estral Beach six minutes later. Based on the extent of damage, NOAA classified the tornado as an EF1 on the enhanced Fujita scale (i.e., 3-second gusts between 38.4 m/s [86 mph] and 49.2 m/s [110 mph]). Fermi Unit 2, which was along the tornado's path, automatically shut down when offsite power was lost. Although the reactor building (RB) was undamaged, the storm tore a 6-m (20-ft) by 9-m (30-ft) hole in the roof of the building housing the steam turbines, blew off siding from the auxiliary building, and damaged the cooling fins at the twin NDCTs. The Fermi Unit 2 reactor was safely shut down and kept in standby for more than a week as repairs to associated facilities were made.

The applicant calculated the probability of a tornado striking a point structure on the Fermi site by evaluating the frequency of occurrence of tornadoes in the counties that are either fully or partially inside a 2-degree latitude by 2-degree longitude box centered on the Fermi site. The applicant determined a strike probability of 3.87×10^{-4} per year or a recurrence interval of once every 2584 years. The staff performed a similar, independent analysis and derived a tornado strike probability of 4.94×10^{-4} per year or a recurrence interval of 2032 years. The difference between the applicant's and staff's tornado strike probabilities and recurrence intervals may be due, in part, to the fact that the staff identified a slightly different set of counties that were within the 2-degree box.

NUREG/CR–4461 Revision 2, "Tornado Climatology of the Contiguous United States," provides the basis for the design-basis tornado wind speed in Revision 1 to RG 1.76. Appendix A to NUREG/CR-4461 contains estimates of strike probabilities by 2-degree latitude and longitude boxes. The Fermi site is located about N 42.0 degree latitude and W 83.3 degree longitude, near the center of the 2-degree box bounded by 41-degree and 43-degree North latitude and 82-degree and 84-degree West longitude. The expected strike probability per year in this

2-degree box for a structure with a characteristic dimension of 61 m (200 ft) is 5.37×10^{-4}, which corresponds to a mean recurrence interval of approximately once every 1860 years. The staff accepts the applicant's tornado strike probability as it is reasonably close to the staff's estimates.

The applicant chose the tornado site characteristics based on Revision 1 to RG 1.76. RG 1.76 provides design-basis tornado characteristics for three tornado intensity regions throughout the United States, each with a 10^{-7} per year probability of occurrence. The proposed Fermi Unit 3 site is located in tornado-intensity Region I where the most severe tornadoes frequently occur and corresponds to the most severe design-basis tornado characteristics. The applicant has chosen to use the design-basis tornado characteristics from Region I and, correspondingly, proposes the following tornado site characteristics:

- A maximum wind speed of 230 mi/h (103 m/s)
- A translational speed of 46 mi/h (21 m/s)
- A maximum rotational speed of 184 mi/h (82 m/s)
- The radius of a maximum rotational speed of 150 ft (45.7 m)
- A pressure drop of 1.2 pounds per square inch (psi) (83 mb)
- A rate of pressure drop of 0.5 psi per second (37 mb/s)

Because the applicant's design-basis tornado site characteristics are based on RG 1.76, the staff concluded that the applicant has chosen acceptable tornado site characteristics.

Revision 1 of RG 1.76 reduced the design-basis tornado criteria as compared to previous guidance documents. Therefore, it was no longer clear that the design-basis tornado winds and missiles in Revision 1 of RG 1.76 would bound design-basis hurricane wind and missiles in all areas of the United States. As a result, the NRC issued RG 1.221 in October 2011. RG 1.221 provides the design-basis hurricane wind speeds that correspond to an exceedance frequency of 10^{-7} per year, which is similar to the exceedance frequency for the design-basis tornado wind speeds. The staff issued **RAI 02.03.01-20** asking the applicant to include new site characteristics in the FSAR called "hurricane wind speed" and "hurricane missile spectra" or provide a justification as to why the FSAR should not be updated to included these new site characteristics.

In response (ML12095A2830, dated April 3, 2012) to **RAI 02.03.01-20**, the applicant stated that the Fermi 3 site is located well inland from the hurricane wind speed profiles shown in RG 1.221. Therefore, the applicant concluded that the current Fermi 3 tornado site characteristic values remain valid and are inclusive of all winds associated with an annual exceedance frequency of 10^{-7}. The staff found that the applicant's assessment is acceptable because the Fermi 3 site is located well inland from areas impacted by hurricanes. The applicant's commitment to providing this information in a future revision of the FSAR is **Confirmatory Item 02.03.01-20**.

iv. Hail

Subsection 2.3.2.3.1.4 of the FSAR provides a discussion on hail and is intended to provide a general climatic understanding of the severe weather phenomena in the site region. However, the discussion does not generate site characteristics for use as design or operating bases.

The online NWS Glossary defines hail as showery precipitation in the form of irregular pellets or balls of ice more than 5 millimeters (mm) in diameter, falling from a cumulonimbus or thunderstorm cloud. Hail generally occurs during the spring and can be a major weather hazard, causing significant damage to crops and property.

The applicant used the NCDC online storm database to find that in the 5-county area surrounding the Fermi site 571 severe hail events were reported over the 53-year period of January 1, 1955, through December 31, 2007, producing an average of 10.8 occurrences of severe hail per year. Eighty-seven of these hail events involved large hail (defined as diameter equal to or greater than 4.4 cm [1.75 in.]). The largest hail diameter reported was 10.2 cm (4.00 in.) in Wayne County on November 13, 1955, and in Monroe County on March 27, 1991. During the 53-year period, there were no reports of hail during the winter months of December and January.

In Revision 1 of FSAR Subsection 2.3.1.3.1.4, "Hail," the staff finds the reporting of hail events to be generally consistent with the NCDC online storm database, although the staff counted 576 hail events using the same online database. Some of the hail events probably spanned multiple counties, so the number of hail events may actually have been fewer. However, hail reports may have begun later than 1955 in four of the counties. Therefore, the number of hail events during the period considered may be underestimated. If the number of hail events reported in the NCDC online storm database reflect unique events, hail events per year for the 5-county area is likely greater than stated by the FSAR, although the number of events per year in Monroe County itself is very small. If the hail events in the NCDC online storm database are not unique, but span multiple counties, this should be stated by the FSAR as a justification for the smaller number of hail event reports. Consequently, the staff issued **RAI 02.03.01-5** asking the applicant to clarify its reporting of hail events.

In response (ML093570220, dated February 8, 2010) to **RAI 02.03.01-5** the applicant stated it recounted the same number of hail events. In addition, the applicant demonstrated that, in comparison with hail events reporting during the 1960–1969 and 1970–1979 periods, the limited number of hail events reported between 1955 and 1959 is representative of the 1955–1959 period. The staff finds the applicant's analysis acceptable, and thus **RAI 02.03.01-5** is considered resolved.

v. Drought

Subsection 2.3.1.3.1.5 of the FSAR is a discussion on drought that is intended to provide a general climatic understanding of the severe weather phenomena in the site region. However, the discussion does not generate site characteristics for use as design or operating bases.

The applicant states that periodic extreme drought can occur from time to time in the vicinity of the Fermi site. Based on hourly precipitation data at the Detroit Metropolitan Airport during 1961–2007, the longest period with no measurable precipitation occurred for 644 hours (26.8 days) from June 17 through July 13, 1963. According to an analysis performed by the NCDC, 10 extreme droughts (Palmer Drought Index ≤–4) have occurred in Michigan between 1900 and February 2008.

The staff examined the same databases (Solar and Meteorological Surface Observational Network (SAMSON) data for 1961–1990, Hourly U.S. Weather Observations (HUSWO) data for 1991–1995, and Integrated Surface Hourly Data (ISHD) for 1996–2007) and verified the longest

drought stretch in the summer of 1963 and the number of drought periods reported by the applicant in FSAR Subsection 2.3.1.3.1.5.

b. Probable Maximum Annual Frequency of Occurrence and Duration of Dust (Sand) Storms

Subsection 2.3.1.3.2 of the FSAR is a discussion on dust and sand storms that is intended to provide a general climatic understanding of the severe weather phenomena in the site region. However, the discussion does not generate site characteristics for use as design or operating bases.

The applicant states that prolonged dry periods are infrequent and the occurrence of dust, blowing dust, blowing sand, and dust storms are rare in the vicinity of the Fermi site. Dust storms are most likely when dry conditions and high winds occur in the southern plains States and/or the upper Midwest, with synoptic systems carrying the dust northeastward. FSAR Table 2.3-207 presents the annual number of hours that dust was reported for each year during the period 1961–1995 at the Detroit Metropolitan Airport using the SAMSON and HUSWO databases. Dust was reported for very few years, and the majority of dust events lasted four hours or less, with a maximum of seven hours. The applicant determined the probable maximum annual frequency of occurrence as 0.09 percent of hours annually (8 hours), corresponding with the year that contained the highest number of hours of reported dust. The applicant also determined the probable maximum duration of dust events as seven hours, based on the longest duration during the same period.

The staff verified the applicant's statements in FSAR Subsection 2.3.1.3.2 concerning dust (sand) storm occurrence in the region surrounding the Fermi site using the same database and found one dust event in July 4, 1974, that was missing. **RAI 02.03.01-6** was issued asking the applicant to confirm the missing 1974 dust event. In its response (ML093570220, dated February 8, 2010) to **RAI 02.03.01-6**, the applicant again reviewed the database and found the one missing event and revised the text in Revision 2 of the FSAR accordingly. Thus **RAI 02.03.01-6** is considered resolved.

c. Probable Maximum Annual Frequency of Occurrence, Duration, and Historical Amounts of Freezing Rain

Subsection 2.3.1.3.3 of the FSAR is a discussion on freezing rain that is intended to provide a general climatic understanding of the severe weather phenomena in the site region. However, the discussion does not generate site characteristics for use as design or operating bases.

The applicant reported that freezing rain and ice pellet events have occurred from November through April, but mostly from December through March for the Fermi region for the 1976–1990 period. In addition, freezing rain occurred about four to five days per year around the Fermi site, while ice pellets occurred about four days per year. A total of 24 ice events were reported in the 5-county area surrounding the Fermi site during the period 1993–2007. The frequency of freezing rain events during this 15-year period was calculated at 1.6 events per year by the applicant. The applicant stated that a severe winter storm lasting nearly 24 hours during January 1967 produced ice accumulations of up to 7.6 cm (3 in) across northwest Ohio and parts of southern Michigan. The staff verified these values using the NCDC storm database and storm data reports.

In Revision 1 to FSAR Subsection 2.3.1.3.3, “Probable Maximum Annual Frequency of Occurrence and Duration of Freezing Rain,” the applicant uses the terms “freezing rain” and “ice pellets” interchangeably to refer to ice events. However, these two phenomena are different. Freezing rain is rain that falls in liquid form and freezing upon impact to form a coating of glaze upon the ground and exposed objects, whereas ice pellets are a type of precipitation consisting of pellets of ice. It is sometimes confusing within the FSAR as to whether the two types of ice events are being spoken of separately, as a group, or interchangeably. The NCDC ice storm reports include freezing rain only. The FSAR also refers to a “sub-freezing air mass near the surface,” which more accurately should be called a “sub-freezing air layer.” The staff issued **RAI 02.03.01-7** requesting that the applicant clarify these issues.

In response (ML093570220, dated February 8, 2010) to **RAI 02.03.01-7**, the applicant revised the text in FSAR Revision 2 as suggested by the staff to indicate that ice events mean freezing rain events. Thus **RAI 02.03.01-7** is considered resolved.

d. Roof Loads of Winter Precipitation Events on Fermi Structures

Subsection 2.3.1.3.4 of the FSAR is a discussion on roof loads of winter precipitation events.

DC/COL-ISG-7, “Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures,” (ML091490565) states that normal and extreme winter precipitation events should be identified in SRP Section 2.3.1 as a COL site characteristic for use in SRP Section 3.8.4 to determine the normal and extreme winter precipitation loads on the roofs of seismic Category I structures.

ISG-7 states that the normal winter precipitation roof load should be a function of the normal winter precipitation event. The extreme winter precipitation roof loads should be based on the weight of the antecedent snowpack resulting from the normal winter precipitation event plus the larger resultant weight from either (1) the extreme frozen winter precipitation event or (2) the extreme liquid winter precipitation event. The extreme frozen winter precipitation event is assumed to accumulate on the roof on top of the antecedent normal winter precipitation event, whereas 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.

Appropriate methodologies for determining the normal and extreme winter precipitation events are discussed in ISG-7. For example, ISG-7 states that the extreme liquid winter precipitation event should be determined in accordance with the Hydrometeorological Reports (HMRs) published by NOAA’s Hydrometeorological Design Studies Center.

The staff issued **RAI 02.03.01-9** requesting the applicant evaluate the winter precipitation roof loadings in FSAR Revision 1 Section 2.3.1.3.4 using the criteria presented in ISG-7 or justify an alternative methodology. The staff also stated in the RAI that FSAR Revision 1, Subsection 2.3.1.3.4, assumes that scuppers and drains on the roof of the ESBWER are designed to limit water accumulation to no more than 10.2 cm (4 in.) of water. This assumption conflicts with the ESBWR DCD Tier 2, Table 3G.1-2 which assumes water accumulation on the roof could reach 0.61 meter (2.0 feet), which is the height of the parapets, during the extreme winter precipitation event when the roof scuppers and drains are assumed to be clogged.

The applicant’s response (ML093570220, dated February 8, 2010) to **RAI 02.03.01-9,** presented an evaluation of the winter precipitation roof loads based on ISG-7. The staff reviewed the response to **RAI 02.03.01-9** and determined that, for the reasons cited below, the

question is closed but there were two issues that remained unresolved. To address these issues, the staff issued follow-up questions **RAI 02.03.01-16** and **RAI 02.03.01-18**.

i. Maximum Ground-Level Weight of the Normal Winter Precipitation Event

Guidance from ISG-7 defines the normal winter precipitation event as the highest ground-level weight (lb_f/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. In its evaluation of the ground-level weight of the normal winter precipitation event, the applicant developed the following:

- Weight of the 100-year return period snowpack: 1403 Pa (29.3 lb_f/ft^2)

  The applicant stated in its response (ML093570220) to **RAI 02.03.01-9** that ASCE/SEI 7-05 identifies the Fermi Unit 3 site as being located in a ground snow load zone of 1149 Pa (24 lb_f/ft^2) based on a 50-year return period and used a conversion factor of 1.22 (derived from Table C7-3 of ASCE/SEI 7-05) to convert to a 100-year return period ground snow load of 1403 Pa (29.3 lb_f/ft^2). The staff reviewed the ground snow load map (Figure 7-1) in ASCE/SEI 7-05 and concludes that the applicant appropriately assigned the Fermi Unit 3 site as being located in a 100-year return period ground snow load zone of 1403 Pa (29.3 lb_f/ft). The applicant included this information in Revision 2 to FSAR Section 2.3.1.3.4.

- Weight of the historical maximum snowpack: 1551 Pa (32.4 lb_f/ft^2)

  The applicant stated in its response (ML093570220) to **RAI 02.03.01-9** that the maximum snow depth measurement obtained for stations surrounding the Fermi site was 60.96 cm (24 in.) occurring at the Detroit Metropolitan Airport in January 1999. The applicant used Equation 1 from ISG-7 to convert this maximum snow depth to a maximum snowpack event weight of 1005 Pa (21 lb_f/ft^2).

  The staff issued **RAI 02.03.01-16** asking the applicant to reevaluate the historical maximum snowpack event, as the staff found a higher snowpack record than that used by the applicant. The staff found an extreme daily snow cover value of 83.82 cm (33.0 in.) for the Willis 5 SSW COOP station (located approximately 32 km [20 mi] northwest of the Fermi 3 site in Washtenaw County) using the NCDC Snow Climatology database. Using Equation 1 from ISG-7, the staff converted the 83.82 cm (33.0-in.) snow cover to a snowpack weight of 1551 Pa (32.4 lb_f/ft^2).

  In response (ML102570700, dated September 2, 2010) to **RAI 02.03.01-16**, the applicant confirmed the historical maximum snowpack weight for the Fermi vicinity is 1551 Pa (32.4 lb_f/ft^2), based on 83.82 cm (33 in.) snow cover that was recorded at the Willis 5 SSW COOP station. The applicant revised the weight of the historical maximum snowpack from 21 lb_f/ft^2 (1005 Pa) to 1551 Pa (32.4 lb_f/ft^2) in Revision 4 of FSAR Subsection 2.3.1.3.4.1. Therefore, **RAI 02.03.01-16** is considered to be resolved.

- Weight of the 100-year return period two-day snowfall event: 685 Pa (14.3 lb_f/ft^2)

  The applicant stated in its response (ML093570220) to **RAI 02.03.01-9** that maximum 100-year return period snowfall for the Fermi region is 46.48 cm (18.3 in.) based on data from the NCDC Snow Climatology database. The applicant used the assumptions

presented in Equation 2 from ISG-7 to convert this maximum snowfall to a snow load weight of 685 Pa (14.3 lb_f/ft^2). Therefore, the staff finds the applicant's weight of the 100-year return period two-day snowfall event to be acceptable. The applicant included this information in Revision 2 to FSAR Subsection 2.3.1.3.4.

- Weight of the historical maximum two-day snowfall event: 915 Pa (19.1 lb_f/ft^2)

  Revision 1 to FSAR Subsection 2.3.1.3.4.2 stated that the highest 24-hour snowfall was 62.2 cm (24.5 in.) during April of 1886 in the vicinity of what is now the Detroit City Airport whereas the highest 2- and 3-day snowfalls occurred at the Flint recording station where 57.7 cm (22.7 in.) was reported for both snowfalls. The reported maximum 2- and 3-day snowfalls at Flint were inconsistent with (i.e., lower than) the maximum 24-hour snowfall at the Detroit City Airport. The staff issued **RAI 02.03.01-8** to clarify this apparent discrepancy in snowfall statistics.

  In response (ML093570220) to **RAI 02.03.01-8** (dated February 8, 2010), the applicant stated that the maximum 2- and 3-day snowfall data were obtained from the NCDC snow climatology database and that this database has a shorter period-of-record than the database used to obtain the maximum 24-hour snowfall data. Therefore, the applicant stated that it is appropriate that the maximum 24-hour snowfall value of 62.2 cm (24.5 in.) also be used to represent the maximum 2- and 3-day snowfall values for the Fermi site. The staff finds this assessment acceptable because it results in a higher maximum 2-day snowfall than that indicated by the NCDC snow climatology database which is referenced in ISG-7. The applicant revised the text in Revision 2 to FSAR Subsections 2.3.1.3.4.1 and 2.3.2.1.3 accordingly, and thus **RAI 02.03.01-8** is considered resolved.

The applicant used the assumptions presented in Equation 2 from ISG-7 to convert the 62.2 cm (24.5 in.) snowfall to a snow load weight of 915 Pa (19.1 lb_f/ft^2). Therefore, the staff finds the applicant's weight of the historical maximum two-day snowfall event to be acceptable. The applicant included this information in Revision 2 to FSAR Subsection 2.3.1.3.4.

As part of its response (ML102570700) to **RAI 02.03.01-16**, the applicant identified the weight of the historical maximum snowpack (1551 Pa [32.4 lb_f/ft^2]) as providing the maximum ground-level weight for the normal winter precipitation event. This estimate is bounded by the corresponding ESBWR standard plant site parameter value of 2394 Pa (50 lb_f/ft^2). The staff finds the applicant's ground-level weight for the normal winter precipitation event to be acceptable because it is based on guidance provided in ISG-7.

ii. Maximum Ground-Level Weight of the Extreme Winter Precipitation Event

ISG-7 states that the extreme frozen winter precipitation event should be the higher ground-level weight (lb_f/ft^2) between (1) the 100-year return period two-day snowfall event (i.e., 685 Pa [14.3 lb_f/ft^2]) and (2) the historical maximum two-day snowfall event in the site region (i.e., 915 Pa [19.1 lb_f/ft^2]). Therefore, the extreme frozen winter precipitation event results in a ground-level weight of 915 Pa (19.1 lb_f/ft^2).

ISG-7 states that 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-square-kilometer (10-square-mile) area at a particular geographical location during those months with the historically highest snowpacks. The applicant estimated that the extreme

liquid winter precipitation event is 49 cm (19.3 in.) in accordance with HMR-53 (NUREG/CR-1486). This is equivalent to a weight of 4805 Pa (100.4 lb_f/ft^2). The staff independently used HMR-53 to calculate a slight lower value for the extreme liquid precipitation event. Therefore, the staff finds the applicant's extreme liquid winter precipitation event of 49 cm (19.3 in.) to be acceptable.

iii. Maximum Roof Load

Guidance from ISG-7 defines the extreme winter precipitation roof load as the weight of the antecedent snowpack resulting from the normal winter precipitation event (i.e., 1551 Pa [32.4 lb_f/ft^2]) plus the larger resultant weight from either (1) the extreme frozen winter precipitation event or (2) the extreme liquid winter precipitation event.

Revision 2 to FSAR Subsection 2.3.1.3.4 calculated the maximum roof load for the Fermi site for the following three scenarios:

- the extreme liquid winter precipitation event (e.g., the 48-hour PMWP) on top of the 100-year return ice accretion
- historical maximum snowfall on top of the 100-year return period snowpack
- the extreme liquid winter precipitation event on top of the 100-year return period snowpack with a 5 lb_f/ft^2 rain-on-snow surcharge

Because the applicant calculated a revised historical maximum snowpack weight of 1551 Pa (32.4 lb_f/ft^2) in its response to **RAI 02.03.01-16** which is higher than the 100-year return period snowpack weight of 1403 Pa (29.3 lb_f/ft^2), the applicant revised the last two scenarios listed above and provided maximum roof load calculations for the following three scenarios as part of its response to **RAI 02.03.01-16**:

- the extreme liquid winter precipitation event (e.g., the 48-hour PMWP) on top of the 100-year return ice accretion
- historical maximum snowfall on top of the historical maximum snowpack
- the extreme liquid winter precipitation event on top of the historical maximum snowpack with a 5 lb_f/ft^2 rain-on-snow surcharge

The applicant found the last scenario listed above resulted in the most severe roof load, 7407 Pa (154.7 lb_f/ft^2), and stated this roof load was bounded by the ESBWR maximum roof load resulting from the normal and extreme winter precipitation events (7828 Pa [163.5 lb_f/ft^2]).

The FSAR derived the 7828 Pa [163.5 lb_f/ft^2] ESBWR maximum roof load value by summing the roof load resulting from the normal winter precipitation event (1843 Pa [38.5 lb_f/ft^2]) and the extreme winter precipitation event (5985 Pa [125 lb_f/ft^2]) maximum roof snow load values that are listed in ESBWR DCD Tier 2, Table 3G.1-2. This summation conflicts with the GEH response to RAI 2.3-4 S05 dated May 11, 2009 (ML091320434) which states that the 5985 Pa (125 lb_f/ft^2) extreme live load for roofs includes the contribution of 1843 Pa (38.5 lb_f/ft^2) from the normal winter precipitation event. Similarly, footnote 5 to ESBWR DCD Tier 2, Table 2.0.1, states the corresponding maximum ground snow load for the extreme winter precipitation event

(7757 Pa [162.5 lb_f/ft^2]) includes the contribution from the normal winter precipitation event (2394 Pa [50 lb_f/ft^2]). The staff issued **RAI 02.03.01-18** asking the applicant to address this apparent contradiction in defining the ESBWR extreme winter precipitation event roof load.

In its response (ML110110550) to **RAI 02.03.01-18** dated January 10, 2011, the applicant agreed that the methodology it used to derive the maximum roof load in Revision 2 to FSAR Section 2.3.1.3.4 as modified as part of its response to **RAI 02.03.01-16** is not consistent with the ESBWR DCD. Instead, the applicant stated the extreme frozen winter precipitation event is considered to be the higher ground-level weight between the 100-year return period snowfall event (685 Pa [14.3 lb_f/ft^2]) and the historical maximum snowfall event (915 Pa [19.1 lb_f/ft^2]). Adding this value (915 Pa [19.1 lb_f/ft^2]) to the maximum ground snow load for the winter precipitation event (1551 Pa [32.4 lb_f/ft^2]) results in a total maximum ground snow load for both the normal and extreme frozen winter precipitation events of 2466 Pa (51.5 lb_f/ft^2). This ground snow load value is bounded by the ESBWR maximum ground snow load for extreme winter precipitation event site parameter value of 7757 Pa (162 lb_f/ft^2).

The applicant also notes in its response (ML110110550) dated January 10, 2011, to **RAI 02.03.01-18** that the parapets on the roof of the ESBWR could allow water to accumulate up to 60.96 cm (24 in.) during an extreme winter precipitation event when the roof scuppers and drains are assumed to be clogged. The ESBWR extreme live load roof design of 5985 Pa (125 lb_f/ft^2) is based on 60.96 cm (24 in.) of standing water on the roof. Therefore, the staff notes that the Fermi 3 extreme liquid winter precipitation event of 49 cm (19.3 in.) of water does not challenge the integrity of the ESBWR extreme live load roof design.

The staff finds the applicant’s response to **RAI 02.03.01-18** acceptable because the applicant derived its extreme winter precipitation event roof load following the description of the ESBWR roof design as described in the DCD. The applicant incorporated the information provided in response to **RAI 02.03.01-18** into Revision 4 of the FSAR. Therefore, **RAI 02.03.01-18** is considered to be resolved.

e. Design Basis Ambient Temperature and Humidity Statistics

In Subsection 2.3.1.3.5 of the FSAR, the applicant presented ambient temperature and humidity statistics for the Detroit Metropolitan Airport in Table 2.3-210 of the FSAR Revision 1 (dated March 2009). The Detroit Metropolitan Airport is the closest first-order NWS climatic observation station to the Fermi Unit 3 site (located approximately 17 mi [27 km] to the north-northwest) which has a long-term history of recording hourly temperature and humidity data. The staff expects that the temperature and humidity data recorded at the Detroit Metropolitan Airport should be generally representative of Fermi 3 site conditions. In order to confirm this hypothesis, the staff generated 2001-2007 Detroit Metropolitan Airport dry-bulb (DB) statistics from the NCDC ISHD database and compared them with similar statistics generated from the applicant’s 2001-2007 onsite meteorological database. The results of this comparison are as follows:

Dry-Bulb Statistic	2001-2007	
	Detroit Metro Airport	**Fermi 3 Site**
Maximum	37.2 °C	34.6 °C
1 Percent Exceedance	31.0 °C	29.4 °C
Median	10.0 °C	10.5 °C
99 Percent Exceedance	-12.2 °C	-12.6 °C
Minimum	-20.6 °C	-19.9 °C

This comparison shows that the maximum and 1 percent exceedance Detroit Metropolitan Airport DB statistics tend to be higher (more conservative) than the Fermi 3 site statistics, probably due to the Fermi 3 site location being closer to Lake Erie and the lake's moderating effects on temperature during the summer (more detail is provided in SER Subsection 2.3.2). The 99 percent exceedance and minimum Detroit Metropolitan Airport DB statistics are generally representative of (e.g., within 1 degree C) of the Fermi 3 data.

The staff also compiled and compared the Detroit Metropolitan Airport dew point statistics with the onsite dew point data provided by the applicant.

Dew Point Statistic	2001-2007	
	Detroit Metro Airport	**Fermi 3 Site**
Maximum	26.0 °C	23.7 °C
1 Percent Exceedance	22.2 °C	20.2 °C
Median	5.0 °C	3.2 °C

This comparison shows that the Detroit Metropolitan Airport dew point statistics tend to be higher (more conservative) than the Fermi 3 site statistics. This may be due, in part, to the differences in instrumentation between the Detroit Metropolitan Airport station and the Fermi 3 station.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) climatic design data are available for the Detroit Metropolitan Airport. Based on 1972–2001 period of record in the 2005 ASHRAE Handbook, the applicant identified the maximum 2.0 and 1.0 percent annual DB cooling exceedance temperatures with the corresponding mean coincident wet-bulb (MCWB) temperatures, the maximum 2.0 and 1.0 percent annual non-coincident WB cooling exceedance temperatures, and the minimum 99.0 and 99.6 percent annual DB heating exceedance temperatures. The staff compared the applicant's 2.0 and 1.0 percent exceedance DB and coincident and non-coincident WB temperatures and 99-and 99.6 percent exceedance DB temperature with the Detroit Metropolitan Airport data statistics published by ASHRAE. The staff confirmed that the statistics provided by the applicant are correct.

In addition, the applicant calculated zero percent exceedance (i.e., historic) values of maximum DB temperature with the corresponding MCWB temperature, maximum non-coincident WB temperature, and minimum DB temperature for the 1961 to 2007 period of Detroit Metropolitan Airport data. The applicant also estimated values of the 100-year maximum and minimum DB temperatures and 100-year maximum non-coincident WB temperature based on the same 1961–2007 database.

10 CFR 52.79(a)(iii) states, in part, that the COL FSAR shall include the meteorological characteristics of the proposed site with appropriate consideration of the most severe of the

natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated. In order to be compliant with 10 CFR 52.79(a)(1)(iii), the ambient design temperature site characteristics should be based on the more extreme of either historic or 100-year return period values. Temperatures based on a 100-year return period are considered to provide a sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated as required by regulation.

The zero percent exceedance ambient design temperature Fermi Unit 3 site characteristic values presented in Revision 1 to FSAR Table 2.0-201 (Sheet 6 of 28) are based on historic extreme values. NRC staff issued **RAI 02.03.01-10** requesting the applicant justifies why these site characteristic values are not based on the more extreme of either the historic or 100-year return values. Note that FSAR Section 2.3.1.3.5 already states that the more extreme 100-year temperature values are considered representative of the Fermi site for design purposes. The staff further requested a revision of FSAR Revision 1, Table 2.0-201 (Sheet 6 of 28) to identify the Fermi Unit 3 maximum and minimum zero percent exceedance ambient design temperature site characteristic values as the more extreme of either the historic recorded values or the 100-year return values.

In the response (ML093570220) to **RAI 02.03.01-10**, dated February 8, 2010, the applicant estimated a 100-year return period MCWB temperature by using the 2009 ASHRAE's Weather Data Viewer Version 4.0 (WDView 4.0) to extrapolate a MCWB temperature value from a joint frequency matrix of 1982-2006 Detroit Metropolitan Airport DB and WB values. NRC staff also compiled and compared maximum DB with MCWB, maximum non-coincident WB, and minimum DB temperatures as shown in the table below.

Maximum DB with MCWB, Maximum Non-coincident WB, and Minimum DB Temperatures[a]

Parameter		DCD 0 percent Exceedance Values	Fermi 3 Values					
			DTE		LCD	NRC		
			Historic	100-yr	Historic	Historic	100-yr	
Max	DB	47.2	40.0[b]	40.1[c]	40.0[b]	39.4[d]	40.8[e]	40.3[f]
	MCWB	26.7	24.8[c]	23.3[f]	-[g]	23.3[d]	23.8[e]	23.2[f]
	WB	31.1	29.4[c]	30.0[c]	-	29.4[d]	30.1[d]	-
Min	DB	–40.0	–29.4[b]	–34.9[c]	–29.4[b]	–28.9[d]	–33.8[e]	–33.2[f]

(a) Unit in the table is in degrees Celsius. To convert to degrees Fahrenheit, use the formula: F = 1.8 C + 32.
(b) Based on the 1959–2006 data (source: 2007 LCD).
(c) Based on the 1961–2007 data (source: SAMSON/HUSWO/ISHD).
(d) Based on the 1961–2009 data (source: SAMSON/HUSWO/ISHD).
(e) Based on the 1972–2001 data (source: 2005 ASHRAE Handbook).
(f) Based on the 1982–2006 data (source: 2009 ASHRAE Handbook).
(g) Not available.

- Maximum Dry Bulb Temperature: The applicant determined the Fermi 3 site characteristic value of 40.1 degrees C (104.2 degrees F) based on a 100-year value derived from a review of the 1961–2007 Detroit Metropolitan Airport annual maximum DB temperature values using a Gumbel distribution. The staff performed an

independent evaluation of the 100-year site characteristic value using Equation 1 from Chapter 14 of the *2009 ASHRAE Handbook – Fundamentals*. Using the Detroit Metropolitan Airport 1972–2001 mean and standard deviation of annual extreme maximum DB temperature data provided in the *2005 ASHRAE Handbook*, the staff derived a value of 40.8 degrees C (105.4 degrees F); using the 1982–2006 mean and standard deviation data provided in the *2009 ASHRAE Handbook*, a value of 40.3 degrees C (104.5 degrees F) was derived. The staff calculated maximum DB temperature values than were slightly higher than the applicant's values; however, given that the corresponding ESBWR site parameter value, 47.2 degrees C (117 degrees F), is significantly higher than either the applicant's or staff's maximum DB temperature values, the applicant's site characteristic value is considered acceptable.

- <u>Mean Coincident Wet Bulb Temperature:</u> The applicant determined the Fermi 3 site characteristic value of 23.3 degrees C (73.9 degrees F) based on its review of Detroit Metropolitan Airport 1982–2006 MCWB temperature values (from the 2009 ASHRAE database, WDView 4.0) extrapolated to a DB temperature value of 40.1 degrees C (104.2 degrees F). Using the 2005 ASHRAE database WDView 3.0, the staff extrapolated a MCWB temperature of 23.8 degrees C (74.8 degrees F) for a DB temperature of 40.8 degrees C (105.4 degrees F). Using the 2009 ASHRAE database WDView 4.0, the staff extrapolated a MCWB temperature of 23.2 degrees C (73.8 degrees F) for a DB temperature of 40.3 degrees C (104.5 degrees F). Although the staff calculated slightly higher values, the applicant's site characteristic value of 23.3 degrees C (73.9 degrees F) is considered acceptable, given that the corresponding ESBWR site parameter value of 26.7 degrees C (80 degrees F) is significantly higher than either the applicant's or staff's MCWB temperature values.

- <u>Maximum Wet Bulb Temperature:</u> The applicant determined the Fermi 3 site characteristic value of 30.0 degrees C (86.0 degrees F) based on a 100-year value derived from a review of Detroit Metropolitan Airport 1961–2007 mean and standard deviation of annual maximum WB temperatures using a Gumbel distribution. Using the 1961–2009 mean and standard deviation of annual maximum WB temperatures with a Gumbel distribution, the staff derived a maximum WB temperature of 30.1 degrees C (86.2 degrees F). Because the staff's value is only slightly higher than the applicant's site characteristic value, the applicant's value is considered acceptable.

- <u>Minimum Dry Bulb:</u> The applicant determined the Fermi 3 site characteristic value of –34.9 degrees C (–30.8 degrees F) based on a 100-yr value derived from a review of the Detroit Metropolitan Airport 1961–2007 mean and standard deviation of annual minimal DB temperatures using a Gumbel distribution. Using the 1972–2001 mean and standard deviation of annual extreme minimum DB temperatures provided in the 2005 ASHRAE Handbook, the staff derived a value of –33.8 degrees C (–28.8 degrees F); using the 1982–2006 mean and standard deviation data provided in the 2009 ASHRAE Handbook, a value of –33.2 degrees C (–27.8 degrees F) was derived. On this basis, the staff concludes that the applicant's site characteristic value of –34.9 degrees C (–30.8 degrees F) is conservative.

The applicant revised the zero percent exceedance ambient design temperature site characteristic values presented in FSAR Table 2.0-1 to be the more extreme of either the historic or 100-year return values. For this reason, **RAI 02.03.01-10** is considered resolved.

GEH added three new site parameters related to ESBWR control room habitability area (CRHA) transient room temperature analysis in Revision 8 to DCD Tier 2, Table 2.0-1. The applicant submitted proposed changes to the Fermi 3 COL FSAR in response to ESBWR DCD Revision 8 in a letter dated November 9, 2010. These three new site parameters, along with the corresponding Fermi 3 site characteristic values developed by the applicant, are as follows:

- Maximum average dry bulb temperature for zero-percent exceedance maximum temperature day

  This ESBWR site parameter value, 39.7 degrees C (103.5 degrees F), is used to evaluate maximum temperature conditions for the CRHA transient room temperature analysis. The corresponding site characteristic value is defined as the average of the zero percent exceedance maximum dry bulb temperature and the dry bulb temperature resulting from a daily temperature range, where the daily temperature range is defined as the dry bulb temperature difference between the zero percent exceedance maximum dry bulb temperature and the dry bulb temperature that corresponds to the higher of the two lows occurring within 24 hours before and after that maximum.

  The applicant reported that the historic maximum dry bulb temperature value reported for the Detroit Metropolitan Airport during the period 1961-2007 was 40.0 degrees C (104.0 degrees F) which occurred on June 25, 1988. The applicant stated that the higher of the two lows occurring within 24 hours before and after the historic maximum dry bulb temperature was 18.9 degrees C (66.0 degrees F). Because the 100-year return maximum dry bulb temperature (40.05 degrees C [104.1 degrees F]) is higher than the historic maximum dry bulb temperature, the applicant used the higher 100-year value in calculating a Fermi 3 maximum average dry bulb temperature for zero-percent exceedance maximum temperature day site characteristic value of 29.48 degrees C (85.1 degrees F). The resulting Fermi 3 site characteristic value is bounded by the corresponding ESBWR site parameter value.

- Minimum average dry bulb temperature for zero-percent exceedance minimum temperature day

  This ESBWR site parameter value, −32.5 degrees C (−26.5 degrees F), is used to evaluate minimum temperature conditions for the CRHA transient room temperature analysis. The corresponding site characteristic value is defined as the average of the zero percent exceedance minimum dry bulb temperature and the dry bulb temperature resulting from a daily temperature range, where the daily temperature range is defined as the dry bulb temperature difference between the zero percent exceedance minimum dry bulb temperature and the dry bulb temperature that corresponds to the lower of the two highs occurring within 24 hours before and after that minimum.

  The applicant reported that the historic minimum dry bulb temperature value reported for the Detroit Metropolitan Airport during the period 1961-2007 was −29.44 degrees C (−21.0 degrees F) which occurred on January 21, 1984. The applicant stated that the lower of the two highs occurring within 24 hours before and after the historic maximum dry bulb temperature was −17.8 degrees C (−0.04 degrees F). Because the 100-year return minimum dry bulb temperature (−34.89 degrees C [−30.8 degrees F]) is lower than the historic minimum dry bulb temperature, the applicant used the lower 100-year value in calculating a Fermi 3 minimum average dry bulb temperature for zero-percent exceedance minimum temperature day site characteristic value of −26.35 degrees C

(−15.4 degrees F). The resulting Fermi 3 site characteristic value is bounded by the corresponding ESBWR site parameter value.

- Maximum high humidity average web bulb globe temperature index for zero-percent exceedance maximum wet bulb temperature day

  This ESBWR site parameter value, 30.3 degrees C (86.6 degrees F), is used to evaluate high humidity conditions for the CRHA transient room temperature analysis. It is defined as the average of the wet bulb globe temperature (WBGT) index values for the zero-percent exceedance maximum wet bulb temperature and the highest of the six low wet bulb temperatures that occurs in each of the three 24-hour periods before and after the zero-percent exceedance wet bulb temperature. The WBGT index value is defined as the dry bulb temperature multiplied by 0.3 plus the wet bulb temperature multiplied by 0.7.

  The applicant reported that the historic maximum wet bulb temperature value reported for the Detroit Metropolitan Airport during the period 1961-2007 was 29.44 degrees C (85.0 degrees F) which occurred on July 14, 1995. The coincident dry bulb temperature was 36.7 degrees C (98.1 degrees F). Because the 100-year return maximum wet bulb temperature (30.0 degrees C [86.0 degrees F]) is higher than the historic maximum wet bulb temperature, the applicant used the higher 100-year value in calculating a WBGT index of 32.01 degrees C (89.62 degrees F).

  The applicant stated that the highest of the six low wet bulb temperatures that occurred in each of the 24-hour periods before and after the historic maximum wet bulb temperature was 24.1 degrees C (75.4 degrees F). The coincident dry bulb temperature was 28.9 degrees C (84.0 degrees F), resulting in a WBGT index of 25.54 degrees C (77.97 degrees F).

  The average of the WBGT index values for the zero-percent exceedance maximum wet bulb temperature and the highest of the six low wet bulb temperatures that occurs in each of the three 24-hour periods before and after the zero-percent exceedance wet bulb temperature is 28.78 degrees C (83.80 degrees F). This value represents the site characteristic value for the Fermi 3 maximum high humidity average web bulb globe temperature index for zero-percent exceedance maximum wet bulb temperature day. The resulting Fermi 3 site characteristic value is bounded by the corresponding ESBWR site parameter value.

The staff reviewed meteorological data from the Detroit Metropolitan Airport for the period 1961-2009 and identified the same dates and times as the applicant regarding the occurrence of the historic maximum and minimum dry bulb temperatures and the historic maximum wet bulb temperature. The staff also found that its historic temperature values were the same or bounded by the applicant's values. The staff also concluded that the applicant used the correct methodology in developing the three CRHA transient room temperature analysis site parameter values by following the definitions presented in ESBWR DCD Tier 2, Appendix 3H, Section 3H.3.2.1. Therefore, the staff finds the applicant's three CRHA transient room temperature analysis site parameter values to be acceptable.

The staff issued **RAI 02.03.01-19** requesting that the applicant address the following in its proposed revision to the FSAR that develops the CRHA transient room temperature analysis site characteristic values: (1) change the use of the term "Fermi site parameters" to "Fermi site

characteristics” in order to be consistent with the terms defined in 10 CFR 52.1(a), and (2) more precisely describe the methodology used in determining the CRHA site characteristic values in accordance with Revision 8 to ESBWR DCD Tier 2, Appendix 3H, Section 3H.3.2.1.

In its response (ML110110550) to **RAI 02.03.01-19** dated January 10, 2011, the applicant agreed to revise the FSAR to change the term “Fermi site parameters” to “Fermi site characteristics” when referring to the site-specific CRHA transient room temperature analysis values. The applicant also agreed to update the FSAR to more precisely describe the methodology used in determining the CRHA transient room temperature analysis site characteristic values in accordance to the definitions in the ESBWR DCD. The staff reviewed the applicant response to **RAI 02.03.01-19** and finds the response acceptable because the applicant agreed to revise the FSAR to address the staff’s concerns.

The applicant incorporated the three CRHA transient room temperature analysis site characteristic values into Revision 4 of the Fermi 3 FSAR, including the changes indentified in the applicant’s response to **RAI 02.03.01-19**. Therefore, **RAI 02.03.01-19** is considered to be resolved.

f. Ultimate Heat Sink

Subsection 2.3.1.3.7 of the FSAR discusses the ultimate heat sink (UHS) function for the ESBWR design that is provided by safety systems integral and interior to the reactor plant. DCD Tier 2, Subsection 3.1.4.15, states that the ESBWR UHS is the isolation condenser/passive containment cooling system (IC/PCCS) pool. In the event of a design-basis accident, heat is transferred to the IC/PCCS pool(s) through the isolation condenser system and the PCCS. The water in the IC/PCCS pool(s) is allowed to boil, and the resulting steam is vented to the environment.

Because the UHS for the Fermi Unit 3 ESBWR design does not require an external source of safety-related cooling water and there are no cooling towers, basins, or cooling water intake/discharge structures external to the reactor plant, specialized meteorological data for evaluating the UHS are not required.

g. Regional Air Quality

i. Background Air Quality

In Revision 1 of FSAR Subsection 2.3.1.3.8, the applicant states that air quality at the Fermi site is heavily influenced by the Detroit and Toledo Metropolitan areas and surrounding emission sources. The Michigan Department of Environmental Quality (MDEQ) evaluates the air quality in the Detroit metropolitan area with a network of monitors mostly located in Wayne County, north of the Fermi site. The MDEQ routinely monitors the EPA criteria pollutants of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter equal to or smaller than 2.5 micrometers in diameter ($PM_{2.5}$), particulate matter equal to or smaller than 10 micrometers in diameter (PM_{10}), and ozone (O_3). The applicant identified that Monroe County is designated a nonattainment area for EPA’s annual $PM_{2.5}$ standard (i.e., the three-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors exceeded 15.0 $\mu g/m^3$) and 8-hour O_3 standard (i.e., the three-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year exceeded 0.075 ppm). Maximum concentrations for the annual average of $PM_{2.5}$ and 8-hour O_3 pollutants were obtained from monitors in Monroe and Wayne

Counties. The applicant reports that the highest annual $PM_{2.5}$ concentration reported between 1999 and 2006 is 20.1 $\mu g/m^3$, occurring at the Dearborn monitor located west of downtown Detroit. During the same period, the highest 8-hour O_3 concentration recorded was 0.104 ppm, measured at the East Seven Mile monitor located in northeastern Wayne County.

NRC staff verified the statements and values determined by the applicant using the EPA's *Green Book* and *Air Data* database, and MDEQ' *2006 Annual Air Quality Report*.

In Revision 1 of FSAR Subsection 2.3.1.3.8.1, "Background Air Quality," the applicant stated that Monroe County is a member of the Air Quality Control Region (AQCR) that included the counties of the Detroit metropolitan area. However, per 40 CFR 81.43, Monroe County is in Metropolitan Toledo Interstate Air Quality Control Region (AQCR 124), and the nonattainment status for $PM_{2.5}$ and O_3 is reported as a part of the Detroit-Ann Arbor designated area as in 40 CFR 81.243. NRC staff issued **RAI 02.03.01-11** asking the applicant to clarify the jurisdiction for air quality control management at the Fermi Unit 3 site.

The applicant's response (ML093570220) to **RAI 02.03.01-11** (dated February 8, 2010) revised Revision 2 of FSAR to state that Monroe County is a member of the Metropolitan Interstate Toledo AQCR and is also included in the Detroit-Ann Arbor air quality designation area. The applicant also updated the FSAR to indicate that the Detroit-Ann Arbor air quality designation area is reclassified as a maintenance area for 8-hour O_3 standard on June 29, 2009. NRC staff confirmed this information, and thus **RAI 02.03.01-11** is considered resolved.

In Revision 1 of FSAR Subsection 2.3.1.3.8.1, "Background Air Quality," the FSAR states that only annual-average $PM_{2.5}$ concentrations exceeded the ambient air quality standards. However, 24-hour average $PM_{2.5}$ concentrations at monitoring stations around the Fermi site frequently exceeded the respective 35 $\mu g/m^3$ standard as well. NRC staff issued **RAI 02.03.01-12** asking the applicant to discuss exceedances of 24-hour $PM_{2.5}$ concentrations around Fermi site and to revise the $PM_{2.5}$ units used in this section from mg/m^3 to $\mu g/m^3$.

In its response (ML093570220) to **RAI 02.03.01-12** (dated February 8, 2010), the applicant agreed to revise the FSAR to include the latest $PM_{2.5}$ nonattainment area designations for Monroe County and nearby monitor concentrations for 24-hour $PM_{2.5}$. The applicant also corrected the units associated with the $PM_{2.5}$ standard. Consequently, **RAI 02.03.01-12** is considered resolved.

Section C.I.2.3.1.2 of RG 1.206 and Section III.3.e of SRP Section 2.3.2 state that regional air quality conditions that should be considered in the evaluation of the design and operation of the facility should be identified. Revision 1 of FSAR Section 2.3.1.3.7.1 states that Monroe County is a member of an Air Quality Control Region (AQCR) that has been classified as nonattainment for $PM_{2.5}$ and O_3 national ambient air quality standards (NAAQS). NAAQS are promulgated to protect public health and welfare. NRC staff issued **RAI 02.03.01-13** requesting the applicant to discuss the impact on plant design and operation due to the Fermi site being located in a $PM_{2.5}$ and O_3 nonattainment area.

The applicant response (ML093570220) to **RAI 02.03.01-13** (dated February 8, 2010) states that the Detroit-Ann Arbor designation area including Monroe County is redesignated as a maintenance area for the 8-hour O_3 standard, and thus is currently a nonattainment area for $PM_{2.5}$ only. The applicant states that the construction and operation of Fermi Unit 3 would meet the MDEQ regulations and programs and that only few infrequently operated sources of criteria pollutants exist at a new nuclear unit. The applicant concluded that the operation of Fermi

Unit 3 will have neither a negative impact on the current air quality nor impede the State's plans for attaining the NAAQS, and thus will not adversely impact public health and welfare via air quality. In addition, the applicant mentioned the need for a conformity analysis for construction and operation at the Fermi Unit 3 site because the project is subject to a Federal action (i.e., NRC's approval for construction and operation) and the area is classified as a maintenance and nonattainment area for 8-hour O_3 and $PM_{2.5}$ standards, respectively.

The NRC staff reviewed the applicant's response to **RAI 02.03.01-13** and accepts portions of the applicant's statement. NRC staff concluded that the conformity analysis will be addressed separately from this SER. However, the NRC staff found the response to **RAI 02.03.01-13** incomplete. The staff closed **RAI 02.03.01-13** and issued a follow-up question, **RAI 02.03.01-17**, to address the unresolved issues.

The staff issued **RAI 02.03.01-17** asking the applicant to address the impact on plant design and operation due to the Fermi site being located in a $PM_{2.5}$ nonattainment area. For example, the applicant should discuss whether the increased particulate loading associated with a $PM_{2.5}$ nonattainment area would adversely impact dust loading on HVAC filter systems.

The applicant's response (ML102570700) to **RAI 02.03.01-17** (dated September 2, 2010) states that Monroe County is below the NAAQS for $PM_{2.5}$ based on recent (2006-2008) monitoring data. The applicant further states that, per a letter from MDEQ to U.S. EPA, dated March 4, 2009, only one monitor in Southeast Michigan, in Wayne County, shows nonattainment of the standard. All other monitors in Southeast Michigan, including the eight other monitors in Wayne County, are meeting the 24-hour $PM_{2.5}$ standard. The applicant further states that, given that the entire state of Michigan will be in attainment with the $PM_{2.5}$ NAAQS prior to construction and operation of Fermi 3, there is no impact on plant design and operation. The staff confirmed that there are two exceedances among the monitors in the current nonattainment area of Southeast Michigan, including Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne Counties, based on 2006-2008 monitoring data (U.S. EPA's *AirData* database, available at http://www.epa.gov/air/data/, accessed October 29, 2010). One exceedance occurred in Dearborn, Wayne County, which is located about 25 miles north of the Fermi site. The other exceedance occurred in Port Huron, St. Clair County, which is located about 82 miles north-northeast of the Fermi site. The 2000-2008 monitoring data show a general decreasing trend of 24-hour and annual $PM_{2.5}$ concentrations in Monroe County, except for peaks in 2002 and 2005. The staff also notes that in July 2011, the MDEQ submitted a request asking the EPA to redesignate southeast Michigan as being in attainment with the $PM_{2.5}$ NAAQS. This request would be based, in part, on air quality monitoring data collected in the 2007-2010 period showing all seven counties in southeast Michigan in attainment for the $PM_{2.5}$ NAAQS.

Considering all of these findings, the staff accepts the applicant's conclusion that $PM_{2.5}$ concentrations in Monroe County would be likely to comply with NAAQS during construction and operation of Femi 3 and are not likely to adversely impact dust loading on HVAC filter systems. Therefore, **RAI 02.03.01-17** is considered resolved.

ii. Air Stagnation

In Revision 1 to FSAR Subsection 2.3.1.3.8.3 "Air Stagnation," the applicant estimates that high-pressure stagnation conditions, usually accompanied by light and variable wind conditions, can be expected at the proposed Fermi Unit 3 site. These conditions would occur about 10 days per year or in about two cases per year, with a mean duration of about three to four days for each case. This estimation is based on findings by Wang and Angell (NOAA/Air Resources

Laboratory ATLAS No. 1, "Air Stagnation Climatology for the United States (1948-1998)," April 1999). Stagnation conditions primarily occur from May through October, with the highest incidences recorded between July and September. This 3-month period also coincides with the lowest monthly mean wind speeds during the year, as reported by the LCD summary for Detroit Metropolitan Airport.

The staff confirmed that the information presented by the applicant regarding restrictive dispersion conditions is correct. Subsection 2.3.1 of this SER discusses the proposed Fermi Unit 3 site air quality conditions for design and operating considerations. Sections 2.3.4 and 2.3.5 of this SER discuss atmospheric dispersion site characteristics used to evaluate short-term, post-accident airborne releases and long-term routine airborne releases, respectively.

Potential Changes in Climate

As specified in NUREG–0800, the applicability of data used to discuss severe weather phenomena that may impact the proposed COL site during the expected period of reactor operation should be substantiated. Long-term environmental changes and changes to the region resulting from human or natural causes may affect the applicability of the historical data to describe the site's climate characteristics. The staff believes current climate trends should be analyzed for potential ongoing environmental changes.

The applicant did not address potential impacts associated with climate changes in Revision 1 of the FSAR. SRP Section 2.3.1 states that the applicability of the data on severe weather phenomena that is used to represent site conditions during the expected period of reactor operation should be substantiated. SRP Section 2.3.1 further states that current literature on possible changes in the weather in the site region should also be reviewed to be confident that the methods used to predict weather extremes are reasonable. **RAI 02.03.01-14** was issued requesting that the applicant evaluate the trends in severe weather phenomena and extremes in the proposed site vicinity and discuss whether such trends may be indicative of climate change.

The applicant's response (ML093570220) to **RAI 02.03.01-14** (dated February 8, 2010) states the applicant analyzed normal temperature and rainfall trends during a 70-year period for successive 30-year intervals by decade for the climate division in which the Fermi site is located. The applicant states that normal (i.e., 30-year average) temperatures have not changed between the beginning period of 1931–1960 and the latest period of 1971–2000, but the normal rainfall has trended upward from 78.0 cm (30.72 in.) per year for the 1931–1960 period to 83.5 cm (32.86 in.) per year for the 1971–2000 period. The applicant also showed that a change in annual-average temperature between the 1920–1940 period and 1980–2000 period for the Detroit Metropolitan Airport has no trend, but annual-average temperature for the 2000–2009 period increased about 0.5 degrees C (0.9 degrees F) compared to the 1980–2000 period. The annual-average precipitation generally shows upward trends: from 77.2 cm (30.4 in.) for the 1920–1940 period to 86.1 cm (33.9 in.) for the 1980–2000 period and 86.6 cm (34.1 in.) for the 2000–2009 period.

The U.S. Global Change Research Program (GCRP) released a report to the President and Members of Congress in June 2009 titled, *Global Climate Change Impacts in the United States*. This report was produced by an advisory committee chartered under the Federal Advisory Committee Act. The report summarizes the science of climate change and the impacts of climate change on the United States.

The GCRP report found that the average annual temperature of the Midwest (which includes the State of Michigan where the Fermi Unit 3 site is located) did not change significantly during the past century as a whole, but the annual average temperature has risen about 1–2 degrees F since 1961. Climate models predict continued warming across the Midwest and an increase in the rate of warming throughout the end of the 21st century. Under a low heat-trapping gas emission scenario, average temperatures around the Fermi site are projected to rise by about 5–6 degrees F by the 2080s, while a higher emissions scenario yields about a 9 degrees F increase in average warming.

The GCRP report also states that there is a 15 to 20 percent increase in observed annual average precipitation from 1958 to 2008 in the region in the proposed location of the Fermi Unit 3. Future changes in total precipitation are more difficult to project than changes in temperature. Model projections of future precipitation generally indicate that northern areas of the United States will become wetter due to more northward incursions of storm tracks, with about a 15 to 20 percent increase in winter and spring, a 5 to 10 percent decrease in summer, and a zero to 5 percent increase in fall around the Fermi site.

The applicant stated that there are no discernable trends in extreme weather events, considering that extreme temperatures and precipitation events around the Fermi site occurred more than 30 years ago and increasing trends of severe weather events are primarily due to a simple increase in communication techniques in more recent years. The applicant concluded that the data for extreme weather events presented in the FSAR remain bounded by the design values, as this type of return period goes beyond the design life of the proposed new unit.

The GCRP reports that the distribution by intensity of the strongest 10 percent of hail and wind reports has changed little, and there is 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 verified that, except for a couple of incorrect temperatures, the data and related discussion presented in the response to **RAI 02.03.01-14** are reasonable and thus **RAI 02.03.01-14** is considered resolved.

The NRC staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. There is uncertainty in projecting future conditions because the assumptions regarding the future level of emissions of heat-trapping gases depends on projections of population, economic activity, and choice of energy technologies. The GCRP report states that climate will be continually changing toward more extreme weather events. However, there is considerable margin between many of the ESBWR climatic site parameters and the corresponding Fermi 3 site characteristic values as shown in FSAR Table 2.0-201. 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.

NRC staff reviewed the application and found that the applicant has presented and substantiated information to establish the regional meteorological characteristics.

2.3.1.5 Post Combined License Activities

There are no post-COL activities associated with this section.

2.3.1.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. With the exception of Confirmatory Item 02.03.01-20, the staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

NRC staff reviewed the application and found that the applicant has presented and substantiated information to establish the regional meteorological characteristics. The staff's review confirmed that the applicant has established the meteorological characteristics at the site and in the surrounding area acceptable to meet the requirements of 10 CFR 100.20(c)(2) and 100.21(d) with respect to determining the acceptability of the site.

The staff found that the applicant has considered the most severe natural phenomena historically reported for the site and surrounding area in establishing its site characteristics. Specifically, the staff accepted the methodologies used to analyze these natural phenomena and determine the severity of the weather phenomena reflected in these site characteristics. Because the applicant has correctly implemented these methodologies, as described above, the staff has determined that the applicant has considered these historical phenomena with margin sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concludes that the identified site characteristics meet the requirements of 10 CFR 52.79(a)(1)(iii) with respect to identifying the most severe of the natural phenomena historically reported for the site and surrounding area and with a sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated.

The staff's review confirmed that the applicant has adequately addressed the COL license information item in accordance with Section 2.3.1 of NUREG–0800.

2.3.2 Local Meteorology

Measurements from the Fermi onsite meteorological tower, located approximately one-quarter mile from the Fermi 3 RB, will be used in this section to characterize the local meteorology conditions at the Fermi site.

2.3.2.1 Introduction

Subsection 2.3.2, "Local Meteorology," of the Fermi 3 COL FSAR, Revision 4, addresses the local (site) meteorological characteristics, the 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 operations, and provides a topographical description of the site and its environs.

2.3.2.2 Summary of Application

Subsection 2.3.2 of the Fermi 3 COL FSAR, Revision 4, discusses local meteorology at the Fermi 3 site. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-8-A Local Meteorology

  The onsite meteorological tower (the details of which are contained in Subsection 2.3.3) collects wind speed, wind direction, and ambient temperature at the 10-m (33-ft) and 60-m (197-ft) levels, dew-point temperature at 10-m (33-ft) level, and vertical air temperature difference (ΔT) between the 60-m (197-ft) and 10-m (33-ft) levels. In addition, precipitation is collected at ground level near the base of the tower.

2.3.2.3 Regulatory Basis

The acceptance criteria for identifying regional climatology are based on meeting the relevant requirements of 10 CFR Part 52 and 100. The staff considered the following regulatory requirements in reviewing the applicant's discussion of site location and description:

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated.

- 10 CFR 100.20(c)(2), and 100.21(d) with respect to the consideration that has been given to the local meteorological and air quality characteristics of the site and other physical characteristics of the site that can influence the local meteorology.

NUREG-0800, Section 2.3.2, specifies that an application meets the above requirements, if the application satisfies the following criteria:

- local summaries of meteorological data based on onsite measurements are provided in accordance with RG 1.23 and NWS station summaries or other standard installation summaries from appropriate nearby locations (e.g., within 80 km [50 miles]) are presented as specified RG 1.206, Section 2.3.2.1

- a complete topographical description of the site and environs out to a distance of 80 km (50 mi) from the plant, as described in RG 1.206, Section 2.3.2.2, is provided

- a discussion and evaluation of the influence of the plant and its facilities on the local meteorological and air quality conditions are provided and the applicant identifies potential changes in the normal and extreme values resulting from plant construction and operation

- a description of local site airflow that includes wind roses and annual joint frequency distributions (JFDs) of wind speed and wind direction by atmospheric stability for all measurement levels is provided using the criteria provided in RG 1.23

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

2.3.2.4 Technical Evaluation

The NRC staff reviewed the application and the applicant's responses to RAIs to verify the accuracy, completeness, and sufficiency of the information regarding local meteorology. The staff followed the procedures in Section 2.3.2 of NUREG–0800 as part of this review.

COL Item

- EF3 COL 2.0-8-A Local Meteorology

This COL information item requires that the COL applicant supply site-specific information in accordance with SRP Subsection 2.3.2; that is, the COL applicant should provide summaries of the local (site) meteorological characteristics, an assessment of the potential influence of the proposed plant and its facilities on local meteorological conditions, the impact of these modifications on plant design and operation, and a topographical description of the site and its environs.

In response to this COL information item, the applicant provides the following:

- Summaries of the local (site) meteorology in terms of temperature, atmospheric moisture, precipitation, fog and smog, wind direction and wind speeds, wind persistence, mixing heights, and atmospheric stability and inversions.

- An assessment of the construction and operation impacts of the plant and its facilities on the local meteorological parameters listed above. These impacts include the effects of plant structures, terrain modification, and heat and moisture sources due to plant operation.

- A topographical description of the site and its environs, as modified by the plant structures.

NRC staff reviewed the applicant's resolution to EF3 COL 2.0-8-A related to supplying site-specific information in accordance with SRP Subsection 2.3.2. The staff's review of the applicant's summaries of the local (site) meteorological characteristics, an assessment of the potential influence of the proposed plant and its facilities on local meteorological conditions, the impact of these modifications on plant design and operation, and a topographical description of the site and its environs is described below.

Normal, Mean, and Extreme Values

In Subsection 2.3.2.1 of the FSAR, the applicant uses measurements made at the Fermi onsite meteorological tower, located approximately one-quarter mile from the Fermi 3 RB, to characterize the local meteorology conditions at the Fermi site. The onsite meteorological tower collects wind speed, wind direction, and ambient temperature at the 10-m (33-ft) and 60 m (197-ft) levels, dew-point temperature at 10-m (33-ft) level, and vertical air temperature difference (ΔT) between the 60-m (197-ft) and 10-m (33-ft) levels. In addition, precipitation is

collected at ground level near the base of the tower. The vertical temperature difference (ΔT) between the 60-meter (197-foot) and 10-meter (33-foot) levels is used to compute atmospheric stability in accordance with the guidance provided in RG 1.23. Hourly data from a recent 5-year period (2003 through 2007) were used by the applicant in the analysis of the local meteorology of the Fermi site. The data recovery rate for all the meteorological parameters during this period exceeded 94 percent. Wet-bulb temperature, relative humidity, and the occurrence of fog and visibility are not collected at the Fermi onsite meteorological station; subsequently, the applicant presents data from the nearby Detroit Metropolitan Airport to supplement Fermi site data. The applicant also presents data from the next two closest first-order NWS stations, Toledo, Ohio, and Flint, Michigan. The applicant also obtained extreme values of temperature, rainfall, and snowfall for four NWS COOP stations located within 80 km (50 mi) of the Fermi site (Monroe, Michigan; Windsor, Ontario; Ann Arbor, Michigan; and Adrian, Michigan), since those parameters are also representative from a regional perspective.

a. Temperature

In Subsection 2.3.2.1.1 of the FSAR, the applicant presents monthly and annual temperature data for 10-meter (33-foot) and 60-meter (197-foot) levels at the Fermi site and for the 10-meter (33-foot) level at the Detroit Metropolitan Airport for the 5-year period 2003–2007 in FSAR Section 2.3.2.1.1. While mean annual temperatures at the 10-meter (33-foot) level at the Fermi site and the Detroit Metropolitan Airport are comparable, the mean monthly values are somewhat different. Due to its proximity to Lake Erie, the Fermi site experiences moderating effects of the water's high heat content by onshore and offshore breezes throughout the year except for winter. During winter months, Lake Erie is generally covered with ice, which inhibits the moderating effects of Lake Erie, and thus temperatures between the two sites are nearly identical. During the spring, ice over the lake melts but the water temperature is still cold, which results in cooler temperatures at the Fermi site than those at the Detroit Metropolitan Airport, which is farther inland. As the lake water warms up during the late spring, the lake exerts moderating effects on temperature, and the temperature contrast along the coast creates onshore and offshore breezes. As a result, temperatures at the Fermi site are a little cooler than those at the Detroit Metropolitan Airport. During the fall season, lake water remains warm, and thus temperatures at the Fermi site are warmer than at the Detroit Metropolitan Airport. Due to the moderating effects of lake water, the Fermi site experiences lower maximum and higher minimum temperatures than the Detroit Metropolitan Airport. The applicant states that, in consequence, annual mean temperatures of the Detroit Metropolitan Airport are representative of the Fermi site from a longer climatological standpoint.

The staff evaluated the applicant's statements in FSAR Subsection 2.3.2.1.1 regarding mean, maximum, and minimum temperatures using the 2003–2007 meteorological data from the Fermi site and from the Detroit Metropolitan Airport.

The applicant originally submitted its 2001-2007 onsite meteorological database in response to **environmental RAI AQ2.7-3** (ML093090165, dated October 30, 2009). The applicant subsequently reviewed its onsite database to confirm the validity of the data as described in the supplemental response to **RAI 02.03.04-3** (ML100960472, dated March 30, 2010) and provided a revised 2001-2007 onsite database in a supplemental response to **environmental RAI AQ2.7-3** (ML093090165, dated March 30, 2010). The staff performed a precursory review of the revised database and determined that the database still contained errors. The staff subsequently issued **RAI 02.03.02-7** asking the applicant to review the revised 2001-2007 onsite meteorological database for mislabeled hours and for DB and dew-point temperature

data that were out of range and drastically different from the surrounding data and revise the database accordingly.

In response (ML102570700) to **RAI 02.03.02-7** (dated September 2, 2010), the applicant states that it conducted a comprehensive review of the onsite meteorological database to identify instances where the hourly DB and dew-point temperature data may be out of range. The applicant flagged for further analysis those hours with a temperature change of ±3 degrees C from the previous hour. The applicant reviewed the validity of the flagged data by considering frontal passages, precipitation events, sea/land breezes, or instrument malfunctions, and also by comparisons with hourly observations at the Detroit Metropolitan Airport. The applicant subsequently identified 25 hours in the 2001-2007 database that contained questionable DB or dew-point temperature values as compared with their surrounding hourly values. The 25 hours amount to about 0.04 percent of the over 60,000 observations contained in the 2001-2007 onsite meteorological database. The applicant further states that no additional hours were found where wind speed, wind direction, or stability class data were considered questionable. The applicant stated that these problematic data have no or minor impact on the SACTI cooling tower plume modeling analysis and the JFD tables of wind speed, wind direction, and atmospheric stability presented in the FSAR. In addition, the applicant revised the monthly and annual onsite dew-point temperature summary presented in FSAR Table 2.3-212. The applicant provided a revised 2001-2007 onsite database in its response to **RAI 02.03.02-7** which corrected the mislabeled hours and the questionable DB and dew-point temperature data.

The staff examined the applicant's revised onsite database for mislabeled hours and large hour-to-hour changes in parameter values by performing time-series plotting and found no discontinuities in time labels or out-of-range data. The staff also compiled its own monthly and annual dew-point temperature statistics, which it compared with the revised summary table (FSAR Table 2.3-212) presented by the applicant. The staff found the two sets of dew-point temperature data statistics to be consistent (within 0.056 degree C [0.1 degree F]). Accordingly, the **RAI 02.03.02-7** is considered resolved.

The staff issued **RAI 02.03.02-8** asking the applicant to confirm the extreme monthly DB temperature values presented in Revision 2 to FSAR Table 2.3-211 for the Detroit Metropolitan Airport. The applicant derived the values presented in FSAR Table 2.3-211 using the NCDC's ISHD. The staff also compiled extreme monthly DB temperature values from the ISHD and found discrepancies between the applicant's values and the staff's values.

In response (ML102570700) to **RAI 02.03.02-8** (dated September 2, 2010), the applicant confirmed that it also found data discrepancies that occurred through the use of different versions of the ISHD database; i.e., a full ISHD format used by the staff versus an abridged ISHD format used by the applicant. The applicant reported the apparent data discrepancies to the NCDC. The NCDC acknowledged that its application that is used to generate the abridged ISHD format contained an error and began working to resolve the issue. The applicant reanalyzed the DB temperature data using the full ISHD format and revised the Detroit Metropolitan Airport extreme monthly DB temperature values reported in FSAR Table 2.3-211 accordingly. The applicant incorporated the revised Table 2.3-211 into Revision 3 of the FSAR. Therefore, **RAI 02.03.02-8** is considered resolved.

The staff compiled its own monthly DB temperature statistics from the onsite and Detroit Metropolitan Airport data and compared its statistics with the revised DB statistics in the applicant's proposed revision to FSAR Table 2.3-211. In general, the discrepancies between the two are within an acceptable range, but a couple of monthly values are different by more

than one degree F: For example, the staff compiled a mean January temperature for the Detroit Metropolitan Airport of –3.3 degree C (26.1 degree F) as compared to the applicant's value of –2.6 degree C (27.4 degree F); similarly, the staff compiled a 60-meter onsite minimum September temperature of 5.5 degree C (41.9 degree F) as compared to the applicant's value of 2.9 degree C (37.3 degrees F). These few temperature discrepancies do not affect the staff's determination that the applicant has adequately described the temperature conditions at the Fermi 3 site.

b. Atmospheric Moisture

In FSAR Subsection 2.3.2.1.2, the applicant compares long-term atmospheric moisture parameters (relative humidity, wet-bulb temperature, and dew-point temperature) among the three first-order NWS stations in the region surrounding the Fermi site. In FSAR Section 2.3.2.1.2, the applicant states that the atmospheric moisture content for stations in the Fermi region is directly related to the latitude of the station and, to a smaller extent, the distance from the Lake Erie shoreline. The applicant indicates that the atmospheric moisture conditions at the Detroit Metropolitan Airport are representative of those at the Fermi site and the atmospheric moisture content at the Fermi site is influenced by Lake Erie and the other Great Lakes.

During the five-year period 2003–2007, the applicant found that the Fermi site meteorological data shows the mean annual dew point temperature for the Fermi site to be 3.1 degree C (37.6 degree F), with the mean monthly dew point temperature highest during July and August (14.5 degree C [58.1 degree F]) and lowest in February (–9.1 degree C [15.7 degree F]). The highest dew point temperature measured was 23.7 degree C (74.7 degree F) while the lowest dew-point temperature measured was –29.9 degree C (–21.8 degree F). Mean monthly diurnal variations in dew point vary the least during summer and early fall when mean dew point temperatures are highest.

The NRC staff evaluated and confirmed the applicant's statements about monthly and annual, dew point temperature data summaries at the Fermi site in FSAR Section 2.3.2.1.2 using 2003–2007 hourly meteorological data from the Fermi station. The staff therefore concludes that the applicant has adequately described the atmospheric moisture conditions at the Fermi 3 site.

c. Precipitation

In FSAR Subsection 2.3.2.1.3, the applicant states that the Fermi onsite meteorological station precipitation sensor malfunctioned several times during the 2003–2007 period, so the applicant used precipitation records for the Detroit Metropolitan Airport to describe the precipitation characteristics of the Fermi site. The applicant characterized the Fermi region as having consistent precipitation amounts during the year and routine wintertime snowfall. The applicant concluded that, when comparing precipitation data from NWS first-order and COOP stations in the Fermi region, precipitation values are reasonably uniform over the region, and therefore are representative of precipitation that would be observed at the Fermi site.

The applicant found that the highest 24-hour precipitation amount measured at the seven stations used to characterize the Fermi Unit 3 site climate was 15.3 cm (6.04 inches) during September 1950 at Flint. The highest monthly precipitation, 28.0 cm (11.04 inches), was also observed at Flint during August 1975. Based on the most recent five years of data from the Detroit Metropolitan Airport (2003–2007), the applicant found precipitation was recorded about

16 percent of the time. January experiences the most frequent hourly precipitation while September has the lowest. The applicant also found that majority of hourly precipitation is of light intensity (less than 0.25 cm [0.1 inches]), and hourly rainfall events greater than 1.27 cm (0.50 inches) occur most frequently with winds from the southwest and south-southwest.

The staff evaluated and confirmed the applicant's statements in FSAR Subsection 2.3.2.1.3 by reviewing NCDC's Local Climatological Data Summary for the three first-order NWS stations (Detroit, Flint, and Toledo) and Climatography for four COOP stations (Adrian 2 NNE, Ann Arbor, Monroe, and Windsor) in the Fermi region and the NCDC's TD-3240 hourly precipitation data at Detroit Metropolitan Airport for the period 2003–2007.

d. Fog and Smog

In FSAR Subsection 2.3.2.1.4, the applicant uses 1961–1995 hourly surface observation data from the Detroit Metropolitan Airport to describe fog and smog conditions at the Fermi site. The applicant stated that the Detroit Metropolitan Airport is the nearest NWS station that monitors visibility and fog. Detroit Metropolitan Airport also has similar elevation and relative proximity to Lake Erie as does the Fermi site, implying that fog conditions would be similar for the two locations. The applicant stated that fog[1] occurred 12.7 percent of the time (1112 hours per year) at Detroit Metropolitan Airport. Fog is most frequent in November and December (14.8 and 17.4 percent, respectively) and least frequent in June and July (9.0 and 9.3 percent, respectively). Heavy fog, defined as a horizontal visibility of 0.4 km (0.25 mi) or less, was found by the applicant to occur about 0.7 percent of the time (60.2 hours per year), most frequently (8 to 11 hours per month) during December through March and least frequently (1 to 2 hours per month) during April through July. The applicant found that smog, defined as a combination of fog and smoke, occurred most frequently during summer and early fall (June through September), and is characterized by warmer air above the surface and lighter winds. This corresponds with the months of weak atmospheric dispersion conditions.

The staff evaluated and confirmed the applicant's statements in FSAR Subsection 2.3.2.1.4 using 1961–1995 hourly surface observation data for the Detroit Metropolitan Airport (NCDC's SAMSON database for 1961–1990 and HUSWO database for 1991–1995 on CD-ROMs).

e. Wind Direction and Wind Speeds

In Subsection 2.3.2.1.5 of the FSAR, the applicant compares the wind direction and wind speed characteristics of the Fermi site and the Detroit Metropolitan Airport in FSAR Subsection 2.3.2.1.5. The applicant states that the mean annual wind speeds for the 10-meter (33-foot) and 60-meter (197-foot) levels at the Fermi site were 10.6 km/hr (6.57 mph) and 20.5 km/hr (12.74 mph), respectively. The mean annual wind speed at the Detroit Metropolitan Airport is reported as 14.1 km/hr (8.75 mph) at the 10-meter (33-foot) level. The applicant attributes the differences in wind speeds at 10-meter (33-foot) level between the Detroit Metropolitan Airport and the Fermi site to land use characteristics (e.g., Detroit Metropolitan Airport has a flat and suburban location versus the Fermi meteorological tower which is located near a grove of trees that may be reducing the measured wind speed at the 10-meter [33-foot] elevation). Due to frictional effects of the earth's surface, wind speeds at the 60-meter

[1] The applicant states that fog is reported by the NWS when horizontal visibility is less than or equal to 9.7 km (6 mi) and the difference between the temperature and dew point is five degrees F or less. However, per SAMSON and HUSWO data format, fog is recorded when visibility is less than 11.3 km (7 mi).

(197-foot) level at the Fermi site are considerably higher than those at the 10-meter (197-foot) level at the Fermi site and the Detroit Metropolitan Airport.

The applicant states that wind directions at the Detroit Metropolitan Airport and at the Fermi site are predominantly from the southwesterly directions and wind directions with a northwesterly component are the second most comment direction. Monthly wind roses for Detroit Metropolitan Airport show definite wind direction patterns by season, depending on the location of the Bermuda High and mean storm track. There is a greater frequency of easterly and southeasterly winds at the Fermi site when compared to the Detroit Metropolitan Airport at the 10-meter (33-foot) level, which the applicant attributes to onshore lake breezes which occur more frequently at the Fermi site.

The staff independently plotted annual and monthly wind roses using 2003–2007 meteorological data from the Fermi site and the Detroit Metropolitan Airport. The staff confirmed that the applicant's statements in FSAR Subsection 2.3.2.1.5 are correct.

The NRC staff issued **RAI 02.03.02-1** requesting the applicant to review and explain the reason for the differences in ratios between 10-meter (33-foot) and 60-meter (197-foot) onsite wind speeds, compared with other meteorological towers. Staff experience indicates 60-meter (197-foot) wind speeds are typically 1.2–1.6 times higher than the 10-meter (33-foot) wind speed during the day and twice as high or higher at night. The Fermi site wind roses appear to show a difference of a factor of about 2 for all hours combined, whereas the staff would expect a factor closer to 1.5 to 1.7. In response (ML093570220) to **RAI 02.03.02-1** (dated February 8, 2010), the applicant stated that the differences between 10-meter (33-foot) and 60-meter (197-foot) wind speeds were possibly due to the presence of the polar jet, the occurrence of offshore winds, and deciduous tree growth to the west of the onsite meteorological tower. The impacts of the apparent increasing frequency of low wind speed observations due to the flow blockage resulting from the trees to the west of the Fermi meteorological tower is discussed further in the applicant's response to **RAI 02.03.03-1** in SER Subsection 2.3.3. **RAI 02.03.02-1** is therefore considered resolved.

The NRC staff issued **RAI 02.03.02-2** requesting the applicant to address whether the contents of FSAR Figure 2.3-204 changed from a precipitation rose in FSAR Revision 0 to a wind rose in FSAR Revision 1. In response (ML093570220) to **RAI 02.03.02-2** (dated February 8, 2010), the applicant stated that the FSAR Figure 2.3-204 precipitation rose graphic in Revision 0 was correct and revised Figure 2.3-203 in FSAR Revision 2 to once again be a precipitation rose. Thus **RAI 02.03.02-2** is considered resolved.

The NRC staff issued **RAI 02.03.02-3** requesting the applicant to describe the methodology it used to generate the Detroit Metropolitan Airport wind and precipitation roses presented in FSAR Figures 2.3-204 through 2.3-229. The applicant used wind direction data from the ISHD database to develop these figures and the wind direction data in the ISHD database are reported to the nearest 10 degrees. However, the precipitation and wind rose wind directions plotted from the ISHD database by the applicant are binned into sixteen 22.5 degree sectors, which means the reported wind direction data are typically more concentrated in the four cardinal directions (N, E, S, and W) if wind direction randomization is not applied. In response (ML093570220) to **RAI 02.03.02-3** (dated February 8, 2010), the applicant stated that it randomized the wind directions in order to prevent directional bias for the four cardinal wind directions. Because the applicant used randomized wind direction data to generate the Detroit Metropolitan Airport wind and precipitation roses, **RAI 02.03.02-3** is considered resolved.

f. Wind Persistence

In FSAR Subsection 2.3.2.1.6, the applicant presented wind direction persistence summaries based on measurements at the Fermi site for the five-year preoperational period 2003 through 2007. The summaries account for consecutive hours of wind direction at 10-meter (33-foot) and 60-meter (197-foot) levels from the 22½-degree (single) and 67½-degree (three adjoining) wind sectors. The applicant reports in FSAR Section 2.3.2.1.6 that the longest persistence periods for a single sector were 31 hours (in the north and southwest sectors) at the 10-meter level and 36 hours at the 60-meter level (in west-southwest sector). The longest persistence periods for three adjoining sectors occurred 158 hours (west-southwest) at both 10-meter (33-foot) and 60-meter (197-foot) levels.

The staff issued **RAI 02.03.02-9** asking that the applicant provide the methodology used to generate the wind direction persistence summaries for the 67½-degree wind sectors. The NRC staff performed an independent analysis of these statistics and found similar distributions of persistence for the 22½-degree wind sectors. However, the staff could not reproduce the applicant’s values for the 67½-degree wind sectors.

In response (ML102570700) to **RAI 02.03.02-9** (dated September 2, 2010), the applicant provided a detailed step-by-step procedures and a schematic diagram describing its methodology for generating the 67½-degree wind sector persistence summaries. The staff processed the onsite meteorological data using the applicant’s methodology and compared its results to the applicant’s results. There are some discrepancies between the staff’s and the applicant’s wind persistence summaries, especially for the 67½-degree wind sectors, but the staff does not consider these discrepancies to be significant. Consequently, the staff finds the applicant's wind direction persistence summaries to be acceptable and thus considers **RAI 02.03.02-9** to be resolved.

g. Mean Monthly Mixing Heights

In FSAR Subsection 2.3.2.1.7, the applicant noted that from a climatological standpoint, the lowest morning mixing heights occur in the summer and fall and the highest mixing heights occur in the winter. Conversely, afternoon mixing heights reach a seasonal minimum in the winter and a seasonal maximum during the summer, which is expected because of more intense summer heating. The applicant presented on a monthly and annual basis mean morning and afternoon mixing height data calculated by NCDC during 2003–2007 for White Lake, Michigan, which is located about 84 km (52 mi) north-northwest of the Fermi site. The NCDC calculated daily morning and afternoon mixing height data based on vertical temperature and wind information at White Lake along with surface data from the Detroit Metropolitan Airport.

The NRC staff confirmed that the applicant’s annual and monthly morning and afternoon mixing height statistics for White Lake, Michigan, are correct by processing the NCDC 2003–2007 twice-daily mixing height data.

h. Inversions

An air stagnation event is associated with persistent light or calm winds and the presence of an inversion, which is defined as an increase in temperature with height. In FSAR Subsection 2.3.2.1.8, the applicant describes the annual and monthly frequency and persistence of temperature inversions for the 2003–2007 time period, based on the temperature

difference (ΔT) between the 10-meter (33-foot) and 60-meter (197-foot) levels at the Fermi onsite meteorological tower being greater than zero. An inversion was present for 13,098 of the 42,800 hours analyzed during the five-year period, which was equivalent to about 30.6 percent of the total hours. About 48.5 percent of the inversions lasted six hour or less, while about 1.3 percent of the inversions lasted longer than 24 hours, with the longest one lasting 76 hours. Inversions are more common during March through October and are most prominent during the summer months of June through August. The applicant states that this concurs with the findings by Wang and Angell (NOAA/Air Resources Laboratory ATLAS No. 1, "Air Stagnation Climatology for the United States (1948-1998)," April 1999) that air stagnation days are highest during July through September.

A comparison of an estimate made by the NRC staff from the hourly ΔT data submitted by the applicant with the summary table presented by the applicant showed reasonable agreement.

i. Atmospheric Stability

In FSAR Subsection 2.3.2.1.9, the applicant discusses atmospheric stability, which is a critical parameter for estimating dispersion characteristics. The dispersion of effluents is greatest for extremely unstable atmospheric conditions (i.e., Pasquill Stability Class A) and decreases progressively through extremely stable conditions (i.e., Pasquill Stability Class G). The applicant based its stability classification on temperature change with height (i.e., vertical temperature difference or ΔT) between the 60-meter and 10-meter height, as measured by the Fermi onsite meteorological monitoring program during the five-year preoperational period 2003–2007 in accordance with the guidance provided in RG 1.23.

The applicant provided seasonal and annual frequencies of atmospheric stability classes. According to the applicant, there is a predominance of neutral stability (Pasquill Stability Class D) and slightly stable (Pasquill Stability Class E) conditions about 56 percent of the time at the proposed Fermi 3 site, which range from approximately 45 percent of the time during the summer to approximately 68 percent of the time during the winter. Extremely unstable conditions (Pasquill Stability Class A) occur most frequently during the summer and least frequently during the winter. Conditions that are extremely and moderately stable (Pasquill Stability Classes G and F, respectively) occur most frequently during the summer and fall months.

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

Based on the NRC staff's past experience with stability data at various sites, a predominance of neutral (Pasquill Stability Class D) and slightly stable (Pasquill Stability Class E) conditions at the proposed Fermi site is considered generally consistent with expected meteorological conditions. A more detailed review of the applicant's hourly ΔT data is provided by the staff in SER Subsection 2.3.3.

Regional Topography

The proposed Fermi Unit 3 site is located in the northeastern part of Monroe County, Michigan, along the western shoreline of Lake Erie. In FSAR Section 2.3.2.2, the applicant presents maps of topographical features within a 5-mile (8-km) and a 50-mile (80-km) radius of the site. The applicant also presents terrain elevation profiles along each of the 16 standard 22½-degree compass radials to distances of 5 miles (8 km) and 50 miles (80 km). Based on these profiles, the applicant characterizes the proposed Fermi Unit 3 site terrain as flat plains that gently slope to higher elevations to the west and northwest of the site (towards the Irish Hills) and to lower elevations to the northeast clockwise to the southwest of the site (towards Lake Erie).

Based on topography data from the USGS and on a site visit, the staff accepts this terrain characterization. The NRC staff concludes that the applicant has provided the necessary topographic information.

Influence of Fermi 3 and Its Facilities on Local Meteorology

In FSAR Subsection 2.3.2.2, the applicant states that potential impacts from construction activities for Fermi Unit 3 on the local climate are expected to be minor. Fermi Unit 3 will be located in the southwest portion of the Fermi site, which is already cleared of trees and may require a low level of grading, leading to minimal change in the overall topography. In addition, construction of new roads for the new facility and addition of new structures would have little to no effect on the local meteorology of the site. The staff accepts that these construction activities are too small in scale to impact the local meteorological characteristics of the site.

The NDCT for Fermi 3 will be built in the approximate location of the current onsite meteorological tower. Thus, a new meteorological tower will be erected in the southeast corner of the Fermi site (approximately 1268 meters [4160 feet]) from the existing meteorological tower) prior to the construction of Fermi 3. In FSAR Subsection 2.3.2.2, the applicant discusses the possible influence of Fermi 3 and its facilities on the proposed location of the new meteorological tower. That discussion is reviewed by the staff in SER Subsection 2.3.3.

The applicant states that emissions of particulate matter and cooling tower plumes associated with large electricity generation could have effects on the local climate. Potential air emission sources of particulate matter include two standby diesel generators, an auxiliary boiler, a diesel fire pump, and increased traffic. Given their small size and infrequent operation, the applicant states that these emission sources will have a minimal impact on the local climate as well as the local and regional air quality. The staff finds the applicant’s assessment to be acceptable.

The applicant states that plumes emitted from cooling towers can also influence local climate. Fermi Unit 3 will use the NDCT as a primary means of heat dissipation and two multi-cell MDCTs as an auxiliary cooling method. The applicant stated that the potential meteorological effects due to the operation of these cooling towers may include enhanced ground-level fogging and icing, plume shadowing, as well as increased salt deposition.

The applicant states that the operation of the two multi-cell MDCTs is expected to be minimal because they will be used to dissipated heat from the plant service water system primarily during plant cool down and shutdown. For this reason, the applicant considers the environmental impact associated with the operation of the two multi-cell MDCTs to be bounded by the impacts associated with the NDCT and therefore only evaluated the potential plume impacts associated with the operation of the NDCT.

The applicant modeled the NDCT plume impacts with EPRI's Seasonal/Annual Cooling Tower Impact (SACTI) prediction code. The applicant states that this model is endorsed by the staff's Environmental Standard Review Plan (NUREG-1555). The applicant executed the SACTI model using five years (2003-2007) of meteorological data provided as input to the code in the NCDC card deck 144 (CD-144) format. Wind direction, wind speed, dew-point temperature, and DB temperature data were taken from the onsite meteorological tower. When the CD-144 format is used as the meteorological input to SACTI, the model determines stability class based on measured wind speed, ceiling height, cloud cover, solar elevation angle, and time of day. Because the onsite meteorological tower does not record ceiling height or cloud cover data, these data were obtained from the Detroit Metropolitan Airport. Mean monthly mixing height data from White Lake, Michigan were also used as input to the SACTI cooling tower model analysis.

The NRC staff issued **RAI 02.03.02-4** requesting the applicant to justify why meteorological data were provided as input to the code in the CD-144 format instead of the optional NRC format. If the meteorological data were to be provided as input in the NRC format mode, the SACTI code would determine stability class using the NRC RG 1.23 ΔT methodology instead of the ceiling height/cloud cover method mentioned above. In response (ML093570220) to **RAI 02.03.02-4** (dated February 8, 2010), the applicant justified its use of the CD-144 format by stating that no format example or references to any formatting guides are provided in the SACTI user's manual and the NRC format expected by SACTI code is not the official meteorological format published by the NRC in Appendix A of RG 1.23. The applicant further stated that the SACTI model is not extremely robust when it comes to the execution of its code. For example, only two of the five years of onsite data in the NRC format (2005 and 2006) executed successfully and the model did not provide error messages as to why the other three years of onsite data in NRC format would not execute. The applicant compared the results using the five years of meteorological data in the CD-144 format with the results using the two years of meteorological data in the NRC format and concluded there were no significant changes in model-predicted results between the two data sets. The applicant stated that parameters such as maximum annual and seasonal plume length and average hours per year of shadowing showed a decrease in impacts when using the NRC-formatted dataset whereas other parameters such as maximum annual water deposition showed a slight increase. The applicant further stated that maximum annual and seasonal salt deposition showed no change between the two datasets. The NRC staff finds the applicant's assessment acceptable because the staff also ran the SACTI code using onsite meteorological data in the NRC format input to the model and obtained similar results (for example, less than one percent difference in the annual average plume lengths).

In **RAI 02.03.02-4**, the staff requested the applicant to justify the use of a surface roughness of 100 cm as input to the SACTI cooling tower model analysis. The applicant assumed that the area surrounding the site is an urban environment (a roughness height of 100 cm) by considering that the Fermi facility is an industrial complex. However, the farther area is agricultural land or water bodies. The area of interest is somewhere between urban and rural. In response (ML093570220) to **RAI 02.03.02-4**, the applicant stated that it found that the SACTI model shows no sensitivity in the selection of surface roughness heights between 10 cm and 100 cm for a NDCT analysis. The NRC staff ran the SACTI code with different surface roughness and also found that the SACTI code is insensitive to surface roughness length. Thus the staff accepts the applicant's conclusion because it meets the requirements of 10 CFR 52.79(a)(1)(iii),10 CFR 100.20(c)(2), and 100.21(d).

In the **RAI 02.03.02-4**, the staff also requested the applicant to justify the use of mean monthly mixing heights as inputs to the SACTI cooling tower model analysis, even though twice-daily

morning and afternoon mixing height data are available and are accepted as input by the SACTI code. In response to **RAI 02.03.02-4**, the applicant stated that monthly average mixing height data were chosen to simplify the analysis since the NCDC twice daily mixing height data would undoubtedly contained missing height values which would require data filling and substitution. The applicant also performed a mixing height sensitivity analysis between monthly mixing heights and twice-daily mixing heights and concluded that there were no significant changes in the model-predicted results between the two data sets. In comparing the model results using the twice-daily mixing height data versus the monthly mixing height data, the applicant found a decrease in maximum annual and seasonal plume lengths and average hours per year of shadowing, no change in maximum and seasonal salt deposition, and a slight increase in maximum water deposition. The NRC staff reran the SACTI code with different mixing height inputs and also found that the SACTI code is insensitive to mixing height input option. Thus the staff accepts the applicant's assessment.

For the reasons stated above, the staff considers **RAI 02.03.02-4** to be resolved.

The applicant used its SACTI model runs to conclude that the annual average plume length is 1.15 miles (1.85 km), with seasonal average plume lengths ranging from a high of 1.47 miles (2.37 km) during winter to a low of 0.24 miles (0.39 km) during the summer. The applicant stated that cooling tower plumes will influence some of the ground level meteorological variables very near the base of the cooling tower. The applicant stated that the NDCT draws air at the base of the tower by the driving force of a density differential that exists between the heated (less dense) air inside the stack and the relatively cool (more dense) ambient air outside the tower. As air rises in the tower, it begins to cool and eventually saturates, which forms a plume at the top of the tower. The air flow toward the cooling tower is localized, and thus its effects will likely be limited to the Fermi property. In addition, a hyperbolic-shaped tower such as the NDCT creates a wake effect to the downwind distance of about five times the width of the top of the tower, i.e., about 445 meters (1460 feet). The applicant stated that some of the heat and moisture from the plume is transported downward to the ground downwind of the NDCT and therefore slightly warmer temperatures and increase absolute humidity can be expected at times within a few hundred feet of the tower. The applicant also reported that the SACTI code predicts a water deposition rate for the NDCT of about 0.00001 mm per month, which corresponds to 0.0001 percent of the mean monthly rainfall of the driest month at the Detroit Metropolitan Airport. Thus, water deposition (additional precipitation) from the NDCT is anticipated to be small at the Fermi site. Ground-level fogging occurs when the visible plume strikes the ground. Icing occurs when the visible plume strikes the ground under freezing conditions. Fogging and icing from the NDCT are very unlikely, and thus the SACTI code does not compute fogging and icing impacts for the NDCT.

The staff issued **RAI 02.03.02-5** requesting the applicant to provide estimates of the likelihood of drizzle icing effects from the NDCT. The Revision 1 to FSAR Subsection 2.3.2.2.2 addressed icing as a result of fogging from the NDCT plume, but did not discuss icing resulting from drizzle produced by the NDCT plume. In response (ML093570220) to **RAI 02.03.02-5** (dated February 8, 2010), the applicant stated that drizzle and light snow have been observed downwind of the NDCT but it is rare and localized. The applicant further stated that freezing drizzle from the NDCT occurs less frequently, as the surface temperature has to be at or below freezing for freezing drizzle to occur. The SACTI code predicts that water deposition rate from the NDCT to be less than 0.0001 percent of the mean monthly rainfall of the driest month. This would result in an even smaller percent of contribution. The staff finds the applicant's analysis to be reasonable and **RAI 02.03.02-5** is considered resolved.

The staff issued **RAI 02.03.02-6** asking the applicant to revise FSAR Subsection 2.3.2.2 to address the effects of the natural draft cooling tower moisture and salt deposition on electrical transmission lines and electrical equipment (including transformers and switchyard). In response (ML093570220) to **RAI 02.03.02-6** (dated February 8, 2010), the applicant stated that due to the high initial plume height, the SACTI modeling predicts that no salt will be deposited within 4100 meters (13,500 feet) of the NDCT. Given this large distance, no salt deposition is expected at the existing Fermi Unit 2 switchyard or the planned Fermi Unit 3 switchyard and main transformer area, all of which are located within the Fermi property. The other electrical equipment associated with the operation of Fermi Unit 3 are the transmission lines running offsite. The applicant predicted that the maximum seasonal salt deposition rate of 0.02 kg/km^2/month will occur between 4400 and 9400 meters (14,400 and 30,800 feet) east-northeast of the NDCT. The applicant stated that this value is well below the lowest bound salt deposition density level of 300 kg/km^2 for light contamination environments suggested by the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) C57,19.100-1995 (IEEE-Guide for Application of Power Apparatus Bushings). The applicant concluded that cumulative salt deposition buildup would not cause a contaminated environment on electrical equipment because the predicted maximum monthly deposition rate is orders of magnitude below the light contamination level and natural precipitation would wash off salt deposition before significant salt buildup would occur.

The staff ran the SACTI code and found that maximum seasonal salt deposition occurs at a rate about four times higher than the applicant's value and at closer distance but still beyond the Fermi property boundary. The staff's estimate is still well below the lowest bound salt deposition density level of 300 kg/km^2 for light contamination environments suggested by IEEE Std C57,19.100-1995. For this reason, the NRC staff finds that the applicant's conclusion that the operation of the NDCT is not expected to adversely impact the electrical transmission lines and other electrical equipment to be reasonable, and thus considers **RAI 02.03.02-6** to be resolved.

The staff ran the SACTI code to examine the plume behaviors using the same tower-specific data, such as tower dimensions, circulating water flow rate, drift loss rate, exit air flow rate, heat rejection rate, and drift droplet diameter spectrum. Rather than using the CD-144 format from the applicant, the staff used onsite meteorological data in the NRC format input to the model and obtained similar results as described above. The staff verified the applicant's SACTI modeling results and concludes that the applicant has demonstrated that the results presented in the FSAR are a representative and valid analysis of potential impacts associated with operation of the proposed NDCT.

2.3.2.5 Post Combined License Activities

There are no post-COL activities associated with this section.

2.3.2.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

NRC staff reviewed the application and found that the applicant has presented and substantiated information describing the local meteorological, air quality, and topographic characteristics important to evaluating the adequacy of the design and siting of this plant. The staff reviewed the information provided and, for the reasons given above, concludes that the identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area are acceptable and meet the requirements of 10 CFR 100.20(c)(2) and 100.21(d), with respect to determining the acceptability of the site.

The staff found that the applicant has considered the appropriate site phenomena in establishing the site characteristics. Specifically, the staff has generally accepted the methodologies used to determine the meteorological, air quality, and topographic characteristics as documented in SERs for previous licensing actions. Because the applicant has correctly implemented these methodologies, as described above, the staff has determined that the use of these methodologies results in site characteristics containing margin sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concludes that the identified site characteristics meet the requirement of 10 CFR 52.79(a)(1)(iii) with respect to identifying the most severe of the natural phenomena historically reported for the site and surrounding area and with a sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated.

The staff's review confirmed that the applicant has adequately addressed the COL license information item in accordance with Section 2.3.2 of NUREG–0800.

2.3.3 Meteorological Monitoring

The current Fermi onsite meteorological monitoring program has been in place since it was implemented for Fermi 2 pre-operational meteorological assessment beginning in June 1975.

2.3.3.1 Introduction

Subsection 2.3.3, "Meteorological Monitoring," of the Fermi 3 COL FSAR, Revision 4, addresses the pre-application meteorological measurements program as well as the onsite meteorological monitoring program to be used during site preparation and construction, pre-operation, and operation (i.e., the operational meteorological measurements program). The staff's review covers the following specific areas: meteorological instrumentation, including siting of sensors, sensor type and performance specifications, methods and equipment for recording sensor output, the quality assurance program for sensors and recorders, data acquisition and reduction procedures, and special considerations for complex terrain sites.

The staff's review also evaluated the resulting onsite meteorological database from the pre-application monitoring phase, including consideration of the period of record and amenability of the data for use in characterizing atmospheric dispersion conditions.

2.3.3.2 Summary of Application

Subsection 2.3.3, "Meteorological Monitoring," of the Fermi 3 COL FSAR, Revision 4, addresses site-specific information on the onsite meteorological measurement program. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-9-A Onsite Meteorological Measurements Program

  The purpose of this section is to confirm that the onsite meteorological measurements program provides an adequate meteorological database for estimating atmospheric dispersion for design basis accident and routine radiological releases and for evaluating the effects of plant operation.

2.3.3.3 Regulatory Basis

The acceptance criteria for an onsite meteorological measurements program are based on meeting the relevant requirements of 10 CFR Parts 20, 50, 52, and 100. The staff considered the following regulatory requirements in reviewing the applicant's descriptions of its pre-application and operational onsite meteorological measurements programs:

- 10 CFR Part 20, Subpart D with respect to the meteorological data used to demonstrate compliance with dose limits for individual members of the public.

- 10 CFR Part 50, Paragraphs 50.47(b)(4), 50.47(b)(8), and 50.47(b)(9), as well as Section IV.E.2 of Appendix E with respect to the onsite meteorological information available for determining the magnitude and continuously assessing the impact of the releases of radioactive materials to the environment during a radiological emergency.

- 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 19, "Control Room," with respect to the meteorological data used to evaluate the personnel exposures inside the control room during radiological and airborne hazardous material accident conditions.

- 10 CFR Part 50, Appendix I with respect to meteorological data used in determining the compliance with numerical guides for design objectives and limiting conditions for operation to meet the requirement that radioactive material in effluents released to unrestricted areas be kept as low as is reasonable achievable.

- 10 CFR 52.79(a)(1)(vi), with respect to a safety assessment of the site, including consideration of major structure, system and components (SSCs) of the facility and site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

- 10 CFR 100.20(c)(2), with respect to the meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design in determining the acceptability of a site for a nuclear power plant.

- 10 CFR 100.21(c), with respect to 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 outer boundary of the LPZ.

NUREG-0800, Section 2.3.3 specifies that an application meets the above requirements, if the application provides the following information:

- The pre-application and operational monitoring programs should be described, including (1) a site map (drawn to scale) that shows 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 from the pre-application monitoring program should be presented in the form of JFDs of wind speed and wind direction by atmospheric stability class in the format described in RG 1.23. An hour-by-hour listing of the hourly-averaged parameters should be provided in the format described in RG 1.23. 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 one-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 FSAR Section 2.3.4 and (2) the long-term atmospheric dispersion estimates for routine releases discussed in FSAR Section 2.3.5.

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

When independently assessing the acceptability of the information presented by the applicant in FSAR Chapter 2.3.3, the NRC Staff applied the same above-cited methodologies and techniques.

2.3.3.4 Technical Evaluation

The staff reviewed Section 2.3.3 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 4, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirmed that the information contained in the application and the information incorporated by reference address the relevant information related to this section.

NRC staff reviewed the application and the applicant's responses to RAIs to verify the accuracy, completeness, and sufficiency of the information regarding the onsite pre-application and operational meteorological measurements programs. The staff followed the procedures described in Section 2.3.3 of NUREG–0800 as part of this review.

<u>*COL Item*</u>

- EF3 COL 2.0-9-A Onsite Meteorological Measurements Program

---

[1] See "*Finality of Referenced NRC Approvals*," in SER Section 1.2.2, for a discussion on the staff's review related to verification of the scope of information to be included in a COL application that references a design certification.

This COL information item states that the COL applicant should supply site-specific information in accordance with SRP Section 2.3.3; that is, the COL applicant should describe its onsite meteorological measurements program and provide a copy of the resulting meteorological data. In response to this COL information item, the applicant describes the following:

- A description of the pre-application and operational meteorological monitoring programs, including siting of sensors, sensor type and performance specifications, methods and equipment for recording sensor output, the quality assurance program for sensors and recorders, data acquisition and reduction procedures.

- The meteorological database resulting from the pre-application monitoring program, presented in the form of a JFD of wind speed and direction by atmospheric stability class and an hour-by-hour listing of the hourly-averaged parameters.

NRC staff reviewed the applicant's resolution to EF3 COL 2.0-9-A related to supplying site-specific information in accordance with SRP Section 2.3.3. The staff's review of the applicant's description of its onsite meteorological measurements program and the resulting meteorological data is described below.

Fermi 3 Pre-application Meteorological Measurement Program

Subsection 2.3.3.1 of the FSAR discusses the pre-application meteorological monitoring program for Fermi Unit 3 that is based on the preexisting operational meteorological monitoring program and equipment used for Fermi 2.

In Subsection 2.3.3 of the FSAR, the applicant states that the current onsite meteorological monitoring program has been in place since June 1975 and complies with Proposed Revision 1 to RG 1.23, except for the proximity of trees to the meteorological tower. The staff notes that most of pre-application meteorological data was collected prior to the implementation of Revision 1 to RG 1.23. Thus, the staff reviewed the pre-application meteorological monitoring program primarily against the criteria in proposed Revision 1 to RG 1.23.

The information on the pre-application meteorological measurements program presented below is based on information presented in FSAR Subsection 2.3.3.1, applicant's responses to RAIs, and an onsite environmental site audit conducted by the staff on February 2-6, 2009.

a. Tower and Instrument Siting

In Subsection 2.3.3.1.1 of the FSAR the applicant discusses the 60-meter (197-foot) open-latticed guyed meteorological tower that serves as the primary data collection system, including redundant sensors at both the 10-meter (33-foot) and 60-meter (197-foot) levels. The width of the tower at its base exceeds 6 meters (20 feet) and decreases with height. The meteorological sensors are mounted on booms which are greater than one tower width away from the tower and are oriented normal to the prevailing wind direction. The tower is situated in a relative flat area with natural ground cover. A small climate controlled instrument shelter is located at the base of the onsite meteorological tower.

Proposed Revision 1 to RG 1.23 states that the meteorological tower site should represent as close as possible the same meteorological characteristics as the region into which any airborne material will be released. Whenever possible, the tower or mast should be sited at approximately the same elevation as finished plant grade. The height of natural or man-made

obstructions to air movement should ideally be lower than the measuring level to a horizontal distance of ten times the measuring level height. Revision 1 to RG 1.23 provides clarifying guidance regarding the tower's proximity to obstructions to air movement, stating that wind sensors should be located over level, open terrain at a distance of at least ten times the height of any nearby obstruction if the height of the obstruction exceeds one-half the height of the wind measurement.

Visual inspection during a site audit conducted on February 2 - 6, 2009, indicated that the distance from the meteorological tower to the nearest obstructions (i.e., a wooded area located west of the tower where some of the trees were higher than 10 meters (33 feet)) did not meet the distance offset criterion identified in Revision 1 to RG 1.23. The applicant stated during the audit that this was a self-identified issue which was entered into the Fermi 2 corrective action system in 2004 and was resolved as having no impact on the monitoring program based on a comparison with historic data collected during the previous 30 years. The staff asked the applicant in **RAI 02.03.03-1** to identify the current average height of these trees and their closest distance to the tower. The staff also asked the applicant in **RAI 02.03.03-1** to describe the 2004 corrective action evaluation that closed out this issue.

In its original response (ML093570220) to **RAI 02.03.03-1** (dated February 8, 2010), the applicant provided a figure showing the current separation between the meteorological tower and nearby trees to the west. This figure showed that there are trees within ten times their height of the meteorological tower. The applicant also stated that it evaluated the impact of the trees by comparing the 10-meter (33-foot) and 60-meter (197-foot) wind roses from the 1974/1975 time frame with 10-meter (33-foot) and 60-meter (197-foot) wind roses from 1985, 1994, 2003, 2004, and 2005 and concluded that there was no significant difference in wind direction and speed patterns between the time periods analyzed.

Based on the information provided by the applicant in its December 23, 2009 response to a similar question (**environmental RAI AQ6.4-1**), the staff compared the percent of time the wind speed was less than three miles per hour (mph) between the "downwind sectors" (i.e., when the wind was from the west-southwest clockwise to west-northwest sectors and the meteorological tower was downwind of the trees) and the "upwind sectors" (i.e., when the wind was from the north-northwest clockwise to south-southwest sectors and the meteorological tower was upwind of the trees). This comparison indicated that, at the 10-meter (33-foot) level, the percent of time the wind speed was less than three mph for the downwind sectors increased from 5.6 percent in 1985 to 19.9 percent in 1994 to 26.5 percent in 2003-2005. For the upwind sectors, the percent of time the wind speed is less than three mph at the 10-meter (33-foot) level also increased, but not in such a drastic fashion. The staff noted that there was essentially no change in the percent of time the wind speed was less than three mph at the 60-meter (197-foot) level for either the upwind or downwind sectors during the time periods analyzed. The staff determined these statistics support the conclusion that the heights of nearby trees have impacted the wind flow in certain wind direction sectors. The staff provided this feedback to the applicant in an e-mail dated January 26, 2010.

In response to the January 26, 2010 e-mail, the applicant provided a supplemental response (ML100960474) to **RAI 02.03.03-1** (dated March 30, 2010), stating it performed an additional review of the 10-meter (33-foot) and 60-meter (197-foot) wind roses ranging from 1975 through 2003. The applicant concluded that there is an apparent increase in the percent of time that the indicated wind speed was less than three mph at the 10-meter (33-foot) elevation for a given wind direction sector and therefore the potential exists for the wind measurements at the 10-meter (33-foot) elevation to be lower than the actual wind speed at the 10-meter (33-foot)

elevation. The applicant also assessed the effect of lower measured wind speeds at the 10-meter (33-foot) level on a number of evaluations presented within the FSAR, including the short-term (accident) dispersion estimates presented in FSAR Subsection 2.3.4 and the long-term (routine) dispersion estimates presented in FSAR Subsection 2.3.5. Because the applicant acknowledged that nearby trees could be impacting the 10-meter (33-foot) wind speed measurements and assessed the effect of lower measured wind speeds at the 10-meter (33-foot) level on a number of evaluations presented in the FSAR, the staff considers **RAI 02.03.03-1** to be resolved. The staff has also evaluated the effects of lower measured wind speeds on the applicable evaluations within Subsections 2.3.4 and 2.3.5 of this report.

The staff finds that the tower is appropriately located such that it can measure the onshore flow conditions that could affect gaseous effluent releases from Fermi Unit 3. The effect of the nearby trees on prior measurements and the adjustments made to compensate for lower measured wind speeds due to the proximity of the trees, are described above. In all other respects, the staff finds the tower location complies with the recommendations provided in Proposed Revision 1 to RG 1.23 and is therefore acceptable to the staff.

b. Instrumentation and Their Accuracies and Thresholds

In FSAR Subsection 2.3.3.1.2, the applicant states that the meteorological tower instrumentation consists of wind speed and wind direction sensors at the 10-meter (33-foot) and 60-meter (197-foot) levels, a temperature sensor at the 10-meter (33-foot) level, a vertical air temperature difference (ΔT) system between the 60-meter (197-foot) and 10-meter (33-foot) levels, and a dew-point temperature sensor at the 10-meter (33-foot) level. A heated tipping bucket precipitation gauge which is surrounded by a windscreen is located at ground level at the base of the meteorological tower. External heaters are installed on the primary wind sensors to minimize data loss during ice storms.

Based on an onsite environmental site audit conducted by the staff on February 2-6, 2009, the staff noticed that the wind speed and wind direction sensor information provided in Revision 0 to FSAR Table 2.3-289 appeared to be in error. The staff also noticed an apparent discrepancy in the dew point monitoring system description in the FSAR. The staff subsequently asked the applicant in **RAI 02.03.03-2** to verify all of the instrumentation information provided in FSAR Table 2.3-289, including sensor performance specifications and system accuracies, and update FSAR Table 2.3-289 accordingly. The applicant was also asked to identify any deviations from the guidance provided in RG 1.23.

The applicant provided a response (ML100960472) to **RAI 02.03.03-2** (dated February 8, 2010) in which the applicant updated Table 2.3-289 in FSAR Revision 2 by listing the sensor manufacturer and model numbers, range, system accuracy, starting threshold, and measurement resolution. The applicant also revised Subsection 2.3.3.1.2 in FSAR Revision 2 to state that the accuracies and thresholds for each sensor are within the limits specified in the Proposed Revision 1 to RG 1.23. The staff reviewed the response to **RAI 02.03.03-2** and determined that the question is closed but there were issues that remained unresolved. To address these issues, the staff issued follow-up question **RAI 02.03.03-8**.

The staff notes that FSAR Table 1.9-202 is intended to evaluate the applicant’s conformance with applicable RGs in effect six months prior to the submittal of the Fermi 3 COL application. Included in Table 1.9-202 of FSAR Revision 2 is the applicant’s evaluation regarding the pre-application meteorological monitoring program conformance to Revision 1 to RG 1.23. The staff

issued **RAI 02.03.03-8** regarding the following information contained in FSAR Tables 1.9-202 and 2.3-289 regarding the pre-application meteorological monitoring program:

a. Revision 2 to FSAR Table 2.3-289 lists the differential temperature (ΔT) channel as having a system accuracy of ±0.15 °C which exceeds the Revision 1 to RG 1.23 specified accuracy of ±0.1 °C. The staff asked the applicant to revise the FSAR to address the ΔT channel nonconformance with the system accuracy specified in Revision 1 to RG 1.23, including the impact this nonconformance may have on any analyses presented in FSAR Section 2.3.

   In its response (ML102570700) to **RAI 02.03.03-8** dated September 2, 2010, the applicant stated that pre-application monitoring program ΔT channel accuracy of ±0.15 °C is consistent with the guidance provided in Proposed Revision 1 to RG 1.23, which was the regulatory guidance in effect during most of the pre-application monitoring program. The staff finds it acceptable that the majority of the onsite ΔT data submitted by the applicant was collected by a monitoring program that was in compliance with the regulatory guidance in effect at the time. The applicant committed to updating FSAR Subsection 2.3.3.1.2 to state that the accuracy of the ΔT channel does not comply with Revision 1 to RG 1.23 but does comply with Proposed Revision 1 to RG 1.23, which was the regulatory guidance in effect during most of the pre-application monitoring program.

b. Revision 2 to FSAR Subsection 2.3.3.1.1 states the sensors for the existing pre-application meteorological monitoring program are mounted on booms that are greater than one tower width away from the tower. Revision 1 to RG 1.23 states (1) wind sensors on the side of a tower should be mounted at a distance equal to at least twice the longest horizontal dimension of the tower and (2) temperature sensor shield inlets should at least 1½ times the tower horizontal width away from the nearest point on the tower. The staff asked the applicant to revise the FSAR to clarify whether the pre-application meteorological monitoring program was in conformance with the boom length criteria specified in Revision 1 to RG 1.23. If the pre-application program is not in conformance with Revision 1 to RG 1.23, the staff asked the applicant to discuss the impact the nonconformance may have on any analyses presented in FSAR Section 2.3.

   In its response (ML102570700) to **RAI 02.03.03-8**, the applicant stated that the length of the instrument booms on the Fermi 3 pre-application meteorological tower do not meet the Revision 1 to RG 1.23 criteria of two tower widths. However, the width of the meteorological tower at the 10-meter (33-foot) elevation is nearly 6 meters (20 feet) and the staff finds that boom lengths of 12 meters (40 feet) are not practical. The large open areas between the support frames of such a wide open-lattice tower also tend to lessen the impact from turbulent flow downwind of the tower structure. For these reasons, the staff finds the instrument booms on the pre-application meteorological tower to be acceptable. The applicant committed to updating FSAR Subsection 2.3.3.1.1 to address the pre-application monitoring program boom length exception to Revision 1 to RG 1.23.

c. Revision 1 to RG 1.23 specifies a digital sampling rate of at least once every 5 seconds. The staff asked the applicant to revise the FSAR to discuss the digital sampling rates for the pre-application meteorological monitoring program. If the pre-application monitoring program is not in conformance with Revision 1 to RG 1.23, the staff asked the applicant to discuss the impact the nonconformance may have on any analyses presented in FSAR Section 2.3.

In its response (ML102570700) to **RAI 02.03.03-8**, the applicant stated that the digital recorders used for the pre-application meteorological monitoring system sample data at least once every five seconds and therefore meet the sampling criteria in Revision 1 to RG 1.23. The applicant committed to updating FSAR Subsection 2.3.3.1.2 to include the digital recorders sampling rate.

The applicant incorporated the information discussed above into Revision 4 of the FSAR.

The staff found the applicant's response (ML110110550), dated January 10, 2011, to **RAI 02.03.03-8** to be acceptable for the reasons cited above, except that one issue remained unresolved. To address this issue, the staff issued follow-up **RAI 02.03.03-9** which is discussed later in this SER Subsection.

c. Instrumentation Calibration

In FSAR Subsection 2.3.3.1.3, the applicant describes the calibration of the sensors, electronics, and recording equipment. The applicant states the sensors, electronics, and recording equipment are calibrated on a six-month basis. More frequent onsite calibrations are performed if the past operating history of the sensor indicates it is necessary. The applicant states any necessary adjustments are made onsite and the equipment that malfunctioned is either corrected onsite or replaced with similar equipment. After any adjustments or repairs, the calibration is repeated. The records documenting the results of calibration drift and the corrective action taken are kept and filed onsite.

The staff asked the applicant in **RAI 02.03.03-3** to describe the calibration practices used to ensure that the wind sensors starting thresholds meet the starting threshold criteria presented in RG 1.23. The applicant provided a response (ML100960472) to **RAI 02.03.03-3** (dated February 8, 2010) in which it describes the calibration practices used. In particular, the applicant states that a wind tunnel is used to determine the starting thresholds of the wind speed sensors and the starting thresholds of the wind direction sensors are assessed by rotating the wind direction sensor body with the shaft in the horizontal plane and observing that the vane remains stationary. Because these are standard industry practices, the staff finds the information provided in the response to **RAI 02.03.03-3** acceptable and thus **RAI 02.03.03-3** is considered to be resolved. The applicant incorporated this information on wind sensor starting threshold tests into Revision 2 of FSAR Subsection 2.3.3.1.3.

The staff asked the applicant in **RAI 02.03.03-4** to clarify the statement made by the Fermi meteorological system engineer, during the February 2–6, 2009, Fermi environmental site audit, that the secondary ΔT channel recorded values were consistently higher than the primary ΔT channel values. The staff requested that the applicant (1) identify the ΔT channel having the more accurate measurements, (2) describe the impact of the ΔT channel offset on the atmospheric dispersion and deposition factors presented in FSAR Subsections 2.3.4 and 2.3.5, and (3) describe the corrective actions to be taken to address this apparent deviation from RG 1.23 criteria.

The applicant provided a response (ML100960472) to **RAI 02.03.03-4** (dated February 8, 2010) in which it presents the conclusions of a review of the meteorological data that evaluated the differences between the primary and secondary ΔT measurements. The applicant's data review indicates that there is not a consistent variance between the primary and secondary ΔT indications. That is, the secondary ΔT does not always indicate higher than the primary ΔT.

Instead, the applicant stated that its data review indicated that the instantaneous readings from the primary and secondary ΔT indications consistently follow each other over time and any difference in temperature indications is random. The applicant further states that the review of ΔT data, meteorological instrumentation, calibration and surveillance requirements and historical records, and system configuration identified no consistent data variance in primary and secondary channel measurements. The applicant also clarified the statement made by the Fermi meteorological system engineer during the site audit that the difference between the primary and secondary ΔT channel recorded values is due to sensor "wobble" that is corrected by the plant computer software.

Because the primary and secondary ΔT indications follow reliably over time and do not exhibit a consistent difference between the two channels, the staff considers this issue to be resolved and therefore considers **RAI 02.03.03-4** to be closed.

d. Instrumentation Service and Maintenance

Proposed Revision 1 to RG 1.23 states that meteorological instruments should be inspected at a frequency that will ensure data recovery of at least 90 percent on an annual basis.

In FSAR Subsection 2.3.3.1.4, the applicant describes the service and maintenance of the meteorological sensors and supporting equipment. Visits are made periodically to the 60-meter (197-foot) tower to make a visual inspection of the sensors, as well as the data output and recording equipment in the instrument shelter, to see if they are damaged and need maintenance. In the event the sensors or monitoring equipment are found damaged or malfunctioning, the equipment is replaced or corrected in a timely fashion. A stock of spare parts and equipment is maintained to minimize and shorten the periods of outages. The instrumentation is checked using the same precision test equipment used for calibration. Records documenting the results of major causes of instrument sensor outages and other malfunctions of the meteorological monitoring system are kept and filed onsite.

The staff finds that instrumentation service and maintenance are in accordance with the guidance of Proposed Revision 1 to RG 1.23 and follow standard industry practice.

e. Data Reduction and Transmission

In FSAR Subsection 2.3.3.1.5, the applicant describes the data reduction and transmission. The pre-application meteorological monitoring program is composed of two independent meteorological trains of instrumentation – a primary train and a secondary train – mounted on the meteorological tower. Sensor signals from both trains are independently conditioned inside the environmentally controlled instrument shelter located near the base of the meteorological tower and the outputs from the signal conditioning equipment are transmitted to the Fermi 2 control room via two independent transmission lines. Both trains feed the digital data acquisition equipment belonging to the Integrated Plant Computer System (IPCS) located in the Fermi 2 control room.

The staff finds that data reduction and transmission techniques are performed in accordance with Proposed Revision 1 to RG 1.23 and follow standard industry practice.

f. Data Acquisition and Processing

Proposed Revision 1 to RG 1.23 states that meteorological monitoring systems should use a dual recording system consisting of one digital and one auxiliary analog system. The Fermi 3 pre-application monitoring program utilizes dual digital recorders that monitor both trains of instrumentation at the meteorological instrument building to archive raw data. An analog backup recorder is utilized as well.

In FSAR Subsection 2.3.3.1.6, the applicant describes data acquisition and processing. Dual IPCS data acquisition multiplexers accept two trains of data from the primary and secondary data acquisition equipment. These data are provided to the IPCS computers to screen data for data validity and quality, perform meteorological calculations, update the data archive, display the information on the man–machine interface, and output the data to communication devices. The IPCS system monitors error signals to determine equipment status. If an instrument input malfunctions, if data are suspect, or if an instrument input is manually removed from service, the IPCS will substitute the reading from the next level of redundancy and indicate the substitution on the IPCS computers.

The applicant states that the meteorological data are generally reviewed each day by personnel to identify possible data problems. The meteorological data are also validated to ensure that the regulatory requirement for minimum recovery rate of 90 percent (on an annual basis), as outlined in RG 1.23, is met. The data validation process includes utilizing software to review the raw data, identifying and editing questionable or invalid data, recovering data from backup sources, and adjusting the data to reflect calibration sources. After the validation process is completed, the processed data are archived and permanently stored electronically.

Meteorological data are available in five different formats: instantaneous values, 1-minute blocked averages, 15-minute rolling averages, 15-minute block averages, and 1-hour block averages. Routine data summaries are generated for each day, calendar month, and calendar year, and then archived on the IPCS computers. In addition, JFDs of wind speed and wind direction for each stability category are created from the 1-hour block averages. The applicant states that the format of the annual onsite meteorological data summaries and JFD tables conforms to the recommended format found in RG 1.23.

The staff finds that the data acquisition and processing conform to the guidelines in Proposed Revision 1 to RG 1.23 and follow standard industry practice.

g. Resulting Meteorological Database

The applicant presented several years of meteorological data from the pre-application meteorological monitoring program to support its Fermi 3 COL application:

- Five years of data (2003-2007) were used for evaluation of site meteorological characteristics and cooling tower plume modeling. JFDs of wind speed, wind direction, and atmospheric stability from the onsite meteorological monitoring program for both the 10-meter (33-foot) and 60-meter (197-foot) levels are provided in FSAR Tables 2.3-269 through 2.3-284 for the period 2003 through 2007.

- Six years of data (2002-2007) were used for calculating the short-term off-site and the long-term atmospheric dispersion estimates. JFDs for the 10-meter (33-foot) level are provided in FSAR Tables 2.3-292 through 2.3-299 for the period 2002 through 2007.

The applicant used the data in these tables as input to the dispersion analyses discussed in FSAR Subsections 2.3.4 and 2.3.5.

- Seven years of data (2001-2007) were used for calculating the short-term on-site atmospheric dispersion estimates. The applicant provided an hourly listing of the original 2001-2007 onsite meteorological database in its response to **environmental RAI AQ2.7-3** dated October 30, 2009.

The staff asked the applicant in **RAI 02.03.03-5** to explain apparently data discrepancies within Revision 0 to FSAR Tables 2.3-269 through 2.3-284. In particular, the number of hourly observations reported in these tables (17,533 hours for the 10-meter (33-foot) level and 17,520 hours for the 60-meter (197-foot) level) was considerably less than the 43,842 hours contained in the five-year period 2003-2007. Also, the number of hours reported for each stability category did not total the number of hours reported for all stability categories combined. In its response (ML100960472) to **RAI 02.03.05-5** dated February 8, 2010, the applicant stated that the JFDs in FSAR Tables 2.3-269 through 2.3-284 were incorrect and provided a revised set of tables that were eventually incorporated into Revision 2 to the FSAR. This revised set of tables reported 43,018 hours of data for the 10-meter (33-foot) level and 42,956 hours of data for the 60-meter (197-foot) level. The number of hours reported for each stability category also totaled the number of hours reported for all stability categories. Because the revised set of Tables 2.3-269 through 2.3-284 presented in FSAR Revision 2 addressed the staff's concerns, **RAI 02.03.03-5** is considered to be resolved.

The applicant provided a copy of the original 2001-2007 hourly database to the staff in its response to **environmental RAI AQ2.7-3**. The staff performed a quality review of this database using the methodology described in NUREG–0917, "Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data," issued in July 1982. The staff used computer spreadsheets to further review the data. As expected, the staff's examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable and neutral conditions during the day. Wind speed, wind direction, and stability class frequency distributions for each measurement channel were reasonably similar from year to year.

The staff performed a comparison of stability category frequency distributions (based on the onsite meteorological tower ΔT measurements) between the 1974-1975 period of record reported in the Fermi 2 FSAR Table 2.3-11 and the 2002-2007 period of record reported in Fermi 3 FSAR (Revision 0), Tables 2.3-292 through 2.3-298 and found the following:

Stability Category Frequency Distribution (Values in Percent)

Stability Category	Period of Record	
	1974-1975	2002-2007
A (extremely unstable)	9.2	20.1
B (moderately unstable)	2.1	5.4
C (slightly unstable)	2.4	5.2
D (neutral)	30.3	30.7
E (slightly stable)	40.5	24.5
F (moderately stable)	10.3	9.4
G (extremely stable)	5.3	4.6

In its review of the original 2001-2007 hourly ∆T measurements, the staff also found that during the period 2004-2007 there were approximately 420 occurrences per year (on average) when the autoconvective lapse rate of -3.4 °C per 100 meters was exceeded (the autoconvective lapse rate represents severe extremely unstable conditions when the density of the atmosphere increases with height). Many of these hours exceeded a lapse rate of -5.0 °C per 100 meters. Consequently, the staff issued **RAI 02.03.03-6** requesting that the applicant explain the almost 11 percent annual increase in A stability occurrences (from 9.2 percent to 20.1 percent) and the almost 16 percent annual decrease in E stability occurrences (from 40.5 percent to 24.5 percent) from 1974-1975 to 2002-2007. The staff also asked the applicant in **RAI 02.03.03-6** to explain the relatively frequent occurrence (approximately five percent of the time annually) of autoconvective lapse rate conditions during 2004-2007.

In its response (ML100960472) to **RAI 02.03.03-6** dated February 8, 2010, the applicant stated that it evaluated the atmospheric stability category frequency distribution for each year from 1995 through 2007 in an effort to correlate any possible data inconsistencies with instrumentation replacements or modifications. The applicant found a noticeable decreasing trend in the frequency of neutral (stability category D) conditions with a corresponding trend in increasing frequency of both stable (stability categories E, F, and G) and unstable (stability Category A, B, and C) conditions. The applicant also reviewed stability information from the Detroit Metropolitan Airport for the same time period and found similar trends in stability conditions. The applicant concluded that although it found a trend in the Fermi onsite stability frequencies, no correlations with instrumentation change-outs were evident and the stability classification trend was also verified to be consistent with other local meteorological data.

The applicant also reported in its response to **RAI 02.03.03-6** that approximately 3.9 percent of the hourly ∆T measurements for the years 2001 through 2007 exceeded the autoconvective lapse rate. The applicant found that most of these occurrences were at times when the wind direction was onshore from Lake Erie when strong cold advection is affecting the 60-meter (197-foot) tower level more than the 10-meter (33-foot) tower level. This occurs because the lower portion of the onshore flow is heated first by the land surface as it comes ashore.

In its supplemental response (ML100960474) to **RAI 02.03.04-3** dated March 30, 2010, the applicant stated that it performed further reviews of the original 2001-2007 hourly database submitted to the staff in its response to **environmental RAI AQ2.7-3**. Included in this evaluation was a review of the hourly data for cases when the ∆T measurements exceeded the autoconvective lapse rate. The applicant found that most of the occurrences when the wind direction was not onshore from Lake Erie to be improbable and removed these occurrences from the analysis.

The staff determined that the Fermi onsite meteorological data trends in decreasing frequency of neutral conditions with corresponding increasing frequencies of both stable and unstable conditions is plausible based on similar data trends observed at the Detroit Metropolitan Airport for the same time period. The staff also found that the applicant's explanation that autoconvective lapse rate occurs during onshore flows with rapid heating at the surface to be plausible. Consequently, the staff considers **RAI 02.03.03-6** to be resolved.

The applicant also stated in its supplemental response to **RAI 02.03.04-3** that it performed other data reviews to confirm the validity of the original 2001-2007 Fermi onsite meteorological data submitted in response to **environmental RAI AQ2.7-3**. The applicant also found 460 occurrences where either the 10-meter (33-foot) or the 60-meter (197-foot) measurements were

deemed too improbable because of unreasonable ratios between the 10-meter (33-foot) and 60-meter (197-foot) wind speeds and removed these occurrences from the analysis.

As a result of its review of the Fermi onsite meteorological data discussed above, the applicant proposed numerous changes to the FSAR. Included in these proposed revisions were updates to the JFDs presented in FSAR Tables 2.3-269 through 2.3-284 and Tables 2.3-292 through 2.3-299 and the wind roses presented in FSAR Figures 2.3-230 through 2.3-255. The applicant incorporated these revised tables and figures into Revision 4 of the FSAR.

The applicant also provided a copy of the 1985-1989 Fermi onsite meteorological database in its supplemental response (ML100960472) to **RAI 02.03.03-1** dated March 30, 2010. The applicant stated that aerial photographs of the area surrounding the Fermi meteorological tower in 1981 and 1991 confirm the absence of significant air flow obstructions to wind measurements at the 10 meter (33-foot) elevation. Therefore the applicant presented the 1985-1989 meteorological database as an alternative for performing dispersion analysis in those situations where it is not apparent that lower wind speeds measured at the 10-meter (33-foot) level produce conservative results.

The staff generated a JFD from the 1985-1989 data for comparison with the revised 2002-2007 JFD presented by the applicant in its supplemental response (ML100960474) to **RAI 02.03.04-3.** The staff found similar 10-meter (33-foot) and 60-meter (197-foot) wind direction frequency distributions between the two JFDs. However, the staff found that the 1985-1989 JFD had a lower frequency of (1) 10-meter (33-foot) low wind speed conditions (the frequency of winds less than 1.5 meters per second (m/s) increased from 9.1 percent in the 1985-1989 data to 17.0 percent in the 2002-2007 data) and (2) extremely unstable (stability category A) conditions (the frequency of extremely unstable conditions increased from 7.1 percent in the 1985-1989 data to 19.3 percent in the 2002-2007 data). Discrepancies in wind speed and stability class frequency distributions between these two databases create uncertainty as to which meteorological data set (1985-1989 versus 2002-2007) is most representative of long-term site conditions. Given the uncertainty in the data, the staff believes the dispersion analyses presented in FSAR Subsections 2.3.4 and 2.3.5 should be evaluated using both sets of data and the more conservative (bounding) dispersion estimates be used. This topic is discussed in more detail in SER Subsections 2.3.4 and 2.3.5.

Site Preparation and Construction, Pre-Operational, and Operational Onsite Meteorological Monitoring Program

FSAR Subsection 2.3.3.2 states that because the NDCT for Fermi Unit 3 will be built in the approximate location of the current (pre-application) onsite meteorological tower, a new meteorological tower will be erected in the southeast corner of the Fermi site. The applicant has made a commitment in FSAR Subsection 2.3.3.2 that the new tower will be operational for at least one year prior to the decommissioning of the existing onsite meteorological tower.

> **[START COM FSAR-2.3-003]**.The new meteorological tower will be operational for at least one year prior to the decommissioning of the existing onsite meteorological tower. The meteorological data recorded concurrently from the current and new onsite meteorological towers will undergo a detailed analysis to ensure the meteorological parameters measured at the new meteorological tower are representative of the atmospheric conditions at the Fermi site **[END COM FSAR-2.3-003]**.

The meteorological data recorded concurrently from the current (pre-application) and new (operational) onsite meteorological towers will undergo a detailed analysis to ensure the meteorological parameters measured at the new meteorological tower are representative of the atmospheric conditions at the Fermi site.

The proposed operational onsite meteorological monitoring program is described in greater detail in the following sections.

a. Tower and Instrument Siting

The NDCT for Fermi 3 will be built in the approximate location of the current onsite meteorological tower. Thus, the applicant states that a new meteorological tower will be erected in the southeast corner of the Fermi site (approximately 1268 meters (4160 feet)) from the existing meteorological tower) prior to the construction of Fermi 3. The new meteorological tower will be a guyed open-latticed tower that will be 60 meters (197 feet) tall.

FSAR Subsection 2.3.2.2 discusses the possible influence of Fermi 3 and its facilities on the proposed location of the new meteorological tower. That discussion is reviewed here.

Wind flow may be altered immediately adjacent to and downwind of larger site structures, but these effects will likely dissipate within ten structure heights downwind. The applicant states that the large structures associated with the operation of Fermi Unit 3, such as a 182.9-meter (600-foot) tall NDCT, the two multi-cell mechanical-draft cooling towers (MDCTs), and the 48.2-meter (158-foot) tall RB, will influence the airflow trajectories downwind of the new structures. Revision 1 to RG 1.23 states that a meteorological tower should be located at a distance of at least ten times the height of any nearby obstructions (e.g., large structures, trees, and nearby terrain) to avoid airflow modifications by the obstructions. The building wakes from the Fermi 3 RB and MDCTs should not impact the new meteorological tower since the new tower will be located more than ten times the heights of these obstructions downwind.

The ten-building-height distance of separation is typically applied to square or rectangular structures, whereas rounded and sloping structures such as hyperbolic NDCTs can be expected to produce a smaller wake zone. According to the applicant, the NDCT will be built to a height of 182.3 meters (600 feet) above plant grade, the tallest structure at the Fermi site. The NDCT will be hyperbolically shaped with a maximum width at the base of 140.2 meters (460 feet) and will be located at a distance of approximately 1268 meters (4160 feet) northwest of the new meteorological tower.

Section 123 of the Clean Air Act as amended in 1990 defines good engineering practice stack height as the height necessary to ensure that emissions from a stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of a source as a result of atmospheric downwash, eddies, and wakes which may be created by the source itself, by nearby structures, or by nearby terrain obstacles. The EPA defines “nearby structures” in its regulations (40 CFR 51.100(jj)(1)) as that distance up to five times the lesser of the height or the width dimension of a structure; that is, the downwind distance in which a structure is presumed to have a significant influence as a result of downwash, eddies, and wakes extends downwind approximately five times either the height or width (whichever is less) of the structure. The EPA regulatory guidance document for determining good engineering practice stack heights (EPA-450/4-80-023R, June 1985) also states that this area of influence becomes significantly smaller as the height to width ratio of a structure increases. Based on the EPA guidance for this type of structure, which will have a maximum width of 140.2 meters (460 feet), the outermost

boundary of influence exerted by the proposed NDCT is estimated to be approximately 701 meters (2300 feet). Since this distance is shorter than the 1268 meters (4160 feet) separation between the proposed NDCT and the new meteorological tower, the staff concludes that the proposed NDCT will not adversely affect measurements made at the new meteorological tower.

The applicant states in FSAR Subsection 2.3.3.2.1 that other structures near the location of the new meteorological tower include a water tower with a height of 44.2 meters (144.9 feet) and a maximum width of approximately 16.2 meters (53.3 feet). The water tower is circular and the tank head is spherical with a sloping surface. Based on the EPA guidance for this type of structure (as discussed above), the outermost boundary of influence exerted by the water tower with a maximum width of 16.2 meters (53.3 feet) is estimated to be approximately 81 meters (266 feet). Since this distance is shorter than the 210.9 meter (692 foot) separation between the water tank and the new meteorological tower, the staff concludes that the water tank will not adversely affect measurements made at the new meteorological tower.

The applicant states that the operational meteorological tower will have meteorological sensors located at the 10-meter (33-foot) and 60-meter (197-foot) elevations to estimate dispersion conditions. Wind sensors will be mounted at a distance equal to at least twice of the longest horizontal dimension of the triangular tower. Temperature sensors will be oriented such that the aspirated temperature shields are either pointed downward or laterally towards the north and the shield inlet is at least 1½ times the tower horizontal width away from the nearest point on the tower.

The applicant states that influence of terrain near the base of the new meteorological tower on temperature measurements is expected to be minimal because the area surrounding the new meteorological tower will not be paved or contain temporary land disturbances such as plowed fields and rock piles. The applicant further states that the tower will be situated in a relatively flat area that will be at a similar elevation as the plant structures. Because the location of the new meteorological tower is wooded and contains trees that would influence wind measurements if left at their current height, the applicant states the trees will be trimmed to a height outwards to a distance that satisfies the ten-obstruction-height distance separation criterion stated in Revision 1 to RG 1.23.

The staff finds that the new meteorological tower will be appropriately located such that it can measure the onshore flow conditions that could affect gaseous effluent releases from Fermi Unit 3. The staff finds the tower location complies with the recommendations provided in Revision 1 to RG 1.23 and is therefore acceptable to the staff.

b. Instrumentation

In FSAR Subsection 2.3.3.2.2, the applicant states that the new meteorological tower instrumentation will consist of wind speed and wind direction sensors at the 10-meter and 60-meter levels, a temperature sensor at the 10-meter (33-foot) level, a ΔT system between the 60-meter (197-foot) and 10-meter (33-foot) levels, and a dew-point temperature sensor at the 10-meter (33-foot) level. A heated tipping bucket precipitation gauge surrounded by a windscreen will be located at ground level at the base of the meteorological tower. External heaters will be installed on the primary wind sensors to minimize data loss during ice storms. Redundant secondary wind and temperature sensors will also be installed at the 10-meter (33-foot) and 60-meter (197-foot) levels. The applicant states the accuracies and thresholds for each sensor on the new meteorological tower will be within the values specified in RG 1.23.

Revision 2 to FSAR Subsection 2.3.3.2.2 states the new meteorological tower will use meteorological instrumentation that matches the manufacturer and model numbers used on the current tower and FSAR Table 2.3-289 provides the accuracies for each meteorological sensor located on the current meteorological tower. Revision 2 to FSAR Table 2.3-289 shows that the system accuracy for the differential temperature instrumentation is ±0.15 °C which exceeds the Revision 1 to RG 1.23 specified accuracy of ±0.1 °C. Consequently, the staff asked the applicant in **RAI 02.03.03-9** to justify why the differential temperature instrumentation accuracy for the new meteorological tower that will be erected to support the operational meteorological monitoring program will exceed the Revision 1 to RG 1.23 criterion of ±0.1 °C.

In its response (ML110110550) to **RAI 02.03.03-9** dated January 10, 2011, the applicant clarified that the reference to Table 2.3-289 in FSAR Subsection 2.3.3.2.2 was intended to present the accuracies for the current instrumentation and was not intended to imply that these same accuracies would be used for the new meteorological tower instrumentation. The applicant revised Subsection 2.3.3.2.2 in Revision 4 of the FSAR to clarify that the accuracies and thresholds for each sensor on the new meteorological tower will be within the values specified in Revision 1 to RG 1.23. The staff finds this response to be acceptable and considers **RAI 02.03.03-9** to be resolved.

The applicant also states that the data recording process planned for the new meteorological tower will mirror the data recording process for the existing (preoperational) meteorological tower. The staff finds this acceptable.

c. Instrument Calibration, Service, and Maintenance

The applicant states the instrumentation, service, and maintenance procedures in place for the existing (pre-application) meteorological monitoring program as described in FSAR Subsections 2.3.3.1.3 and 2.3.3.1.4 will continue for the new meteorological monitoring program. The staff finds this acceptable.

d. Data Reduction, Transmission, Acquisition, and Processing

The applicant states the method of data reduction, transmission, acquisition, and processing described in FSAR Subsections 2.3.3.1.5 and 2.3.3.1.6 for the pre-application monitoring program will be used for the new meteorological monitoring program. The staff finds this acceptable.

The staff asked the applicant in **RAI 02.03.03-7,** in accordance with criteria specified in Section C.8 of RG 1.23, to discuss any provisions that will be in place to obtain representative meteorological data (e.g., wind speed and direction representative of the 10-meter (33-foot) level and an estimate of atmospheric stability) from alternative sources during an emergency, if the site meteorological monitoring system should be unavailable.

The applicant provided a response (ML100960472) to **RAI 02.03.03-7** (dated February 8, 2010) in which it was stated that there is sufficient redundancy built into the meteorological measurement system such that only under the most unusual circumstances would data be unavailable. Should any of the parameters required for dose assessment become unavailable, supplementary meteorological data will be available via the corporate computer system. As indicated in Section H, Sections 6 and 7, of the Fermi 3 Emergency Plan, in the unlikely event that both the primary and backup meteorological systems become inoperable during an

emergency, Detroit Edison maintains a contract with a vendor to provide pertinent weather and forecast data. In addition, ambient temperature, wind direction, wind speed, and estimated atmospheric stability data will be available by contacting the nearest NWS office.

The staff finds that sufficient provisions are in place for Fermi 3 to obtain representative meteorological data from alternative sources in the event of an emergency when meteorological data from the site are unavailable. The staff considers **RAI 02.03.03-7** to be resolved.

The staff's review found that the applicant has described an onsite meteorological monitoring program and generated a resulting database, which are acceptable and meet the requirements of 10 CFR 100.20 and 100.21 with respect to determining the acceptability of the site.

2.3.3.5 Post Combined License Activities

The following items were identified by the applicant:

> **[START COM FSAR-2.3-003]**. The new meteorological tower will be operational for at least one year prior to the decommissioning of the existing onsite meteorological tower. The meteorological data recorded concurrently from the current and new onsite meteorological towers will undergo a detailed analysis to ensure the meteorological parameters measured at the new meteorological tower are representative of the atmospheric conditions at the Fermi site **[END COM FSAR-2.3-003]**

Table 2.3-1 of Part 10 of the COL application contains EP inspection, test, analysis, and acceptance criteria (ITAAC). The following EP-ITAAC involve demonstrating that the operational onsite meteorological monitoring program appropriately supports the emergency plan:

- EP Program Element 8.6: The means exists to provide meteorological information, consistent with Appendix 2 of NUREG-0654/FEMA-REP-1, Revision 1. The acceptance criterion is that the means to obtain meteorological information described in Section II.H.7 of the Fermi 3 COL application Emergency Plan are addressed in emergency plan implementing procedures, "Dose Assessment Methodology."

- EP Program Element 9.3: The means exist to continuously assess the impact of the release of radioactive materials to the environment, accounting for the relationship between effluent monitor readings, and onsite and offsite exposures and contamination for various meteorological conditions. The acceptance criterion is that Emergency Plan implementing procedure, "Dose Assessment Methodology," and the ODCM calculate the relationship between effluent monitor readings and offsite exposures and contamination for various meteorological conditions.

- EP Program Element 9.4: The means exists to acquire and evaluate meteorological information. The acceptance criteria are (1) the specified meteorological data (i.e., wind speed at 10 meters and 60 meters, wind direction at 10 meters and 60 meters, and ambient air temperature at 10 meters and 60 meters) are available at the control room, technical support center (TSC), and emergency operations facility and (2) the specified meteorological data are transmitted to and received by the offsite NRC center and State of Michigan.

EP and EP-ITAAC are addressed in SER Section 13.3, "Emergency Planning."

2.3.3.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

NRC staff reviewed the information in Subsection 2.3.3 of the COL FSAR and confirmed that the applicant has presented and substantiated information pertaining to the onsite meteorological monitoring program and the resulting database. The staff's review found that the applicant has established the structure for the onsite meteorological monitoring program and the resulting database, which are acceptable and meet the requirements of 10 CFR 100.20 and 100.21 with respect to determining the acceptability of the site.

The staff concluded that the onsite data also provide an acceptable basis for estimating atmospheric dispersion for design-basis accident and routine releases from the plant. The data meet the requirements of GDC 19, 10 CFR 100.20, 10 CFR 100.21, 10 CFR Part 20, and Appendix I to 10 CFR Part 50. Finally, the equipment for measuring meteorological parameters during the course of accidents is sufficient to reasonably predict atmospheric dispersion of airborne radioactive materials, in accordance with 10 CFR 50.47(b) and Appendix E to 10 CFR Part 50.

The staff's review confirmed that the applicant has adequately addressed the COL license information item in accordance with Section 2.3.3 of NUREG–0800.

2.3.4 Short-Term (Accident) Diffusion Estimates

The consequence of a design basis accident in terms of personnel exposure is a function of the atmospheric dispersion conditions at the site of the potential release. Atmospheric dispersion conditions are represented by relative air concentration (χ/Q) values. This section describes the development of the short-term dispersion estimates that are used to evaluate design basis accident radiological exposures for the EAB, the outer boundary of the LPZ, and the control room.

2.3.4.1 Introduction

Subsection 2.3.4, "Short-Term (Accident) Diffusion Estimates," of the Fermi 3 FSAR addresses the atmospheric dispersion factor (χ/Q or relative concentration) estimates at the EAB, the outer boundary of the LPZ, the control room, and TSC for postulated design-basis accidental radioactive airborne releases. This SER subsection also reviews Appendix 2A, "ARCON96 Source/Receptor Inputs," of the Fermi 3 COL FSAR which addresses the use of the ARCON96 atmospheric dispersion model to derive site-specific control room and TSC χ/Q values.

Dispersion estimates from the onsite and/or offsite airborne releases of hazardous materials such as flammable vapor clouds, toxic chemicals, and smoke from fires are reviewed in SER Subsection 2.2.3.

2.3.4.2 Summary of Application

Subsection 2.3.4 and Appendix 2A of the Fermi 3 COL FSAR, Revision 4, describes the atmospheric dispersion factor (χ/Q or relative concentration) estimates at the EAB, the outer boundary of the LPZ, the control room, and TSC for postulated design-basis accidental radioactive airborne releases. In addition, the applicant provides the following:

COL Items

- EF3 COL 2.0-10-A Short-Term Dispersion Estimates for Accidental Atmospheric Release

  Subsection 2.3.4 describes the development of the short-term atmospheric dispersion estimates for the EAB, outer boundary of the LPZ and the control room.

- EF3 COL 2A.2-1-A Confirmation of the ESBWR χ/Q Values

  Subsection 2.3.4 and Appendix 2A describe the development of the short-term atmospheric dispersion estimates for the control room and TSC. Subsection 2.0 compares the resulting control room and TSC χ/Q values with the corresponding ESBWR DCD site parameter values.

- EF3 COL 2A.2-2-A Confirmation of the Reactor Building χ/Q Values

  Appendix 2A states that the doors and personnel air locks on the east sides of the reactor building and fuel building are administratively controlled to remain closed during refueling.

2.3.4.3 Regulatory Basis

The acceptance criteria for identifying short-term atmospheric dispersion estimates for accident radiological releases are based on meeting the relevant requirements of 10 CFR Part 52 and 10 CFR Part 100. NRC staff considered the following regulatory requirements in reviewing the applicant's discussion of site location and description:

- 10 CFR Part 50, Appendix A, GDC 19, "Control Room," with respect to the meteorological considerations used to evaluate the personnel exposures inside the control room during radiological accident conditions.

- 10 CFR 52.79(a)(1)(vi), with respect to a safety assessment of the site, including consideration of major SSCs of the facility and site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

- 10 CFR 100.21(c)(2), with respect to the atmospheric dispersion characteristics used in the evaluation of EAB and LPZ radiological dose consequences for postulated accidents.

NUREG–0800, Section 2.3.4 specifies that an application meets the above requirements if the application provides the following information:

- A description of the atmospheric dispersion models used to calculate χ/Q values for accidental releases of radioactive materials into the atmosphere.

- Meteorological data used for the evaluation (as inputs 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 constructed to describe the probabilities that these χ/Q values will be exceeded.

- Atmospheric dispersion factors used for the assessment of consequences related to atmospheric radioactive releases to the control room for design-basis accidents.

- For control room habitability analysis, a site plan drawn to scale showing true North and potential atmospheric accident release pathways, control room intake, and unfiltered in-leakage pathways.

In addition, the short-term atmospheric dispersion estimates for accident radiological releases should be consistent with the appropriate sections from the following RGs:

- RG 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants," provides criteria for an acceptable onsite meteorological measurements program; these data are used as inputs to atmospheric dispersion models.

- RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," presents criteria that characterize atmospheric dispersion conditions and evaluate the consequences of radiological releases to the EAB and LPZ.

- RG 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," presents criteria that characterize atmospheric dispersion conditions and evaluate the consequences of radiological releases to the control room.

When independently assessing the acceptability of the information presented by the applicant in FSAR Tier 2, Subsection 2.3.4, NRC staff applied the same methodologies, models, and techniques cited above.

2.3.4.4 Technical Evaluation

NRC staff reviewed the application and the applicant's responses to RAIs to verify the accuracy, completeness, and sufficiency of the information from the applicant regarding short-term atmospheric dispersion estimates for accident releases. The staff followed the procedures described in Subsection 2.3.4 of NUREG–0800 as part of this review.

COL Items

- EF3 COL 2.0-10-A Short-Term (Accident) Dispersion Estimates

  This COL information item states that the applicant supply site-specific information, in accordance with SRP Subsection 2.3.4, to show that the site's meteorological dispersion values as calculated in accordance with RG 1.145 and RG 1.194 and compared to dispersion values in Chapter 15, result in doses less than those stipulated in 10 CFR 52.79(a)(1)(vi) and the applicable portions of SRP Sections 11 and 15.

In response to this COL information item, the applicant describes (1) the atmospheric dispersion models to calculate atmospheric dispersion factors for postulated accidental radioactive airborne releases, (2) the meteorological data and other assumptions used as inputs to atmospheric dispersion models, (3) the derivation of diffusion parameters (σ_y and σ_z), and (4) the determination of conservative χ/Q values used to assess the consequences of postulated design-basis atmospheric radioactive releases to the EAB, LPZ, control room, and TSC.

NRC staff reviewed the applicant's resolution to EF3 COL 2.0-10-A related to the determination of conservative χ/Q values used to assess the consequences of postulated design-basis atmospheric radioactive releases to the EAB, LPZ, control room, and TSC in accordance with RGs 1.145 and 1.194. The staff's review of the applicant's offsite (i.e., EAB and LPZ) and onsite (i.e., control room and TSC) meteorological dispersion estimates is discussed later in this subsection.

The staff also reviewed the applicant's atmospheric dispersion values to ensure that they result in doses less than those stipulated in 10 CFR 52.79(a)(1)(vi) and in the applicable portions of SRP Sections 11 and 15. This review involves demonstrating that the Fermi 3 meteorological dispersion (accidental release) site characteristic values fall within the corresponding ESBWR DCD meteorological dispersion site parameter values. Section 2.0 of the Fermi 3 COL FSAR evaluated whether the Fermi 3 site characteristics fall within the ESBWR DCD site parameter values. A comparison of the ESBWR DCD accidental atmospheric dispersion factors with the Fermi 3 accidental atmospheric dispersion factors is in Fermi 3 COL FSAR, Table 2.0-201. Smaller χ/Q values are associated with a greater dilution capability, resulting in lower radiological doses. When comparing an ESBWR DCD site parameter χ/Q value and a Fermi 3 site characteristic χ/Q value, the Fermi 3 site is acceptable for the ESBWR design if the Fermi 3 site characteristic χ/Q value is smaller than the corresponding ESBWR site parameter χ/Q value. Such a comparison shows that the Fermi 3 site has better dispersion characteristics than the ESBWR reactor design requires.

The staff reviewed this comparison to ensure the applicant appropriately compared the ESBWR DCD site parameter values with the Fermi 3 site characteristics. The staff issued **RAI 02.03.04-6,** requesting that the applicant justify the values selected as the Fermi 3 RWB unfiltered in-leakage and air intake χ/Q site characteristic values for the control room.

In its response (ML102570700) to **RAI 02.03.04-6** dated September 2, 2010, the applicant stated that the Fermi 3 site characteristic values used for comparison with the ESBWR DCD control room RWB unfiltered in-leakage and air intake χ/Q site parameter values are the same values used for the PCCS vent releases. The applicant pointed out that the relevant analysis in the ESBWR DCD that uses χ/Q values from the RWB is the liquid-containing tank failure

described in DCD Tier 2, Subsection 15.3.16. The applicant stated that the ESBWR DCD used the PCCS vent χ/Q values in this analysis because the PCCS vent χ/Q values are assumed to bound any release from the RWB based on distance and direction to the control room receptors. The applicant therefore concludes that its use of the PCCS vent release site characteristic χ/Q values to represent releases from the RWB is consistent with the ESBWR DCD.

The staff reviewed the Fermi 3 RWB site characteristic χ/Q values and confirmed that they are bounded by the Fermi 3 PCCS vent site characteristic χ/Q values. Consequently, the staff finds the use of the PCCS vent release site characteristic χ/Q values to represent releases from the RWB to be conservative and therefore acceptable and considers **RAI 02.03.04-6** to be resolved.

Fermi 3 COL FSAR, Table 2.0-201 shows that the Fermi 3 EAB, LPZ, control room, and TSC site characteristic χ/Q values are all less than the corresponding ESBWR DCD site parameter χ/Q values, thereby demonstrating that site meteorological dispersion conditions result in doses less than those stipulated in 10 CFR 52.79(a)(1)(vi) and in the applicable portions of SRP Sections 11 and 15.

- EF3 COL 2A.2-1-A Conformation of the ESBWR χ/Q Values

  This COL information item states that when referencing the ESBWR DCD to confirm that site characteristics at a given site are bounded by the ESBWR DCD site parameter values per 10 CFR 52.79, the COL applicant shall perform ARCON96 determinations for all source/receptor pairs listed in ESBWR DCD Tables 2A-3 and 2A-4 using site-specific meteorological data. The applicant responded to this COL information item by calculating and presenting control room and TSC χ/Q values in FSARs Tables 2.3-301 and 2.3-378 and comparing them to the corresponding ESBWR DCD site parameter values in FSAR Table 2.0 201.

The staff's review of the applicant's resolution to COL Information Item EF3 COL 2A.2-1-A is discussed later in this section.

- EF3 COL 2A.2-2-A Conformation of the Reactor Building χ/Q Values

  This COL information item states that if the χ/Q values for a release from any door on the east sides of the reactor building or fuel building have χ/Q values that would result in doses greater than the bounding dose consequence reported for the fuel handling accident (DCD Tier 2, Table 15.4-4), the affected doors or personnel air locks are administratively controlled to remain closed during movement of irradiated fuel bundles. The applicant responded to this COL information item by stating that the doors and personnel air locks on the east sides of the RB and FB are administratively controlled to remain closed during refueling.

NRC staff reviewed the applicant's resolution to EF3 COL 2A.2-2-A and found it acceptable because the applicant is going to administratively control the doors on the east sides of the RB and FB during refueling so they remain closed during the movement of irradiated fuel bundles regardless of the RB χ/Q Values.

Offsite Dispersion Estimates

a. 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.

The PAVAN code estimates χ/Q values for various time-averaged periods ranging from 2 hours to 30 days. The meteorological input to PAVAN consists of a JFD 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 into 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 (N, NNE, NE, ENE, etc.), PAVAN calculates χ/Q values for each combination of wind speed and atmospheric stability at the appropriate downwind distance (i.e., the EAB and the outer boundary of the LPZ). The χ/Q values calculated for each sector are then placed in order from the greatest to the 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), so that no plotted point is above the curve. From this upper envelope, the χ/Q value, which is equaled or exceeded 0.5 percent of the total time, is obtained. The maximum 0.5 percent χ/Q value from the 16 sectors becomes the 0–2 hour "maximum sector χ/Q value."

Using the same approach, PAVAN also combines all χ/Q values independent of wind direction into a cumulative frequency distribution for the entire site. An upper envelope curve is determined, and the program selects the χ/Q value that is equaled or exceeded no more than 5.0 percent of the total time. This value is known as the 0–2 hour "5-percent overall site χ/Q value."

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

To determine LPZ χ/Q values for longer time periods (e.g., 0–8 hours, 8–24 hours, 1–4 days, and 4–30 days), PAVAN performs a logarithmic interpolation between the 0–2 hour χ/Q values and the annual average (8,760 hours) χ/Q values for each of the 16 sectors and the overall site. For each time period, the highest among the 16-sector and overall site χ/Q values is identified and becomes the short-term site characteristic χ/Q value for that time period.

b. Release Characteristics and Receptors

The applicant modeled one ground-level release point and did not take credit for building wake effects. Ignoring building wake effects for a ground-level release decreases the amount of

atmospheric turbulence assumed to be in the vicinity of the release point, resulting in higher (more conservative) χ/Q values for a flat terrain site such as Fermi 3. A ground-level release assumption that does not take credit for building wake effects is therefore acceptable to the staff.

Revision 0 to FSAR Subsection 2.3.4.1 stated the EAB and outer boundary of the LPZ are both circles centered at the RB, with radii of 892 meters and 4824 meters, respectively. The staff asked the applicant in **environmental RAI AQ2.7-5** to describe and justify the methodology used to determine the distances to the EAB and LPZ. It was not apparent to the staff that the applicant followed the guidance in RG 1.145 in determining the distances to the EAB and LPZ. RG 1.145 states that, for ground-level releases through vents or building penetrations, the distances for each of the 16 downwind sectors for the EAB and LPZ χ/Q calculations should be based on the nearest point on the building to the EAB or LPZ within a 45-degree sector centered on the compass direction of interest.

In its response to **environmental RAI AQ2.7-5** dated August 25, 2009, the applicant defined an effective (dose calculation) EAB and LPZ for the purposes of determining χ/Q values. The applicant drew a circle from the center of the RB which encompasses all the postulated design basis accident release locations and defined the dose calculation EAB and LPZ as the distance between this circle and the EAB and LPZ, respectively. The resulting distances for the dose calculation EAB and LPZ were 740 meters and 4670 meters, respectively. The staff found that the applicant's revised approach for calculating distances to the EAB and LPZ acceptable because it follows the guidance of RG 1.145. The applicant also provided the revised PAVAN input and output files in its response to **environmental RAI AQ2.7-4** dated September 30, 2009.

The staff subsequently issued **RAI 02.03.04-1** requesting that the applicant revise FSAR Section 2.3.4 and Table 2.0-201 to present the higher of either the 0.5 percentile maximum sector or 5 percentile overall site χ/Q values (pursuant to RG 1.145) resulting from the new dose calculation EAB and LPZ distances presented in **environmental RAI AQ2.7-5**. The applicant provided the requested information in Revision 2 to the FSAR. Therefore, the staff considers **RAI 02.03.04-1** to be resolved.

c. 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 2002 through 2007. The wind data were obtained from the 10-meter level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-T) measurements taken between the 60-meter and 10-meter levels on the onsite meteorological tower.

d. Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.145 as a function of atmospheric stability for the PAVAN model runs. The EAB extends over Lake Erie in the east-northeast clockwise to the southeast sectors and outer boundary of the LPZ extends over Lake Erie in the northeast clockwise to the southwest sectors. Subsequently, the staff asked the applicant in **RAI 02.03.04-2** to discuss the impact of changes in surface temperature and roughness resulting from over-water trajectories on the resulting offsite short-term atmospheric dispersion estimates. Dispersion parameters obtained over land and classified according to overland stabilities may not be directly applicable over water. The smooth water surface can result in less mechanically generated turbulence than over land, while the air-water temperature difference can either enhance or hinder convective turbulence.

In its response (ML100960472) to **RAI 02.03.04-2** dated February 8, 2010, the applicant stated it did not consider it necessary to specifically account for potential impacts to the atmospheric dispersion factors due to surface temperature and roughness resulting from over-water trajectories. The response to **RAI 02.03.04-2** states that the applicant used the default open terrain correction factors provided by the PAVAN atmospheric dispersion model to account for spatial and temporal variations in airflow resulting from recirculation and stagnation effects. The staff notes the PAVAN model only uses the open terrain correction factors in calculating the annual average χ/Q values that are used in the logarithmic interpolation to derive the intermediate time period (0-8 hours, 8-24 hours, 1-4 days, and 4-30 days) LPZ χ/Q values. The open terrain correction factors also do not account for changes in surface temperature and reduced surface roughness resulting from over water trajectories.

The response to **RAI 02.03.04-2** also stated that the PAVAN maximum atmospheric dispersion values chosen as site characteristics for comparison with the ESBWR site parameters occurred in the ESE direction over Lake Erie and not over habitable locations. The applicant considers this to be a conservative approach. The staff disagrees in that the EAB and outer boundary of the LPZ are both hypothetical boundaries; it makes no difference in the dose analysis whether these boundaries are over land or over water.

Although the applicant did not specifically account for potential impacts to the atmospheric dispersion factors due to surface temperature and roughness resulting from over-water trajectories, the staff finds that the applicant has presented conservative short-term atmospheric dispersion estimates by using the 2002-2007 JFD. As discussed in the applicant's supplemental response (ML1106-960472) to **RAI 02.03.03-1** dated March 30, 2010, the potential exists for the 2002-2007 wind speed measurements to be lower than the actual wind speed at the 10-meter elevation. This is especially true for the ESE downwind sector, where the PAVAN maximum atmospheric dispersion values chosen as site characteristics occurred, because the meteorological tower is downwind of the nearby trees in this sector. The use of lower wind speeds at the 10-meter elevation produces higher (more conservative) χ/Q values from the PAVAN model which compensates for potential impacts to the atmospheric dispersion factors resulting from over-water trajectories. Therefore, the staff considers **RAI 02.03.04-2** to be resolved.

e. Resulting Relative Concentration Factors

The staff performed an independent evaluation of the applicant's PAVAN results by generating a JFD from the original 2002-2007 hourly onsite meteorological database provided in response to **environmental RAI AQ2.7-3** dated October 30, 2009 and rerunning the PAVAN computer

code. The staff's JFD was based on the wind speed classes presented in Table 3 of Revision 1 to RG 1.23 (i.e., calm, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 8.0, 10.0 and > 10.0 meters per second). The staff's results were more conservative (i.e., higher) than those generated by the applicant's PAVAN run. The staff believes its more conservative results were primarily due to the difference in the frequency of calm winds between the applicant's JFD and the staff's JFD. The staff issued **RAI 02.03.04-3** requesting that the applicant explain the difference in the number of calm winds presented in FSAR (Revision 0), Tables 2.3-292 through 2.3-299 versus the number of hours of calm winds reported in the 2002-2007 hourly database. The staff also asked the applicant to explain how the calm winds presented in FSAR (Revision 0), Tables 2.3-292 through 2.3-299 were assigned to wind direction sectors for executing PAVAN and justify any deviations from the methodologies presented in RG 1.23 and RG 1.145. RG 1.23 states that the starting threshold for the wind sensors should be less than 0.45 meters per second and RG 1.145 states that wind directions during calm conditions should be assigned in proportion to the directional distribution of non-calm winds with speeds less than 1.5 meters per second.

In its supplemental response (ML100960474) to **RAI 02.03.04-3** dated March 30, 2010, the applicant stated that it performed further reviews of the original 2001-2007 hourly Fermi onsite meteorological database submitted to the staff in its response to **environmental RAI AQ2.7-3** and revised the database accordingly. A copy of the revised 2001-2007 database (in RG 1.23 format) was provided as part of the applicant's supplemental response to **environmental RAI AQ2.7-3** dated March 30, 2010; a copy of the revised 2002-2007 database (in RG 1.194 format) was also provided as part of the applicant's supplemental response (ML110960472) to **RAI 02.03.04-4** dated March 30, 2010. The applicant used the revised 2002-2007 database to derive a new JFD assuming a wind sensor starting threshold of 0.45 meters per second (one mile per hour) and assigning wind directions during calm conditions consistent with the guidance in RG 1.145. This new JFD was included in the supplemental response to **RAI 02.03.04-3** as proposed revisions to FSAR Tables 2.3-292 through 2.3-299. The staff generated its own JFD frequency distribution from the revised 2002-2007 database submitted in the supplemental response to **RAI 02.03.04-4** and obtained similar results.

Because the applicant provided a revised JFD and assigned wind directions during calm conditions consistent with the guidance provided in RG 1.145, **RAI 02.03.04-3** is considered to be resolved. The applicant incorporated the revised FSAR Tables 2.3-292 through 2.3-299 into Revision 4 of the FSAR.

The applicant reran the PAVAN atmospheric dispersion model for the dose calculation EAB (740 meters) and LPZ (4670 meters) using the revised 2002-2007 JFD distribution and presented the results in a proposed revision to FSAR Subsection 2.3.4 as part of its supplemental response to **RAI 02.03.04-3**. The staff independently reran the PAVAN code using a JFD it derived from the revised 2002-2007 database submitted in the supplemental response to **RAI 02.03.04-3** and obtained similar results (± 2 percent). The applicant incorporated the revised PAVAN results into Revision 4 of the FSAR.

In its supplemental response (ML100960474) to **RAI 02.03.04-3**, the applicant also proposed a revision to FSAR Subsection 2.3.4.2 stating that the meteorological tower is located east of a grove of trees that is situated less than ten times the obstruction height recommended in RG 1.23. The impact of the trees is to reduce the measured wind speed at the 10-meter level for upwind sectors. The proposed FSAR revision further states that the use of lower measured wind speeds provides conservative results for the PAVAN model. In order to test this hypothesis, the staff independently reran the PAVAN model using a JFD derived from the 1985-1989 database submitted in the applicant's supplemental response to **RAI 02.03.03-1**.

The applicant stated that aerial photographs of the area surrounding the Fermi meteorological tower during this time period confirm the absence of significant air flow obstructions to wind measurements at the 10 meter elevation. The staff found that its resulting short-term atmospheric dispersion values using the 1985-1989 JFD were lower (less conservative) than the site characteristic values selected by the applicant using the revised 2002-2007 JFD. The staff therefore concludes that the applicant has selected conservative EAB and LPZ short-term atmospheric dispersion factors as site characteristic values by using the revised 2002-2007 JFD.

Atmospheric Dispersion Factors for On-Site Doses

a. Atmospheric Dispersion Model

The applicant used the computer code ARCON96 (NUREG/CR–6331, "Atmospheric Relative Concentrations in Building Wakes") to estimate χ/Q values at the control room and TSC for potential accidental releases of radioactive material. The ARCON96 model implements the methodology outlined in RG 1.194.

The ARCON96 code estimates χ/Q values for various time-averaged periods ranging from 2 hours to 30 days. The meteorological input to ARCON96 consists of hourly values of wind speed, wind direction, and atmospheric stability class. The χ/Q values calculated through ARCON96 are based on the theoretical assumption that material released into the atmosphere will be normally distributed (Gaussian) about the plume centerline. A straight-line trajectory is assumed between the release points and receptors. The diffusion coefficients account for an enhanced dispersion under low wind speed conditions and in building wakes.

The hourly meteorological data are used to calculate hourly relative concentrations. The hourly relative concentrations are then combined to estimate concentrations ranging in duration from 2 hours to 30 days. Cumulative frequency distributions are prepared from the average relative concentrations and the relative concentrations that are exceeded no more than 5 percent of the time for each averaging period are selected.

b. Meteorological Data Input

The meteorological input to ARCON96 used by the applicant consisted of hourly onsite wind speed, wind direction, and atmospheric stability data from two periods of record: 1985 through 1989 and 2001 through 2007. The wind data were obtained from the 10-meter and 60-meter levels of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-T) measurements taken between the 60-meter and 10-meter levels on the onsite meteorological tower.

c. Diffusion Parameters

The diffusion coefficients used in ARCON96 have three components. The first component, the diffusion coefficient, is used in other NRC models such as PAVAN. The other two components are corrections to account for the enhanced dispersion under low wind speed conditions and in building wakes. These components are based on an analysis of diffusion data collected in various building wake diffusion experiments, under a wind range of meteorological conditions. Because the diffusion occurs at short distances within the plant's building complex, the ARCON96 diffusion parameters are not affected by nearby topographic features, such as

bodies of water. Therefore, NRC staff found that the applicant's use of the ARCON96 diffusion parameter assumptions is acceptable.

d. Resulting Relative Concentrations

Appendix 2A to ESBWR DCD Tier 2 provides the source/receptor inputs required to execute the ARCON96 model using site-specific meteorological data. Included in Appendix 2A is Figure 2A-1 which shows the location of potential atmospheric accident release pathways and the control room and TSC receptors. Note that the Fermi 3 site plan in FSAR Figure 2.1-204 shows that true north is approximately nineteen degrees counter-clockwise from plant north. True north is the basis for the wind direction data recorded by the Fermi 3 onsite meteorological program whereas plant north is the basis for the source/receptor directions presented in Table 2A-4 in Appendix 2A of ESBWR DCD Tier 2. Therefore, the applicant adjusted the source-to-receptor data presented in ESBWR DCD Tier 2, Table 2A-4 by nineteen degrees to account for the difference in angle between the ESBWR plant north and the Fermi 3 true north.

The staff attempted to independently confirm the applicant's ARCON96 atmospheric dispersion model results by executing the ARCON96 model using the meteorological data provided in response to **environmental RAI AQ2.7-3**. Because the meteorological data provided in response to **environmental RAI AQ2.7-3** were in a format compatible to Appendix A to RG 1.23, the staff had to convert these data into RG 1.194 format for input into the ARCON96 model. The staff executed the ARCON96 model using its converted meteorological database and obtained ARCON96 results that, in some cases, differed from the applicant's results reported in the FSAR. Subsequently, the staff asked the applicant in **RAI 02.03.04-4** to provide in electronic form the meteorological input file and all the output files associated with these ARCON96 computer code runs. These files were necessary for the staff to complete its assessment of the applicant's resulting onsite χ/Q estimates.

The applicant provided the requested information in its supplement response (ML100960474) to **RAI 02.03.04-4** dated March 30, 2010. The supplemental response to **RAI 02.03.04-4** provided a revised set of 2001-2007 ARCON96 meteorological input files based on the review of the original 2001-2007 database described in the supplemental response to **RAI 02.03.04-3**. The supplemental response to **RAI 02.03.04-4** also provided a revised set of input and output files associated with rerunning the ARCON96 computer code with the revised 2001-2007 meteorological data. Because the applicant provided the requested files, the staff considers **RAI 02.03.04-4** to be resolved.

The staff believes that there were numerous data discrepancies in the applicant's original 2001-2007 RG 1.194 formatted meteorological database that the applicant used to run ARCON96 and that these data discrepancies resulted in the staff obtaining ARCON96 results that were different from the applicant's results. These data discrepancies appear to have been resolved by the applicant with the revised set of ARCON96 input files provided in the applicant's supplemental response to **RAI 02.03.04-4**. To verify this hypothesis, the staff generated a JFD from the revised 2002-2007 ARCON96 database for comparison with the revised 2002-2007 JFD presented in the applicant's response to **RAI 02.03.04-3**. The staff found the two JFDs to be similar. The staff also reran the ARCON96 computer code with the revised 2001-2007 ARCON96 database and obtains results that were similar to the applicant's.

In its supplemental responses to **RAI 02.03.03-1** and **RAI 02.03.04-3**, the applicant explains that the meteorological tower is located east of a grove of trees that is situated less than ten times the obstruction height recommended in RG 1.23. The impact of these trees is to reduce the

measured wind speed at the 10-meter level for upwind sectors. Because the ARCON96 diffusion coefficients are a function of a low wind speed correction and a building wake correction, the limiting ARCON96 χ/Q values may not occur at the lowest wind speeds. Therefore, the applicant generated control room and TSC χ/Q values using two sets of meteorological data: 1985-1989 and the revised 2001-2007. The applicant concluded that χ/Q values from both data sets are bounded by the corresponding DCD site parameter values. Nonetheless, in its response to **RAI 02.03.04-3**, the applicant proposed presenting only ARCON96 χ/Q values derived from the revised 2001-2007 meteorological data as control room and TSC site characteristics in the FSAR.

The applicant provided a copy of the 1985-1989 data from the Fermi meteorological tower in its supplemental response to **RAI 02.03.03-1**. The staff compared these data against the 2001-2007 dataset and found the older dataset had lower frequencies of (1) low wind speed conditions at the 10-meter elevation and (2) extremely unstable (stability class A) conditions. Discrepancies in wind speed and stability class frequency distributions create uncertainty as to which meteorological data set (1985-1989 versus 2001-2007) is most representative of site conditions. Given the uncertainty in the data, the staff asked the applicant in **RAI 02.03.04-5** to justify why both sets of control room and TSC atmospheric dispersion factors should not be presented in FSAR Subsection 2.3.4.3 and the more conservative resulting χ/Q values be presented in FSAR Table 2.0-201 as Fermi 3 site characteristic values.

In its response (ML102570700) to **RAI 02.03.04-5** dated September 2, 2010, the applicant agreed to revise FSAR Section 2.3.4.3 to include χ/Q values calculated with both the 1985-1989 data base and the 2001-2007 data base and to include the more conservative results in FSAR Table 2.0-201. The applicant also recalculated the 1985-1989 and 2001-2007 control room and TSC χ/Q values using revised input parameters to the ARCON96 model as specified in Revision 8 of Appendix 2A to ESBWR DCD Tier 2, Chapter 2. The applicant implemented these proposed changes in Revision 4 of the FSAR. Because the applicant revised the FSAR to include χ/Q values calculated with both the 1985-1989 and 2001-2007 data sets, **RAI 02.03.04-5** is considered to be resolved.

Included in the response to **RAI 02.03.04-5** were ARCON96 input and output files for both the 1985-1989 and 2001-2007 meteorological data sets. The staff reviewed the applicant's inputs to the ARCON96 code and found them consistent with the information presented in Appendix 2A of Revision 8 to ESBWR DCD Tier 2, Chapter 2.

Because the FSAR included χ/Q values calculated with both the 1985-1989 data base and the 2001-2007 data base, the staff accepts the control room and TSC χ/Q values presented by the applicant.

The staff reviewed the information provided and, for the reasons given above, concludes that the applicant's atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR 100.21(c)(2).

2.3.4.5 Post Combined License Activities

There are no post COL activities related to this section.

2.3.4.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

NRC staff reviewed the application and found that the applicant has presented and substantiated information regarding short-term atmospheric dispersion estimates for accident releases. The staff reviewed the information provided and, for the reasons given above, concludes that the applicant's atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR 100.21(c)(2). This conclusion is based on the conservative assessments of post-accident atmospheric dispersion conditions that have been made by the applicant and the staff from the applicant's meteorological data and appropriate dispersion models. These atmospheric dispersion estimates are appropriate for the assessment of consequences from radioactive releases for design basis accidents in accordance with 10 CFR 52.79(a)(1)(vi) and GDC 19.

The staff's review confirmed that the applicant has adequately addressed the COL license information items in accordance with Subsection 2.3.4 of NUREG–0800.

2.3.5 Long-Term (Routine) Diffusion Estimates

For a routine release, the concentration of radioactive material in the surrounding region depends on the amount of effluent released, the height of the release, the momentum and buoyancy of the emitted plume, the wind speed, atmospheric stability, airflow patterns of the site, and various effluent removal mechanisms.

2.3.5.1 Introduction

Subsection 2.3.5, "Long-Term (Routine) Diffusion Estimates," of the Fermi 3 FSAR addresses the atmospheric dispersion factor (χ/Q or relative concentration) and atmospheric deposition factor (D/Q or relative deposition) estimates to a distance of 80 kilometers (50 miles) from the plant for releases of radiological effluents to the atmosphere during normal plant operation for annual average release limit calculations and offsite dose estimates. This SER subsection also reviews Appendix 2B, "Ventilation Stack Pathway Information for Long-Term χ/Q Values," of the Fermi 3 COL FSAR which presents the gaseous effluent release pathway information for each of the three ventilation stacks for use in generating site-specific long-term χ/Q and D/Q values.

2.3.5.2 Summary of Application

Subsection 2.3.5 and Appendix 2B of the Fermi 3 COL FSAR, Revision 4 address site-specific information on long-term atmospheric dispersion estimates for routine releases. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-11-A Long-Term Diffusion Estimates

  This COL information item states that the applicant supply site-specific information in accordance with SRP Section 2.3.5; that is, the COL applicant should provide χ/Q and D/Q estimates for calculating concentrations in the air and the amount of material deposited on the ground as a result of routine releases of radiological effluents into the atmosphere during normal plant operation.

2.3.5.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is in NUREG–1966, the FSER related to the certified ESBWR DCD.

The acceptance criteria for identifying long-term atmospheric dispersion estimates of routine releases are based on meeting the relevant requirements of 10 CFR Parts 20, 50, and 100. NRC staff considered the following regulatory requirements in reviewing the applicant's discussion of site location and description:

- 10 CFR Part 20, Subpart D, with respect to establishing atmospheric dispersion site characteristics for demonstrating compliance with dose limits for individual members of the public.

- 10 CFR 50.34a and Sections II.B, II.C and II.D of Appendix I of 10 CFR Part 50, with respect to establishing atmospheric dispersion site characteristics for evaluating the numerical guides for design objectives and limiting conditions for operation to meet the requirements that radioactive material in effluents released to unrestricted areas be kept as low as is reasonably achievable.

- 10 CFR 100.21(c)(1), with respect to establishing atmospheric dispersion site characteristics so that radiological effluent release limits associated with normal operation can be met for any individual located offsite.

NUREG–0800, Section 2.3.5 specifies that an application meets the above requirements if the application provides the following information:

- 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 into the atmosphere.

- A discussion of atmospheric diffusion parameters, such as a 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 into 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., nearest vegetable garden, nearest resident, nearest milk animal, and nearest meat cow in each 22½-degree direction sector within a 5-mile [8-kilometer] radius of the site).

- The χ/Q and D/Q values to be used for assessing the consequences of routine airborne radiological releases described in Section 2.3.5.2 of RG 1.206:

  1. Maximum annual average χ/Q values and D/Q values at or beyond the site boundary and at specific locations of potential receptors of interest utilizing 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 miles (80 kilometers) from the plant using appropriate meteorological data.

In addition, the long-term atmospheric dispersion estimates for routine releases should be consistent with appropriate sections from the following RGs:

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

- RG 1.109, presents criteria for identifying specific receptors of interest.

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

- RG 1.112, which provides criteria for identifying release points and release characteristics.

When independently assessing the acceptability of the information presented by the applicant in FSAR Tier 2, Section 2.3S.5, NRC staff applied the same methodologies, models, and techniques cited above.

2.3.5.4 Technical Evaluation

NRC staff reviewed the application and the applicant's responses to RAIs to verify the accuracy, completeness, and sufficiency of the information regarding long-term atmospheric dispersion estimates for routine releases. The staff followed the procedures described in Section 2.3.5 of NUREG–0800 as part of this review.

<u>*COL Item*</u>

- EF3 COL 2.0-11-A Long-Term Diffusion Estimates

  For a routine release, the concentration of radioactive material in the surrounding region depends on the amount of effluent released, the height of the release, the momentum and buoyancy of the emitted plume, the wind speed, atmospheric stability, airflow patterns of the site, and various effluent removal mechanisms. Annual average relative concentration, χ/Q, and annual average relative deposition, D/Q, for gaseous effluent routine releases were, therefore, calculated.

In response to this COL information item, the applicant describes the following:

- Atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material into the atmosphere

- The characteristics assumed for each release point and the location of potential receptors for dose computations

- Meteorological data and other assumptions used as inputs to the atmospheric dispersion models

- Diffusion parameters (σ_z)

- χ/Q and D/Q values used to assess the consequences of routine airborne radioactive releases

NRC staff reviewed the applicant's resolution to EF3 COL 2.0-11-A related to supplying site-specific information in accordance with SRP Subsection 2.3.5. The staff's review of the applicant's χ/Q and D/Q estimates for calculating concentrations in the air and the amount of material deposited on the ground as a result of routine releases of radiological effluents into the atmosphere during normal plant operation is described below.

a. Atmospheric Dispersion Model

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

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

Because geographic features such as hills, valleys, and large bodies of water can potentially influence dispersion and airflow patterns, terrain recirculation factors can be used to adjust the results of a straight-line trajectory model such as XOQDOQ to account for terrain-induced flows, recirculation, or stagnation. In order to account for possible lake breeze and land breeze effects from Lake Erie on the long-term atmospheric dispersion estimates for routine releases, the applicant used default open terrain correction factors from the XOQDOQ dispersion model. This means that all χ/Q and D/Q values out to a distance of one kilometer were multiplied by a factor of four and all χ/Q and D/Q values between one and ten kilometers were multiplied by a factor that deceased logarithmically from four at one kilometer to one at ten kilometers.

The staff agreed with the applicant that the use of the default XOQDOQ open terrain correction factors conservatively account for possible recirculation due to land-water boundaries at the proposed Fermi 3 site.

b. Release Characteristics and Receptors

The ESBWR standard design employs three ventilation stacks that are routine airborne release points: the RB/FB vent stack, the turbine building (TB) vent stack, and the RWB vent stack. Two of these stacks, the RB/FB vent stack and the TB vent stack, qualify as mix-mode (part-time elevated, part-time ground-level) releases pursuant to RG 1.111 because their release points (52.8 meters and 71.3 meters above finished ground level, respectively) are above the height of adjacent solid structures (i.e., the 52.0-meter high turbine building), but less than two times the height of adjacent solid structures. The third stack, RWB vent stack, qualifies as a ground-level release because its release point (18.2 meters above finished ground level) is below the height of adjacent solid structures.

The applicant executed the XOQDOQ computer code assuming a mix-mode release for both the RB/FB vent stack and the TB vent stack. The RB/FB vent stack was modeled assuming a release height of 52.77 meters, an adjacent FB height of 48.2 meters, an inside vent diameter of 2.4 meters, and an average vent exit velocity of 17.78 meters per second. The TB vent stack was modeled assuming a release height of 71.3 meters, an adjacent turbine building height of 52 meters, an inside vent diameter of 1.95 meters, and an average vent exit velocity of 17.78 meters per second. The applicant also executed the XOQDOQ computer code assuming a ground-level release for the RWB vent stack with an adjacent building height conservatively set equal to zero.

Although the ESBWR standard design has three normal operation release pathways to the atmosphere, the applicant originally used one set of distances to the site boundary and special receptors of interest to model releases from all three pathways in Revision 0 to the FSAR. The locations for the special receptors of interest (i.e., nearest resident, garden, sheep, goat, meat cow, and milk cow) were based on the 2005 through 2007 land use census. The staff asked the applicant in **RAI 02.03.05-1** to explain the methodology used to derive the one set of distances to each receptor location. If applicable, the staff asked the applicant to justify not using a "power block envelope" concept that encompasses all the normal operation release pathways for determining the distance to each receptor location.

In its response (ML093130117) to **RAI 02.03.05-1** dated November 4, 2009, the applicant stated that the long-term χ/Q and D/Q values are based on the distance from the RB centerline to the various receptors. The applicant estimated the distances from each of the vent stacks to the site boundary in each direction and found that in many cases the distances from the vent stacks to the various receptors were shorter than the distances from the RB to the same receptors. Nonetheless, the applicant defended the selective use of long-term χ/Q and D/Q values based on the distance from the RB centerline to the various receptors depending on the analysis being performed.

However, in its subsequent responses (ML102180224) to **RAIs 02.03.05-3 and 02.03.05-4** dated July 26, 2010, the applicant provided a revised set of long-term χ/Q and D/Q values to the site boundary and receptors of interest based on the distance from the outer edge of a circle, centered on the RB, which encompasses all possible release points to the receptors. Because the applicant eventually recalculated the long-term χ/Q and D/Q values using a "power block envelope" concept, the staff considers **RAI 02.03.05-1** to be resolved.

The applicant added Appendix 2B, “Ventilation Stack Pathway Information for Long-Term χ/Q Values,” to Revision 2 of the Fermi 3 FSAR. Table 2B-201 in FSAR Appendix 2B provides gaseous effluent release pathway information for each of the three ventilation stacks. The ventilation stack parameters presented in Revision 2 to FSAR Table 2B-201 reflected the values presented in Revision 6 to ESBWR DCD Tier 2, Table 2B-1. Several of these parameter values were revised in Revision 7 to the ESBWR DCD. However, the applicant’s letter dated November 9, 2010 which was submitted to identify proposed changes to the Fermi 3 COL FSAR to reflect ESBWR DCD Revision 7 and anticipated changes to ESBWR DCD Revision 8 did not identify these changes in FSAR Table 2B-201 ventilation stack parameter values. Consequently, the staff asked the applicant in **RAI 02.03.05-5** to revise FSAR Table 2B-201 to reflect the gaseous effluent release pathway information presented in Revision 8 to the ESBWR DCD and revise FSAR Appendix 2B to identify any assumptions used in deriving the Fermi 3 long-term dispersion site characteristic values that differ from the information provided in the revised FSAR Table 2B-201.

In its response (ML110110550) to **RAI 02.03.05-5** dated January 10, 2011, the applicant stated that FSAR Appendix 2B is intended to incorporate the information in ESBWR DCD Tier 2, Appendix 2B with no site specific changes. Consequently, the applicant updated Revision 4 to FSAR Appendix 2B, including Table 2B-1, to indicate that DCD Tier 2, Appendix 2B is incorporated by reference with no departures or supplements. The staff finds this response acceptable and considers **RAI 02.03.05-5** to be resolved.

c. Meteorological Data Input

The applicant originally executing the XOQDOQ model using a JFD of wind speed, wind direction, and atmospheric stability based on hourly onsite data from the six-year period 2002-2007. The wind data were obtained from the 10-meter level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-T) measurements taken between the 60-meter and 10-meter levels on the onsite meteorological tower.

The supplemental response (ML100960474) to **RAI 02.03.03-1** dated March 30, 2010 states that after a review of wind rose data spanning a period of over 30 years, the applicant concluded that the potential exists for recent wind speed measurements at the 10-meter elevation to be slower than the actual wind speeds at the 10-meter elevation due to trees located in the vicinity of the Fermi meteorological tower. The applicant further concluded that the slower wind speeds measured at the 10-meter elevation during 2002-2007 produces higher (more conservative) long-term χ/Q and D/Q values as compared to faster actual wind speeds at the 10-meter elevation. In its supplemental response to **RAI 02.03.04-3**, the applicant proposed a revision to FSAR Subsection 2.3.5.2 stating that the meteorological tower is located east of a grove of trees that is situated less than ten times the obstruction height recommended in RG 1.23. The impact of the trees is to reduce the measured wind speed at the 10-meter level for upwind sectors. The proposed FSAR revision further states that the use of lower measured wind speeds provides conservative results for the XOQDOQ model.

The staff disagreed with the assessment that slower wind speeds at the 10-meter elevation produce higher χ/Q and D/Q values for mixed-mode (part-time ground, part-time elevated) releases. The applicant has modeled the RB/FB vent stack and the TB vent stack as mixed-mode releases pursuant to RG 1.111 because these two stacks are higher than the adjacent buildings. Regulatory position C.2.b of RG 1.111 states that mixed-mode releases can be considered to be elevated releases whenever the plume exit velocity is at least five times the

horizontal wind speed at the height of the release. Because the wind speed provided as input to the XOQDOQ dispersion code is measured at 10-meters, the code corrects the 10-meter wind speed to the stack height. Providing faster 10-meter elevation wind speeds as input to the XOQDOQ dispersion code decreases the percent of time the plume is assumed to be an elevated release, potentially resulting in higher χ/Q and D/Q values.

The applicant provided a copy of the 1985-1989 data from the Fermi meteorological tower in its supplemental response (ML100960474) to **RAI 02.03.04-4** dated March 30, 2010. The applicant stated that aerial photographs of the area surrounding the Fermi meteorological tower in 1981 and 1991 confirm the absence of significant air flow obstructions to wind measurements at the 10 meter (33-foot) elevation during this time period. The staff generated a JFD from the 1985-1989 data for comparison with the new 2002-2007 JFD presented by the applicant in its supplemental response to RAI 02.03.04-3. The staff found the 1985-1989 JFD has a lower frequency of (1) slow wind speed conditions (the frequency of wind speeds less than 1.5 meters per second increased from 9.1 percent in the 1985-1989 data to 17.0 percent in the 2002-2007 data) and (2) extremely unstable (stability class A) conditions (the frequency of extremely unstable conditions increased from 7.1 percent in the 1985-1989 data to 19.3 percent in the 2002-2007 data). These discrepancies in wind speed and stability class frequency distributions discussed above create uncertainty as to which meteorological data set (1985-1989 versus 2002-2007) is most representative of long-term site conditions. Given the uncertainty in the data, the staff asked the applicant in **RAI 02.03.05-3** to justify why the long-term (routine) χ/Q and D/Q values should not be generated using both meteorological data sets and the more conservative resulting χ/Q and D/Q values be presented in FSAR Subsection 2.3.5.

In its response (ML102180224) to **RAI 02.03.05-3** dated July 26, 2010, the applicant stated that it reran the XOQDOQ dispersion code using meteorological data from the 1985-1989 time frame to assess the influence of the trees on the χ/Q and D/Q values. The applicant compared the 1985-1989 χ/Q and D/Q values to the XOQDOQ results using the 2002-2007 meteorological data and found that in several cases the 1989-1989 meteorological data provided higher χ/Q and D/Q values than the 2002-2007 meteorological data. The applicant subsequently presented χ/Q and D/Q values from both sets of data in Revision 4 of the FSAR. For this reason, **RAI 02.03.05-3** is considered to be resolved.

d. Diffusion Parameters

The applicant initially chose to implement the diffusion parameter assumptions outlined in RG 1.111, as a function of atmospheric stability for the XOQDOQ model runs.

The applicant did not generate estimates for site boundary χ/Q and D/Q values in the east-northeast clockwise through southeast sectors because the site boundary is directly overwater for these sectors. For the same reason, there are no special receptors of interest in these downwind sectors. However, the applicant did generate annual average χ/Q and D/Q values out to a distance of 80 kilometers (50 miles) in all downwind sectors as provided in FSAR Tables 2.3-328 through 2.3-339. These latter set of χ/Q and D/Q values are used by the applicant to generate population dose estimates for the 80 kilometer (50-mile) population in support of the gaseous radwaste system design basis cost benefit evaluation required by 10 CFR Part 50, Appendix I, Section II.D. Because some of these χ/Q and D/Q values represent plume transport over water for significant distances, the staff asked the applicant in **RAI 02.03.05-2** to revise the FSAR as necessary to discuss the impact of changes in surface temperature and roughness resulting from over-water trajectories on the resulting long-term atmospheric dispersion and deposition estimates.

In its response (ML093570220) to **RAI 02.03.05-2** dated February 8, 2010, the applicant stated that the majority (approximately 85 percent) of the collective population within 80 kilometers (50 miles) of the site resides in areas where the trajectory would not be over water. Another 13 percent of the collective population within 80 kilometers (50 miles) of the site resides in areas where the trajectory over water is 32 kilometers (20 miles) or less and therefore the deposition rate would not be significantly different than that over land. Less than two percent of the collective population within 80 kilometers (50 miles) resides in areas where the trajectory over water could extend up to the 80-kilometer (50-mile) radius. Therefore the applicant concluded that the potential impact to the collective population would be very small.

The staff reviewed the response to **RAI 02.03.05-2** and determined that the question was closed but the issue remained unresolved. The staff subsequently issued **RAI 02.03.05-4** stating that it found the response to **RAI 02.03.05-2** incomplete. As discussed in the response to **RAI 02.03.05-2**, the overwater trajectories for the population living within 80 kilometers (50 miles) in the NE, ENE, E, SE, SSE, S and SSW sectors can range from 16 to 80 kilometers (10 to 50 miles). Air trajectories over such extensive water surfaces could affect atmospheric diffusion rates when compared with overland trajectories due to: (1) the generally smoother water surface decreasing the contribution to diffusion by mechanical turbulence and (2) cooler water temperatures (as compared to air temperatures) decreasing the contribution to diffusion from convectional turbulence. The staff asked the applicant to revise FSAR Section 2.3.5 to discuss the impact of changes in surface temperature and roughness resulting from over-water trajectories on the resulting long-term (routine) atmospheric dispersion and deposition estimates.

In its response (ML102180224) to **RAI 02.03.05-4** dated July 26, 2010, the applicant stated that air trajectories over large water surfaces could reduce the rate of atmospheric dispersion due to differences in surface roughness and static stability as compared to transport over land. The applicant consequently adjusted the stability class for the direction sectors that are upwind to the water sectors (i.e., SW clockwise to NNE) in the JFDs to the next higher stability class level in order to model the potential decrease in the rate of atmospheric dispersion for over water trajectories; that is, the hours for the upwind sectors originally associated with stability class A were shifted to stability class B, stability class B hours were shifted to stability class C, etc., and the hours in stability class F were added to the hours originally identified in stability class G. The applicant performed this adjustment to both the 1985-1989 JFD and the 2002-2007 JFD and reran the XOQDOQ dispersion model. The applicant subsequently included both sets of revised χ/Q and D/Q values in Revision 4 of the FSAR. The staff considered the stability class adjustment to account for changes in atmospheric dispersion characteristics over water to be reasonable and therefore considered **RAI 02.03.05-4** to be resolved.

e. Resulting Relative Concentration and Deposition Factors

FSAR Tables 2.3-307 through 2.3-327 and Tables 2.3-366 through 2.3-377 list the long-term atmospheric dispersion and deposition estimates for the site boundary and special receptors of interest that the applicant derived from the XOQDOQ model. The χ/Q values in these tables reflect several plume radioactive decay and deposition scenarios. Section C.3 of RG 1.111 states that radioactive decay and dry deposition should be considered in radiological impact evaluations of potential annual radiation doses to the public that result from routine releases of radioactive materials in gaseous effluents. Section C.3.a of RG 1.111 states that an overall half-life of 2.26 days is acceptable for evaluating the radioactive decay of short-lived noble gases, and an overall half-life of 8 days is acceptable for evaluating the radioactive decay for all

iodines released into the atmosphere. Definitions for the χ/Q categories listed in the headings of FSAR Tables 2.3-307 through 2.3-327 are as follows:

- 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 or radioactive decay.

- 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-133m.

- 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.

FSAR Tables 2.3-328 through 2.3-339 and Tables 2.3-366 through 2.3-377 list the applicant's long-term atmospheric dispersion and deposition estimates for all 16 radial sectors from the site boundary to a distance of 80 kilometers (50 miles) from the proposed facility.

The staff performed an independent evaluation of the applicant's XOQDOQ results by executing XOQDOQ with JFDs it generated from the 1985-1989 and 2002-2007 hourly onsite meteorological databases submitted in the supplemental response to **RAI 02.03.04-4** and obtaining similar results for the site boundary and special receptors of interest (i.e., most values within ± 10 percent). The applicant presents the higher of either the 1985-1989 or the 2002-2007 χ/Q and D/Q values as site characteristic values in Section 2.0 of the Fermi 3 COL FSAR and used the higher values in its offsite airborne dose evaluation presented in FSAR Section 12.2.2.2. The staff finds the applicant's approach of using the higher (more conservative) of either the 1985-1989 or the 2002-2007 χ/Q and D/Q values in its offsite airborne dose evaluations to be acceptable.

The staff reviewed the information provided and, for the reasons given above, concludes that the applicant's atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR 100.21(c)(1).

2.3.5.5 Post Combined License Activities

There are no post COL activities associated with this FSAR section.

2.3.5.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

NRC staff reviewed the application and found that the applicant has presented and substantiated information regarding long-term atmospheric dispersion estimates for routine releases. The staff reviewed the information provided and, for the reasons given above,

concludes that the applicant's atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR 100.21(c)(1). Representative atmospheric dispersion and deposition factors have been calculated for 16 radial sectors from the site boundary to a distance of 50 miles (80 kilometers) as well as for specific locations of potential receptors of interest. The characterization of atmospheric dispersion and deposition conditions are appropriate for the evaluation to demonstrate compliance with the numerical guides for doses contained in Subpart D of 10 CFR Part 20 and Appendix I to 10 CFR Part 50.

The staff's review confirmed that the applicant has adequately addressed the COL license information item in accordance with Subsection 2.3.5 of NUREG–0800.

2.4 Hydrology

This section of the SER addresses the Fermi 3 COL FSAR, Revision 4, site-specific hydrological site parameters and site characteristics identified in Chapter 5 of Tier 1 and Chapter 2 of Tier 2 of the ESBWR DCD, Revision 9.

2.4.1 Hydrologic Description

2.4.1.1 Introduction

The hydrologic description of the nuclear power plant site includes the interface of the plant with the hydrosphere, hydrological causal mechanisms, surface and groundwater uses, hydrologic data, and alternate conceptual models. The review covers the following specific areas: (1) interface of the plant with the hydrosphere including descriptions of site location, major hydrological features in the site vicinity, surface water and groundwater related characteristics, and the proposed water supply to the plant; (2) hydrological causal mechanisms that may require special plant design bases or operating limitations with regard to floods and water supply requirements; (3) current and likely future surface and groundwater uses by the plant and water users in the vicinity of the site that may impact safety of the plant; (4) available spatial and temporal data relevant for the site review; (5) alternate conceptual models of the hydrology of the site that reasonably bound hydrological conditions at the site; (6) potential effects of seismic and non-seismic data on the postulated design bases and how they relate to the hydrology in the vicinity of the site and the site region; and (7) any additional information requirements prescribed within the "Contents of Application" sections of the applicable Subparts to 10 CFR Part 52.

2.4.1.2 Summary of Application

Subsection 2.4.1 of the Fermi 3 COL FSAR, Revision 4, describes the site from the standpoint of hydrologic considerations and provides topographic and regional maps showing proposed changes to the site's natural drainage features and major hydrological features. The applicant addressed these issues as follows:

COL Item

- EF3 COL 2.0-12-A Hydrologic Description

  To address this COL item, the applicant described the site and all safety-related elevations, structures, and systems from the standpoint of hydrologic

considerations and provided a topographic map of the site that showed proposed changes to natural drainage features.

The applicant described the location, size, shape, and other hydrologic characteristics of streams, lakes, and shore regions influencing plant citing. Groundwater environments were not discussed in this section. The applicant stated that there are no known present or future water control structures in the vicinity of or at the site.

The applicant provided a regional map showing major hydrologic features.

2.4.1.3 Regulatory Basis

Guidance relevant to the Commission's regulations for the hydrologic descriptions, and the associated acceptance criteria, are in Section 2.4.1 of NUREG-0800. The staff reviewed Section 2.4.1 of the FSAR for conformance with the applicable regulations and considered the corresponding regulatory guidance.

The applicable regulatory requirements for review of the applicant's hydrologic description are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrologic features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Section 2.4.1:

- Interface of the Plant with the Hydrosphere: The application should provide a description of hydrology in the vicinity of the site and site regions and of how the plant interfaces with the hydrosphere.

- Hydrological Causal Mechanisms: The application should provide a description of hydrological causal mechanisms that affect the safety of the plant.

- Surface and Ground Water Uses: The application should provide a description of surface and ground water uses in the vicinity of the site that affect the safety-related water supply to the plant.

- Data: The application should provide a complete description of all spatial and temporal datasets used by the applicant in support of its conclusions regarding safety of the plant.

- Alternate Conceptual Models: The application should provide a description of alternate conceptual models of site hydrology.

- Consideration of Other Site-Related Evaluation Criteria: The application should demonstrate that the potential effects of site-related proximity and of seismic and non-seismic information as they relate to hydrologic description in the vicinity of the proposed plant site and site regions are appropriately taken into account.

The description of hydrologic characteristics should correspond to those of the United States Geological Survey (USGS), Natural Resources Conservation Service (NRCS), U.S. Army Corps of Engineers (USACE), or appropriate State and river basin agencies.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RG 1.27, RG 1.29, “Seismic Design Classification,” RG 1.59, “Flood Design Basis for Nuclear Power Plants,” as supplemented by best current practices, and RG 1.102, “Flood Protection for Nuclear Power Plants.”

2.4.1.4 Technical Evaluation

NRC staff reviewed Subsection 2.4.1 of the Fermi 3 COL FSAR, Revision 4. The staff conducted a site visit in accordance with the guidance provided in Subsection 2.4.1 of NUREG-0800. The staff used information from the site visit, USGS topographic maps, topographic maps of the site provided by the applicant, available references, and independent calculations to verify the hydrologic description provided in Subsection 2.4.1 of the Fermi 3 FSAR.

COL Item

- EF3 COL 2.0-12-A Hydrologic Description

  To address this COL item, the applicant described the site and all safety-related elevations, structures, and systems from the standpoint of hydrologic considerations and provided a topographic map of the site that showed proposed changes to natural drainage features.

  The applicant described the location, size, shape, and other hydrologic characteristics of streams, lakes, and shore regions influencing plant citing. Groundwater environments were not discussed in this section. The applicant stated that there are no known present or future water control structures in the vicinity of or at the site.

  The applicant provided a regional map showing major hydrologic features.

Site and Facilities

The staff has reviewed the information submitted by the applicant related to the hydrological parameters of the site and facilities. Throughout Section 2.4 of the FSAR, the applicant presented the elevations of various plant and flooding features using four different reference datums. The four datums referenced in the Fermi 3 FSAR include: the North American Vertical Datum of 1988 (NAVD 88), the Fermi plant grade datum (plant), the National Geodetic Vertical Datum of 1929 (NGVD 29), and the International Great Lakes Datum of 1985 (IGLD 85). The staff constructed the following table displaying elevations of important hydrological features in each of the four datums.

Feature	Elevations by Reference Datum (ft)			
	NAVD 88	**Plant**	**IGLD 85**	**NGVD 29**
Current Fermi plant grade	581.8	583.0	581.5	582.4
Planned Fermi 3 plant grade	588.8	590.0	588.5	589.4
Fermi 3 safety structures	589.3	590.5	589.0	589.9
Lake Erie low water datum	569.5	570.7	569.2	570.1
Elevation of water intake pipe	553.3	554.5	553.0	553.9
100-year lake level calculated by the applicant (FSAR Section 2.4.5)	575.1	576.3	574.8	575.7
100-year lake level calculated by FEMA (2000)	578.2	579.4	577.9	578.8
Average elevation of Lake Erie	571.6	572.8	571.3	572.2
Flood elevation from probable maximum precipitation (PMP) at the Fermi 3 site	584.4	585.6	584.1	585.0
Flood elevation from PMP plus snowmelt a the Fermi 3 site	584.8	585.0	584.5	585.4
Applicant's Flooding Alternative I	579.4	580.6	579.1	580.0
Applicant's Flooding Alternative II	579.2	580.4	578.9	579.8
Applicant's Flooding Alternative III	585.4	586.6	585.1	586.0
Applicant's Flooding Alternative III plus snowmelt and PMF on Swan Creek	585.5	586.7	585.2	586.1
Staff's Flooding Alternative III plus snowmelt and Probable Maximum Flood (PMF) on Swan Creek	586.3	587.5	586.0	586.9

The staff uses the NAVD 88 coordinate system throughout this document to describe hydrological features. The applicant's information is presented herein using the datum referenced for that feature in the FSAR that was submitted.

Information Submitted by the Applicant

The applicant described the site hydrology, described the principal plant structures and their design elevations, and presented topographic maps showing changes in site drainage patterns between the existing conditions and the final grade.

According to Subsection 2.4.1.1 of the FSAR, the site is located in Monroe County, Michigan, on the west bank of Lake Erie. The Fermi 3 unit is located approximately 0.40 km (0.25 mi) west of the Lake Erie shoreline. The applicant provided a USGS topographic map with the site boundary delineated. The applicant stated that site elevations range from 577 to 600 ft NGVD 29. The majority of the Fermi plant facility, including the Fermi 2 unit, is located at elevation 583.0 ft plant grade datum, and the Fermi 3 unit is located on an area elevated to 590.0 ft plant grade datum, with safety-related facilities at a minimum of 590.5 ft plant grade datum.

The applicant referenced ESBWR DCD Section 1.2 to describe the seven principal plant structures including the RB/FB, Control Building and Fire Water Service Complex as the only seismic Category 1 structures of Fermi 3. The applicant described that Lake Erie is the primary source of makeup water for the Fermi 3 unit. Potable water needs and makeup demineralizer water is supplied by the Frenchtown Township municipal water supply. A new pump house is planned to be constructed to pump water from Lake Erie for Fermi 3, utilizing the intake bay currently used by Fermi 2. Discharge from Fermi 3 is through a new pipe to Lake Erie.

NRC Staff's Technical Evaluation

NRC staff checked the referenced USGS Stony Point topographic map and found that elevations within the Fermi Property boundary were less than 575 ft to greater than 595 ft NAVD 88. According to NOAA (NOAA, 2009), the average elevation of Lake Erie is 571.6 ft NAVD 88. The applicant submitted elevation maps of the current plant grade as a response (ML100830380) to **RAI 2.4.1-1**. The staff used these maps to verify the elevations of the current Fermi plant facility. The staff verified the applicant's stated plant grade elevation of 581.8 ft NAVD 88.

Also in **RAI 2.4.1-1**, the staff requested that the applicant provide proof in the form of a letter or other documentation that the Frenchtown Township municipal water supply is available for Fermi 3 potable water needs and makeup demineralizer water. In their response (ML100830380), the applicant stated that they have confirmed that the Frenchtown Township service and current utility infrastructure is adequate for the additional Fermi 3 water demand (Detroit Edison 2009b). The staff found this response acceptable.

Hydrosphere

Information Submitted by the Applicant

The applicant described the local and regional hydrology surrounding the Fermi 3 site. Fermi 3 is contained within the Swan Creek Watershed. Swan Creek is a 106 square mile (mi^2) watershed that drains into Lake Erie approximately 1 mi north of the Fermi Site.

The Fermi property is bordered by Lake Erie along its eastern edge. Lake Erie is a part of the Great Lakes Drainage Basin and is the shallowest and warmest of the Great Lakes with a water surface area of 9,910 mi^2. The applicant stated that the drainage area of Lake Erie is

approximately 23,400 mi^2 and it has twelve main tributaries. The main tributaries of Lake Erie nearest to the Fermi site are the River Raisin to the south and the Detroit River to the north. The western basin of Lake Erie borders the Fermi property. The western basin of Lake Erie is very shallow basin with an average depth of 24 ft. A rock barrier is present along the eastern edge of the Fermi site at the shoreline to protect the Fermi site against the high water levels of Lake Erie. The rock barrier crest elevation is at 583.0 ft plant grade datum.

The applicant described the Detroit River as “the largest and most important tributary for the western basin of Lake Erie as it provides approximately 80 percent of Lake Erie’s water inflow. The applicant provided a short description of the 126 mi^2 Stony Creek Watershed, as it is adjacent to the Swan Creek Watershed to the south. The River Raisin Watershed has a drainage area of 1,070 mi^2 and is south of the Stony Creek Watershed. The applicant discussed the River Raisin because it impacts “sediment and other water quality characteristics within the western basin of Lake Erie in the vicinity of the Fermi site.” The applicant did not discuss the groundwater environment in the vicinity of the site in Subsection 2.4.1 but provided detailed information in Subsection 2.4.12 of the FSAR.

As Lake Erie is the primary source of water for the operation of Fermi 3, the applicant stated that Fermi 3 has been designed to operate at full capacity assuming the lowest recorded water level on Lake Erie at the intake pipe for the plant. The elevation of the base of the intake pump is 553 ft IGLD 85, which the applicant said is 10 feet below the lowest lake level for operation of 563.64 IGLD 85, as discussed in Section 2.4.11 of the FSAR. The applicant described the current and past surface water use of Lake Erie, following SRP Section 2.4.1. Tables 2.4-201 through 2.4-204 present water use information for Lake Erie for the years between 1998 and 2004. Tables 2.4-205 through 2.4-208 present water use information for Monroe County for the years between 2000 and 2006. Table 2.4-209 presents the net basin water supply of Lake Erie by month. Using data from the tables presented, the applicant stated that Monroe County, Michigan uses approximately 1.4 percent of the total water supply for Lake Erie.

NRC Staff’s Technical Evaluation

The NRC staff could not verify the boundary of the Swan Creek Watershed with the information provided by the applicant. In response (ML082730763, dated September 18, 2008) to **RAI 2.4.1-1** asking for a detailed topographic map of the Swan Creek Watershed, the applicant submitted the USGS Stony Point quadrangle. The staff reviewed this quadrangle. The mouth of Swan Creek is contained in the Stony Point quadrangle, but the majority of the watershed is not in the quadrangle. Adjacent USGS quadrangles, containing the rest of the Swan Creek Watershed include: Flat Rock, Monroe, Estral Beach, Rockwood, Carlton, Ypsilanti East, Belleville, and Maybee. To verify the watershed boundary, the staff requested that the digital elevation model (DEM) for the Swan Creek watershed be submitted. This was requested as **RAI 2.4.1-2**. The staff delineated the Swan Creek watershed boundary using the information submitted by the applicant. The watershed boundary submitted by the applicant (ML082730763, dated September 18, 2008) was found to be slightly larger than the watershed found by the review team. The entire Fermi site was found by the review team to be included in the Swan Creek Watershed and the total watershed area was calculated to be 101 mi^2.

The watershed area of Swan Creek is listed as 100 mi^2 on the MDEQ Flood Discharge Request Record for Swan Creek (MDEQ, 2009). The applicant stated that the watershed area is slightly larger (106 mi^2), which makes an analysis of flooding more conservative. The staff verified the watershed area is accurate.

The staff confirmed that the River Raisin is the largest watershed in the vicinity of the site. The staff evaluated flooding levels on the River Raisin to determine if flooding on the River Raisin could impact the Fermi 3 site. The confluence of the River Raisin with Lake Erie is over six miles south of the location of Fermi 3. A FEMA report (FEMA, 2000) provides flood elevations for the River Raisin approximately three miles inland from the river's confluence with Lake Erie. The 100-year flood elevation for this location on the River Raisin is estimated to be 583.2 ft NAVD 88 considering ice-jam effects and 580.0 NAVD 88 ft without ice-jam impacts. The flood elevations downstream of this point are assumed to be lower. The elevations of the land surface between Fermi 3 and the River Raisin are up to 599.7 ft NAVD 88. Based on review of the topography of the area and the information contained in the local FEMA report (2000), the staff determined that there is no risk of flooding at Fermi 3 due to flooding on the River Raisin because the topography of the area restricts the flooding of the site from adjacent watersheds.

The Detroit River enters Lake Erie more than 6 miles north of the Fermi 3 site. The USACE (1998) estimated that the 500-year flood elevation at the mouth of the Detroit River was approximately 578.3 ft NAVD 88. The staff reviewed the topography and determined that there is no risk of flooding at Fermi 3 due to flooding on the Detroit River because the plant is located at an elevation of 590.5 and in an adjacent watershed.

The applicant did not discuss groundwater in Subsection 2.4.1 of the FSAR, but did address groundwater in Subsection 2.4.12 of the FSAR. The staff's reviews the information submitted by the applicant is located in Subsection 2.4.12, below.

SRP Section 2.4.1 states that flood maps should be provided, showing the areas to be inundated by floods of different magnitudes, with all plant structures and components identified on the maps. The staff identified FEMA maps showing the 100-yr and 500-yr flood plains in the vicinity of the site (FEMA, 2000). The applicant did not include these maps in the FSAR, but submitted the maps in response to an RAI filed for the Environmental Impact Statement, **RAI HY2.3.1-10**. The staff verified that the submitted maps were from the *Flood Insurance Study, Monroe County* (FEMA, 2000).

The applicant described the current and past surface water use of Lake Erie. The information about water use in the Lake Erie watershed presented in Tables 2.4-201 through 2.4-204 was verified by the staff using annual reports by the Great Lakes Commission (GLC, 1998; GLC, 1999; GLC, 2000; GLC, 2001; GLC, 2002; GLC, 2003; GLC, 2004). The information presented in Table 2.4-205 about water use in Monroe County from 2000-2006 was reviewed by the staff using sector-specific water use reports presented by the MDEQ (http://www.michigan.gov/deq/0,1607,7-135-3313_3684_45331-72931--,00.html). The staff verified the values presented in Table 2.4-205, however, the values presented for water withdrawn for agricultural irrigation in 2001 were not those found on the MDEQ website. According to the MDEQ, the surface water use was 2.27 million gallons per day (Mgd) and the groundwater use was 0.88 Mgd for agricultural irrigation in 2001. The information presented in Tables 2.4-206 through 2.4-208 could not be verified by the staff. The staff could not find the documents referenced in these tables and could not find other documents containing this information. Additionally, the source information presented in Table 2.4-209 was not clear. In **RAI 2.4.1-3** (ML100830380, dated March 19, 2010), the staff requested the applicant to provide the references used to create Tables 2.4-206 through 2.4-208 related to Monroe County water supply and water use. The staff also requested that the data presented in Table 2.4-209 concerning the water supply of Lake Erie be further explained with detailed documentation of how the values in the table were determined. The response submitted by the applicant contained unpublished Monroe County water use data tables obtained from the MDEQ to

produce FSAR Tables 2.4-206 through 2.4-208. DTE stated that this information was sent by the MDEQ in response to a request for data. The applicant also explained the derivation of the Lake Erie water balance values presented in Table 2.4-209. DTE downloaded the monthly hydrologic data from the Great Lakes Environmental Research Laboratory (GLERL) website. The applicant also stated that the data from the Detroit River was no longer available through GLERL, but pointed out that the data could be found through a USACE website. The staff downloaded the data from both websites and verified the values presented in Table 2.4-209. The staff therefore finds the response acceptable.

The applicant did not provide an estimate of future likely water use for Lake Erie in the FSAR. A discussion of future groundwater use was presented in Subsection 2.4.12.2.2 of the FSAR with reference to Table 2.4-277, which presents the estimates of future groundwater use by category through the year 2060. The groundwater use data for the year 2000 in FSAR Table 2.4-205 differed, in some instances, from the groundwater use data presented in Table 2.4-227. The staff requested that the applicant provide additional information on the material contained in the different tables as **RAI 2.4.1-4** (ML100830380, dated March 19, 2010). The applicant responded with a detailed table comparing the sources of information for each category of groundwater use in Monroe County. The applicant selected the most conservative (largest) estimate of water use from all of the referenced sources to perform estimates of future water use. The staff finds this approach acceptable. In the response (ML100830380, dated March 19, 2010) to **RAI 2.4.1-4**, the applicant also provided the website address of the data that was used in the tables. The staff downloaded the groundwater use data and verified the values used in the tables. The staff finds the response to **RAI 2.4.1-4** acceptable.

The applicant did not describe all of the datasets used in support of its conclusions regarding safety of the plant in this section, as called for in SRP 2.4.1. Datasets were described instead in FSAR Subsection 2.4.2. Lake Erie data was obtained by the applicant from the GLERL. The applicant provided this dataset electronically to the staff in response to **RAI 2.4.5-1** (ML092790561, dated September 30, 2009). Verification of this dataset by the staff is discussed in Subsection 2.4.5 below.

Alternate conceptual models of site hydrology are provided in Subsection 2.4.12 of the FSAR and are discussed below in Subsection 2.4.12, herein.

For the reasons given above, the staff concluded that the identification and consideration of the hydrology in the vicinity of the site and site regions are acceptable and meet the requirements of 10 CFR Part 50, 10 CFR 52.79, and 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

2.4.1.4 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.1.5 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.1 of NUREG–0800, and other NRC RGs. The

staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-12-A as it relates to the hydrologic description.

As set forth above, the applicant has presented and substantiated information relative to the hydrologic description in the vicinity of the site and site regions important to the design and siting of this plant. The staff reviewed the available information provided. For the reasons given above, the staff concluded that the identification and consideration of the hydrology in the vicinity of the site and site regions are acceptable and meet the requirements of 10 CFR Part 50, 10 CFR 52.79, and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

The staff finds that the applicant has considered the appropriate site phenomena for establishing the design bases for SSCs important to safety. The staff accepted the methodologies used to determine the hydrologic description in the vicinity of the site and site regions reflected in site characteristics documented in the SER. Accordingly, the staff concluded that the use of these methodologies results in site characteristics containing sufficient margins for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concluded that the identified site characteristics meet the requirements of 10 CFR 52.79 and 100.20(c), with respect to establishing the design basis for SSCs important to safety.

2.4.2 Floods

2.4.2.1 Introduction

This subsection discusses the historical flooding at the proposed site or in the region of the site. The information summarizes and identifies the individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. The discussion also covers the potential effects of local intense precipitation. The flood history and the potential for flooding are reviewed for the sources and events listed below. Factors affecting potential runoff (such as urbanization, forest fire, changes in agricultural use, erosion, and sediment deposition) are considered in the review. In addition to describing flood history, this subsection also determines the local intense precipitation on the site to estimate local flooding. Local intense precipitation is reported as a site characteristic used in site grading design.

2.4.2.2 Summary of Application

Subsection 2.4.2 of the Fermi 3 COL FSAR, Revision 4, addresses site-specific information on flood history at the Fermi 3 site. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-13-A Floods

  To address this COL item, the applicant discussed the flood potential from streams, reservoirs, adjacent watersheds, and site drainage and described the effects of local PMP on site drainage systems, including drainage from the roofs of structures. Additionally, the applicant provided a discussion of the effects of snow accumulation on site facilities where such accumulation could coincide with

local probable maximum (winter) precipitation and cause flooding or other damage to safety-related facilities.

2.4.2.3 Regulatory Basis

The applicable regulatory requirements for identifying floods are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).
- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.2:

Local Flooding on the Site and Drainage Design: The application should include an estimate of local intense precipitation or local PMP and a determination of the capacity of site drainage facilities (including drainage from the roofs of buildings and site ponding).

- Stream Flooding: The application should include documentation of the potential sources of flood and flood response characteristics.
- Surges: The application should include the complete history of storm surges in the vicinity of the site.
- Seiches: The application should include the complete history of seiches in the vicinity of the site.
- Tsunami: The application should include the complete history of tsunami in the vicinity of the site.
- Seismically Induced Dam Failures (or Breaches): The application should include the flooding hazard at the plant site resulting from seismically induced dam failure upstream of the site location.
- Flooding Caused by Landslides: The application should include the flooding hazard at the plant site from flood waves induced by landslides and backwater effects due to stream blockage from landslides.
- Effects of Ice Formation in Water Bodies: The application should include information concerning potential flooding at the plant site due to flood waves resulting from the collapse of an ice dam or backwater effects due to stream blockage due to an ice dam or an ice jam downstream of the plant site.
- Combined Events Criteria: The application should include information concerning design basis flooding at the plant site, including consideration of

appropriate combinations of individual flooding mechanisms in addition to the most severe effects from individual mechanisms themselves.

- Consideration of Other Site-Related Evaluation Criteria: The application should demonstrate that the potential effects of site-related proximity, seismic, and non-seismic information as they relate to hydrologic description in the vicinity of the proposed plant site and site regions are appropriately taken into account.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, as supplemented by best current practices and RG 1.102.

2.4.2.4 Technical Evaluation

NRC staff reviewed Subsection 2.4.2 of the Fermi 3 COL FSAR, Revision 4, related to flood history, flood design, and the effects of the PMP as follows:

COL Item

- EF3 COL 2.0-13-A Floods

  Based on a review of the Fermi Unit 3 site grading plan and the FSAR, the design plant grade elevation is 588.8 ft NAVD 88, with the safety features planned at an elevation of 589.3 ft NAVD 88. The design plant grade is approximately 3.4 ft above the maximum flood level at the site calculated in the FSAR resulting from a probable maximum surge and seiche on Lake Erie corresponding with the 100-year lake level and coincident wave action (elevation 585.4 ft NAVD 88).

The NRC staff's evaluation of COL Item EF3 COL 2.0-13-A is presented below.

Flood History

Information Submitted by Applicant

The applicant stated that "Lake Erie is the primary surface-water body to potentially impact Fermi 3." Historical floods on Lake Erie were discussed in Subsection 2.4.2.1 of the FSAR. The applicant states that Lake Erie water level data is available from 1860 to the present. The response to **RAI 2.4.5-1** (ML092790561, dated September 30, 2009) provided additional explanation of the values presented in Table 2.4-210. Table 2.4-210 of the FSAR provides maximum and minimum water levels recorded at the Fermi Power Plant gaging station on Lake Erie from 1970 through 2007. The applicant also described storm events, some with winds gusting higher than 62 mph that caused peak water levels near the Fermi Site. Peak water levels, up to 0.5 ft above the values in Table 2.4-210, were also presented in this section of the FSAR.

The applicant presented peak flow rates for Swan Creek referencing an MDEQ website as the source of the information. The applicant also provides descriptions of and peak flow rates for the adjacent Stony Creek, the River Raisin, and the Detroit River.

NRC Staff's Technical Evaluation

RAI 2.4.2-1 (ML092790561, dated September 30, 2009) included a request for records of water levels for Lake Erie from 1860 to present. The historical records prior to 1970 were not provided or discussed in the FSAR. In the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), the applicant provided a table of average monthly water level observations for Lake Erie from 1918 to 2007 downloaded from the USACE website. The staff verified the data presented in the table by checking the referenced USACE website. The applicant compared the average monthly water levels from 1970 through 2007 to the water levels observed over the entire period of record, and found that the period from 1970 through 2007 included the highest water levels from this dataset. The averages of the monthly water levels for the period from 1970 through 2007 were also higher than the averages for the entire period of record, 1918 through 2007. The staff checked the referenced data and confirmed the conclusion that the period between 1970 and 2007 represents a conservative period to evaluate characteristic water levels for Lake Erie.

The staff requested an explanation of the values presented in Table 2.4-210 in **RAI 2.4.5-1** (ML092790561, dated September 30, 2009). The applicant responded that the values represent the maximum and minimum hourly observations of water levels on Lake Erie measured each year at the Fermi Site gage (ID 9063090). The applicant also submitted the hourly water level observations at the Fermi Site gage (in addition to 12 other Lake Erie gages) between 1966 and 2007. This data for the Fermi Site gage (ID 9063090) was submitted to the NRC staff in Microsoft Excel format as a response to **RAI 2.4.5-1** (ML092790561, dated September 30, 2009) requesting data used to develop the 100-year water level for Lake Erie. The staff used this data to verify the information presented in the Table 2.4-210. The staff found that the values presented in Table 2.4-210 did not correspond in to the yearly maximum or minimum values of the hourly observations presented in the Microsoft Excel file for the years between 1970 and 1996 (e.g., 1987 maximum lake level in the excel file is 576.04 ft IGLD 85 not 574.39 IGLD 85 as presented in Table 2.4-210). The values of maximum and minimum water elevations presented in the table for the years from 1997 to 2007 correspond with the data contained in the Microsoft Excel file. The staff requested further explanation of the values presented in Table 2.4-210 in **RAI 2.4.5-9** (ML101320136, dated May 7, 2010). An updated table was submitted as part of the response to **RAI 2.4.5-9**, correcting the values in Table 2.4-210 for the years 1970 through 1996 to be the yearly maximum or minimum values of the hourly lake level data. The staff finds the response acceptable.

To verify the information presented about flow in Swan Creek, the staff performed a search of USGS gaging stations. The staff identified measurements taken from 12 locations in the upper watershed of Swan Creek, but data were limited to between one and four measurements per site. Data for 12 of the periods between 1971 and 1991 but could not be used to describe peak flows on the watershed. The data were also insufficient to describe statistically the properties of the discharge from the Swan Creek Watersheds. Therefore, staff reviewed the Monroe County FEMA report, which provided estimates of the 10, 2, 1, 0.5 and 0.2 percent Swan Creek peak flow rates based on data available for the other streams in the region (FEMA, 2000). The applicant reports these flow rates in the FSAR and references a MDEQ webpage as the source. However, in the response to **RAI 2.4.3-1** (ML092790561, dated September 30, 2009), the applicant referenced the FEMA report for the peak flow data which is a more accurate representation of the source of the data. Peak flow rates are also presented for the adjacent Stony Creek watershed and the largest watershed in the region, River Raisin.

Flood Design Considerations

Information Submitted by the Applicant

The applicant discussed the analysis and results of combined events in general in Subsection 2.4.2.2 of the FSAR and in detail in Subsection 2.4.3.3 of the FSAR. The applicant stated in Subsection 2.4.2.2 of the FSAR that the flooding possibilities applicable to the Fermi site include: the local PMP runoff, the PMF of streams and rivers, probable maximum surge and seiche flooding, and flooding due to ice effects. However, the applicant did not consider flooding due to ice effects on Swan Creek. In Subsection 2.4.3 of the FSAR, the applicant stated that snowmelt and ice effects are of minimal impact "due to the relatively flat topography of the area, seasonal Lake Erie water level data, and the historical climatology of the region."

The applicant submitted a revised analysis of the PMF including snowmelt runoff at both the local Fermi 3 site and within the Swan Creek Watershed with the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). This analysis revised the flood information previously submitted by the applicant and is discussed further in Subsections 2.4.2.3 and 2.4.3.3, herein.

The three alternative flooding combinations considered by the applicant follow the guidelines of the *American National Standard for Determining Design Basis Flooding at Power Reactor Sites, ANSI/ANS-2.8-1992* (American Nuclear Society, 1992). Each of the alternatives considered has three stated combinations of events that could cause the highest flood level at the site. Alternative I included: 1) one-half PMF or 500-year flood, whichever is less; 2) surge and seiche from the worst regional hurricane or windstorm with wind wave activity; and 3) 100-year or maximum controlled level of water body, whichever is less. Alternative II examined: 1) the PMF within the Swan Creek Watershed; 2) 25-year surge and seiche with wind wave activity; and 3) 100-year or maximum controlled level of water body, whichever is less. Finally, Alternative III considered: 1) 25-year flood within the Swan Creek Watershed; 2) probable maximum surge and seiche with wind wave activity; and 3) 100-year or maximum controlled level of water body, whichever is less.

The applicant states that the most severe flooding combination of events results from a potential high surge from Lake Erie as considered in Alternative III. DCD Tier 1, Chapter 5, Table 5.1-1 requires that the maximum flood level be 1.0 ft below the design plant grade elevation. Based on a review of the Fermi 3 grading plan, the design plant grade elevation is 589.3 ft NAVD 88. The DCD maximum flood level corresponds to an elevation of 588.3 ft NAVD 88. The flood level calculated by the applicant for Alternative III is at 585.4 ft NAVD 88. The applicant also submitted a revised calculation of the PMF in the response to **RAI 2.4.2-**1 (ML092790561, dated September 30, 2009) that considers 1) the PMF on Swan Creek, 2) probable maximum snowmelt, 3) probable maximum surge and seiche on Lake Erie, and 4) 100-year elevation of Lake Erie. The flood level calculated by the applicant for this scenario is 585.5 ft NAVD 88, making it the highest elevation flood calculated for the site.

NRC Staff's Technical Evaluation

The NRC staff reviewed the application and verified information discussed in this section.

The staff checked the referenced ANSI/ANS-2.8-1992 guidelines to determine if the applicant's combinations meet the standards. The standards that the applicant referenced are for a *Streamside Location* (Section 9.2.3.2 of ANSI/ANS-2.8-1992). The staff verified that the

applicant used the guidance properly in the determination of the highest possible flood level at a streamside location. The ANSI/ANS-2.8-1992 guidelines also include specifications for calculating floods at shoreline locations. The guidance suggests that floods may result from 1) the probable maximum surge and seiche and 2) the 100-year lake level. These floods were considered by the applicant as a part of Alternative III.

In order to verify the analysis and Alternative III, the staff independently calculated a maximum flood level at the site resulting from 25-year flood on Swan Creek, 100-year FEMA flood level on Lake Erie, and maximum surge on Lake Erie to be 585.4 ft NAVD 88, as discussed below. This provides additional assurance that the combination of events was correctly addressed in the application.

ANSI/ANS-2.8-1992 also provides guidance on determining the largest possible precipitation flood at the plant site. Three alternatives are provided that could produce the worst flooding at the site. Alternative I combines 1) mean monthly (base) flow; 2) median soil moisture; 3) antecedent (or subsequent) rain equal to 40 percent of the PMP or 500-year rain, whichever is less; 4) the PMP; and 5) the 2-year wind speed applied in the critical direction. Alternative II includes 1) mean monthly (base) flow; 2) probable maximum snowpack; 3) coincident snow season PMP; and 4) the 2-year wind speed applied in the critical direction. Alternative III combines 1) mean monthly (base) flow; 2) 100-year snowpack; 3) coincident snow season PMP; and 4) 2-year wind speed applied in the critical direction.

The staff compared the applicant's analysis of plant site flooding against the three Alternatives presented in ANSI/ANS-2.8-1992. The applicant calculated a combination of Alternatives II and III in response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). The applicant calculated the flood resulting from 1) the probable maximum snowpack, 2) the PMP, and 3) the 2-year wind speed. The applicant also assumed that the temperature was equal to the 100-year recurrence dew point temperature for April, 69.1 degrees Fahrenheit. The staff considers this to be a conservative assumption for the snowmelt calculation. The flood elevation associated with this combination of events was determined by the staff to be 584.8 ft NAVD 88, the same value as calculated by the applicant. The staff considers the applicant's analysis to be conservative as the PMP and the probable maximum snowmelt are considered in the same case.

Effects of Local Intense Precipitation

Information Submitted by the Applicant

The applicant discussed the existing drainage patterns on the site shown on Figure 2.4-214 of the FSAR. Of the six areas described to handle existing storm discharge, only one, the drainage outfall pipe is called out on Figure 2.4-214. The remaining outlets were not called out on the map.

A map showing the final grade drainage areas and patterns was provided in the FSAR as Figure 2.4-215. The drainage area for the Fermi 3 final grade is less than 1 mi^2. The applicant described the runoff from the Fermi 3 final grade as primarily flowing into onsite drop inlets that discharge to the outfall pipe that drains into an overflow canal which then enters the North Lagoon. The applicant stated that the storm water may also "possibly flow toward two lagoons (North Lagoon and South Lagoon)." Flow from the North Lagoon reportedly flows to Swan Creek and flow from the South Lagoon flows directly to Lake Erie. A map showing the drainage of the Fermi 3 final grade assuming that all onsite drop inlets and drains blocked was provided in the FSAR as Figure 2.4-217.

The applicant calculated the discharge from the existing site sub-basins that are shown on Figure 2.4-214. Table 2.4-212 presents the discharge from the 22 sub-basins for the 10, 25, 50, and 100-year recurrence intervals. Table 2.4-213 presents the discharge from the sub-basins on final grade of the Fermi 3 (shown in Figure 2.4-215) for the 10, 25, 50, and 100-year recurrence intervals. An updated version of Table 2.4-213 was included with the response to **RAI 2.4.2-1**. The applicant used the rational method to calculate the runoff amounts for both the existing and final grade sub-basins. Table 2.4-214 presents total discharges for the 10, 25, 50, and 100-year recurrence intervals for both the existing condition and the final grade. An updated version of Table 2.4-214 was also presented with the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). The applicant compared the runoff from the existing condition to the final grade and estimated that runoff would be increased by 44 percent for the 10-year storm for the final grade and 88 percent for the 100-year storm.

The applicant calculated the PMF at the site using the rational method to determine peak runoff rates from the PMP. The applicant calculated the PMP for a 1 mi^2 area using the methods outlined in NOAA Hydro-Meteorological Report (HMR) 51 and HMR-52, as clarified by **RAI 2.4.2-2** (ML092750405, dated November 20, 2009). The calculated PMP depths for storms lasting 12 hours or less are presented in Table 2.4-211. The investigated PMP is 69.6 inches per hour, which is the intensity that lasts for a duration of 5 minutes. As a basis for selecting the 5-minute PMP duration, the applicant stated that this duration is shorter than the time of concentration and provides a more conservative estimate of runoff using the rational method. Time of concentration values for each of the final grade sub-basin areas are presented in Table 2.4-213.

In response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), the applicant described calculation of the time of concentration for each of the individual Fermi 3 sub-basins, provided the equations used to calculate time of concentration, and presented a table with input values used in the equations. The equations used to calculate the time of concentration were from the USDA's *Urban Hydrology for Small Watershed, Technical Release 55* (TR-55) (USDA, 1986).

The applicant used the rational method to determine PMF from the PMP assuming all the storm drains at the site were blocked. The runoff coefficient was conservatively set to 1.0 representing completely impervious soil/concrete or saturated antecedent conditions. The applicant assumed the area of runoff included the Fermi 3 nuclear island, an area where the SSCs are located (18.1 acres) plus the area located to the southwest, termed N3 in the FSAR (see Figure 2.4-217 of the FSAR). This area is approximately 25.96 acres and is assumed to contribute to the site runoff because there may be backwater effects from this area to prevent water from draining from the Fermi 3 nuclear island.

The applicant calculated a peak flow of 3,066 cubic feet per second (cfs) resulting from the PMP over Fermi 3 safety-related area of 18.09 acres and the adjacent drainage area to the west and south of the Fermi 3 nuclear island of 25.96 acres, for a total of 44.05 acres. The adjacent area was included to address the effects of a backwater scenario due to the water running off the steeper sides of the nuclear island with the safety structures and onto the lesser sloped adjacent area. For this scenario, the runoff was assumed to drain off the slopes of the Fermi 3 final grade because the storm drains at the site are assumed to be blocked.

The applicant then used Manning's equation to predict a runoff depth of 2.55 ft resulting from the peak flow rate of 3,066 cfs. The applicant assumed a channel width of 75 ft, vertical sides, a slope of 0.006 ft/ft (the slope of the area adjacent to the Fermi 3 nuclear island), and a roughness coefficient of 0.013.

In response to a subsection of **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), the applicant conducted an analysis of the impact of snowmelt in addition to the PMF at the site. The applicant revised the analysis to address snow pack and assumed an initial snowpack covering the entire site with no significant variation in snow temperature or snow depth. The applicant then calculated snowmelt as a function of wind velocity, rainfall rate, air temperature, and a wind coefficient using equation 5-19 presented in the USACE document, *Runoff from Snowmelt* (USACE, 1998). The applicant assumed the PMP rain on snow event would occur in April, as relatively high temperatures occurred historically after freezing during the month of April. The applicant used the observed dew point temperatures as representative of air temperature during a PMP rain on snow event. The wind velocity and temperature were derived from historical data from the Detroit Metropolitan Airport meteorological station. The applicant analyzed 34 years of data (1961-1995) for the month of April to determine the 2-year occurrence wind speed, 32.5 mph, and the 100-year occurrence dew point temperature, 69.1 degrees Fahrenheit. The applicant selected the highest hourly dew point temperature and the highest hourly wind speed from each April on record. The applicant stated an extreme frequency analysis was done with the resultant data, but did not describe the methodology taken to determine the values. The applicant assumed these values were constant through the entire storm.

For the 5-minute storm duration, the applicant calculated the snowmelt to be 1.54 inches. This runoff from snowmelt was then added on to the 5-minute precipitation value of 69.6 inches/hour, to produce an equivalent rainfall intensity of 88.1 inches/hour. The rational method was used to calculate a PMF runoff of 3,880 cfs from the 44.05 acre area including the Fermi nuclear island and the area to the south and west of the island. Using the same assumptions about the channel, the applicant used Manning's equation to calculate a flow depth of 2.97 ft resulting from the runoff.

RAI 2.4.2-1 (ML092790561, dated September 30, 2009) requested information related to the potential erosion of the slopes of the Fermi 3 site. The applicant's response stated that erosion protection measures such as mulching, seeding, sodding, and other will be incorporated in the design of the slopes. The applicant stated that erosion protection measures will be taken following guidelines in *The Guidebook of Best Management Practices for Michigan Watersheds* (MDEQ, 1998). The applicant also stated that very little runoff is expected to occur on the slopes. The runoff from the Fermi 3 nuclear island will be routed to a stormwater collection system, so the only expected runoff on the slopes is what results from direct precipitation onto the slopes. The applicant stated that this runoff will be at low velocities and therefore will not cause erosion.

NRC Staff's Technical Evaluation

The NRC staff reviewed the information submitted by the applicant concerning the flooding caused by the PMP at the site and verified that information by comparing it to results using the rational method. **RAI 2.4.2-1** requested significant additional information about the calculation of the PMP and the local runoff resulting from the PMP. The staff verified from the literature that the 5-minute PMP duration provides a more conservative estimate of runoff using the rational method (Pilgrim and Cordery, 1993). The time of concentration is a key parameter in completing the rational method and is the time it takes for flow to travel from the top of the watershed to the downstream end where flow is measured (Lettenmaier and Wood, 1993). The staff checked the TR-55 reference and confirmed that the equations from TR-55 were appropriate to calculate the time of concentration. The staff also checked the values presented for input into the equations and confirmed the values were appropriate (USDA, 1986; US

Weather Bureau, 1961; Engman, 1986). The staff independently confirmed that the time of concentration values presented in Table 2.4-213 were correct. Thus, the staff verified the applicant's calculation of time of concentration, as presented in the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), to be acceptable.

The staff independently developed rainfall intensities. First, the staff independently determined the 60-minute, 1 mi^2 PMP to be 17.3 inches from Figure 24 in HMR-52 (NOAA, 1982). The 5-minute, 1 mi^2 PMP was determined independently by the staff to be 5.8 inches using Figure 36 of HMR-52 (NOAA, 1982). The 5-minute PMP value of 5.8 inches corresponds to a rainfall intensity of 69.6 inches/hour. This verifies the applicant's calculation of the 5-minute, 1 mi^2 PMP that was presented in the response to **RAI 2.4.2-1**. The staff verified the value of PMP presented by the applicant.

The applicant used the rational method to determine PMF from the PMP assuming all storm drains are blocked. The staff considers this method of calculation to be conservative, as the Rational Method captures a snapshot in time of the worst potential precipitation of almost6 inches in a 5 minute window. Also, the applicant assumed no infiltration or other losses of the PMP, which is a conservative assumption. The applicant assumed the area of runoff included the Fermi 3 nuclear island (18.1 acres) plus the area located to the southwest, termed N3 in the FSAR (see Figure 2.4-217 of the FSAR). This area is approximately 25.96 acres and is assumed to contribute to the site runoff because there may be backwater effects from this area to prevent water from draining from the Fermi 3 nuclear island. The staff confirmed that the runoff from this total area of 44.05 acres resulting from the 5-minute PMP is calculated to be 3,066 cfs.

To calculate the depth of flow potentially resulting from the peak runoff rates, the applicant used the Manning's equation. The staff evaluated the inputs to the equation. The Manning's roughness coefficient used for the analysis is appropriate for concrete or bare soil (Engman, 1986). The staff finds this value appropriate for roughness at the Fermi 3 site. The width of 75 feet is arbitrary, as there is currently no channel into which the flow is directed. The staff performed the calculation to determine the depth of flow using the applicant's stated assumptions and found a flow depth of 2.57 ft. This verified the applicant's calculation. The staff finds this analysis of runoff depth acceptable because the assumption of a 75 foot channel is conservative.

The staff reviewed the applicant's analysis of PMF plus snowmelt runoff when all storm drains were blocked as presented in the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). The staff verified the equation for snowmelt runoff by checking the applicant's reference (USACE, 1998). The equation used by the applicant is conservative because it assumes a constant snowpack that does not decrease during the PMF. Input values to the equation included wind velocity, air temperature, rainfall rate and a wind coefficient. The staff verified that the wind coefficient of 1 used by the applicant is a conservative assumption (USACE, 1998). The resulting snowmelt would have been reduced if the value was assumed to be lower than 1. The rainfall rate that the applicant used was the same as was used for the PMF calculation, 69.6 in/hour. The staff obtained Detroit Metro Airport climate data from the NCDC to verify the applicant's wind velocity and air temperature assumptions. The staff obtained average daily dew point temperature and average daily wind speed information from 1984 through 2009. For a conservative analysis the staff chose the highest wind speed and dew point temperature for the month of April from each of the 25 years on record. Both datasets were found to be normally distributed using the EPA's ProUCL software (USEPA, 2007). For each of the resultant datasets, a normal cumulative distribution function of the values was

examined to determine the recurrence interval of the applicant's selected values. The staff found that the average daily wind speed of 32.5 mph (assumed by the applicant for snowmelt calculations) occurred less frequently than the 100-year wind speed. Thus, the staff verified that this is a conservative value for wind speed during the PMF with snowmelt. For the daily dew point temperature, the staff also found the value of 69.1 degrees Fahrenheit (assumed by the applicant for snowmelt calculations) occurred less frequently than the 100-year value for the month of April. The staff's calculations verified that the applicant selected a conservative value of dew point temperature for the calculation of snowmelt.

For the 5-minute storm duration, the staff verified that the snowmelt was calculated to be 1.54 inches using the applicant's conservative assumptions. The staff verified that the snowmelt added to the 5-minute precipitation value of 69.6 inches/hour produced an equivalent rainfall intensity of 88.1 inches/hour. The PMF runoff of 3,880 cfs was then calculated by the staff using the rational method. Using the same assumptions about the channel, the staff verified the flow depth calculation using Manning's equation. A flow depth of 2.97 ft was calculated by the staff, verifying the applicant's calculation. The flood elevation associated with this runoff depth was determined by the staff to be 584.8 ft NAVD 88, the same value as calculated by the applicant.

In the FSAR, the applicant did not discuss any erosion protection measures or the potential erosional impacts of PMP flooding on the slopes of the Fermi 3 elevated area containing the safety structures. **RAI 2.4.2-1** (ML092790561, dated September 30, 2009) requested information related to the potential erosion of the slopes of the Fermi 3 site. The applicant stated that the slopes are 8 percent and thus the staff does believe that erosion protection measures, such as described in *The Guidebook of Best Management Practices for Michigan Watersheds* (MDEQ, 1998) should be taken to prevent erosion on the slopes. Additionally, these erosion protection measures should be monitored and maintained to ensure that they are functioning properly. Additionally, NRC guidelines NUREG 1623 provide guidance on designing erosion protection along slopes that may be helpful to the applicant. In **RAI 2.4.2-4**, the staff requested additional information on the specific erosion protection measures to be used for the slopes of the Fermi 3 elevated area. The staff requested that (1) the applicant calculate the potential maximum velocity of runoff from the 8 percent slopes during the PMP at the site and (2) the applicant provide detailed information on specific erosion protection measures designed to resist erosion under the maximum predicted water velocities. The applicant used Manning's equation to calculate the potential velocities of water running down the slopes during the local PMF assuming all the drains are blocked. The maximum velocity calculated by the applicant was 5.64 ft per second (fps) and thus the applicant used this velocity as the design velocity to determine proper erosion protection measures for the slopes of the nuclear island. The applicant stated that grass cover established by sod or a riprap cover with a median diameter of 3 inches would comply with the requirements in *The Guidebook of Best Management Practices for Michigan Watersheds* (MDEQ, 1998). The staff checked the applicant's calculations and finds this response to be conservative and acceptable in determining erosion protection measures for the local PMP on the slopes of the nuclear island.

In the FSAR, the applicant did not consider potential impacts of PMP flooding at the Fermi 3 site on the adjacent Fermi 2 site. **RAI 2.4.2-3** (ML093280179, dated November 20, 2009) requested an analysis of potential impacts of the PMP flood at the Fermi 3 site on the Fermi 2 safety facilities, assuming all runoff drop inlets are blocked (i.e., the worst case scenario). In the response, the applicant calculated the maximum additional depth of water at Fermi 2 to be 4 inches during the PMP flood. The Fermi 2 UFSAR (Detroit Edison, 2009a) states that the Fermi 2 safety structures are water tight to a minimum of 586.8 ft NAVD 88. The staff determined that

there would be no impact to the Fermi 2 safety structures from the local PMP flooding at Fermi 3.

The applicant discussed predevelopment and final Fermi 3 plant site runoff for storms smaller than the PMP. The information presented concerning the 10-year through 100-year rainfall intensities and resulting runoff for the existing drainage and the final grade drainage (presented in Table 2.4-212, 2.4-213 and 2.4-214) was not considered to be essential to the staff's review of safety-related features, and this information was not reviewed by the staff. For the reasons given above, the staff concluded that the identification and consideration of the floods at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79(a)(31) and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

2.4.2.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.2.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.2 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-13-A as it relates to floods.

As set forth above, the applicant has presented and substantiated information relative to the floods important to the design and siting of this plant. The staff reviewed the available information provided. For the reasons given above, the staff concluded that the identification and consideration of the floods at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79(a)(31) and 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

The staff found that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs important to safety. The staff accepts the methodologies used to determine the locally intense precipitation flood event. Accordingly, the staff concludes that the use of these methodologies results in design bases containing a sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concluded that the identified design bases meet the requirements of 10 CFR 100.20(c) with respect to establishing the design basis for SSCs important to safety.

2.4.3 Probable Maximum Flood on Streams and Rivers

2.4.3.1 Introduction

The PMF on streams and rivers is used to determine the extent of any flood protection required for those safety-related SSCs necessary to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition. The specific areas of review are as follows: (1) design

basis for flooding in streams and rivers, (2) design basis for site drainage, (3) consideration of other site-related evaluation criteria, and (4) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.3.2 Summary of Application

Subsection 2.4.3 of the Fermi 3 COL FSAR, Revision 4, addresses the need for information on site specific PMF on streams and rivers. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-14-A Probable Maximum Flood

  To address this COL item, the applicant discussed considerations of storm configuration, maximized precipitation amounts, time distributions, orographic effects, storm centering, seasonal effects, antecedent storm sequences, antecedent snowpack, and a snowmelt model in defining the PMP. The applicant described the absorption capability of the basin, including consideration of initial losses and infiltration rates as well as the hydrologic response characteristics of the watershed to precipitation and provided verification from synthetic procedures.

In addition, the applicant presented the controlling PMF runoff hydrograph at the plant site that would result from rainfall and described the translation of the estimated peak PMP discharge to elevation using cross-section and profile data, standard step methods, roughness coefficients, verification, and estimates of PMF water surface profiles. Finally, the applicant discussed setup, maximum wave heights, run-up, and resultant static and dynamic effects of wave action on each safety-related facility from wind-generated activity that may occur coincidentally with the peak maximum flood water level.

2.4.3.3 Regulatory Basis

The applicable regulatory requirements for identifying PMF on streams and rivers are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirements to consider physical site characteristics in site evaluations are specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are:

- Design Bases for Flooding in Streams and Rivers: To meet the requirements of 10 CFR Part 100, estimates of the following characteristics are needed, and should be based on conservative assumptions of hydrometeorologic characteristics in the drainage area: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth of PMP and the PMP hyetograph, (c) the maximum PMF water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC important to safety. If a potential hazard to SSC important to safety exists, the applicant should document and justify the design bases of affected facilities.

- Design Bases for Site Drainage. To meet the requirements of 10 CFR Part 100, estimates of the following characteristics are needed: the runoff from the immediate site area and the drainage from areas adjacent to the site, including the roofs of safety-related structures. Flood response characteristics should be identified to estimate flooding adjacent to and on the plant site. The effects of erosion and sedimentation during the flooding should be identified and their effects on SSC important to safety should be determined. If a potential hazard to SSC important to safety exists, the applicant should document and justify the design bases of affected facilities.

- Consideration of Other Site-Related Evaluation Criteria. To meet the requirements of 10 CFR Part 100 information about the potential effects of site-related proximity, seismic, and non-seismic information as they relate to flooding in streams and rivers and local flooding adjacent to and on the plant site is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from RGs:

- RG 1.27, describes the applicable UHS capabilities.

- RG 1.29, identifies seismic design bases for SSC important to safety.

- RG 1.59, as supplemented by current best practices provides guidance for developing the hydrometeorological design bases.

- RG 1.102, describes acceptable flood protection to prevent the safety-related facilities from being adversely affected.

2.4.3.4 Technical Evaluation

NRC staff reviewed Subsection 2.4.3 of the Fermi 3 COL FSAR.

<u>COL Item</u>

- EF3 COL 2.0-14-A Probable Maximum Flood

  To address this COL item, the applicant discussed considerations of storm configuration, maximized precipitation amounts, time distributions, orographic effects, storm centering, seasonal effects, antecedent storm sequences,

antecedent snowpack, and a snowmelt model in defining the PMP. The applicant described the absorption capability of the basin, including consideration of initial losses and infiltration rates as well as the hydrologic response characteristics of the watershed to precipitation and provided verification from synthetic procedures.

In addition, the applicant presented the controlling PMF runoff hydrograph at the plant site that would result from rainfall and described the translation of the estimated peak PMP discharge to elevation using cross-section and profile data, standard step methods, roughness coefficients, verification, and estimates of PMF water surface profiles. Finally, the applicant discussed setup, maximum wave heights, run-up, and resultant static and dynamic effects of wave action on each safety-related facility from wind-generated activity that may occur coincidentally with the peak maximum flood water level.

2.4.3.4.1 Probable Maximum Precipitation

Information Submitted by the Applicant

In Subsection 2.4.3.1 of the FSAR, the applicant calculated the PMP over the entire Swan Creek Watershed. In the response to **RAI 2.4.3-1** (ML092790561, dated September 30, 2009), the applicant stated that the PMP was calculated using HMR-51. The applicant estimated a storm depth of 31.4 inches over a 72-hour period as the PMP. The applicant presented the distribution of rainfall during the 72-hour period in Table 2.4-216 of the FSAR and referenced the ANSI/ANS-2.8-1992 for this calculation. The applicant stated that an antecedent condition was assumed, but no further explanation is provided.

In response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), the applicant performed an analysis of snowmelt impacts in addition to the PMP in the Swan Creek Watershed. For this calculation, the applicant used the HMR-52 software program (USACE, 1984) to determine the PMP for the Swan Creek Watershed. The HMR-52 software determines the size of the storm and spatially orients the storm within the watershed to determine the worst possible scenario for the PMP. The applicant performed this storm orientation with the probable maximum storm in the Swan Creek Watershed. The applicant determined that a storm size of 100 mi^2 with an orientation of 311 degrees produced the largest precipitation values. Other inputs required for using the HMR-52 software include delineation of the watershed boundary, depth-area-duration data and the ratio of the 1-hour to 6-hour storm, as illustrated in Figure 39 of HMR-52 (NOAA, 1982). The applicant derived the depth-area-duration data from HMR-51 (NOAA, 1978). The applicant stated that the value of the ratio of the 1-hour to the 6-hour storm was 0.302.

Snowmelt resulting from rain on snow was calculated using the *Runoff from Snowmelt* guidance provided by the USACE (1998). The applicant used a lumped model approach assuming that all the parameters are constant across the watershed to simplify the problem. The applicant then calculated snowmelt as a function of wind velocity, rainfall rate, air temperature, and a wind coefficient using equation 5-19 of the USACE guidance. The applicant assumed the PMP rain on snow event would occur in April because, historically, relatively high temperatures have occurred after freezing during the month of April. The applicant used the observed dew point temperatures as representative of air temperature during a PMP rain on snow event. The wind velocity and temperature were derived from historical data from the Detroit Metropolitan Airport meteorological station. The applicant analyzed 34 years of data (1961-1995) for the month of April to determine the 2-year occurrence wind speed, 32.5 mph, and the 100-year occurrence

dew point temperature, 69.1 degrees Fahrenheit. The applicant selected the highest hourly dew point temperature and the highest hourly wind speed from each April on record. The applicant stated an extreme frequency analysis was done with the resultant data, but did not describe the methodology taken to determine the values. The applicant assumed these values were constant through the entire storm.

NRC Staff's Technical Evaluation

The NRC staff checked the applicant's PMP calculation that was based on the HMR-51 and HMR-52 reports (NOAA, 1978; NOAA, 1982). First, the staff used the method described in HMR-51 to determine the PMP depth at the site. The staff found values of PMP depth corresponding to the location of Fermi 3 in Figure 18 through Figure 47 of HMR-51 (NOAA, 1978). Information developed by staff for standard increments and basin size is found below in Table 2.4.3-1 below.

	Storm Duration (hours)				
Basin Size (mi^2)	6	12	24	48	72
10	25.5	28.75	30.5	32.9	34.9
200	17.8	21.2	22.7	25.6	27.5
1000	12.9	15.6	17.4	20	21.95
5000	7.8	10.6	12.4	14.85	16.6
10000	6	8.5	10	13	14.7
20000	4.2	6.7	8.3	10.9	12.4

Table 2.4.3-1. Depth-area-duration tables for the Fermi site.

Smooth depth-area-duration curves were then graphed on semi-log paper. This graph was used to find the PMP depths for the 100 mi^2 Swan Creek Watershed. The staff determined that the 72-hour PMP depth for Swan Creek is 29.3 inches. The staff then used the USACE computer program HMR-52 to determine the probable maximum storm in Swan Creek Watershed. The HMR-52 software calculated the 72-hour PMP to be 28.9 inches.

The HMR-52 software requires several inputs including: points outlining the watershed, the ratio of the 1-hour to the 6-hour storm, the position of the maximum 6-hour rainfall increment, the temporal distribution of the PMP over the entire storm, the storm area, the storm center, the depth-area-duration information derived from HMR-51, and the preferred storm orientation information from HMR-51 (NOAA, 1978; USACE, 1984). The staff determined that the

1 to 6-hour ratio for the 20,000 mi^2 storm at the Fermi site was 0.302 by checking Figure 39 of HMR-52 (NOAA, 1982). The staff set the position of the maximum 6-hour precipitation increment to the 7th increment, following the ANSI/ANS-2.8-1992 guidance. The staff also followed the ANSI/ANS-2.8-1992 guidance to set the distribution of the PMP over the entire storm. The storm area size and the storm orientation were set as variables, so the HMR-52 program could change these parameters to maximize the probable maximum storm. The preferred storm orientation listed in HMR-51 of 245 degrees was also input into HMR-52. The staff ran the HMR-52 model to determine the PMP for Swan Creek. The resultant storm size was 100 mi^2 and the storm orientation was 309 degrees, the same storm properties that the applicant determined. The HMR-52 software calculated the 72-hour PMP to be 28.9 inches. The 12 rainfall intervals, 6 hours each, were calculated by the HMR-52 model. The intervals were reordered based on guidance from ANS 2.8 -1992. The information is tabulated below.

6-Hour Interval	Rainfall Depth (in)	Order of Interval in Storm
1	19.76	7
2	2.70	6
3	1.50	8
4	1.04	5
5	0.80	9
6	0.65	4
7	0.55	10
8	0.47	3
9	0.42	11
10	0.37	2
11	0.34	12
12	0.31	1

Table 2.4.3-2. Rainfall distribution of probable maximum storm for the Swan Creek Watershed.

Table 2.4.3-2 can be directly compared to FSAR Tables 2.4-216 and 2.4-217 to see that the applicant's calculated probable maximum storm is larger and therefore more conservative than the staff calculated storm. The staff finds the applicant's calculation of PMP to be acceptable, because the applicant's PMP is higher (more conservative) than the value calculated by the staff.

The staff also checked the applicant's calculation of PMP with snowmelt, as submitted in the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). First, the applicant used the USACE HMR-52 software to define the PMP, similar to the method described by the staff, above. Second, the applicant calculated snowmelt for each time interval during the storm. The values for rainfall and snowmelt were combined for each time interval to become a total value of effective precipitation on the watershed.

The applicant's input and output values for the HMR-52 program were very similar to the staff's. Both the staff and the applicant used a value of 0.302 for the ratio of the 1 to 6 hour storm. The staff found a maximum storm orientation of 309 degrees and the applicant found a maximum storm orientation of 311 degrees. The depth-area-duration curves used by the applicant were slightly larger overall than those used by the staff, and thus the applicant's analysis was more conservative. Therefore, the applicant's input values were found to be acceptable. The applicant calculated a PMP of 28.9 from the HMR-52 software, the same value determined by the staff's calculation.

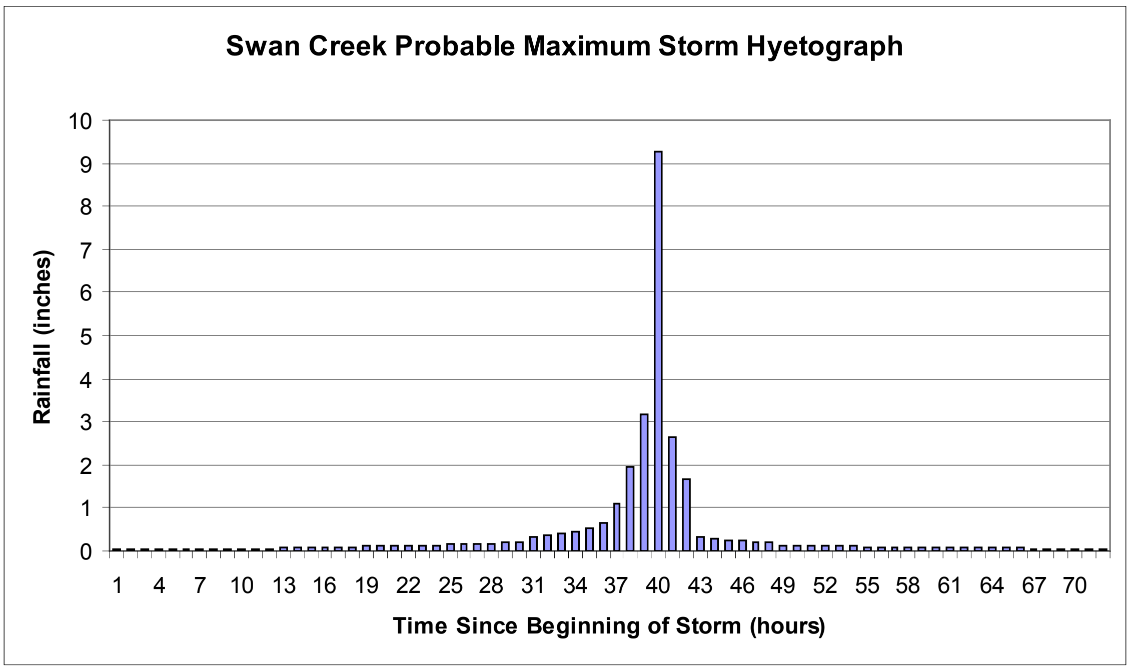


Figure 2.4.3-1. Hourly distribution of the probable maximum precipitation for the Swan Creek Watershed.

The hourly distribution of the probable maximum storm was also calculated by HMR-52. The probable maximum storm for the Swan Creek Watershed shown in Figure 2.4.3-1 above can be directly compared to Figure 2.4-XX-2 submitted by the applicant with the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). The staff finds the applicant's calculation of PMP from HMR-52 to be acceptable, because the applicant's PMP is the same as the value independently calculated by the staff.

The applicant calculated snowmelt for each time step using equation 5-19 from the USACE manual *Runoff from Snowmelt* (USACE, 1998). A full discussion of the verification of the snowmelt calculations is presented in Section 2.4.2.4.3 above. The staff verified the results of

the snowmelt calculations and independently calculated the same cumulative rain and snowmelt total of 70.3 inches over 72-hours.

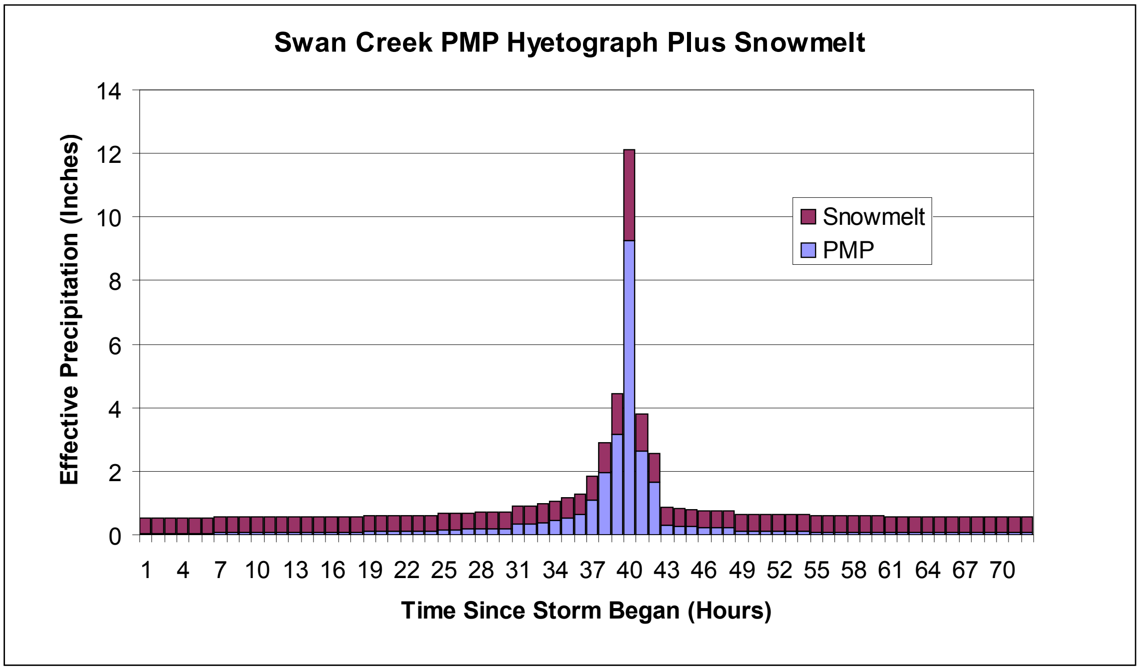


Figure 2.4.3-2. Hourly distribution of the probable maximum storm with snowmelt for the Swan Creek Watershed.

The staff-calculated PMP with snowmelt for the Swan Creek Watershed shown in Figure 2.4.3-1 above can be directly compared to Figure 2.4-XX-3 submitted by the applicant with the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009). The staff finds the applicant's calculation of PMP with snowmelt to be acceptable, because the applicant's PMP is the same as the value calculated by the staff.

Precipitation Losses

Information submitted by the applicant

In Subsection 2.4.3.2 of the FSAR, and in the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009) and **RAI 2.4.3-1** (ML092790561, dated September 30, 2009), the applicant describes precipitation losses for the Swan Creek Watershed and how they were calculated. In the response to **RAI 2.4.2-1**, the applicant calculated initial losses using the NRCS default equation and a curve number of 98. The curve number of 98 was used to represent saturated conditions. The response to **RAI 2.4.3-1** provided a different analysis of losses using curve numbers representative of different land use types to a stated composite curve number of 84.25. However, after discussing the calculation of this curve number, the applicant stated these losses were "not applied to the resultant hydrograph."

NRC Staff's Technical Evaluation

The NRC staff reviewed the information submitted by the applicant. A curve number of 98 is a considered by the staff to be a conservative value because it assumes that the watershed is

completely saturated from antecedent storm conditions. This assumption means that very little precipitation loss occurs and that almost all of the PMP is transmitted through the watershed. Using the NRCS default equation and a curve number of 98, the staff calculated an initial loss of 0.04 inches across the watershed. The staff finds the applicant used conservative assumptions for precipitation losses in the calculation of the PMF on Swan Creek.

Runoff and Stream Course Models

Information submitted by the applicant

In Subsection 2.4.3.3 of the FSAR, the applicant used the NRCS synthetic unit hydrograph method to transform the rainfall into runoff within the Swan Creek Watershed. The applicant provided the ordinates of the hydrograph in Table 2.4-218 of the FSAR. The applicant presented a graph of the 6-hour unit hydrograph for Swan Creek Watershed in Figure 2.4-219 of the FSAR. The applicant stated that the peak flow for the 6-hour, 1-inch storm was 4,690 cfs.

The applicant used the NRCS unit hydrograph method to transform the PMP into the PMF runoff from the Swan Creek Watershed. To transform rainfall into runoff using this method, an estimate of the basin lag time is required. The basin lag was calculated based on the time of concentration for the watershed. The applicant used the Kirpich equation to calculate the time of concentration for the basin. In the response to **RAI 2.4.2-1** (ML092790561 dated September 30, 2009), the applicant stated that the time of concentration was calculated to be 16.4 hours. The applicant provided an equation using the time of concentration to determine the basin lag of 9.84 hours (590 minutes).

An additional analysis of the PMF on the Swan Creek Watershed was submitted in response to **RAI 2.4.2-1**, which included analysis of the impacts of snowmelt. The applicant used the NRCS (also called the SCS) unit hydrograph method within the Hydological Engineering Centers Hydrological Modeling System (HEC-HMS) 3.1.0 rainfall-runoff model software package (USACE, 2006) to generate runoff in Swan Creek resulting from the PMP with snowmelt.

NRC Staff's Technical Evaluation

NRC staff reviewed the information submitted by the applicant concerning the selection of runoff and stream course models. NRC staff independently calculated the unit hydrograph for the Swan Creek watershed resulting from the 1 inch of rainfall falling over a 6-hour period and verified the applicant's results. The staff independently calculated the time of concentration to be 12.6 hours using the Kirpich equation, assuming a maximum travel length of 18 miles. The staff verified the Kirpich equation in the literature (Pilgrim and Cordery, 1993). The staff calculated a basin lag of 7.6 hours (455 minutes) using the equation provided by the applicant. The equation that the applicant presented for basin lag was found by the staff in TR-55 (NRCS, 1986) and verified. The staff also used two alternative equations to calculate the time of concentration and basin lag to determine if the equation that the applicant chose provided a conservative result. There are several methods available in the literature to determine the time of concentration of a watershed. Each watershed generates runoff uniquely, according to its features, such as slope and preciousness. Thus, the staff wanted to verify that the most conservative method was used to determine runoff in the Swan Creek Watershed. The staff used the Snyder method to calculate basin lag of 9 hours (550 minutes) and used the method presented in TR-55 to calculate a time of concentration of 11.5 hours and a basin lag of 413 minutes (Pilgrim and Cordery, 1993; NRCS, 1986).

The NRC staff checked the applicant's calculation of the 6-hour, 1 in. unit hydrograph for the Swan Creek Watershed by performing a unit hydrograph simulation in HEC-HMS. The staff used a basin lag of 413 minutes, the most conservative of the values found from the above analysis. The staff assumed no initial loss of rainfall to infiltration and used a curve number of 98. The staff calculated the peak runoff to be 4,300 cfs. The staff considers the applicant's calculation to be conservative because the runoff calculated by the applicant was higher than that calculated by the staff.

Probable Maximum Flood Flow

Information submitted by the applicant

In Subsection 2.4.3.4 of the FSAR the applicant used the NRCS synthetic unit hydrograph method to transform the rainfall into runoff within the Swan Creek Watershed. The applicant calculated a PMF peak flow of 113,000 cfs resulting from the PMP.

A modified analysis of the PMF was submitted in response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009), which included analysis of the impacts of snowmelt on the PMF. The applicant used a curve number of 98 for the loss estimate in HEC-HMS to represent the saturated ground conditions. The applicant used 1-hour time steps for the calculation of flood discharge. The applicant calculated a PMF peak runoff of 168,000 cfs from the PMP with snowmelt. The RAI response also updated the analysis of water surface elevations using Hydological Engineering Centers River Analysis System (HEC-RAS), as discussed in Section 2.4.3.5 below.

NRC Staff's Technical Evaluation

NRC staff reviewed the information submitted by the applicant concerning the flow resulting from the PMF. NRC staff independently calculated the PMF for Swan Creek using the SCS unit hydrograph method in HEC-HMS 3.1.0. and obtained a value of 134,000 cfs, which is approximately 18 percent higher than the value presented by the applicant. The staff used the smallest and most conservative time of concentration value calculated by the three methods presented above, 413 minutes. The staff also assumed a constant baseflow equivalent to the mean monthly flow for the month of April presented in Table 2-215 of the FSAR of 120 cfs.

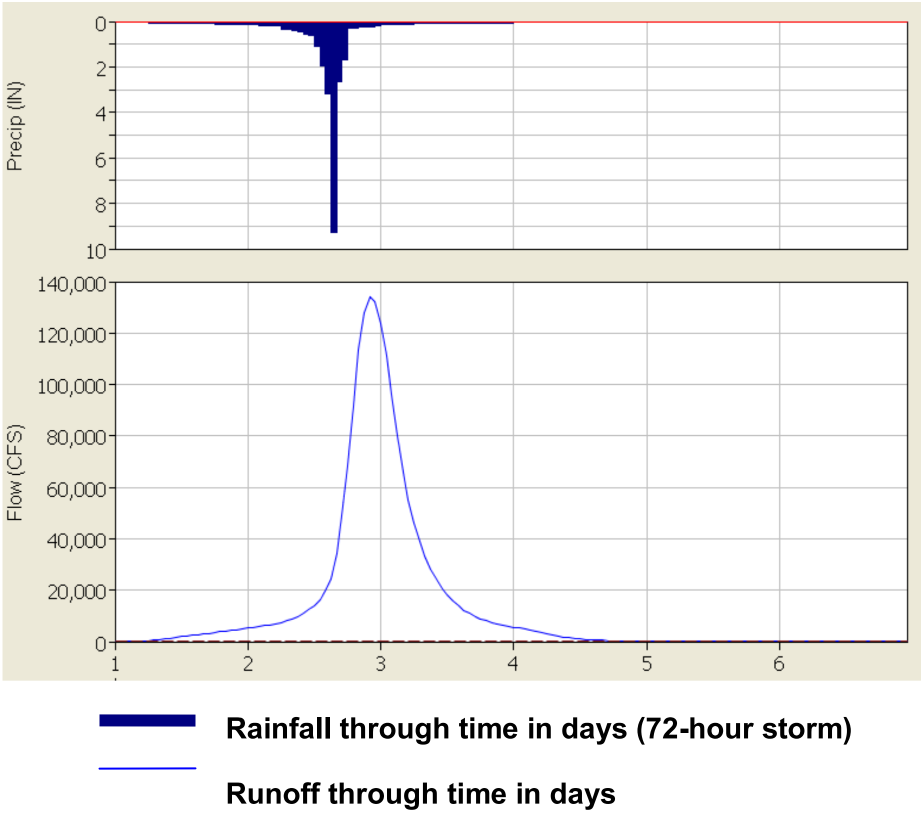
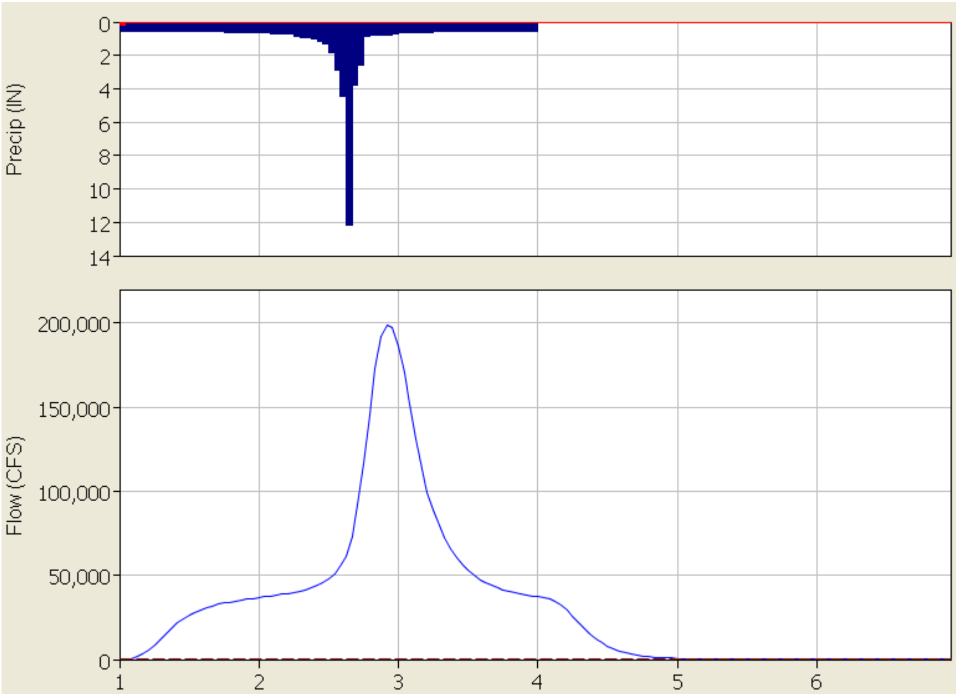


Figure 2.4.3-3. Probable maximum flood runoff using HEC-HMS 3.1.0 rainfall-runoff model.

Staff developed flood hydrographs (Figure 2.4.3-3) based on the parameters discussed above. By developing an independent hydrograph, Figure 2.4.3-3 can be directly compared with Figure 2.4-219 of the FSAR to examine the PMF runoff calculated by the staff versus the PMF runoff calculated by the applicant.

NRC staff independently calculated the PMF with snowmelt for Swan Creek and obtained a value of 199,000 cfs, which is approximately 18 percent higher than the value presented in the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009).



Rainfall plus snowmelt through time in days (72-hour storm)

Runoff through time in days

Figure 2.4.3-4. Probable maximum flood with snowmelt runoff using HEC-HMS 3.1.0 rainfall-runoff model.

Staff independently developed a flood hydrograph that include snowmelt (Figure 2.4.3-4) The staff hydrograph in Figure 2.4.3-4 can be directly compared with Figure 2.4-2-XX-4 of the response to **RAI 2.4.2-1** (ML092790561, dated September 30, 2009) to examine the runoff from the PMF plus snowmelt calculated by the staff versus the PMF plus snowmelt runoff calculated by the applicant.

The runoff amounts for both the PMF and the PMF with snowmelt calculated by the staff are 18 percent larger than the applicant's calculated values. Although the precipitation inputs developed by staff are higher than the applicants, the resultant water surface elevation are not significantly impacted. Therefore, the staff finds the analysis performed by the applicant to be acceptable because the water levels determined by HEC-RAS from NRC staff-calculated peak runoff do not vary significantly from the water levels calculated by the applicant (discussed in the following section).

Water Level Determination

Information submitted by the applicant

In Subsection 2.4.3.5 of the FSAR, the applicant used HEC-RAS Version 4.0.0 (USACE, 2008) to determine water surface profiles on Swan Creek resulting from the three possible maximum flooding scenarios: Alternative I, Alternative II, and Alternative III (see Section 2.4.2.4.2 above). The 500-year and 25-year flood levels on Swan Creek were derived from the *FEMA Flood Insurance Study for Monroe County* (FEMA, 2000). According to the response to **RAI 2.4.3-1** (ML092790561, dated September 30, 2009), the applicant created geometric cross-sections across Swan Creek using a 10-meter resolution DEM. The applicant created 8 cross-sections to represent approximately 11,000 feet of the downstream end of the Swan Creek channel. The applicant submitted input and output files to the NRC staff as a part of the response to **RAI 2.4.1-1**. The staff reviewed these files to examine the applicant's approach in detail. The applicant used a Manning's roughness coefficient of 0.02 for the channel and a value of 0.06 for the floodplain. The applicant assumed a constant water surface elevation in Lake Erie as the downstream boundary condition and a normal depth slope of 0.001 ft/ft as an upstream boundary condition. Each of the flooding alternatives has a different downstream elevation of Lake Erie and contributing flow from Swan Creek. The applicant provided detail on the derivation of the elevation of Lake Erie for each of the alternatives. Alternative I used the 100-year elevation of Lake Erie, 575.1 ft NAVD 88, combined with the estimate of the 100-year surge of 4.0 ft as presented in Table 2.4-222 of the FSAR. Alternative II used the 100-year elevation of Lake Erie, 575.1 ft NAVD 88, combined with the estimate of the 33-year surge of 3.2 ft as presented in Table 2.4-222 of the FSAR. Alternative III used the 100-year elevation of Lake Erie, 575.1 ft NAVD 88, combined with the estimate of probable maximum surge height of 10.3 ft. The following table summarizes the applicant's HEC-RAS inputs and the results.

Combined Events	**Input Parameters**		**Results**
Flood Scenario	**Flow in Swan Creek (cfs)**	**Calculated Lake Elevation (ft NAVD 88)**	**Resulting Fermi Flood Elevation (ft NAVD 88)**
Alternative I: • 500-yr flood in Swan Creek (5000 cfs) • largest observed surge in Lake Erie (4.0 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	5,000	579.1	**579.4**

Alternative II: • PMF in Swan Creek (113,200 cfs) • 25-year surge in Lake Erie (3.2 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	113,200	578.3	**579.1**
Alternative III: • 25-year flood in Swan Creek (3100 cfs) • Probable maximum surge or seiche in Lake Erie (10.3 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	3,100	585.4	**585.4**
Sensitivity due to Snowmelt Alternative: • PMF in Swan Creek plus snowmelt runoff (168,000 ft) • Probable maximum surge and seiche in Lake Erie (10.3 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	168,000	585.4	**585.5**

Table 2.4.3-3. The applicant's inputs to HEC-RAS and resulting flood elevations at the Fermi Site.

Table 2.4-219 of the FSAR presents the detailed HEC-RAS simulation results of flooding Alternative II, which included the PMF on Swan Creek. The applicant determined the flood elevation for the Fermi site to be the water elevation at the cross section approximately 1,900 feet upstream from Lake Erie. Detailed HEC-RAS results for Alternative I and Alternative III were presented in FSAR Tables 2.4-220 and 2.4-221, respectively. The flood elevations at Fermi 3 for Alternative I and Alternative III were constant at the downstream cross-sections of Swan Creek, according to the information in these tables.

NRC Staff's Technical Evaluation

NRC staff reviewed the information submitted by the applicant. The staff finds the applicant's use of HEC-RAS 4.0.0 to be acceptable for estimating water levels in Swan Creek because the staff verified the geometric cross-sections in the HEC-RAS model of Swan Creek by comparing them with the USGS Stony Point topographic map. However, to fully verify the cross-sections, the staff compared them to the 10-m DEM requested by the staff as **RAI 2.4.1-3** (ML100830380, dated March 19, 2010). The review team extracted cross sections from the DEM submitted by the applicant and evaluated the cross sections in comparison to those submitted by the applicant. This confirmed that the appropriate cross-sections were used in the applicant's model.

The staff verified that the Manning's coefficient values assumed for Swan Creek are conservative by varying the coefficient values and performing simulations. Reasonable values for the Manning's coefficient could range between 0.015 and 0.04 for Swan Creek (Shen and Julien, 1993; FEMA, 2000). Fermi flood elevations were the largest when a Manning's n value of 0.04 was assumed for Swan Creek. Therefore, the staff chose the value of 0.04 for Manning's n to compute the most conservative water levels resulting from the flooding alternatives.

The staff reviewed the *FEMA Flood Insurance Study for Monroe County* (2000), particularly the document's discussion of the Swan Creek Watershed. The staff verified that the 25-year flood is estimated to be 3,100 cfs and the 500-year flood level is estimated to be 5,000 cfs (FEMA, 2000). FEMA determined the flood levels for the Swan Creek watershed by plotting flood levels for streams in the region that have been monitored. The calculated flood levels for Swan Creek are then based on its size in comparison with the size of the monitored watersheds.

The staff reviewed the applicant's calculation of the water level for Lake Erie for each flooding alternative. For Alternative I, the applicant stated that a surge of 4.0 feet was assumed. The applicant used the 100-year recurrence interval surge for the month of December of 4.0 ft to estimate the "surge and seiche resulting from the worst regional hurricane or windstorm with wind-wave activity," as required by the ANSI/ANS-2.8-1992. The staff verified the height of the surge by checking the USACE website that the applicant referenced for the value (USACE, 2009). However, the applicant states in Section 2.4.5.2.2.3 of the FSAR that the maximum rise observed as a result of a seiche was 6.3 ft. In **RAI 2.4.3-2** (ML092870355, dated January 29, 2010), the NRC staff requested that the applicant provide a rationale for choosing the 100-year surge as predicted by the USACE for flooding Alternative I rather than using the maximum recorded seiche at the site of 6.3 ft. The response included a calculation of flooding Alternative I using the maximum recorded seiche at the site. The flooding height was calculated to be 581.7 ft NAVD 88, which is lower than the flooding level of Alternative III. Thus, Alternative I, even with the maximum recorded seiche, would not produce the PMF.

For Alternative II, the applicant stated that a surge of 3.2 feet was assumed, based on the 33-year surge elevation as estimated by the USACE (2009). The staff verified the height of the surge by checking the applicant's reference. For Alternative III, the applicant stated that a surge of 10.3 feet was assumed, based on the calculation of probable maximum surge as discussed further below. However, upon review of the applicant's information submitted in Subsection 2.4.5 of the FSAR, a surge height plus wave action of 12.37 ft at the site was calculated by the applicant with the STWAVE model. This issue is discussed in greater detail in Subsection 2.4.5.

The verification of the Lake Erie elevation for each of the flooding alternatives is discussed below in Subsection 2.4.5. The verification of the calculation of the 100-year elevation of Lake Erie, the probable maximum surge and seiche, and the maximum observed surge elevation are discussed in Subsection 2.4.5, below.

The following table presents the staff's inputs and outputs of the HEC-RAS model.

Combined Events	**Input Parameters**		**Results**
Flood Scenario	**Flow in Swan Creek (cfs)**	**Calculated Lake Elevation (ft NAVD 88)**	**Resulting Fermi Flood Elevation (ft NAVD 88)**
Alternative I: • 500-yr flood in Swan Creek (5000 cfs) • Largest observed surge in Lake Erie (4.0 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	5,000	579.1	**579.1**
Alternative II: • PMF in Swan Creek (134,000 cfs) • 25-year surge in Lake Erie (3.2 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	134,000	578.3	**581.5**
Alternative III: • 25-year flood in Swan Creek (3100 cfs) • Probable maximum surge or seiche in Lake Erie (10.3 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	3,100	585.4	**585.4**

Sensitivity due to Snowmelt Alternative: • PMF in Swan Creek plus snowmelt runoff (199,000 ft) • Probable maximum surge and seiche in Lake Erie (10.3 ft) • 100-year elevation of Lake Erie (575.1 ft NAVD)	199,000	585.4	**586.3**

Table 2.4.3-4. The staff's inputs to HEC-RAS and resulting flood elevations at the Fermi Site.

The highest flood level calculated by the staff is 586.3 ft NAVD 88 and resulted from the PMF plus snowmelt on Swan Creek coincident with the probable maximum surge and seiche in Lake Erie. However, this alternative was performed as a sensitivity analysis to determine the impact of a snowpack at the site. The ANSI/ANS-2.8-1992 guidelines state that the three alternatives are adequate for determining the maximum water level at the site. The staff finds that the maximum water level resulting from flooding is 585.4 ft NAVD 88 in Alternative III, which is 0.1 ft below the applicant's maximum water level is acceptable.

Coincident Wind Wave Activity

Information submitted by the applicant

In Subsection 2.4.3.6 of the FSAR, the applicant calculated the potential for wind-wave activity occurring with flooding Alternative III in Subsection 2.4.5 of the FSAR. The applicant stated that the wave run-up resulting from the probable maximum windstorm winds on Lake Erie was calculated with the Automated Coastal Engineering System (ACES) model. In Subsection 2.4.5 of the FSAR, the applicant calculated the wave run-up estimated to occur on top of the probable maximum surge in Lake Erie of 585.4 ft NAVD 88. The applicant stated that the breaking wave was calculated to be 9.48 ft at the toe of the seawall and 2.23 ft on the toe of the Fermi 3 nuclear island/berm. If waves run up to the slope of berm, the highest run-up level was found to be 3.01 ft.

NRC Staff's Technical Evaluation

The staff reviewed the applicant's calculation of wave run-up presented in Subsection 2.4.5 of the FSAR. The staff requested additional information about the applicant's calculation of wave run-up in **RAI 2.4.5-3** (ML093280179, received November 20, 2009), which is discussed below in Section 2.4.5.

Using the values presented by the applicant, the staff calculated the maximum elevation that waves would break to be 587.7 ft NAVD 88 at the toe of the berm and run up to be 588.41 ft along the slope of the Fermi 3 nuclear island/berm, caused by a combination of the probable maximum surge, wind set-up, and wave run-up. These elevations are 1.4 ft and 0.9 ft below the elevation of the Fermi 3 safety structures, respectively.

Additionally, in **RAI 2.4.3-3** (ML092870355, dated January 29, 2010), the NRC staff requested that the applicant provide additional information on wind-wave activity coincident with a flood under Alternatives I and II. According to section of 9.2.3.2 of ANSI/ANS 2.8-1992, all alternatives need to be evaluated with wind-wave activity. The applicant calculated the wave runup for Alternative I be 0.4 ft below the top of the seawall at the edge of Lake Erie, but the wave runup on the Fermi 2 plant grade was not calculated. The applicant stated that there would be some water splashing up on the Fermi 2 plant grade, but the runup would be much lower than the height of the Fermi 3 safety structures. The wave runup for Alternative II was calculated by the applicant to be 3.6 ft above the top of the seawall, so at an elevation of 585.4 ft NAVD 88, which is 3.9 ft below the elevation of the Fermi 3 safety structures. The applicant did not address potential impacts from the wind wave activity on the slopes of the nuclear island. To address this, the NRC staff transmitted **RAI 2.4.2-5** (ML101320136, dated May 7, 2010) requesting that the applicant (1) evaluate potential erosion on the slopes of the nuclear island caused by wind wave activity and (2) describe the erosion protection measures that will be taken to prevent erosion on the slopes of the nuclear island. In the response to **RAI 2.4.2-5**, Detroit Edison provided an analysis of potential erosion on the slopes of the Fermi 3 nuclear island from wave run-up. The analysis showed that slopes would be protected from wave run-up velocities during the PMF event, using the slope protection methods discussed in the answer to **RAI 2.4.2-4** (grassed slopes or rip-rap with a D50 of 0.25 ft). The applicant estimated that velocities of run-up wave along the slope and breaking waves hitting the slope prior to breaking are approximately 3.4 ft per second and 3.7 ft per second, respectively. Both velocities are below the permissible velocities for the erosion protection methods discussed in **RAI 2.4.2-4**. As the applicant indicated, however, the wave action on the slope of the Fermi 3 nuclear island could provide additional forces that result in erosion. To ensure no damage or displacement of the rip-rap on the slopes, the applicant found that a D50 of 0.5 ft would need to be used. The staff finds this analysis to be conservative and acceptable.

For the reasons given above, the staff conclude that the identification and consideration of the PMF on streams and rivers at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79 and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

2.4.3.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.3.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.3 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-12-A as it relates to probable maximum floods.

As set forth above, the applicant has presented and substantiated information relative to the probable maximum flooding on streams and rivers important to the design and siting of this plant. The staff reviewed the available information provided. For the reasons given above, the

staff conclude that the identification and consideration of the probable maximum flooding on streams and rivers at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79 and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

The staff found that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs important to safety. The staff accepts the methodologies used to determine the probable maximum flooding on streams and rivers. Accordingly, the staff concludes that the use of these methodologies results in design bases containing a sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concluded that the identified design bases meet the requirements of 10 CFR 100.20(c) with respect to establishing the design basis for SSCs important to safety.

2.4.4 Potential Dam Failures

2.4.4.1 Introduction

The potential dam failures are addressed to ensure that any potential hazard to the safety-related facilities due to the failure of onsite, upstream, and downstream water control structures is considered in the plant design. The specific areas of review are as follows: (1) flood waves resulting from a dam breach or failure, including those due to hydrologic failure as a result of overtopping for any reason, routed to the site and the resulting highest water surface elevation that may result in the flooding of SSCs important to safety; (2) successive failures of several dams in the path to the plant site caused by the failure of an upstream dam due to plausible reasons, such as a PMF, landslide-induced severe flood, earthquakes, or volcanic activity and the effect of the highest water surface elevation at the site under the cascading failure conditions; (3) dynamic effects of dam failure-induced flood waves on SSCs important to safety; (4) failure of a dam downstream of the plant site that may affect the availability of a safety-related water supply to the plant; (5) effects of sediment deposition or erosion during dam failure-induced flood waves that may result in blockage or loss of function of SSCs important to safety; (6) failure of onsite water control or storage structures such as levees, dikes, and any engineered water storage facilities that are located above site grade and may induce flooding at the site; (7) the potential effects of seismic and nonseismicnon-seismic data on the postulated design bases and how they relate to dam failures in the vicinity of the site and the site region; and (8) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.4.2 Summary of Application

Subsection 2.4.4, “Potential Dam Failures,” of the Fermi 3 COL FSAR, Revision 4, addresses the needs for site specific information on potential dam failures. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-15-A Potential Dam Failures

  To address this COL item, the applicant stated that there were no known dams on adjacent water bodies that would impact the Fermi 3 Site.

2.4.4.3 Regulatory Basis

The applicable regulatory requirements for identifying site location and description are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.4:

- Flood Waves from Severe Breaching of an Upstream Dam: To meet the requirements of 10 CFR Part 100 and 10 CFR 100.23(d), estimates of the following characteristics are needed, and should be based on conservative assumptions of hydrometeorological, geological, and seismic characteristics in the drainage area: (a) modes of assumed dam breaches or failures, (b) consideration of flood control reservoirs at full pool level, and (c) conservatism of coincident flow rates and water surface elevations.

- Domino-Type or Cascading Dam Failures: To meet the requirements of 10 CFR Part 100 and 10 CFR 100.23(d), an appropriate configuration of the cascade of dam failures and its potential to produce the largest flood adjacent to the plant site is needed.

- Dynamic Effects on Structures: To meet the requirements of 10 CFR Part 100, an estimate of dynamic effects of flood waves, such as velocities and momentum fluxes, on SSC important to safety is needed.

- Loss of Water Supply Due to Failure of a Downstream Dam: To meet the requirements of 10 CFR Part 100 and 10 CFR 100.23(d), an assessment regarding loss of safety-related water supply to the plant caused by failure of a downstream dam is needed.

- Effects of Sediment Deposition and Erosion: To meet the requirements of 10 CFR Part 100 and 10 CFR 100.23(d), an assessment is needed regarding loss of functionality of safety-related water supply to the plant caused by blockages due to sediment deposition or erosion during the dam failure-induced flood event.

- Failure of Onsite Water Control or Storage Structures: To meet the requirements of 10 CFR Part 100, an assessment is needed regarding the failure of any onsite

water control or storage structures that may cause flooding of SSC important to safety.

- Consideration of Other Site-Related Evaluation Criteria: The potential effects of site-related proximity, seismic, and non-seismic information as they relate to flooding due to upstream dam failures and loss of safety-related water supply due to blockages and failures of downstream dam failures adjacent to and on the plant site and site regions are needed to meet the requirements of 10 CFR Part 100.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, as supplemented by best current practices, and RG 1.102.

2.4.4.4 Technical Evaluation

<u>COL Item</u>

- EF3 COL 2.0-15-A Potential Dam Failures

  To address this COL item, the applicant stated that there were no known dams on adjacent water bodies that would impact the Fermi 3 Site.

The staff reviewed FSAR Section 2.4.4, Potential Dam Failures. In Section 2.4.3.4 of the FSAR, the second paragraph states that "There are no dams existing within the Swan Creek watershed ..." In response to this statement, the NRC staff request the applicant to provide additional information on the justification for the statement regarding dams in the watershed through **RAI 2.4.4-1** (ML092790561, dated September 30, 2009). The RAI specified that the applicant should demonstrate that a reasonable search of records or applicable databases has been conducted to support its conclusion. In response to **RAI 2.4.4-1**, the applicant referenced the USACE National Inventory of Dams database. The staff checked the National Inventory of Dams on October 21, 2009 and verified that there are no dams within the Swan Creek Watershed (USACE, 2007). The staff verified that the information in the dam inventory and finds that there is no risk of flooding due to a potential dam failure. For the reasons given above, the staff concluded that the identification and consideration of the effects of dam failures at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79, 100.23(d), and 100.20(c).

2.4.4.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.4.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.4 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the

requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-15-A as it relates to potential dam failures.

As set forth above, the applicant has presented and substantiated information relative to the effects of dam failures important to the design and citing of this plant. The staff reviewed the available information provided. For the reasons given above, the staff concluded that the identification and consideration of the effects of dam failures at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79, 100.23(d), and 100.20(c).

The staff finds that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs important to safety. The staff accepted the methodologies used to determine the effects of dam failures reflected in the site characteristics. Accordingly, the staff concludes that the use of these methodologies results in design bases containing a sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concludes that the identified design bases meet the requirements of 10 CFR 100.23(d) and 10 CFR 100.20(c), with respect to establishing the design basis for SSCs important to safety.

2.4.5 Probable Maximum Surge and Seiche Flooding

2.4.5.1 Introduction

The probable maximum surge and seiche flooding are addressed to ensure that any potential hazard to the safety-related facilities due to the effects of probable maximum surge and seiche is considered in plant design. The specific areas of review are as follows: (1) probable maximum hurricane (PMH) that causes the probable maximum surge as it approaches the site along a critical path at an optimum rate of movement; (2) probable maximum wind storm (PMWS) from a hypothetical extratropical cyclone or a moving squall line that approaches the site along a critical path at an optimum rate of movement; (3) a seiche near the site, and the potential for seiche wave oscillations at the natural periodicity of a water body that may affect flood water surface elevations near the site or cause a low water surface elevation affecting safety-related water supplies; (4) wind-induced wave run-up under a PMH or PMWS winds; (5) effects of sediment erosion and deposition during a storm surge and seiche-induced waves that may result in blockage or loss of function of SSCs important to safety; (6) the potential effects of seismic and non-seismic information on the postulated design bases and how they relate to a surge and seiche in the vicinity of the site and the site region; (7) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.5.2 Summary of Application

Subsection 2.4.5 of the Fermi 3 COL FSAR, Revision 4, addresses probable maximum surge and seiche flooding. In addition, the applicant provides the following:

<u>*COL Item*</u>

- EF3 COL 2.0-16-A Probable Maximum Surge and Seiche Flooding

  The applicant discussed criteria of combined events that cause flood induced by probable maximum surge and seiche along the shore of the Lake Erie and

presented the determination of probable maximum meteorological winds and associated parameters.

The applicant provided historical data related to surges and seiches for the area of Lake Erie in the vicinity of the site and discussed the wind-generated wave activity that can occur independently or coincidentally with a surge or seiche.

The applicant discussed the possibility of oscillations of waves at natural periodicity, such as lake reflection and harbor resonance phenomena, and any resulting effects at the site.

The applicant discussed the location of, and design criteria for, any special facilities for the protection of intake, effluent, and other safety-related facilities against surges, seiches, and wave action.

2.4.5.3 Regulatory Basis

The applicable regulatory requirements for identifying probable maximum surge and seiche flooding are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).
- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves the site.
- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.5:

- Probable Maximum Hurricane: To meet the requirements of 10 CFR Part 100, estimates of the probable maximum hurricane and the probable maximum storm surge, i.e., the storm surge induced by the PMH, are needed.
- Probable Maximum Wind Storm: To meet the requirements of 10 CFR Part 100, estimates of the PMWS and the storm surge induced by the PMWS are needed.
- Seiche and Resonance: To meet the requirements of 10 CFR Part 100, estimates of seiche and resonance in water bodies induced by meteorological causes, tsunamis, and seismic causes are needed.
- Wave Run-up: To meet the requirements of 10 CFR Part 100, an estimate of wind-induced wave run-up under PMH or PMWS winds is needed.
- Effects of Sediment Erosion and Deposition: To meet the requirements of

10 CFR Part 100, an assessment of loss of functionality of safety-related water supply to the plant caused by blockages due to sediment deposition or erosion during the storm surge or seiche is needed.

- Consideration of Other Site-Related Evaluation Criteria: The potential effects of site-related proximity, seismic, and non-seismic information as they relate to flooding and loss of safety-related water supply due to surge and seiche adjacent to the plant site and site regions are needed to meet the requirements of 10 CFR Part 100.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, as supplemented by best current practices and RG 1.102.

2.4.5.4 Technical Evaluation

The staff reviewed Section 2.0 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 4, appropriately represents the complete scope of information relating to this review topic. The staff's review confirmed that the information contained in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 4, as follows:

<u>*COL Item*</u>

- EF3 COL 2.0-16-A Probable Maximum Surge and Seiche Flooding

  The analyses discussed in this section are based on ANSI/ANS-2.8-1992 (Reference 2.4-248). ANSI/ANS-2.8-1992, Section 9.2.3, describes the combined events criteria for an enclosed body of water, which is appropriate for analyzing postulated flooding at the Fermi 3 power reactor site due to wind and wave conditions in Lake Erie. Specifically, ANSI/ANS-2.8-1992, Section 9.2.3.1, states that the following combination of flood causing events provides an adequate design base for shore locations.

  1. Probable maximum surge and seiche with wind-wave activity.
  2. 100-year or maximum controlled level in water body, whichever is less.

Probable Maximum Winds and Associated Meteorological Parameters

In Subsection 2.4.5.1 of the FSAR, the applicant discussed meteorological winds and parameters for the probable maximum windstorm (PMWS). The applicant stated "According to Section 7.2.2 of ANSI/ANS-2.8-1992, for the area of the Great Lakes in the vicinity of the site, the probable maximum surge and seiche is calculated from the PMWS." The applicant implied that the other events, such as probable maximum hurricane (PMH) and moving squall line are not required for this area.

The applicant referenced Section 7.2.2.1 of ANSI/ANS-2.8-1992 to provide a set of parameters associated with PMWS in the area of Great Lakes as follows: (1) set maximum over-water wind speed at ~ 160 km/hr (100 mph); (2) set lowest pressure within the PMWS to ~950 mbar; (3)

apply a most critical, constant translational speed during the life of the PMWS; (4) assume that wind speeds over water vary diurnally from 1.3 (day) to 1.6 (night) times the overland speed; and (5) assume that winds blow 10 degrees across the isobars over the water body.

According to Section 7 of ANSI/ANS-2.8-1992, probable maximum winds and parameters should be presented with three metrological events, respectively: (1) PMH, (2) PMWS, and (3) moving squall line. NRC staff checked region of occurrence for each event as described in the Sections of 7.2.1.1, 7.2.2.1, and 7.2.3.1 of ANSI/ANS-2.8-1992. The staff verified that the Fermi 3 site area is beyond influence of PMH, which is within 200 miles from the U.S. coastline. The moving squall line in western Lake Erie, however, was not discussed by the applicant, even though it is significant in Lake Michigan. As **RAI 2.4.5-5** (ML092870355, dated November 20, 2009) NRC staff requested that the applicant provide an evaluation to justify or an analysis to demonstrate that the surge calculated for moving squall line does not result in the most severe flood condition in this area.

In response to **RAI 2.4.5-5** (ML092870355, dated November 20, 2009), applicant provided additional analysis based on several references listed in ANSI/ANS-2.8-1992 standards (Detroit Edison, 2010a). The main results from the previous studies are as follows:
(1) most of moving squall lines in the Great Lakes region move in a northwest to southwest direction, and (2) the highest storm surge induced by squall lines was predicted at South Haven along the Lake Michigan with propagation speed of 60 knots. Though the Fermi site is sheltered from the predominant direction of squalls in the region, a worst-case scenario was analyzed with assumptions of an 8-mbar pressure jump and a 65-knot speed. The maximum surge would be 5.6 ft under the worst-case scenario at Fermi site. The surge level induced by moving squall lines under the worst-case scenario is much smaller than the maximum surge height of 10.3 ft derived from analysis of storm surge induced by PMWS. Therefore the staff considers **RAI 2.4.5-5** closed.

According to Section 7.2.2.3.1 of ANSI/ANS-2.8-1992, the set of parameters used by the applicant are recommended for the Great Lakes region, in lieu of detailed meteorological study for the area. Therefore, it is acceptable for the applicant to use these parameters for surge calculation.

Surge and Seiche

Information submitted by the applicant,

In Subsection 2.4.5.2 of the FSAR the applicant discussed the determination of the maximum postulated still-water level at the site. It assumes a predicted storm surge developed on the Lake Erie 100-year lake level. As indicated in the Subsection of 2.4.3 of the FSAR, the applicant found that this probable maximum storm surge water level is a key element in flooding Alternative III, which determines the plant design elevation basis.

The applicant discussed the historical lake level data, their sources, and the method to establish the Lake Erie 100-year water level. The applicant concluded that the 100-year lake level is 5.64 ft above the chart datum (or low water datum) for Lake Erie. This lake level corresponds to 575.1 ft (175.3 m) NAVD 88.

The applicant indicated that the surge analysis was guided by USACE's Coastal Engineering Manual (CEM). A method developed by Bretschneider (1966) was used by the applicant for wave setup to generate storm surge. The Bretschneider method assumes wind setup in a

rectangular basin of constant depth with a non-exposed bottom and a perimeter wall. The applicant did not discuss in details how to apply this method to derive storm surge level in the Lake Erie.

As a part of **RAI 2.4.1-1** (ML100830380, dated July 29, 2009), the staff requested additional data packages that support the applicant's calculations. In response to **RAI 2.4.1-1**, the applicant provided data packages including wave calculations. The calculation file consisted of bathymetric data evaluation, tables for calculating stresses and surge height using the Bretschneider method, and input/output files for the STWAVE model and the ACES model. The derivation and selection of parameters, however, was not discussed for the Bretschneider equation, especially the key parameters fetch length and water depth.

In Subsection 2.4.5.2 of the FSAR regarding surge analysis, the applicant mainly described STWAVE, a numerical model requiring input of bathymetric soundings for Lake Erie and discussed a general model setup for wind wave generation. The results of STWAVE model, however, were not used for surge prediction in this section but in the following section regarding wave run-up (2.4.5.3).

The applicant discussed the bathymetric data for Lake Erie and described its sources and input format for the STWAVE model. However, the bathymetric data were also not used for the surge prediction discussed in Subsection 2.4.5.2 of the FSAR.

The applicant concluded that the maximum probable storm surge (10.3 ft) predicted by the Bretschneider method developed on the 100-year lake level (575.1 ft NAVD 88) defines the maximum postulated still-water level on Lake Erie (585.4 ft NAVD 88).

The applicant discussed the historical records of seiche in Lake Erie and identified maximum recorded rise was 1.9 m (6.3 ft) and the maximum recorded fall was 2.7 m (8.9 ft) for the period of 1941-1981. The applicant concluded that the level of the rise due to seiche is significantly less than the calculated surge height.

NRC Staff's Technical Evaluation

NRC staff verified the approach to determine the maximum postulated still-water level at the site area boundary by combining the storm surge with antecedent water level (Lake Erie 100-year lake level), according to the Subsection 2.4.5 of the SRP and Section 7 of ANSI/ANS-2.8-1992.

The staff verified the applicant's calculation of the 100-year Lake Erie water elevation. The staff independently checked the calculation of the average lake elevation from the 13 gaging stations on Lake Erie for each hourly interval. The staff then used the Log Pearson Type III distribution to calculate the 100-year lake elevation. The staff calculated a value of 574.7 ft NAVD 88 for the 100-year Lake Erie water elevation. This value is lower than the value calculated by the applicant of 575.1 ft NAVD 88, making the applicant's assumption more conservative. Therefore, the staff finds the applicants value to be acceptable, and **RAI 2.4.1-1** is closed.

In the FSAR Subsection of 2.4.5.2, the applicant presented a result of 10.3 ft estimated for the probable maximum surge for Lake Erie using the Bretschneider method. The applicant, however, did not provide any discussion on the method, assumptions, parameter selection, and derivation in this section. Instead, the applicant mainly discussed the STWAVE model, which was not used by the applicant for predicting probable maximum surge and its elevation but was used to calculated wave action in the following section (2.4.5.3). According to the Section 7.3 of

ANSI/ANS-2.8-1992, any “method used for surge or seiche level determination should be addressed.” In **RAI 2.4.5-6** (ML092870355, dated January 29, 2010) NRC staff requested that the applicant provide: (1) descriptions of the assumptions of the Bretschneider method used for calculating wind setup under the PMWS, (2) rationale of choosing the Bretschneider method as a conservative approach to predict the probable maximum surge for Lake Erie compared to other commonly used methods, (3) details of the derivation of the key parameters of fetch length and water depth used in the Bretschneider method, and (4) a copy of the reference.

In response to **RAI 2.4.5-6** (ML092870355, dated January 29, 2010), the applicant provided detailed descriptions on the Bretschneider method and its application to calculate the surge under the PMWS condition. Two other methods, Zeider Zee and Sibul methods, were reviewed by the applicant. The applicant indicates that Zeider Zee method was mainly developed for a long and narrow water body at a depth deeper than Lake Erie and Sibul method predicts less surge height. To improve its application of the Bretschneider method, the applicant incorporated variation of lake depth by segmenting the lake along its length. The staff verified the information in the RAI response by performing confirmatory calcluations. Based on the information provided in the response and a literature review, the staff finds the Bretschneider method is conservative and acceptable for the surge calculation.

In applying the Bretschneider method, the key parameters that affect storm surge are the fetch length, water depth, and coefficients under the PMWS condition. The fetch length was estimated by the longest straight line from the Fermi 3 site across Lake Erie to the east coast of the lake. The staff verified its distance of 154,781 m along the straight line. Lake Erie is divided evenly by 10 segments to account for variations of the lake depth, and the average depth for each segment was used for the calculation. The coefficients used for the Bretschneider equation are derived by the Corps of Engineers based on studies conducted at Lake Okeechobee. These coefficients are applicable because they were derived from a lake with similar characteristics. Therefore, the results are acceptable and **RAI 2.4.5-6** is closed.

The applicant discussed the calculation of surge smaller than the probable maximum surge in FSAR Section 2.4.3.3 for calculation of the flooding alternatives. For Alternative I, the applicant stated that a surge of 4.0 feet was assumed. The applicant used the 100-year recurrence interval surge of 4.0 ft for the month of December to estimate the “surge and seiche resulting from the worst regional hurricane or windstorm” as required by ANSI/ANS-2.8-1992. The staff verified the height of the surge by checking the value on the USACE website that the applicant referenced (USACE, 2009). However, the applicant states in Section 2.4.5.2.2.3 of the FSAR that the maximum rise observed as a result of a seiche was 6.3 ft. Therefore, in **RAI 2.4.3-2** (ML092870355, dated January 29, 2010), the staff requested that the applicant provide a rationale for choosing the 100-year surge as predicted by the USACE rather than using the maximum recorded seiche for flooding Alternative I. The response included a calculation of flooding Alternative I using the maximum recorded seiche at the site. The flooding height was calculated to be 581.7 ft NAVD 88, which is lower than the flooding level of Alternative III. Thus, Alternative I, even with the maximum recorded seiche, would not produce the PMF. For Alternative II, the applicant stated that a surge of 3.2 feet was assumed, based on the 33-year surge elevation as estimated by the USACE (2009). The staff verified the height of the surge by checking the applicant’s reference.

The staff verified the bathymetric data for Lake Erie submitted by the applicant to be accurate and that it was converted to a format and used in the STWAVE model appropriately.This information is used by the staff and the applicant to model parameters in the FSAR Subsection of 2.4.5.3.

Staff reviewed the historical data seiche in Lake Erie and confirmed its effect is less than impact of surge under PMWS in the site area. The staff concluded that the information was accurate and applicable to the site.

Wave Action

Information submitted by the applicant

In Subsection 2.4.5.3 of the FSAR, the applicant discussed the wave action from the PMWS winds including wind-induced wave (surge) and wave run-up. The applicant used a two dimensional, steady-state finite-difference model STWAVE to determine the wind-induce wave and its characteristics (wave height and period) at a selected point, which is located at the beginning of the nearshore. As the wave moves across the shore profile, the wave run-up was calculated by using the ACES model to predict the highest wave run-up and overtopping rates on an impermeable structure. The breaking waves and their heights were also predicted by using the ACES model at the points along the shore profile. The applicant states that the calculation assumes the maximum water level combining 100-year lake level and increased wave height due to surge and seiche.

In the wave calculation submitted by the applicant as a part of the response to **RAI 2.4.1-1** (ML100830380, dated July 29, 2009), the applicant discussed the model setup for STWAVE, which included three input files specifying bathymetric grid data, wind parameters, peak frequency, water level correction, incident wave spectrum, and observation points. In the model simulation, Lake Erie is considered as an enclosed water body. A zero incident wave spectrum was assigned to the shoreline. A constant wind speed and direction were assigned to each simulation. The applicant performed 15 simulations with various wind directions from -42^{o} to 42^{o} where 0^{o} is a wind pointed directly to the west toward the site. The model output file presents the parameters of the generated wave at selected 197 observation points. The applicant states that "Several points that were closest to the shore were examined to determine the highest waves generated." Based on the selected point that was located about 61 m (200 ft) from shore at a depth of 1 m (3.3 ft) chart datum, the highest waves were 3.77 m (12.37 ft) high with a peak spectral period of 11.1 seconds.

For wave run-up on an impermeable embankment, the applicant's analysis is based on general assumptions as follows: (1) waves are monochromatic, normally incident to the structure, and unbroken in the vicinity of the structure toe; (2) waves are specified at the structure location; (3) all structure types are considered to be impermeable; (4) for sloped structures the crest of the structure must be above the still-water level; (5) for vertical and composite structures, partial and complete submersion for the structure is considered; (6) run-up estimates on sloped structures require the assumption of infinite structure height and a simple plane slope; and (7) the expressions for the transmission by overtopping use the actual finite structure height.

The applicant presented the ACES model inputs including wave type, breaking criteria, wave height, wave period, structure slope, structure height, slope type, and roughness coefficient. The model outputs from the ACES model were presented. The applicant's simulations using the ACES model provided the following results: (1) a 0.49 ft wave increase when the generated wave moves through the nearshore area, and (2) the non-breaking wave at the toe of the berm can generate a wave run-up on the slope to a height of 3.0 ft, and overtopping rate of 0.16 ft^2/s.

For the breaking waves across the shore profile, the maximum wave height was calculated by the modified 1951 Miche criterion. The applicant presented results showing that the height of the breaking wave is 2.89 m (9.47 ft) at seawall and 0.68 m (2.23 ft) at the berm. However, the FSAR Table 2.4-224 shows inconsistent values for wave height in meters and feet.

Based on the results above, the applicant concluded that the wave run-up and breaking wave could not directly impact Fermi 3.

NRC Staff's Technical Evaluation

NRC staff reviewed the approaches, methodology, and selected models and formulas used by the applicant for simulating wave set up, transmission, run-up, and break across the defined shore profile.

Staff reviewed the input files for the STWAVE model and independently ran all simulations using the given input files and examined all output files, including the wave parameters at 197 locations. Results for wave heights at 197 locations range from 0 m to 5.16 m (16.93 ft). However, the applicant indicated that the wave height predicted by STWAVE at the selected point (200 ft from the shore) is 3.77 m (12.37 ft). In order to clarify the difference between staff and applicant calculated wave heights, the staff requested, in **RAI 2.4.5-3** (ML093280179, dated November 20, 2009), that the applicant provide a plan-view figure detailing the spatially distributed results of the STWAVE simulation from which the storm surge height of 3.77 m (12.37 ft) was derived and to note the locations of Fermi 3 and the point/model cell chosen to determine the storm surge height presented in the response. The response to **RAI 2.4.5-3** (ML093280179, dated November 20, 2009) was reviewed by the staff. This information did not provide all necessary details so the staff requested that the applicant provide a map showing the distribution of the wave height overlain on the contours of the bathymetric map. **RAI 2.4.5-7** (DTE response letter [ML092870355] dated January 29, 2010). This information provided additional insite to review the surges generated by the STWAVE model and examine the relationship between water depth and wave height.

In the responses to **RAI 2.4.5-3** and **RAI 2.4.5-7**, the staff verified the results derived by the applicant by modeling the entire area of Lake Erie using the model grid of 100 m using STWAVE. The resulting distribution of wave heights is shown in Figure 2.4.5-1.

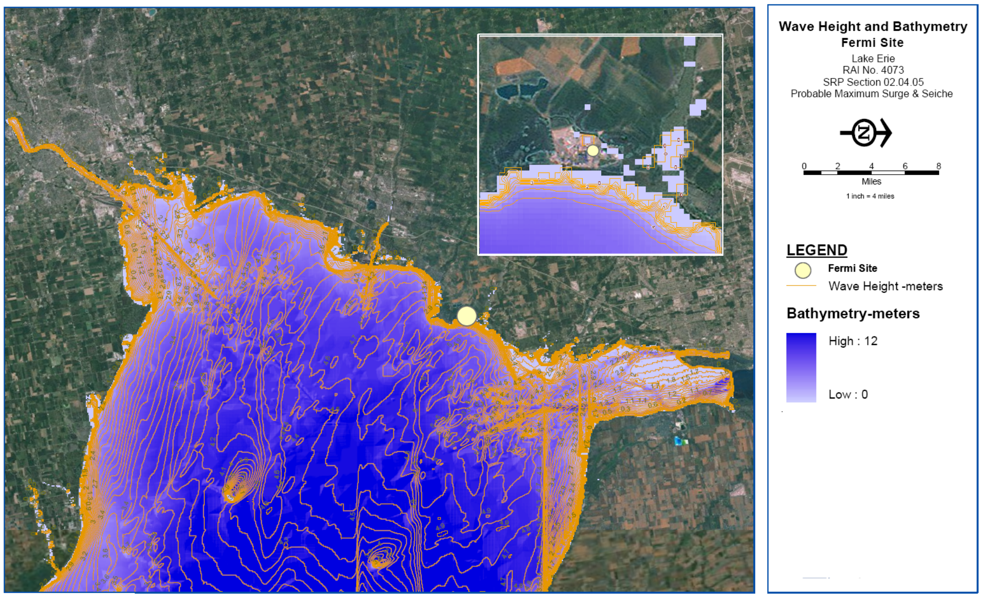


Figure 2.4.5-1. Wave height and Bathymetry of the western Lake Erie derived by STWAVE.

The STWAVE data points near the Fermi 3 are shown in Figure 2.4.5-2. The wave periods at all these points are 11.1 seconds. The wave height at the point near Fermi 3 is 3.7 m. The wave parameters selected by the applicant using STWAVE are conservative based on the staff's independent verification using additional data received in RAI responses. These parameters, including wave period and distribution of wave height, were used for further calculation of wave action across the shore.

Figure 2.4.5-2. STWAVE data points near Fermi 3.

NRC staff reviewed all of the inputs for simulations using the ACES model and equations 4 and 5 presented in Section 2.4.5.3.2 of the FSAR. To better examine the results, the staff summarized all elevations and the derived depths across the shore profile as shown in Table 2.4.5-1 below.

Shore Profile	**Elevation (ft)**		**100-year Lake Level (ft, NAVD 88)**	**Surge Height (ft)**	**Probable Maximum Surge Water Level (ft, NAVD 88)**	**Water Depth (ft)**	**Breaking Wave (ft)**	**Wave Run-up (ft)**
	Plant Grade Datum	**NAVD 88**						
STWAVE Point	567.4	566.2	575.1	10.3	585.4	19.2	--	--
Nearshore	567.4-570.7	566.2-569.5	575.1	10.3	585.4	19.2 – 15.9	--	--
Chart Datum (low water datum)	570.7	569.5	575.1	10.3	585.4	15.9	--	--
Seawall	570.7-583	569.5-581.8	575.1	10.3	585.4	15.9 – 3.65	9.47	--
Onshore / Fermi 2 Plant Grade	583 (flat)	581.8 (flat)	575.1	10.3	585.4	3.65	2.23	--
Berm/ Fermi 3 Plant Grade	583/590.5	581.8/589.3	575.1	10.3	585.4	3.65 / (3.9 below grade)	2.23	3.01

Table 2.4.5-1. Summary of elevations, water depths, and breaking wave/run-up across the shore profile.

In summary, the applicant used the STWAVE model to perform wave set-up, which is developed on a maximum still lake level combining the 100-year lake level and probable surge level derived by the Bretschneider method. The results of STWAVE were used to estimate wave breaking and run-up. According to Chapter 4 of the Coastal Engineering Manual, the wave breaking and run-up mainly depended on the total water depth, which is sum of wave set-up

and still water depth. The applicant, however, did not provide a discussion on the change in total water depth due to the wave set-up across the shore. So, the staff requested that the applicant use graphs to illustrate the shore profile (from an STWAVE point to the Fermi 3 safety structures), wave characteristics across the shore (maximum still water level, wave length, wave height, breaking wave, run-up, etc.), their relationship, and quantitative information that supports conclusion of no impact to Fermi 3 safety structures. **RAI 2.4.5-8** (ML092870355, dated January 29, 2010) was issued to the applicant.

In response to **RAI 2.4.5-8** (ML092870355, dated January 29, 2010), the applicant provided the information regarding the cross section from the STWAVE point to the Fermi 3 safety structures and the calculated the wave characteristics across the shore (Figure 2.4.5-3). The staff verified that all information is correct by checking the cross section data to that information used in the model. The shore profile data were used in the model input for the calculation of the breaking wave and wave run-up.

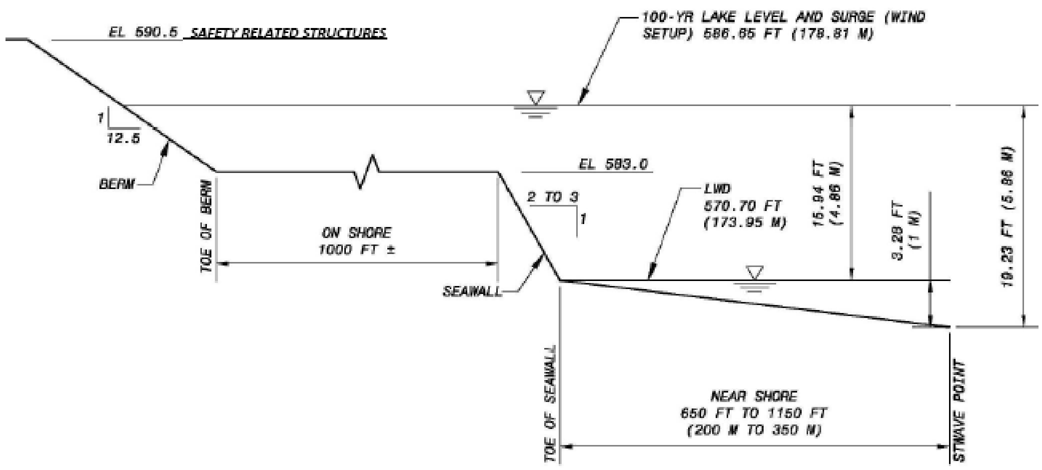


Figure 2.4.5-3. Cross Section from the STWAVE point to the Fermi 3 safety-related structure.

The breaking wave was calculated using the ACES model at two points: the toe of seawall at a water depth of 15.9 ft and the toe of the berm at a depth of 3.65 ft. The wave characteristics were predicted by the model as shown in Figure 2.4.5-4, assuming a constant wave period as incoming wave at 11.1 second. The staff confirms that this assumption is conservative because a possible decreasing period of waves through the shore profile would result in a smaller wave length and height. In response to **RAI 2.4.5-8** (ML092870355, dated January 29, 2010), the applicant also corrected wave heights in the Table 2.4.224. Based on a breaking wave calculated at the toe of the berm, the breaking wave developed on the probable maximum surge (585.4 ft NAVD 88) resulted in a water level of 587.6 ft NAVD 88, which is 1.7 ft below the nominal Fermi 3 plant grade of safety-related structures (589.3 ft NAVD 88). Thus, no breaking waves would impact safety-related structures.

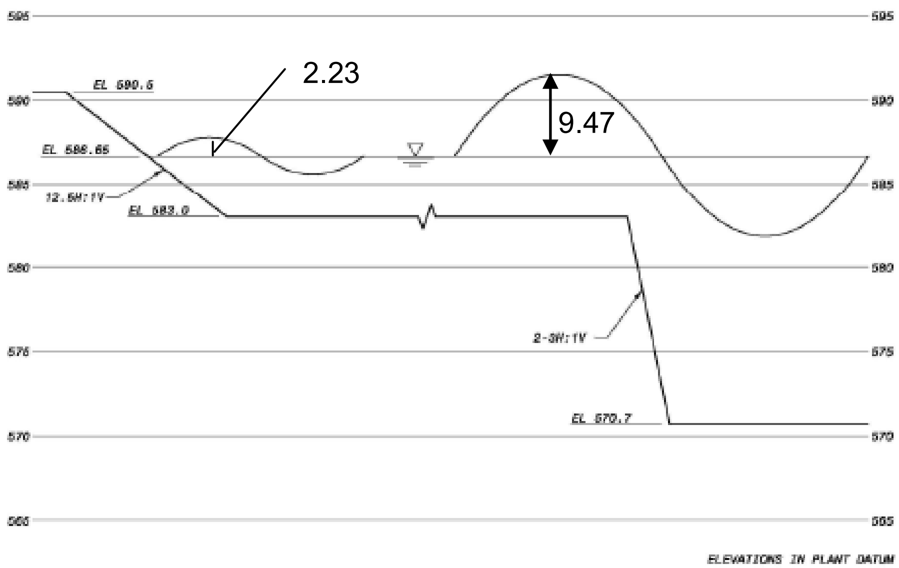


Figure 2.4.5-4. Characteristics of breaking waves at the toes of the seawall and berm (vertical exaggeration, ~10:1; Elevation in Plant Datum).

The wave run-up was also calculated by the applicant using the ACES model to estimate the potential wave run-up developed on the slope of berm. The result of 3.01 ft of wave run-up is verified by the staff by independently running the model and comparing results. The potential highest level of wave run-up would be 588.41 ft (NAVD 88) based on the wave run-up developed on the probable maximum surge (585.4 ft NAVD 88). The highest level of the wave run-up is 0.9 ft below the nominal Fermi 3 plant grade of safety-related structures (589.3 ft NAVD 88). In response to **RAI 2.4.5-8** (ML092870355, dated January 29, 2010), the applicant showed wave characteristics of the potentially highest wave run-up on the shore cross section, demonstrating that no water would wash on to the nuclear island impacting the safety-related structures. The staff finds the conclusion acceptable because it meets the requirements of 10 CFR Part 100, 10 CFR 100.23(d), and 52.79(a)(1)(iii).

To ensure all information on methods, assumptions, and calculations is included the FSAR related to DTE responses to **RAI 2.4.5-5**, **RAI 2.4.5-6**, **RAI 2.4.5-7**, and **RAI 2.4.5-8**, the staff requested an update to the relevant sections in the FSAR. The staff reviewed DTE responses and finds the correction and updates to the FSAR to be acceptable because they meet the requirements of 10 CFR Part 100, 10 CFR 100.23(d), and 52.79(a)(1)(iii).

Resonance

Information submitted by the applicant

In Subsection 2.4.5.4 of the FSAR, the applicant states that the Fermi site's location next to the open water of Lake Erie "results in a natural period of oscillation of the flooded area that is much greater than that of the incident shallow-water storm waves. Consequently, resonance is not a problem at the site during PMWS occurrence."

NRC Staff's Technical Evaluation

NRC staff reviewed this section and finds that the resonance in the enclosed water bodies induced by meteorological causes, tsunamis, and seismic causes were not well addressed. In **RAI 2.4.5-4** (ML093280179, dated November 20, 2009), the staff requested that the applicant provide the quantitative basis and methodology for determining the natural period of oscillation of the flooded area and the incident shallow-water storm waves.

In response to **RAI 2.4.5-4**, the applicant estimated the first six modes of oscillation, which range from 29 to 124 seconds. The peak spectral period of the incoming waves is 11.1 seconds near Fermi 3, derived from the STWAVE model for the Lake Erie. The period of the incoming wave is much less than the period of oscillation. The staff verified the applicant's conclusion that resonance is not a problem at the site during PMWS occurrence.

Sedimentation and Erosion

Information submitted by the applicant

In Subsection 2.4.5.5, the applicant states that "Fermi 3 does not rely on Lake Erie for a safety-related water source. Therefore, the loss of functionality of a safety-related water supply to Fermi 3 caused by blockages due to sediment deposition or erosion during a storm surge or seiche event is not a concern."

NRC Staff's Technical Evaluation

The NRC staff finds that sedimentation and erosion are not problems at the site because safety related water would not be impacted and therefore the requirements of 10 CFR Part 100, 10 CFR 100.23(d), and 52.79(a)(1)(iii) are met.

Protective Structures

Information submitted by the applicant

On the basis of the wave run-up analysis presented in Subsection 2.4.5.6 of the FSAR, the applicant concluded that the waves under PMWS will not overtop the berm to adversely impact Fermi 3. Therefore, additional structures are not needed.

NRC Staff's Technical Evaluation

After NRC staff reviewed the section and subsequent RAIs (**RAI 2.4.5-3**, **RAI 2.4.5-6**, **RAI 2.4.5-7** , **RAI 2.4.5-8**, and **RAI 2.4.5-10**), the wave run-up analysis was verified and found to be acceptable. As discussed in 2.4.5.3, the potential wave run-up (3.01 ft) developed on the probable maximum surge (585.4 ft NAVD 88) could result in a run-up level of 588.41 ft NAVD 88, which is 0.9 ft below the elevation of the safety structures. The waves under PMWS, therefore, would not overtop the berm and adversely impact Fermi 3.

For the reasons given above, the staff concludes that the identification and consideration of the probable maximum storm surge and its wave actions at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79(a)(31) and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

2.4.5.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.5.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.5 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-16-A as it relates to probable maximum surge and seiche flooding.

As set forth above, the applicant has presented and substantiated information relative to the probable maximum storm surge and its wave actions important to the design and siting of this plant. The staff reviewed the available information provided. For the reasons given above, the staff conclude that the identification and consideration of the probable maximum storm surge and its wave actions at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79(a)(31) and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

The staff finds that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs important to safety. The staff accepts the methodologies used to determine the probable maximum storm surge and its wave actions. Accordingly, the staff concludes that the use of these methodologies results in design bases containing a sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concluded that the identified design bases meet the requirements of 10 CFR 100.20(c) with respect to establishing the design basis for SSCs important to safety.

2.4.6 Probable Maximum Tsunami Hazards

2.4.6.1 Introduction

The probable maximum tsunami (PMT) hazards are addressed to ensure that any potential tsunami hazards to the SSCs important to safety are considered in plant design. The specific areas of review are as follows: (1) historical tsunami data, including paleo tsunami mappings and interpretations, regional records and eyewitness reports, and more recently available tide gauge and real-time bottom pressure gauge data; (2) PMT that may pose hazards to the site; (3) tsunami wave propagation models and model parameters used to simulate the tsunami wave propagation from the source toward the site; (4) extent and duration of wave run-up during the inundation phase of the PMT event; (5) static and dynamic force metrics including the inundation and drawdown depths, current speed, acceleration, inertial component, and momentum flux that quantify the forces on any safety-related SSCs that may be exposed to the tsunami waves; (6) debris and water-borne projectiles that accompany tsunami currents and may impact safety-related SSCs; (7) effects of sediment erosion and deposition caused by tsunami waves that may result in blockage or loss of function of safety-related SSCs;

(8) potential effects of seismic and non-seismic information on the postulated design bases and how they relate to tsunami in the vicinity of the site and the site region; (9) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.6.2 Summary of Application

Subsection 2.4.6 of the Fermi 3 COL FSAR, Revision 4, addresses PMT hazards. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-17-A Probable Maximum Tsunami Hazards

  To address this COL item, the applicant stated that there is no tsunami hazard in the vicinity of the Fermi 3 site.

2.4.6.3 Regulatory Basis

The applicable regulatory requirements for identifying PMT hazards are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding areas and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.6:

- Historical Tsunami Data: The application should provide a complete description of historical tsunami data near the proposed plant site.

- Probable Maximum Tsunami: The application should provide an assessment of the PMT for the proposed site.

- Tsunami Propagation Models: The application should provide a description of the tsunami wave propagation models used in the applicant's SAR.

- Wave Runup, Inundation, and Drawdown: The application should provide the extents and durations of inundation and drawdown near the proposed site.

- Hydrostatic and Hydrodynamic Forces. The application should provide a set of metrics that describes the hydrostatic and hydrodynamic forces caused by the PMT on the safety-related SSC.

- Debris and Water-Borne Projectiles. The application should provide an assessment of the debris and water-borne projectiles that may accompany PMT currents.

- Effects of Sediment Erosion and Deposition. The application should provide an assessment of the effects of sediment erosion and deposition near the proposed locations of safety-related SSC.

- Consideration of Other Site-Related Evaluation Criteria. The application should provide an evaluation of the potential effects of site-related proximity, seismic, and non-seismic information as they affect tsunamis near the plant site and site regions.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, “as supplemented by best current practices, and 1.102.

2.4.6.4 Technical Evaluation

COL Item

- EF3 COL 2.0-17-A Probable Maximum Tsunami Hazards

  To address this COL item, the applicant stated that there is no tsunami hazard in the vicinity of the Fermi 3 site.

Information submitted by the applicant

The applicant states that “Based on the history of the area, local seismic disturbances would result only in minor excitations in the lake. No tsunami has been recorded in Lake Erie; the only remotely similar phenomena observed have been low-amplitude seiches resulting from sudden barometric pressure differences.” The applicant concluded that there are no potential tsunamis or tsunami-like waves which could affect safety-related structures or components at Fermi 3.

NRC Staff’s Technical Evaluation

To verify applicant’s conclusion, the NRC staff searched tsunami database (National Geophysical Data Center, NOAA) and found two historical events: one in the northern end of Lake Erie and the other near the Detroit River. The staff requested that the applicant conduct a thorough search for historical tsunamis in the area providing an evaluation to support the applicant's conclusion. **RAI 2.4.6-1**, as issued to the applicant, requested this information.

In response to **RAI 2.4.6-1** (ML100330612, dated January 29, 2010), the applicant provided additional information regarding historic records in the area, indicating that the recorded historical events were only minor disturbances or seiches and no actual tsunamis are evident. The applicant's review of historic data is complete and accurate, and the response is deemed acceptable because it meets the requirements of 10 CFR Part 100, 10 CFR 100.23(d), and 10 CFR 52.79(a)(1)(iii).

2.4.6.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.6.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.6 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-17-A as it relates to probable maximum tsunami hazards.

As set forth above, the applicant has presented and substantiated information relative to PMT important to the design and siting of this plant. The staff reviewed the available information provided. For the reasons given above, the staff conclude that the identification and consideration of the tsunamis at the site and in the surrounding area are acceptable and meet the requirements of 10 CFR 52.79(a)(31) and 10 CFR 100.20(c), with respect to determining the acceptability of the site for the ESBWR design.

The staff finds that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs important to safety. The staff accepts the methodologies used to determine the presence of tsunami. Accordingly, the staff concludes that the use of these methodologies results in design bases containing a sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concluded that the identified design bases meet the requirements of 10 CFR 100.20(c) with respect to establishing the design basis for SSCs important to safety.

2.4.7 Ice Effects

The emergency cooling system for Fermi 3 is provided by the UHS which does not rely on water sources external to the plant and is not affected by ice conditions.

2.4.7.1 Introduction

The ice effects are addressed to ensure that safety-related facilities and water supply are not affected by ice-induced hazards. The specific areas of review are as follows: (1) regional history and types of historical ice accumulations (i.e., ice jams, wind-driven ice ridges, floes, frazil ice formation, etc.); (2) potential effects of ice-induced, high- or low-flow levels on safety-related facilities and water supplies; (3) potential effects of a surface ice-sheet to reduce the volume of available liquid water in safety-related water reservoirs; (4) potential effects of ice to

produce forces on, or cause blockage of, safety-related facilities; (5) potential effects of seismic and non-seismic data on the postulated worst-case icing scenario for the proposed plant site; (6) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.7.2 Summary of Application

Subsection 2.4.7 of the Fermi 3 COL FSAR, Revision 4, addresses ice effects. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-18-A Ice Effects

  To address this COL item, the applicant stated that there are no expected ice effects to safety-related facilities at the site of Fermi 3.

2.4.7.3 Regulatory Basis

The applicable regulatory requirements for identifying ice effects are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).
- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.7:

- Historical Ice Accumulation: The application should include a complete history of ice formation at and in the vicinity of the site.
- High and Low Water Levels: The application should include estimates of water levels resulting from potential ice flooding or low flows.
- Ice Sheet Formation: The application should include estimates of the most severe ice sheet formation in water storage reservoirs.
- Ice-induced Forces and Blockages: The application should provide estimates of the most severe ice-induced forces on safety-related SSC.
- Consideration of Other Site-Related Evaluation Criteria: The application should demonstrate that the potential effects of site-related proximity, seismic, and non-seismic information as they relate to worst-case icing scenarios adjacent to and on the plant site and site regions are appropriately take into account.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, as supplemented by best current practices, and 1.102.

2.4.7.4 Technical Evaluation

COL Item

- EF3 COL 2.0-18-A Ice Effects

  To address this COL item, the applicant stated that there are no expected ice effects to safety-related facilities at the site of Fermi 3.

No discussion was presented on ice effects in the FSAR. The staff submitted **RAI 2.4.3-1** asking for information to support the conclusion that there would be no impacts to Fermi 3 safety-related features due to ice effects. In the response to **RAI 2.4.3-1** (ML092790561, dated September 30, 2009), the applicant cited checking the USACE ice jam database for historical occurrences of ice jams on Swan Creek. The applicant found no historic ice jams on Swan Creek in the ice jam database. Also, in the response to **RAI 2.4.9-1**, the applicant stated that no ice jams were observed on Swan Creek over the period from 1957 to the present, during which time the applicant managed the Fermi site.

To verify the applicant's response, the staff performed a search of the USACE ice jam database and found no evidence of an historical ice jam on Swan Creek (USACE, 2010). However, in the description of the ice jam database, the USACE stated that the historical records of ice jams are primarily limited to waterways that have USGS gaging stations (USACE, 2010). There have never been continuously recording USGS gaging stations on Swan Creek, so the likelihood of an historical ice jam being recorded on Swan Creek is low. However, the applicant stated that there have been no ice jams on Swan Creek since 1957. The gaging station on the River Raisin to the south has recorded several ice jams since that time, and records of this flooding are found both on the ice jam database and in local media sources. No personal accounts or media accounts of flooding in Swan Creek due to ice jams were found. Therefore, the staff finds that the applicant's answer is acceptable in that ice jams are not likely to contribute to flooding in Swan Creek.

2.4.7.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.7.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.7 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-18-A as it relates ice effects.

As set forth above, the applicant has presented and substantiated information relative to the ice effects important to the design and citing of this plant. The staff has reviewed the available information provided and, for the reasons given above, concludes that the identification and consideration of the potential for ice flooding, ice blockage of water intakes, ice forces on structures, and the minimum low water levels (from upstream ice blockage) are acceptable and meet the requirements of 10 CFR 52.79(a)(1)(iii) and 10 CFR 100.20(c), with respect to determining the acceptability of the site.

The staff finds that the applicant has considered the appropriate site phenomena for establishing the design bases for SSCs important to safety. The staff has generally accepted the methodologies used to determine the potential for ice formation and blockage reflected in these site characteristics. Accordingly, the staff concludes that the use of these methodologies results in site characteristics containing margin sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated.

2.4.8 Cooling Water Canals and Reservoirs

2.4.8.1 Introduction

The cooling water canals and reservoirs used to transport and impound water supplied to the SSCs important to safety are reviewed to verify their hydraulic design basis. The specific areas of review are as follows: (1) design bases postulated and used by the applicant to protect structures such as riprap, inasmuch as they apply to safety-related water supply; (2) design bases of canals pertaining to capacity, protection against wind waves, erosion, sedimentation, and freeboard and the ability to withstand a PMF (surges, etc.), inasmuch as they apply to a safety-related water supply; (3) design bases of reservoirs pertaining to capacity, PMF design basis, wind wave and run-up protection, discharge facilities (e.g., low-level outlet, spillways, etc.), outlet protection, freeboard, and erosion and sedimentation processes inasmuch as they apply to a safety-related water supply; (4) potential effects of seismic and non-seismic information on the postulated hydraulic design bases of canals and reservoirs for the proposed plant site; and (5) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.8.2 Summary of Application

Subsection 2.4.8 of the Fermi 3 COL FSAR, Revision 4, addresses the use of cooling water canals and reservoirs. In addition, the applicant provides the following:

<u>COL Item</u>

- EF3 COL 2.0-19-A Cooling Water Canals and Reservoirs

  To address this COL item, the applicant describes in the FSAR that no cooling water canals or reservoirs are used for safety related features by Fermi 3. The staff confirmed that Fermi 3 does not use cooling water canals or reservoirs for plant safety.

2.4.8.3 Regulatory Basis

The applicable regulatory requirements for evaluating cooling water canals and reservoirs are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.8:

- Hydraulic Design Bases for Protection of Structures: To meet the requirements of 10 CFR Part 100, a complete description of the hydraulic design bases for protection of structures is needed.

- Hydraulic Design Bases of Canals: To meet the requirements of 10 CFR Part 100, a complete description of the hydraulic design bases related to the capacity, protection against wind waves, erosion, sedimentation, and freeboard, and the ability to withstand a PMF, surges, etc., is needed.

- Hydraulic Design Bases of Reservoirs: To meet the requirements of 10 CFR Part 100, a complete description of the design bases of safety-related reservoirs related to their capacity, PMF design basis, wind wave and run-up protection, discharge facilities (e.g., low-level outlet, spillways, etc.), outlet protection, freeboard, and erosion and sedimentation processes is needed.

- Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR Part 100, a complete description of the potential effects of site-related proximity, seismic, and non-seismic information on the postulated design bases of safety-related canals and reservoirs is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, as supplemented by best current practices, RG 1.102, and RG 1.125, “Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants.”

2.4.8.4 Technical Evaluation

<u>*COL Items*</u>

- EF3 COL 2.0-19-A

Cooling Water Canals and Reservoirs to address this COL item, the applicant describes in the FSAR that no cooling water canals or reservoirs are used for safety related features by Fermi 3. The staff confirmed that Fermi 3 does not use cooling water canals or reservoirs for plant safety.

NRC staff reviewed Subsection 2.4.8 of the Fermi 3 COL FSAR. The staff confirmed that the information in the application addresses the relevant information related to this subsection is sufficient and appropriate.

The applicant describes in the FSAR that no cooling water canals or reservoirs are used for safety-related features by Fermi 3. The staff confirmed that Fermi 3 does not use cooling water canals or reservoirs for plant safety.

The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the design bases of canals and reservoirs is acceptable and meets the requirements of 10 CFR 100.20(c), with respect to determining the acceptability of the site.

2.4.8.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.8.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.8 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-19-A as it cooling water canals and reservoirs.

As set forth above, the applicant has presented and substantiated information relative to the design bases of canals and reservoirs important to the design and citing of this plant. The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the design bases of canals and reservoirs is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iii), 10 CFR 100.20(c), and 10 CFR 100.23(d), with respect to determining the acceptability of the site.

2.4.9 Channel Diversions

No safety-related systems, structures, or components are impacted. The water supply for Fermi 3 is not obtained from channels; therefore, this subsection is not applicable from a water supply perspective.

2.4.9.1 Introduction

Plant and essential water supplies used to transport and impound water supplies were evaluated to ensure that they will not be adversely affected by stream or channel diversions. The review includes stream channel diversions away from the site (which may lead to a loss of safety-related water) and stream channel diversions toward the site (which may lead to flooding). In addition, in such an event, the applicant needs to show that alternate water supplies are available to safety-related equipment. The specific areas of review are as follows: (1) historical channel migration phenomena including cutoffs, subsidence, and uplift; (2) regional

topographic evidence that suggests a future channel diversion may or may not occur (used in conjunction with evidence of historical diversions); (3) thermal causes of channel diversion, such as ice jams, which may result from downstream ice blockages that may lead to flooding from backwater or upstream ice blockages that can divert the flow of water away from the intake; (4) potential for forces on safety-related facilities or the blockage of water supplies resulting from channel migration-induced flooding (flooding not addressed by hydrometeorological-induced flooding scenarios in other sections); (5) potential of channel diversion from human-induced causes (i.e., land-use changes, diking, channelization, armoring, or failure of structures); (6) alternate water sources and operating procedures; (7) potential effects of seismic and non-seismic information on the postulated worst-case channel diversion scenario for the proposed plant site; (8) any additional information requirement prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.9.2 Summary of Application

Subsection 2.4.9 of the Fermi 3 COL FSAR, Revision 4, addresses channel diversions. In addition, the applicant provides the following:

COL Items

- EF3 COL 2.0-20-A Channel Diversions

  To address this COL item, the applicant stated that there is no potential for upstream diversion or rerouting of the source of cooling water with respect to seismic, topographical, geologic, and thermal evidence in the region. Fermi 3 does not rely on channels for water supply, so this section is not applicable.

2.4.9.3 Regulatory Basis

The applicable regulatory requirements for reviewing channel diversions are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.9:

- Historical Channel Diversions: To meet the requirements of 10 CFR Part 100, a complete history of channel diversions at and in the vicinity of the site is needed.

- Regional Topographic Evidence: To meet the requirements of 10 CFR Part 100, a description of regional topographic evidence as it relates to channel diversions is needed.

- Ice Causes: To meet the requirements of 10 CFR Part 100, estimates of the most severe ice-induced channel diversion are needed.

- Flooding of Site Due to Channel Diversions: To meet the requirements of 10 CFR Part 100, estimates of the most severe channel diversion induced forces on SSC important to safety are needed.

- Human-Induced Causes of Channel Diversion: To meet the requirements of 10 CFR Part 100, an assessment of the potential for human-induced channel diversions, in the vicinity of the site (e.g., land-use changes, diking, channelization, armoring or failure of such structures) is needed.

- Alternate Water Sources: To meet the requirements of 10 CFR Part 100, assessments of alternate water sources and operating procedures are needed.

- Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR Part 100, a description of the potential effects of site-related proximity, seismic, and non-seismic information on the postulated worst-case channel diversion scenario for the proposed plant site is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27, 1.29, 1.59, and 1.102.

2.4.9.4 Technical Evaluation

COL Item

- EF3 COL 2.0-20-A Channel Diversions

  To address this COL item, the applicant stated that there is no potential for upstream diversion or rerouting of the source of cooling water with respect to seismic, topographical, geologic, and thermal evidence in the region. Fermi 3 does not rely on channels for water supply, so this section is not applicable.

The NRC staff reviewed the information submitted by the applicant related to potential channel diversions at the Fermi 3 site.

In the FSAR, the applicant stated that this section is not applicable to Fermi 3, as Fermi 3 does not rely on channels for water supply. The staff submitted **RAI 2.4.9-1** requesting information supporting the conclusion that a diversion along Swan Creek from an ice jam, a landslide, or another mechanism is unlikely. In the response to **RAI 2.4.9-1** (ML092790561, dated September 30, 2009), the applicant provided a discussion supporting the conclusion that a diversion along Swan Creek is unlikely. The applicant stated that the geology and topography of the Swan Creek watershed are not conducive to large scale landslides that could cause a channel diversion. First, the applicant described the geology as being a sequence of bedrock overlain by glacial till deposits overlain by lacustrine deposits. Then the applicant stated that the deposits increase in strength with depth and that the topography of the watershed is not steep,

making the chances of a large area landslide caused by a failing lower layer small. The applicant stated that the banks of Swan Creek do experience small failures, but they would not be of large enough size to divert Swan Creek. Then the applicant referred to FSAR Section 2.4.7 and the response to **RAI 2.4.3-1** (ML092790561, dated September 30, 2009) to support the conclusion that it is unlikely that an ice jam would occur on Swan Creek and cause a diversion. The applicant also stated that no manmade or natural diversions were observed over the period from 1957 to the present, during which time the applicant managed the Fermi site. The staff found the applicant's response acceptable.

2.4.9.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.9.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.9 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-20-A as it relates to channel diversions.

As set forth above, the applicant has presented and substantiated information relative to the channel diversion effects important to the design and citing of this plant. The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the potential for channel diversion is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iii), 10 CFR 100.20(c), and 10 CFR 100.23(d), with respect to determining the acceptability of the site.

2.4.10 Flooding Protection Requirements

2.4.10.1 Introduction

The flooding protection requirements address the locations and elevations of safety-related facilities and those of structures and components required for protection of safety-related facilities. These requirements are then compared with design-basis flood conditions to determine whether flood effects need to be considered in the plant's design or in emergency procedures. The specific areas of review are as follows: (1) safety-related facilities exposed to flooding; (2) type of flood protection (e.g., "hardened facilities," sandbags, flood doors, bulkheads, etc.) provided to the SSCs exposed to floods; (3) emergency procedures needed to implement flood protection activities and warning times available for their implementation reviewed by the organization responsible for reviewing issues related to plant emergency procedures; (4) potential effects of seismic and non-seismic information on the postulated flooding protection for the proposed plant site; and (5) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.10.2 Summary of Application

Subsection 2.4.10 of the Fermi 3 COL FSAR, Revision 4, addresses the site specific information on flooding protection requirements. In addition, the applicant provides the following:

<u>COL Item</u>

- EF3 COL 2.0-21-A Flooding Protection Requirements

  To address this COL item, the applicant stated that the safety-related features of the Fermi 3 plant are designed to be above the probable maximum flood elevation and thus no flooding protection is required.

2.4.10.3 Regulatory Basis

The applicable regulatory requirements for reviewing the applicant's discussion of flooding protection requirements are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Subsection 2.4.10:

- Safety-related Facilities Exposed to Flooding: To meet the requirements of 10 CFR Part 100, identification of all SSC exposed to flooding is needed.

- Type of Flood Protection: To meet the requirements of 10 CFR Part 100, an evaluation of the applicant's proposed flood protection measures is needed.

- Emergency Procedures: To meet the requirements of 10 CFR Part 100, a listing of proposed emergency procedures is needed.

- Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR Part 100, an assessment regarding the potential effects of site-related proximity, seismic, and non-seismic information on the postulated flooding protection is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.29, 1.59, as supplemented by best current practices, and RG 1.102.

2.4.10.4 Technical Evaluation

COL Item

- EF3 COL 2.0-21-A Flooding Protection Requirements

  To address this COL item, the applicant stated that the safety-related features of the Fermi 3 plant are designed to be above the probable maximum flood elevation and thus no flooding protection is required.

NRC staff reviewed Subsection 2.4.10 of the Fermi 3 COL FSAR. The elevation of the design plant grade for Unit 3 is 589.3 ft NAVD 88. NRC staff confirms that this elevation is 3.9 ft above the maximum flood level at the site determined by Alternative III, which is the worst scenario among Alternatives I, II, and III specified by the ANSI/ANS-2.8-1992 guidelines. The Alternative III includes 25-year flood in Swan Creek, probable maximum surge and seiche in Lake Erie, and 100-year elevation of Lake Erie. The staff verified analysis of wave actions caused by the probable maximum storm surge developed on the 100-year lake level and finds that the highest levels of wave breaking and run-up are below the design plant grade.

2.4.10.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.10.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.10 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-21-A as it relates to flooding protection requirements.

As set forth above, the applicant has presented and substantiated information relative to the flood protection measures important to the design and siting of this plant. The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the flood protection measures is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iii), 100.20(c), and 100.23(d), with respect to determining the acceptability of the site.

2.4.11 Low Water Considerations

2.4.11.1 Introduction

The low water considerations address natural events that may reduce or limit the available safety-related cooling water supply. The applicant ensures that an adequate water supply will exist to shut down the plant under conditions requiring safety-related cooling. The specific areas of review are as follows: (1) worst drought considered reasonably possible in the region; (2) effects of low water surface elevations caused by various hydrometeorological events and a

potential blockage of intakes by sediment, debris, littoral drift, and ice because they can affect the safety-related water supply; (3) effects on the intake structure and pump design bases in relation to the events described in FSAR Subsections 2.4.7, 2.4.8, 2.4.9, and 2.4.11, which consider the range of water supply required by the plant (including minimum operating and shutdown flows during anticipated operational occurrences and emergency conditions) compared with availability (considering the capability of the UHS to provide adequate cooling water under conditions requiring safety-related cooling); (4) use limitations imposed or under discussion by Federal, State, or local agencies authorizing the use of the water; (5) potential effects of seismic and non-seismic information on the postulated worst-case low water scenario for the proposed plant site; and (6) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.11.2 Summary of Application

Subsection 2.4.11 of the Fermi 3 COL FSAR, Revision 4, addresses the impacts of low water on water supply. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-22-A Low Water Considerations

  To address this COL item, the applicant described that the no external water sources are relied upon for operation of the UHS, therefore low water levels in Lake Erie and Swan Creek are not critical to the operation safety related features of Fermi 3.

2.4.11.3 Regulatory Basis

The applicable regulatory requirements for low water considerations are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Section 2.4.11:

- Low Water from Drought: To meet the requirements of 10 CFR Part 100, a complete history of low water conditions at and in the vicinity of the site is needed.

- Low Water from Other Phenomena: To meet the requirements of 10 CFR Part 100, a complete history of low water conditions, caused by phenomena other than a drought, at and in the vicinity of the site is needed.

- Effect of Low Water on Safety-Related Water Supply: To meet the requirements of 10 CFR Part 100, a thorough description of all safety-related water supply requirements and the effects of the most severe low water event reasonably possible at or in the vicinity of the site is needed.

- Water Use Limits: To meet the requirements of 10 CFR Part 100, a thorough description of water use and discharge limitations (both physical and legal), already in effect or under discussion by responsible Federal, regional, State, or local authorities, that may affect water supply at the plant that have been considered and are substantiated by reference to reports of the appropriate agencies is needed.

- Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR Part 100, the applicant should provide an assessment of the potential effects of site-related proximity, seismic, and non-seismic information on the postulated worst-case low-flow scenario for the proposed plant site.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.27 and 1.29.

2.4.11.4 Technical Evaluation

COL Item

- EF3 COL 2.0-22-A Low Water Considerations

  To address this COL item, the applicant described that the no external water sources are relied upon for operation of the UHS, therefore low water levels in Lake Erie and Swan Creek are not critical to the operation safety related features of Fermi 3.

NRC staff reviewed Subsection 2.4.11 of the Fermi 3 COL FSAR. The applicant stated that no external water sources are used for safety-related cooling of Fermi 3. Low water elevations in Lake Erie or Swan Creek pose no safety-related risk to Fermi 3.

The applicant stated that Lake Erie provides the make-up cooling water for Fermi 3. The lowest recorded water level at the Fermi gage was 563.9 ft NAVD 88. The invert elevation of the pump suction at the water intake for the Fermi 2 plant is at 553.3 ft NAVD 88, which is 10 feet below the lowest recorded elevation of Lake Erie at the Fermi gage. The applicant then stated that low lake levels would not impact pump suction, due to the depth at which the pump suction occurs.

NRC staff reviewed the lake level data at the Fermi gage submitted by the applicant in response to **RAI 2.4.5-1** (ML092790561, dated September 30, 2009). The staff confirmed that the lowest water elevation at the Fermi gage was 563.9 ft NAVD 88. The staff therefore finds the applicant has addressed low water considerations at Fermi 3 because low water level elevation will not impact safety-related functions.

The staff's review confirmed that the information in the application addresses the relevant information related to this subsection.

2.4.11.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.11.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.11 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-22-A as it relates to low water considerations.

As set forth above, the applicant has presented and substantiated information relative to the low water effects important to the design and siting of this plant. The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the potential for low water conditions is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iii), 10 CFR 100.20(c), and 10 CFR 100.23(d), with respect to determining the acceptability of the site.

2.4.12 Groundwater

2.4.12.1 Introduction

The groundwater description includes the hydrogeological characteristics of the site, and the evaluation includes the effects of groundwater on plant foundations and the reliability of safety-related water supply and dewatering systems. The specific areas of review are as follows: (1) identification of the aquifers, types of onsite groundwater use, sources of recharge, present withdrawals and known and likely future withdrawals, flow rates, travel time, gradients (and other properties that affect the movement of accidental contaminants in groundwater), groundwater levels beneath the site, seasonal and climatic fluctuations, monitoring and protection requirements, and manmade changes that have the potential to cause long-term changes in local groundwater regime; (2) effects of groundwater levels and other hydrodynamic effects of groundwater on design bases of plant foundations and other SSCs important to safety; (3) reliability of groundwater resources and related systems used to supply safety-related water to the plant; (4) reliability of dewatering systems to maintain groundwater conditions within the plant's design bases; (5) potential effects of seismic and non-seismic information on the postulated worst-case groundwater conditions for the proposed plant site; and (6) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.12.2 Summary of Application

Subsection 2.4.12 of the Fermi 3 COL FSAR, Revision 4, addresses the groundwater in terms of impacts on structures and water supply. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-23-A Groundwater

  To address this COL item, the applicant described the regional and local ground water aquifers, formations, sources, and sinks. The Fermi site does not use groundwater for any purposes, and Fermi 3 does not require a dewatering system.

The applicant described the present and projected future regional water use, relying on reports and databases of the USGS, the USEPA, and the State of Michigan. The applicant provided discussion and illustrations of water levels and flow directions both regionally (bedrock aquifer) and on site (bedrock and overburden aquifers).

2.4.12.3 Regulatory Basis

The applicable regulatory requirements for groundwater are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Section 2.4.12:

- Local and Regional Groundwater Characteristics and Use: To meet the requirements of 10 CFR 50.55a, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), a complete description of regional and local groundwater aquifers, sources, and sinks, local and regional groundwater use, present and known and likely future withdrawals, regional flow rates, travel time, gradients, and velocities, subsurface properties that affect movement of contaminants in the groundwater, groundwater levels including their seasonal and climatic fluctuations, groundwater monitoring and protection requirements, and any man-made changes with a potential to affect regional groundwater characteristics over a long period of time is needed.

- Effects on Plant Foundations and other Safety-Related Structures, Systems, and Components: To meet the requirements of 10 CFR 50.55a, 100.20(c)(3), 100.23(d), and 100.20(c), a complete description of the effects of groundwater levels and other hydrodynamic effects on the design bases of plant foundations and other SSC important to safety is needed.

- Reliability of Groundwater Resources and Systems Used for Safety-Related Purposes: To meet the requirements of 10 CFR 50.55a, 100.20(c)(3), 100.23(d), and 100.20(c), a complete description of all SSC important to safety that depend on groundwater is needed.

- Reliability of Dewatering Systems: To meet the requirements of 10 CFR 50.55a, 100.20(c)(3), 100.23(d), and 100.20(c), a complete description of the site dewatering system, including its reliability to maintain the groundwater conditions within the groundwater design bases of SSC important to safety is needed.

- Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR 50.55a, 100.20(c)(3), 100.23(d), and 100.20(c), the applicant's assessment of the potential effects of site-related proximity, seismic, and non-seismic information on the postulated worst-case scenario related to groundwater effects for the proposed plant site is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from RG 1.27.

2.4.12.4 Technical Evaluation

NRC staff reviewed Subsection 2.4.12 of the Fermi 3 COL FSAR and participated in site visits. The staff's review confirmed that the information contained in the application and incorporated by reference addresses the relevant information related to this subsection.

COL Item

- EF3 COL 2.0-23-A Groundwater

  To address this COL item, the applicant described the regional and local ground water aquifers, formations, sources, and sinks. The Fermi site does not use groundwater for any purposes, and Fermi 3 does not require a dewatering system.

The applicant described the present and projected future regional water use, relying on reports and databases of the USGS, the USEPA, and the State of Michigan. The applicant provided discussion and illustrations of water levels and flow directions both regionally (bedrock aquifer) and on site (bedrock and overburden aquifers).

Description and Onsite Use

Information submitted by the applicant

The applicant described the hydrogeologic setting based on USGS reports pertinent to the site location and on their own site subsurface investigation. This study included 28 additional monitoring wells installed in the unconsolidated materials and the bedrock. The unconsolidated materials comprise rock fill, lacustrine deposits of peaty silt and clay, and two clayey glacial till units. The uppermost bedrock is the dolomitic Bass Islands Group aquifer (Bass Islands Dolomite).

Fermi 3 does not use groundwater, as the plant obtains potable water from Frenchtown Township, which has an intake in Lake Erie. Following the construction phase, no permanent dewatering system is needed at Fermi 3.

NRC Staff's Technical Evaluation

NRC staff reviewed the information provided in the FSAR and determined it to be complete in terms of description of local and regional hydrogeology and its description of the lack of onsite groundwater use.

Sources

Information submitted by the applicant

The applicant described present groundwater use in the region, including quarry dewatering, private wells, community water systems, non-community systems, and a municipal system. The locations of these users are presented. Irrigation is mentioned but no details are included. Groundwater flow directions in the overburden and the Bass Islands Dolomite are illustrated in a series of maps. These maps and discussion included a change in flow directions in the Bass Islands Dolomite from pre-development flow to the east (toward Lake Erie) to varied flow directions due to the effects of quarry dewatering in Monroe County. The distribution of hydraulic conductivity values in the overburden and bedrock aquifers was illustrated and qualified in terms of heterogeneities. Hydraulic conductivity measured by slug tests ranged from 9.9e-6 to 5.8e-3 cm/s (0.028 to 16.5 ft/d) for quaternary deposits, 1.3e-5 to 1.6e-5 cm/s (0.036 to 0.046 ft/d) for clay fill, and 0.089 to 0.63 cm/s (251 to 1,776 ft/d) for rock fill. Hydraulic conductivity of the bedrock measured by packer tests ranged from 5.3e-5 to 1.4e-2 (0.15 to 40.07 ft/d).

In a response to **RAI 2.4.13-6** (ML092470230, dated September 1, 2009), the applicant provided information on the porosity of the bedrock based on independent regional reports. MRCSP (2007) described the porosity of the Bass Island Dolomite. Dunning et al. (2004) analyzed groundwater flow in a Midwestern carbonate aquifer with similar porosity, and determined an effective porosity of 1 percent. On the basis of the information sources, and to be conservative in the calculations, the applicant initially selected an effective porosity of 1 percent. However, in a later response to **RAI 2.4.13-11** and **RAI 2.4.13-12** (ML102940218, dated October 19, 2010), the applicant provided a summary of a revised determination of site-specific bedrock porosity based on a method relying on hydraulic conductivity and Rock Quality Designation data. The low end of the range of values, 0.1 percent, was selected for the effective porosity value. This value was used in calculations in revised text in the FSAR and in Environmental Repert Section 2.3.1.2.3.2.

The Bass Islands Dolomite is part of an important regional bedrock aquifer system in the Midwest. No sole source aquifer systems are located in the region of the Fermi site. The nearest sole source aquifer is located in Catawba Island, Ohio, over 48 km (30 miles) southeast of the Fermi property. At that location, a portion of the Bass Islands Group aquifer is identified as a sole source aquifer.

NRC Staff's Technical Evaluation

NRC staff reviewed the FSAR material, RAI response information, and regional reports, and finds the material to be acceptable. The revised, lower value for effective porosity increases the calculated groundwater velocity in the bedrock, thereby increasing the conservatism of subsequent analyses.

Subsurface Pathways

Information submitted by the applicant

The applicant described groundwater flowpaths in the overburden materials, groundwater – surface water interactions, and the flowpaths in the Bass Islands Dolomite. Regional data from the USGS representing pre-development groundwater conditions and recent conditions impacted by quarry operations were presented, along with site-specific measurements for the overburden and the bedrock aquifer.

The applicant presented estimates of the groundwater velocities under present conditions in both the rock fill overburden and the Bass Islands Dolomite aquifer in the FSAR, with additional information on the assumed starting point for groundwater movement provided in the response to **RAI 2.4.12-1** (ML092790561, dated September 30, 2009). For the bedrock, groundwater velocities were revised on the basis of a decreased effective porosity value, as explained in the response to **RAI 2.4.13-11** and **RAI 2.4.13-12** (ML102940218, dated October 19, 2010). The applicant used Darcy's law to determine the average linear velocity of 0.996 m/day (3.27 ft/day) in the overburden based on a hydraulic conductivity of 357 m/day (1,170 ft/day), a gradient of 0.0007, and a porosity of 25 percent. Travel time from the center of the RB to the overflow canal, a distance of 250 m (820 ft), was estimated to be 250 days. For the Bass Islands Dolomite aquifer, the applicant calculated flow rates and travel times based on assumed high and low hydraulic conductivity values along with a gradient of 0.002 and an effective porosity of 0.1 percent. Calculations pertained to the 1450 m (4760 ft) distance from the center of the RB to the offsite well west of the site. For the high hydraulic conductivity case of 5.4 m/d (17.6 ft/d), the velocity is 11 m/d (35 ft/d) or a time of travel of 0.37 years. For the low hydraulic conductivity case of 0.034 m/d (0.11 m/d), the velocity is 0.06 m/d (0.2 ft/d) or a time of travel of 65 years.

The applicant also submitted a calculation of the groundwater velocity in the Bass Islands Dolomite aquifer assuming a pre-development condition with groundwater flowing eastward towards Lake Erie. This represents conditions that could occur if high-rate pumping from quarries west of the site were stopped. Using the hydraulic parameters described above, but with a gradient of 0.001, the applicant calculated a maximum groundwater velocity of 5 m/day (17.6 ft/day). Travel time from the center to the RB to the edge of Lake Erie was then calculated to be a minimum of 0.23 years.

NRC Staff's Technical Evaluation

NRC staff reviewed the available data. The flowpaths in the overburden are complex due to the arrangement of low-permeability muck sediments and glacial tills with high-permeability rock fill. The dolomitic Bass Islands Group aquifer has localized complexities due to stratigraphic variation and fracturing. Water levels at pairs of shallow and bedrock monitoring wells generally indicate downward flow from the overburden to the Bass Islands Dolomite. Several forms of field observations (water level comparisons between paired shallow and deep wells, heat pulse

analyses in selected wells) suggest continued downward flow within the Bass Islands Dolomite and into the underlying Salina Group. Lateral flow in the overburden at the site is generally toward the canals and Lake Erie. Because of large-scale dewatering pumping at quarries west of the site, regional flow in the Bass Islands Dolomite in Monroe County has changed from pre-development eastward flow toward Lake Erie to a more complex flow pattern with locally varying flow directions. Bedrock aquifer flow at the Fermi site has a complex pattern of flow mostly to the south and west.

To clarify the applicant's discussion of pathways for potential radioactive contaminants, the staff submitted **RAI 2.4.12-1** to obtain information on the assumed release point. The staff reviewed the applicant's response to **RAI 2.4.12-1** (ML102940218, dated September 30, 2009), in which the applicant removed all references to "release" and reframed the discussion to examine groundwater velocity and pathways, without reference to contaminant transport. The staff verified that the equations are appropriate to determine groundwater velocity. The staff verified the gradients used in the applicant's calculation of groundwater velocity by checking the submitted groundwater gradient maps.

Groundwater Monitoring

Information submitted by the applicant

The applicant described a network of monitoring wells and piezometers, including 18 overburden wells and 13 bedrock wells. Water levels were measured monthly from June 2007 to May 2008. The FSAR presents four quarterly maps for the overburden, and four for the bedrock, to depict seasonal variations in water levels and flow directions.

NRC Staff's Technical Evaluation

NRC staff reviewed the monitoring well network and determined that it is generally suitable for water level measurements to assess changes in water levels and flow directions due to offsite (e.g. quarry operations) and onsite (e.g. temporary excavation dewatering) impacts. In the future, it would be generally suitable for groundwater quality monitoring, though it may need to be augmented with additional wells depending on the placement of Fermi 3 facilities, and because certain wells may need to be abandoned because of construction activities. The staff finds the applicant's information acceptable based on the existing spatial distribution of the monitoring network and the monitoring data and information provided.

Design Basis for Subsurface Hydrostatic Loadings

Information submitted by the applicant

The applicant described the DCD's requirement of a (maximum) groundwater level to be at least 0.6 m (2 ft) below the Fermi 3 plant grade, which is at an elevation of 179.5 m (588.8 ft) NAVD 88. The historical high groundwater level in any well under non-flood conditions was 175.6 m (576.11 ft) NAVD 88 at MW-7, which is 3.9 m (12.7 ft) below the planned Fermi 3 grade. The applicant further described the PMF elevation of 178.4 m (585.4 ft) NAVD 88, which is relevant to the discussion because high-permeability rock fill may allow onsite groundwater levels to reach the PMF level. This flood elevation is 1.1 m (3.4 ft) below the planned Fermi 3 plant grade. Seismic events are not anticipated to affect groundwater conditions.

NRC Staff's Technical Evaluation

The staff concludes that the identified design bases meet the requirements of 10 CFR 50.55a, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), with respect to establishing the design basis for SSCs important to safety. This addresses EF3 COL 2.0-23-A. In conclusion, the applicant has provided sufficient information on water elevation with respect to plant grade to satisfy corresponding requirements of 10 CFR 52.79(a)(1)(iii), 100.20(c), and 100.23(d).

2.4.12.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.12.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.12 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-23-A as it relates to groundwater.

As set forth above, the applicant has presented and substantiated information relative to the groundwater effects important to the design and siting of this plant. The staff has reviewed the available information provided and, for the reasons given above, concludes that the identification and consideration of the potential effects of groundwater in the vicinity of the site are acceptable and meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), with respect to determining the acceptability of the site.

2.4.13 Accidental Release of Radioactive Liquid Effluent in Groundwater and Surface Waters

2.4.13.1 Introduction

This section considers the potential effects of relatively large accidental releases from systems that handle liquid effluents generated during normal plant operations. Such releases would have relatively low levels of radioactivity, but could be large in volume. Normal and accidental releases are also considered in the applicant's environmental report.

The accidental release of radioactive liquid effluents in ground and surface waters is evaluated based on the hydrogeological characteristics of the site that govern existing uses of groundwater and surface water and their known and likely future uses. The source term from a postulated accidental release is reviewed under SRP 11.2 following the guidance in Branch Technical Position (BTP) 11-6, "Postulated Radioactive Releases Due to Liquid-Containing Tank Failures." The source term is determined from a postulated release from a single tank inside the RWB, but outside of the reactor containment structure.

The specific areas of review are (1) alternate conceptual models of the hydrology at the site that reasonably bound hydrogeological conditions at the site inasmuch as these conditions affect the transport of radioactive liquid effluent in the ground and surface water environment;
(2) bounding set of plausible surface and subsurface pathways from potential points of an accidental release to determine the critical pathways that may result in the most severe impact on existing uses and known and likely future uses of ground and surface water resources in the vicinity of the site; (3) ability of the groundwater and surface water environments to delay, disperse, dilute, or concentrate accidentally released radioactive liquid effluent during its transport; (4) assessment of scenarios wherein an accidental release of radioactive effluents is combined with potential effects of seismic and non-seismic events (e.g., assessing effects of hydraulic structures located upstream and downstream of the plant in the event of structural or operational failures and the ensuing sudden changes in the regime of flow); and (5) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.13.2 Summary of Application

Subsection 2.4.13 of the Fermi 3 COL FSAR, Revision 4, addresses the accidental release of radioactive liquid effluents in ground and surface waters. In addition, the applicant provides the following:

COL Item

- EF3 COL 2.0-24-A Accidental Releases of Liquid Effluents in Ground and Surface Waters

  The applicant described the ability of the ground and surface water environment to delay, disperse, dilute, or concentrate liquid effluents, as related to existing or potential future water users.

2.4.13.3 Regulatory Basis

The applicable regulatory requirements for evaluating accidental release of radioactive liquid effluents in groundwater and surface waters are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are summarized from SRP Section 2.4.13:

- Alternate Conceptual Models: Alternate conceptual models of hydrology in the vicinity of the site are reviewed.

- Pathways: The bounding set of plausible surface and subsurface pathways from the points of release are reviewed.

- Characteristics that Affect Transport: Radionuclide transport characteristics of the groundwater environment with respect to existing and known and likely future users should be described.

- Consideration of Other Site-Related Evaluation Criteria: The applicant's assessment of the potential effects of site-proximity hazards, seismic, and non-seismic events on the radioactive concentration from the postulated tank failure related to accidental release of radioactive liquid effluents to ground and surface waters for the proposed plant site is needed.

- Branch Technical Position BTP 11-6 provides guidance in assessing a potential release of radioactive liquids following the postulated failure of a tank and its components, located outside of containment, and impacts of the release of radioactive materials at the nearest potable water supply, located in an unrestricted area, for direct human consumption or indirectly through animals, crops, and food processing.

In addition, the hydrologic characteristics should be consistent with appropriate sections from RG 1.113, "Estimating Aquatic Dispersions of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I."

2.4.13.4 Technical Evaluation

NRC staff reviewed the resolution to the COL specific items related to the accidental release of radioactive liquid effluents in ground and surface waters included under Section 2.4.13 of the EF3 COL application. The staff's review confirmed that the information in the application addresses the relevant information related to this subsection.

COL Item

- EF3 COL 2.0-24-A Accidental Releases of Liquid Effluents in Ground and Surface Waters

  The applicant described the ability of the ground and surface water environment to delay, disperse, dilute, or concentrate liquid effluents, as related to existing or potential future water users.

Sources and Mitigating Design Features

A liquid radioactive waste tank is assumed to be the source of release to groundwater, as analyzed in the following section. The applicant assessed the scenario of the rupture of an equipment drain collection tank, with the liquid reaching groundwater. Three of these tanks are located below ground level in the RWB, which is designed to seismic requirements as specified in DCD Table 3.2-1. Compartments containing the liquid radwaste tanks are steel lined to a height capable of containing the release of all liquid radwaste. Releases as a result of major

cracks in the tanks would result in the release of the liquid radwaste to the compartment and then to the building sump system for containment in other tanks or emergency tanks.

The applicant states that the release scenario is conservative because of the steel liner and seismic design described above, plus it ignores the basemat concrete barrier and assumes failure of the floor drain system.

The only above-grade tank containing radioactivity outside of the containment is the condensate storage tank. The basin surrounding this outdoor tank is sized to contain the total tank capacity, a design intended to prevent uncontrolled runoff in the event of a tank failure and to collect tank overflow. A sump located inside the retention basin has provisions for sampling collected liquids before routing them to the liquid waste management system or the storm sewer per sampling and release requirements.

Because the key potential release is from an underground tank, the analysis focuses on transport in groundwater. Groundwater discharge to Lake Erie is one flowpath that is investigated, but direct release to surface water from a source is not considered.

Groundwater Analysis

Although mitigating design features are included in the Fermi 3 plant design, as described in the previous section, the applicant analyzed the migration, through groundwater, of radioactive contaminants originating from a postulated underground release of radioactive liquid waste. The source of this release is a tank that was selected based on guidance in Branch Technical Position (BTP) 11-6, "Postulated Radioactive Releases Due to Liquid-containing Tank Failures." Although the postulated release is highly unlikely because of the mitigating design features described above, this analysis provides insight into the possible migration of radioactive contaminants that might originate from other, less severe releases.

Because of the mitigating design features provided for the above-grade condensate storage tank, and the fast response to releases that they would allow, the staff considers that only potential releases to groundwater from an underground liquid radwaste tank represents a significant enough risk to call for detailed analysis.

Information Submitted by Applicant

The below-ground equipment drain collection tank selected as the source is located at a floor elevation of approximately 164.6 m (540 ft) NAVD88 (about 15 m (49 ft) below Fermi 3 plant grade) and has a volume of 140 cubic meters (m^3) (37,000 gallons). The applicant noted that the floor elevation of the source tank is approximately 8.2 m (27 ft) below the ambient groundwater level at the location of the source tank. The tank is postulated to release its volume (112 m^3 or 30,000 gallons) instantaneously due to failure of the tank and its liners at the same time as failure (cracking) of the RWB's basemat and/or exterior walls (described in the response to **RAI 2.4.13-11** and **RAI 2.4.13-12**, (ML102940218, dated October 19, 2010). The combined tank contents and influent groundwater are then used as the source in the applicant's analysis.

Two alternative hydrogeological conceptual models were proposed by the applicant. Both assume conservative, straight-line flowpaths to the nearest receptor. The first is based on currently observed flow directions in the Bass Islands Dolomite aquifer. Flow is assumed to be westward due to continued quarry dewatering operations in Monroe County, and the assumed

flowpath is to the nearest private supply well, approximately 1,450 m (4,756 ft) away. The second analysis assumes a future case in which quarry dewatering has ceased, and groundwater flow returns to the pre-development case of flowing eastward toward Lake Erie, approximately 450 m (1,476 ft) away.

In FSAR Revision 0, mitigating design features were cited as justification for not performing a release analysis. The applicant made several subsequent analyses. In FSAR Revision 1, calculations are described for the analysis of contaminant transport involving radioactive decay, but without including dispersion or retardation of the plume through sorption. In this conservative (i.e. promoting transport) scenario, the containment systems are assumed to fail, a maximum groundwater flow velocity is assumed, no adjustments to concentrations are made for dilution in lake water, and continuous ingestion for a year is assumed. The resulting calculated concentrations at the receptors of several radionuclides (H-3, Mn-54, Fe-55, Co-60, Zn-65, Sr-90, Y-90, Ru-106, Cs-134, Cs-137, and Ce-144) exceeded the effluent concentration limits (ECLs) specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. The highest exceedance was Co-60, which exceeded the ECL by a factor of 4,170. The sum of fractions (maximum calculated values relative to the 10 CFR limits) is used as a point of comparison. In this case, the sum of fractions far exceeded the limit of unity. The FSAR Revision 1 discussion concludes by citing the mitigation measures in the design features.

In **RAI 2.4.13-6**, the staff requested an analysis of groundwater contaminant transport that used the most conservative of plausible conceptual models of the conditions that govern transport of radioactive contaminants from the source to potential receptors. The applicant's second response to **RAI 2.4.13-6** (ML090610219, dated February 16, 2009) was based on modeling conducted using RESRAD-OFFSITE (Yu et al. 2007) to determine concentrations at the receptor locations. This analysis relied on the same conservative assumptions as the prior analysis (maximum groundwater flow velocity), and included the effects of dispersion and retardation. For the sorption component, the analysis used the minimum distribution coefficient (K_d) value from analyses newly performed on Bass Islands Dolomite rock samples (detailed in the response to EIS **RAI HY2.3.1-16**, Attachment 6 to NRC3-10-0004, DTE response letter dated January 29, 2010). In this case, the ECLs for all radionuclides were below ECLs and satisfied the sum of fractions at both the well and the lake. However, the applicant's RESRAD-OFFSITE input files provided along with the RAI show some inconsistencies between the stated assumptions and their implementation in RESRAD-OFFSITE.

To meet the requirements of 10 CFR 100.20(c) and 10 CFR 52.79(a)(1)(iii), and to support the staff's review of the application and the inconsistencies identified above, the staff requested in **RAI 2.4.13-9** additional information related to the RESRAD-OFFSITE simulations as follows:

1. The RESRAD-OFFSITE simulation as performed by the applicant assumes that the contaminants are present initially (i.e. immediately after the release) in a volume of contaminated soil 56 m^2 by 2 m deep. The rates at which contaminants leach from the soil are not explicitly specified in the model input, so that the model uses the supplied K_d values to calculate leaching rates. For radionuclides with large K_d values (e.g. Co-60), this means that very little of the contamination would be leached from the soil and enter the groundwater). Staff requested that the applicant perform RESRAD-OFFSITE simulations in which the contaminants enter the groundwater quickly.

2. The staff requested that the applicant provide additional justification for the well pumping rate. The value of about 5,000 m^3/yr (1,300,000 gal/yr) in the application was based on

an agricultural scenario. Staff requested using a more reasonable pumping rate from a residential well.

3. Staff noted requested that a “risk-informed” section is added that discusses the uncertainty in the estimates of radionuclide concentrations at the receptor points and include sensitivity and/or uncertainty analyses.

The applicant's response to **RAI 2.4.13-9** (ML100330612, dated January 29, 2010) addressed the three issues above. The response to the second issue was acceptable because the applicant; evaluated a more conservative pumping rate and revised the RESRAD-OFFSITE simulation consistent with a residential well. The response to the third issue was also acceptable because a series of analyses investigated variation in key input parameters.

For the first issue, the RAI response described the conceptual model:

- 112 cubic meters of liquid from the equipment drain collection tank escapes to the aquifer due to a combined failure of the tank and the basement floor and/or walls, and

- The 112 cubic meters of liquid is assumed to enter the aquifer instantly, and is modeled "as a volume of contaminated soil 56 square meters by 2 meters deep" (so, a contaminated aquifer volume of 112 cubic meters).

However, the implementation in RESRAD-OFFSITE was inconsistent with the conceptual model:

- The applicant's description ignored the relationship between void volume and solid volume in the setup of the RESRAD source. Porosity needed to be accounted for; an aquifer volume much larger than 112 cubic meters would comprise the source volume.

- The description mentioned the leaching of contaminants from the contaminated zone to the aquifer by assigning a high leach rate value in RESRAD-OFFSITE. This implied that the contaminated soil is in the unsaturated zone, which is not the case for the described failure scenario. The scenario is the instant release of contaminated water into a pristine aquifer, rather than leaching with an initial release rate set to the equilibrium desorption release rate. Contaminant transport analysis would include the dynamics of sorption/desorption, starting with an initial sorbed mass of zero.

Updated text was presented in FSAR Revision 2 (Detroit Edison 2010b), including a summary of the RESRAD-OFFSITE modeling effort. The calculations included the use of minimum K_d values, and the results had sum of fractions below unity for the bedrock pathways to both the well and the lake.

Because of the inconsistency between the conceptual model described and the implementation of that scenario in an appropriate code, additional information was requested as **RAI 2.4.13-10**. In the response, the applicant adequately modified the source volume to account for porosity. The applicant also provided details on the leach rate. A very high leach rate of 525,600/yr was assigned to the source area in an attempt to mimic a catastrophic release to the aquifer. The analysis included not only the transport to the lake and the well via the Bass Islands aquifer, but also via the rock fill. For the rock fill, minimum measured K_d values were assigned, while for the dolomite, K_d values of zero were used. Of these four scenarios, low concentrations (satisfying the sum of fractions) were calculated for the rock fill to Lake Erie scenario, while the other

scenarios had zero concentrations at the receptors. The RESRAD-OFFSITE input files were provided for review. Inspection of the OFFSITE output file SUMMARY.REP indicated that the code found the assigned leach rate unattainable and substituted a significantly smaller leach rate (1.8/yr). The analysis was therefore adding contaminants to the aquifer at a much lesser rate than presumed. In addition, the selection of the Do Not Disperse Vertically option resulted in clean infiltration along the flowpath, unless particular input parameter values are selected. Clean infiltration in this case caused the plume to be driven downward and not intercepted by the receptor, given the Depth of Aquifer Contributing input. In addition, the RESRAD-OFFSITE analysis erroneously used the values of the DCD's tank concentrations (activity per volume of liquid) as input values for OFFSITE's source (activity per gram of soil).

The status of the groundwater scenario analysis relying on RESRAD-OFFSITE led to two additional RAIs. The first (**RAI 2.4.13-11**) noted the discrepancies concerning the leach rates and the vertical dispersion aspects of the model (as described above), and called for a revised analysis. The second (**RAI 2.4.13-12**) described the inability of RESRAD-OFFSITE to model an instantaneous release, and called for revised input parameter values or selection of an alternative method (which had also been suggested in **RAI 2.4.13-10**). The applicant provided a combined response to **RAI 2.4.13-11** and **RAI 2.4.13-12** (ML102940218, dated October 19, 2010). The response included a summary of past analysis approaches, an explanation of a revised approach, and proposed text changes for the FSAR. In the revised approach, the applicant used the following process:

- All contents of the Equipment Drain Collection Tank are released into its underground room, and groundwater floods the room, thereby initially diluting the tank liquid by a factor of at least three.

- Effective porosity is now set to the low end of a range of measurements determined by a method relying on site-specific hydraulic conductivity and Rock Quality Designation measurements. Its value is now decreased from 1 percent to 0.1 percent.

- Fate and transport calculations (without the use of RESRAD-OFFSITE) then followed a conservative approach.

- An initial analysis relied only on advective transport and radioactive decay. Radionuclides with an activity concentration above 1 percent of their ECL were evaluated in the next step.

- A second analysis added the effect of sorption, conservatively using the minimum site-specific distribution coefficients. Radionuclides with an activity concentration above 1 percent of their ECL were evaluated in the next step.

- For the pathway to Lake Erie, the third analysis considered the calculated groundwater discharge relative to the tremendous dilution capacity of an appropriate local volume of Lake Erie (on the order of a factor of 3,500). A conservative factor of 10 was used in the analysis. All radionuclides were below ECLs, and the sum of fractions was less than 1.

- For the pathway to a well, the third analysis added the effect of longitudinal dispersion. Results for radionuclide activity concentrations were below ECLs, but the sum of fractions was greater than 1.

- The final step for the pathway to the well added the effect of transverse dispersion. In this case, the sum of fractions was less than 1.

<u>NRC Staff's Technical Evaluation</u>

NRC staff reviewed the available information in FSAR revisions and RAI responses submitted by the applicant, as summarized above. The ultimate approach and results summarized in the combined response to **RAI 2.4.13-11** and **RAI 2.4.13-12** (ML102940218, dated October 19, 2010) was found acceptable. The analysis clearly described the highly conservative (i.e. promoting transport and high activity concentrations) aspects of the approach. These included

- instantaneous release of the complete contents of the tank with the highest radionuclide activity concentrations (generally by several orders of magnitude) according to the DCD (Rev. 06, Table 12.2-13a),

- rapid groundwater flow, achieved in part by assuming the lowest effective porosity value obtained through a determination on field samples,

- limited sorption taking place, achieved by assuming the lowest distribution coefficients from laboratory work on site samples,

- appropriate careful consideration of realistic transport processes and additional modeling complexity for key radionuclides,

- only minor dilution of groundwater discharging to Lake Erie, and

- a constant concentration source term over the operating life of 60 years for the case of transport to well.

The 60-year constant concentration source used in the well scenario is an unnecessary conservatism, but does not affect the final conclusions.

NRC staff confirmed the calculated results to the receptors by performing independent analyses relying on conservative assumptions. The process, assumptions, and overall results resembled those ultimately provided by the applicant in the combined response to **RAI 2.4.13-11** and **RAI 2.4.13-12** (ML102940218, dated October 19, 2010).

As described above, the dilution of groundwater discharging to Lake Erie is extreme, and the applicant's assumed dilution factor of 10 is a highly conservative low value, yet resulted in sufficiently low radionuclide activity concentrations in lake water. The analysis for the well also produced sufficiently low concentrations once the effect of two-dimensional dispersion was included. Concentrations at the well, however, would be further reduced in actuality because the cone of depression caused by pumping would draw clean groundwater into the well from cross-gradient portions of the Bass Islands aquifer.

The results of the applicant's conservative analyses, and the staff's confirmatory analysis, provide confidence that a catastrophic release of the tank's contents to the Bass Islands aquifer would not result in an exceedance of ECLs or the sum of fractions at the two possible receptors. Therefore, the staff concludes the applicant's response is acceptable.

2.4.13.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.13.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.13 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-24-A as it relates to accidental releases of liquid effluents in ground and surface waters.

The review confirmed that the applicant has satisfactorily addressed the potential for radionuclides to impact receptors under two possible conceptual models for the groundwater flow system. The release scenario considered was a worst-case release to groundwater resulting from a catastrophic release of the contents of an underground equipment drain collection tank, the tank which has the highest anticipated radionuclide activities. A series of conservative (i.e. promoting transport and high concentrations) assumptions were used in an approach to determine the activity concentrations of radionuclides at receptors relative to the effluent concentration limits (ECLs) specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. As described above, the calculated activity concentrations satisfied the ECLs and sum-of-fractions criteria at each receptor. The staff concludes that the analysis and its results provide sufficient information to satisfy the requirements of 10 CFR 100.20(c), 10 CFR 100.23(d), and 10 CFR 52.79(a)(1)(iii).

Mitigating design features, while not considered in the analysis, would further reduce the potential impact to groundwater or surface water for the worst-case scenario described above as well as for other release scenarios.

2.4.14 Technical Specification and Emergency Operation Requirements

2.4.14.1 Introduction

The technical specifications and emergency operation requirements described here implement protection against floods for safety-related facilities to ensure that an adequate supply of water for shutdown and cool-down purposes is available. The specific areas of review are (1) controlling hydrological events, as determined in previous hydrology sections of the SAR, to identify bases for emergency actions required during these events; (2) the amount of time available to initiate and complete emergency procedures before the onset of conditions while controlling hydrological events that may prevent such action; (3) reviewing technical specifications related to all emergency procedures required to ensure adequate plant safety from controlling hydrological events by the organization responsible for the review of issues related to technical specifications; (4) potential effects of seismic and non-seismic information on the postulated technical specifications and emergency operations for the proposed plant site; and (5) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.14.2 Summary of Application

Subsection 2.4.14 of the Fermi 3 COL FSAR, Revision 4, addresses technical specifications and emergency operation requirements. In addition, the applicant provides the following:

<u>COL Item</u>

- EF3 COL 2.0-25-A Technical Specifications and Emergency Operation Requirements

  To address this COL item, the applicant identified that the elevation of exterior access openings, which are above the PMF and local PMP flood levels, and the design of exterior penetrations below design flood and groundwater levels, which are appropriately sealed, result in a design and site combination that do not necessitate emergency procedures or meet the criteria for Technical Specification LCOs to ensure safety-related functions at the plant.

2.4.14.3 Regulatory Basis

The applicable regulatory requirements for reviewing the applicant's discussion of technical specifications and emergency operation requirements are:

1. 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirements to consider physical site characteristics in site evaluations are specified in 10 CFR 100.20(c).

2. 10 CFR 100.23(d), sets forth the criteria to determine the citing factors for plant design bases with respect to seismically induced floods and water waves at the site.

3. 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding areas and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

4. 10 CFR 50.36, as it relates to identifying limiting conditions on technical specifications for safe operation of the plant.

The related acceptance criteria are summarized from SRP Section 2.4.14:

1. Bases for Emergency Actions: To meet the requirements of 10 CFR 50.36 and 10 CFR Part 100, an assessment of the hydrological bases for emergency actions is needed.

2. Available Response Time: To meet the requirements of 10 CFR 50.36 and 10 CFR Part 100, estimates of available response times to initiate and complete emergency procedures are needed.

3. Technical Specifications: To meet the requirements of 10 CFR 50.36 and 10 CFR Part 100, the applicant's proposed technical specifications related to emergency procedures are reviewed.
4. Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR 50.36 and 10 CFR Part 100, the applicant's assessment of the potential effects

of site-related proximity, seismic, and non-seismic information on the postulated technical specifications and emergency operations is needed.

In addition, the hydrologic characteristics should be consistent with appropriate sections from: RGs 1.29, 1.59, and 1.102.

2.4.14.4 Technical Evaluation

The NRC staff reviewed Subsection 2.4.14 of the Fermi 3 COL FSAR and checked the referenced DCD to ensure that the combination of DCD site parameters and the information in the applicant's COL represent the complete scope of information relating to this review topic.

COL Item

- EF3 COL 2.0-25-A Technical Specifications and Emergency Operation Requirements

The NRC staff's evaluation of COL Item EF3 COL 2.0-25-A is presented below.

Information Submitted by the Applicant

The applicant stated that the safety-related features at Fermi 3 are all located at above the maximum flooding level estimated for the site and the maximum groundwater elevation. The applicant also refers to Section 3.4 of the FSAR for a discussion on flood protection for safety-related structures, systems and components (SSCs). The applicant states that technical specifications and emergency procedures are not necessary due to the design of the plant.

NRC Staff's Technical Evaluation

The staff reviewed the information contained in COL FSAR Subsection 2.4.14 and reviewed the information in Section 3.4 of the FSAR referred to by the applicant. Section 3.4 of the FSAR incorporates by reference Section 3.4 of the ESBWR DCD. The DCD Section 3.4.1 states that "safety-related systems and components of the ESBWR standard plant are located in the seismic Category I structures that provide protection against external flood and groundwater damage." The staff reviewed the details in Subsection 3.4.1 of the DCD to verify that the plant design is sufficient to prevent the need for technical specifications and emergency procedures. The DCD specifies that the elevation of the safety-related features must be at least 1 ft above the maximum design flood elevation. The Fermi 3 safety-related features are designed to be at an elevation of 589.3 ft NAVD 88. The staff determined the maximum flood elevation to be 585.4 ft, 3.9 ft lower than the elevation of the safety-related features of Fermi 3. If the predicted maximum height of wind wave at the berm is added on to the flood elevation in Alternative III, the maximum elevation is 587.63 ft NAVD 88, which is 1.67 ft below the elevation of the safety-related features.

The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the technical specifications and emergency operations is acceptable and meets the requirements of 10 CFR 50.36 and 10 CFR 100.20(c) with respect to determining the acceptability of the site.

2.4.14.5 Post Combined License Activities

There are no post COL activities related to this subsection.

2.4.14.6 Conclusion

NRC staff reviewed the application and confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional information in the COL application to the relevant NRC regulations, the guidance in Section 2.4.14 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the requirements of NRC regulations. The staff determined that the applicant has adequately addressed EF3 COL Item 2.0-25-A as it relates to technical specifications and emergency operation requirements.

As set forth above, the applicant has presented and substantiated information relative to the technical specifications and emergency operations important to the design and siting of this plant. The staff has reviewed the available information provided and for the reasons given above, concludes that the identification and consideration of the technical specifications and emergency operations is acceptable and meets the requirements of 10 CFR 50.36, 10 CFR 52.79(a)(1)(iii), 10 CFR 100.20(c), and 10 CFR 100.23(d) with respect to determining the acceptability of the site.