UNITED STATES
**NUCLEAR REGULATORY COMMISSION**
WASHINGTON, D.C. 20555-0001

December 30, 2014

Mr. Joseph H. Plona, Senior VP
and Chief Nuclear Officer
DTE Electric Company
Fermi 2 - 210 NOC
6400 North Dixie Highway
Newport, MI 48166

SUBJECT: FERMI 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (TAC NO. MF1101)

Dear Mr. Plona:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons-learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested licensees to reevaluate flood-causing mechanisms using present-day methodologies and guidance.

By letter dated March 8, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13070A199), DTE Energy Company responded to this request for Fermi 2. In response to NRC staff questions, this response was supplemented by letter dated March 13, 2014.

The NRC staff has reviewed the information provided and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to the 50.54(f) letter. This closes out the NRC's efforts associated with TAC No. MF1101.

If you have any questions, please contact me at (301) 415-2915 or e-mail at Victor.Hall@nrc.gov.

Sincerely,

Victor Hall, Senior Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-341

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENTATION 2.1

RELATED TO THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT

DTE ELECTRIC COMPANY

FERMI, UNIT 2

DOCKET NO. 50-341

## 1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) "Conditions of license" (hereafter referred to as the 50.54(f) letter). The request was issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant as documented in The Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident (NRC, 2011b). Recommendation 2.1 in that document recommended that the staff issue orders to all licensees to reevaluate seismic and flooding for their sites against current NRC requirements and guidance. Subsequent Staff Requirements Memoranda associated with Commission Papers SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazard for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating Flooding Hazard Reevaluation Report (FHRR) deadlines for individual plants. On May 11, 2012, the staff issued its prioritization of the FHRRs (NRC, 2012b).

If the reevaluated hazard for all flood-causing mechanisms is not bounded by the current plant design-basis flood hazard, an Integrated Assessment will be necessary. The FHRR and the responses to the associated Requests for Additional Information (RAIs) will provide the hazard input necessary to complete the Integrated Assessment report, as requested in Enclosure 2 of the 50.54(f) letter.

By letter dated March 8, 2013 (Conner, 2013), DTE Energy Company (DTE, the licensee), provided the FHRR for Fermi, Unit 2 (Fermi 2). The information provided in the FHRR was supplemented by a letter containing the responses to the staff's RAIs, dated March 13, 2014 (Conner, 2014a and 2014b). The licensee did not identify any interim actions. The licensee submitted a separate flooding walkdown report associated NTTF Recommendation 2.3 (DTE, 2012c). The staff prepared a separate staff assessment report to document its review of the licensee's flooding walkdown report (NRC, 2014b).

## 2.0 REGULATORY BACKGROUND

### 2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section describes present-day regulatory requirements that are applicable to the FHRR.

Section 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describes the required content of the preliminary and final safety analysis reports (FSARs), including a discussion of the facility site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the FSAR.

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter requested licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

General Design Criterion 2 in Appendix A of Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time for which the historical data have been accumulated.

Section 50.2 of 10 CFR defines the design-basis as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design which each licensee is required to develop and maintain. These values may be (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (b) requirements derived from an analysis (based on calculation or experiments or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Section 54.3 of 10 CFR defines the "current licensing basis" as: "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications, as well as the plant-specific design-basis information as documented in the most recent FSAR. The licensee's commitments made in docketed licensing correspondence and remain in effect are also considered part of the current licensing basis.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites includes the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

## 2.2 Enclosure 2 to the 50.54(f) Letter

The 50.54(f) letter requests all power reactor licensees and construction permit holders reevaluate all external flooding-causing mechanisms at each site. The reevaluation should apply present-day methods and regulatory guidance that are used by the NRC staff to conduct ESP and COL reviews. This includes current techniques, software, and methods used in present-day standard engineering practice. If the reevaluated flood-causing mechanisms are not bounded by the current plant design-basis flood hazard, an Integrated Assessment will be necessary.

### 2.2.1 Flood-Causing Mechanisms

Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2 of the 50.54(f) letter) discusses flood-causing mechanisms for the licensee to address in the FHRR. Table 2.2.1-1 lists the flood-causing mechanisms the licensee should consider. Table 2.2.1-1 also lists the corresponding Standard Review Plan (SRP) (NRC, 2007) sections and applicable interim staff guidance containing acceptance criteria and review procedures. The licensee should incorporate and report associated effects per Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-05 (NRC, 2012c) in addition to the maximum water level associated with each flood-causing mechanism.

### 2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. JLD-ISG-2012-05 (NRC, 2012c), defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- wind waves and run-up effects
- hydrodynamic loading, including debris
- effects caused by sediment deposition and erosion
- concurrent site conditions, including adverse weather conditions
- groundwater ingress
- other pertinent factors

2.2.3 Combined Effects Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a "Combined Effects Flood." Even if some or all of these individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism in the 50.54(f) letter. (See SRP Section 2.4.2, Area of Review 9 (NRC, 2007)) Attachment 1 of the 50.54(f) letter describes the "Combined Effect Flood" as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992) as follows:

> *For flood hazard associated with combined events,[1] American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.*

If two less-severe mechanisms are plausibly combined (per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992) and SRP Section 2.4.2, Areas of Review 9 (NRC, 2007), then the staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding should be plausibly combined.

2.2.4 Flood Event Duration

Flood event duration was defined in the ISG for the Integrated Assessment for external flooding, JLD-ISG-2012-05 (NRC, 2012c), as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2.4-1 illustrates flood event duration.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated probable maximum flood elevation is not bounded by the current design-basis probable maximum flood elevation for all flood-causing mechanisms, the 50.54(f) letter requests licensees and construction permit holders to:

- Submit an Interim Action Plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard

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1 For the purposes of this Staff Assessment, the terms "combined effects" and "combined events" are synonyms.

- Perform an Integrated Assessment subsequent to the FHRR to (a) evaluate the effectiveness of the current licensing basis (i.e., flood protection and mitigation systems), (b) identify plant-specific vulnerabilities, and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration

If the reevaluated flood hazard is bounded by the current design-basis flood hazard for all flood-causing mechanisms at the site, licensees are not required to perform an Integrated Assessment at this time.

## 3.0 TECHNICAL EVALUATION

The NRC staff has reviewed the information provided for the flood hazard re-evaluation of Fermi 2. The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews. The staff's review and evaluation is provided below.

The licensee's flood hazard reevaluation studies were conducted using customary units of measure. In this report, customary measurements are followed by the equivalent measurement in metric units. Because the conversion to metric units may involve loss of precision, the measurement in conventional units is definitive.

To provide additional information in support of the summaries and conclusions in the FHRR, the licensee made calculation packages available to the staff via an electronic reading room. The staff relied directly on some of these calculation packages in its review; these calculation packages are docketed, and are cited as appropriate in the discussion below. Certain other calculation packages were found only to expand upon and clarify the information provided on the docket, and so are not docketed or cited.

The nominal site grade elevation is 583 feet (ft) (178 m) (New York Mean Tide 1935 (NYMT35). Unless otherwise stated, all elevations in this staff assessment are given with respect to the NYMT35 datum. Table 3.0-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects, the licensee computed to be higher than the powerblock elevation.

The staff requested additional information from the licensee to supplement information provided in the FHRR (NRC, 2014a and 2014c). The licensee provided this additional information by letter dated March 13, 2014 (Conner, 2014a), which is discussed in the appropriate sections below.

### 3.1 Site Information

The 50.54(f) letter includes the SSCs important to safety, and the Ultimate Heat Sink, in the scope of the hazard reevaluation. Per the 50.54(f) letter, Enclosure 2, Requested Information, Hazard Reevaluation Report, Item a, the licensee included pertinent data concerning these SSCs in the FHRR.

The 50.54(f) letter, Enclosure 2 (Recommendation 2.1: Flooding), Requested Information, Hazard Reevaluation Report, Item a, describes site information to be contained in the FHRR. The staff reviewed and summarized this information as follows in the sections below.

3.1.1 Detailed Site Information

In its FHRR, the licensee described the following site information related to the site flood hazard reevaluation: Fermi 2 is located on the western shore of Lake Erie, in Monroe County, MI. According to the licensee, prior to construction of Fermi 2, the site area was a lagoon separated from Lake Erie by a barrier beach, known as Lagoona Beach. The lagoon was connected to Lake Erie by Swan Creek, a perennial stream that discharges into Lake Erie about one mile north of the Fermi site. The licensee stated that the Fermi 2 site was prepared by excavating soft soils and rock, and constructing rock fill to a nominal plant grade of 583.0 ft (177.7 m). The site covers an area of approximately 1260 acres (510 hectares). The licensee provided detailed site layout and topographic maps in the electronic reading room and in references citing the Fermi Unit 3 (Fermi 3) Combined License Application (DTE, 2013). The planned Fermi 3 site is located immediately southwest of the Fermi 2 site. The planned Fermi 3 plant grade is 590.0 ft (179.8 m), which is 7 ft (2.1 m) higher than the Fermi 2 plant grade.

The topography of the site is flat to gentle rolling plain. Site elevations range from the level of Lake Erie to approximately 25 ft (7.6 m) above the lake level on the western edge of the site. The topography on the Fermi 2 site is relatively level in the undeveloped areas, with an average elevation of approximately 10 ft (3 m) above the surrounding area. Lake Erie has an average level of approximately 571 ft (174 m), while the area around the Fermi 2 site ranges from 577 to 600 ft (176 to 183 m). Storm water runoff from the Fermi 2 site flows to three drainage outlets: two ponds and a drainage outfall pipe. The outfall pipe discharges to an overflow canal which then enters the North Lagoon (as shown in Figure 3.2-3). The North Lagoon discharges to Swan Creek which feeds Lake Erie. Runoff may also drain by sheet flow to the North Lagoon and South Lagoon.

The Fermi 2 site is contained within the Swan Creek Watershed. Swan Creek is a 106 $mi^2$ (275 $km^2$) watershed that drains into Lake Erie approximately 1 mi (1.6 km) north of the site. The Fermi 2 site 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 $mi^2$ (25,670 $km^2$). The licensee stated that the drainage area of Lake Erie is approximately 23,400 $mi^2$ (60,700 $km^2$) and it has twelve main tributaries. The main tributaries of Lake Erie nearest to the Fermi 2 site are the River Raisin (approximately 6 mi [9.6 km]) to the south and the Detroit River (approximately 6 mi [9.6 km]) to the north. The western basin of Lake Erie borders the Fermi 2 site. The western basin of Lake Erie is a very shallow basin with an average depth of 24 ft (7.3 m). A rock barrier is present along the eastern edge of the Fermi 2 site at the shoreline to protect the site against the high water levels of Lake Erie. The rock barrier crest elevation is at 583.0 ft (177.7 m).

The licensee 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 licensee provided a short description of the 126 $mi^2$ (326 $km^2$) 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 $mi^2$ (2,770 $km^2$) and is south of the Stony Creek Watershed. The licensee 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."

### 3.1.2 Design-Basis Flood Hazards

The current design-basis flood elevations for various flood causing mechanisms are summarized in Table 3.1.2-1. The design-basis flood level for Fermi 2 is described in the latest version of the Fermi 2 Updated Final Safety Analysis Report (UFSAR) (DTE, 2012b). The design-basis flood elevation was determined through the analysis of three different flood hazards: (1) local intense precipitation (LIP), (2) flooding in streams and rivers, and (3) storm surge.

First, for the LIP analysis, the licensee assumed a probable maximum precipitation (PMP) event on the plant site coincident with runoff from the 2 $mi^2$ (5.2 $km^2$) area above the plant site, assuming blockage of plant drainage. The licensee estimated a probable maximum flood (PMF) of 25,300 $ft^3/s$; (716.4 $m^3/s$) on the adjacent area resulting in a water elevation of less than 582 ft (177 m). Based on this analysis, the licensee determined that a LIP event would have no adverse effects on the safety-related facilities.

Second, for flooding in streams and rivers analysis, the licensee also assumed a PMF scenario on the Swan Creek in the FHRR. This scenario was estimated as the maximum flood runoff resulting from a PMP on the entire drainage basin. The PMF of 115,000 $ft^3/s$ (3,256 $m^3/s$) on Swan Creek coincides with the mean monthly maximum water level on Lake Erie. The resulting PMF flow elevation is 579.1 ft (176.5 m).

Third, for wind-driven storm surge analysis, or the Probable Maximum Meteorological Event (PMME), the potential flooding elevation was determined to be 11.4 ft (3.4 m) above Lake Erie Low Water Datum of 570.5 ft (173.9 m). To obtain a total stillwater elevation for design purposes, the licensee superimposed a slightly higher PMME value of 11.6 ft (3.5 m) on the Lake Erie maximum monthly mean lake level of 4.8 ft (1.5 m). The resulting PMME elevation is 16.4 ft (5.0 m) above Lake Erie Low Water Datum and was selected as the design minimum. The Fermi 2 UFSAR (2012) estimates the stillwater flood elevation is 586.9 ft (178.9 m), or 3.9 ft (1.2 m) above the plant grade elevation due to a wind driven storm surge (PMME). This flood elevation would occur approximately nine hours after the maximum wind from the assumed PMME reaches the shore.

### 3.1.3 Flood-related Changes to the Licensing Basis

In FHRR Section 2.4, the licensee identified two changes to the flood protection features since the initial issuance of the operating license. They are:

- The addition of redundant check valves and manual isolation valves to prevent backflow flooding into the reactor building.
- The redesign of the Category I ductbanks between the Residual Heat Removal (RHR) complex and the Reactor/Auxiliary building.

As a result of the FHRR, a review of the site drawings identified changes made to the security system at Fermi 2 that could impact the LIP and wave runup evaluations. The effects of this change are discussed in Section 3.5 of this report.

3.1.4 Changes to the Watershed and Local Area

The licensee reported in its FHRR that the water level at the site is controlled by Lake Erie. It is reported in the FHRR that the site for Fermi 2 was prepared by excavating soft soils and rock, and constructing rock fill to a nominal plant grade elevation of 583 ft (178 m). The licensee identified no changes to the watershed since the operating license was issued.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The licensee stated that the Seismic Category I reactor/auxiliary building, which houses safety-related systems and components, is watertight up to an elevation of 588 ft (179 m). All penetrations through the exterior walls below the design flood elevation are of watertight design. The RHR complex is watertight to an elevation of 590 ft (180 m). The only openings on the RHR building are the waterproofed pipe-sleeve openings on the east side.

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee provided additional site details to characterize the site and assess the flooding hazards. These details are described below.

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter was sent to licensees on March 12, 2012. Enclosure 4 of the 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Step 6 of the 50.54(f) letter (Requested Information Item 1.c and Step 6 of Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2)), asked the licensee to report any relevant information from the results of the plant walkdown activities.

The licensee responded, by letter dated June 8, 2012 (DTE, 2012a), that they would perform the plant walkdown activities. By letter dated November 26, 2012 (DTE, 2012c), DTE Energy provided the flood walkdown report for Fermi 2.

FHRR Section 2.3 summarizes the following walkdown activities: (1) All structure penetrations below elevations 588 ft (179 m) are sealed against water; (2) There are no differences or contradictions in flood hazard levels in the design or licensing basis documentation; (3) The overall effectiveness of the Fermi 2 flood protection features to perform their credited CLB functions are adequate.

The staff prepared a Staff Assessment report, dated June 18, 2014 (NRC, 2014b), to document its review of the DTE flooding walkdown report. The staff concluded that the licensee's implementation of flooding walkdown methodology met the intent of the walkdown guidance.

## 3.2 LIP and Associated Site Drainage

The licensee reported in its FHRR that the reevaluated flood hazard, including associated effects, for LIP is 583.4 ft (177.8 m). The current design-basis for the LIP and associated site drainage hazard, as described in the Fermi 2 UFSAR, Revision 18 (DTE, 2012b), is less than 582 ft (177 m), which is 1 ft (0.3 m) below plant grade of 583 ft (177.7 m) and 1.5 ft (0.45 m) below the elevation of the door sills of 583.5 ft (177.9 m). The Fermi 2 UFSAR states that "[a]t a hypothetical water surface elevation of less than 582 ft [177 m] ... the maximum water elevation at peak flow due to a local PMP would be more than 1 ft below plant grade (583 ft) and would not pose a threat to safety-related structures onsite." The Fermi 2 UFSAR and the FHRR state that all door sills on safety-related structures are at least 6 inches above the plant grade of 583 ft (177.7 m).

### 3.2.1 FHRR LIP Analysis

The licensee analyzed LIP generated runoff from two drainage areas; (1) a small 51 acres (21 hectares) onsite area including the Fermi 2 site; and (2) a larger 1.78 $mi^2$ (4.61 $km^2$) local watershed area west of the plant site. The licensee determined the local PMP peak runoff values and maximum water surface elevations for each area.

The licensee calculated the PMP for a 1-$mi^2$ (2.6-$km^2$) area using the methods outlined in National Oceanic and Atmospheric Administration (NOAA) Hydro-Meteorological Report (HMR) 51 (NOAA, 1978) and HMR-52 (NOAA, 1982). The licensee derived a PMP duration-intensity curve on the basis of the intensity determined for the 1-hr, 1-$mi^2$ (2.6-$km^2$) PMP and percentage multipliers for 5, 15, and 30 minutes. The licensee calculated the time of concentration for both areas and then selected the appropriate PMP intensity from the duration-intensity curve. The licensee indicated that the shorter PMP duration provides more conservative estimates of runoff using the rational method. The licensee estimated the durations of 5 minutes and 15 minutes for the small onsite drainage area and larger local watershed area west of the plant, respectively. The licensee calculated the resulting PMP intensities and depths to be 70.6 in/hr (179.3 cm/hr) and 5.9 in (14.9 cm) for the small onsite drainage area (5-minute storm) and 36.7 in/hr (93.2 cm/hr) and 9.2 in (23.3 cm) for the larger local watershed area west of the plant (15-minute storm).

To evaluate the worst-case scenario, the licensee analyzed the impact of snowmelt in addition to the PMP at the site by considering an initial snowpack covering the entire site with no significant variation in snow temperature or snow depth prior to the PMP. The licensee 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 snowmelt was calculated as a function of wind velocity, rainfall rate, air temperature, and a wind coefficient using an equation from the U.S. Army Corps of Engineers (USACE) document, *Runoff from Snowmelt* (USACE, 1998). The licensee used the observed dew point temperatures as representative of air temperature during a PMP rain on snow event assuming that rainwater temperature is equal to air temperature. The licensee stated in its FHRR that the wind velocity and dew point temperature were derived from historical data from the Detroit Metropolitan Airport meteorological station. The licensee analyzed 34 years of data for the month of April to determine the hourly wind speed with an exceedance probability of 50 percent and the hourly dew point temperature with an exceedance probability of 1 percent (100-year). The estimated 2-year occurrence hourly wind speed and 100-year occurrence dew point temperature are 32.5 mph (14.5 m/s) and 69.1°F (20.6°C), respectively.

On the basis of the estimated values of hourly wind speed, dew point temperature, the PMP, and a wind coefficient of 1, the simultaneous snowmelt was calculated to be 18.8 in/hr (47.8 cm/hr) for the 51 acres (21 hectares) onsite drainage area and 9.99 in/hr (25.37 cm/hr) for the 1.78 $mi^2$ (4.61 $km^2$) local watershed area west of the plant. The total effective intensity (PMP plus snowmelt) for these areas are 89.4 in/hr (227.1 cm/hr) and 46.7 in/hr (118.6 cm/hr), respectively.

The licensee used the rational method to determine flow (Q) under the PMF from the PMP plus snow melting with a conservative assumption of completely impervious or saturated antecedent conditions for each drainage area resulting in zero loss due to infiltration. The resultant PMF flow was calculated to be 4,599 $ft^3/s$ (130.2 $m^3/s$) for the onsite drainage area and 53,277 $ft^3/s$ (1,508.6 $m^3/s$) for the local watershed area west of the plant.

3.2.1 LIP Flooding Analysis

The licensee calculated the maximum water surface elevation using a hydraulic analysis with the conservative assumption that all drains are blocked and runoff is either overland flow or flow over the open channels. The Hydrologic Engineering Center River Analysis System (HEC-RAS; USACE, 2010a) model was used to determine the hydraulic flow for the 1.78 $mi^2$ (4.61 $km^2$) local watershed of area. The licensee estimated flow depth at various locations for the onsite area using Manning's equation for flow rate.

The licensee constructed a HEC-RAS steady-state model with the inflow rate of the PMF flow of 53,277 $ft^3/s$ (1,508.6 $m^3/s$) from the 1.78 $mi^2$ (4.61 $km^2$) local watershed area west of the plant and a downstream boundary condition of 576.3 ft (175.7 m), which is the 100-year lake level for Lake Erie. The inflow from west of the site travels via the North Reach and South Reach around the site to Lake Erie, and the licensee used a shared cross section extending to the site to calculate the maximum water surface elevation. In the HEC-RAS model, the shared cross section is placed as an upstream boundary of the computation domain for each reach. The balance of the flow distribution between the North Reach and South Reach was estimated using an iterative approach. The criteria to complete the iterations are that the same water surface elevation is reached at the upstream cross section and that the sum of the two flows to the North Reach and South Reach is equal to the total peak flow discharging from the local watershed from the west. The calculated highest water surface elevation is 582.8 ft (177.6 m), which is lower than the plant grade of 583 ft (178 m).

The licensee performed hydraulic analysis for the onsite drainage area using the rational method and Manning's equation. The analysis was used to determine the water surface elevation at three cross sections (A, B, and C), as shown in Figure 3.2-1. The flow rates calculated based on the rational method are 3,844 $ft^3/s$ (108.9 $m^3/s$) for cross section A; 3,040 $ft^3/s$ (86.1 $m^3/s$) for cross section B; and 268 $ft^3/s$ (7.6 $m^3/s$) for cross section C. The licensee assigned a uniform base elevation and slope to each cross section and the estimated unobstructed section width, slope, base elevation and peak runoff are listed in Table 3.2-1. The licensee used Manning's equation to predict a runoff depth corresponding to the flow rate at each cross section and determined the maximum water surface elevation is 583.4 ft (177.8 m) for cross sections A and B and 583 ft (177.7 m) for cross section C.

### 3.2.2 Staff's LIP Flooding Analysis

In order to determine the appropriate estimation of flood hazards from LIP, staff issued RAI No. 1 on February 28, 2014 (NRC, 2014a). DTE replied to the RAI by letter dated March 13, 2014 (Conner, 2014a). The licensee provided electronic versions of input files used for the HEC-RAS analysis in the FHRR. The staff reviewed the HEC-RAS model used in the hydraulic analysis for the 1.78 $mi^2$ (4.61 $km^2$) local watershed area west of the Fermi 2 site. The staff evaluated the model input and output, assumptions, and parameters to confirm the consistency of the FHRR documentation with the implementation of the numerical model. Sensitivity tests were conducted for (1) location of the upstream boundary that extends to the Fermi 2 site, (2) Manning's roughness coefficient, and (3) contraction and expansion coefficients. The staff noted that the location of the upstream boundary will affect the results of the maximum water surface elevation at the cross section. The maximum water surface elevation will increase by 0.1 ft (0.03 m) if the cross section is shifted 200 ft (61 m) to the south near the southern end of the Fermi 2 site. The staff also noted that the maximum water surface elevation will increase with an increase in the Manning's coefficient. However, the staff noted that the maximum water surface elevation was not sensitive to contraction and expansion coefficients used in the HEC-RAS model (less than 0.1 ft (0.03 m)).

The elevation of the door sills for the class I structures is 583.5 ft (177.8 m). On the basis of sensitivity tests, licensee determined in the RAI response that the maximum water surface elevation at the cross section B will not exceed elevation 583.5 ft (177.8 m), even if the combination of the most conservative conditions is considered.

The staff observed that various datums were referenced in the FHRR, and requested in RAI No. 2 (NRC, 2014a) that the licensee describe the source and accuracy of the surface elevations used in the onsite LIP analysis, and provide conversion factors between the various datums used. The licensee responded (Conner, 2014a), that surface elevations used in the on-site LIP analysis were taken from elevations shown on a plant plot plan; the relative accuracy of the elevations on the plant plot plan is +/- 0.1 ft (0.03 m); all elevations described in the FHRR are in the datum of NYMT35 and Plant Datum is a common term for NYMT35; and some elevations and water levels from the source documents that may use different datums have been converted to Plant Datum in the FHRR.

The staff reviewed the site elevation contour plot provided in the electronic reading room as a scanned electronic file and found that a uniform base elevation assigned to the cross sections A and C approximately reflects an average surface elevation along those cross sections. However, cross section B has a surface elevation that varies from slightly less than 582 ft (177.4 m) to nearly 583 ft (177.7 m). The southern part of cross section B, about 40 to 50 percent of its total unobstructed width, coincides with cross section C, which has a base elevation of 582.5 ft (177.5 m). Therefore, the average base elevation for cross section B is mainly between 582 ft (177.4 m) and 582.5 ft (177.5 m). The licensee's estimation assumes a rectangular cross section with a uniform water height over the base elevation. Under this rectangular assumption, an average base elevation representing the varying bottom of the cross section would be reasonable. However, the licensee selected a low end of the base elevation instead of an average base elevation in its calculation, which results in an underestimation of water surface elevation. Staff issued an additional RAI (NRC, 2014c) requesting the licensee to provide (1) a rationale for using the low end of base elevation in its calculation, (2) supporting onsite ground surface elevation in native electronic format, and (3) the basis for the acceptance criterion of 583.5 ft (177.9 m) for the LIP analysis (RAI No.4).

In response to RAI 4, the licensee provided electronic files showing digital contours of ground surface elevations for the onsite area (Conner, 2014b). On the basis of data files provided by the licensee, staff estimated maximum water surface elevation along cross section B. The staff considered two modifications to provide a conservative estimate of water surface elevation. These modifications include (1) changing the geometry of cross section B from a rectangle to semi-trapezoidal, and (2) identifying a more realistic onsite drainage area from which water will flow through cross section B to the west.

As shown in Figure 3.2-2, the ground surface elevation varies along cross section B from 581.6 ft (177.3 m) at the northern end (in Figure 3.2-2, north is toward the top of the figure and south is toward the bottom), 582.5 to 582.8 ft (177.5 to 177.6 m) in the southern portion, and 582 ft (177.4 m) at southern end of cross section. A semi-trapezoidal shape with a bottom elevation ranging from 581.6 ft (177.3 m) at the northern end to 582.8 ft (177.6 m) at the southern end is considered as a conservative approach to represent the actual shape of cross section B. The water surface elevation can be estimated by water depth ($d_1$) plus the base elevation (581.6 ft (177.3 m)) at the northern end or water depth ($d_2$) plus the base elevation (582.8 ft (177.6 m)) at the southern end. The water depths ($d_1$ and $d_2$) are calculated by Manning's equation. The semi-trapezoidal cross section has a lesser flow area than the rectangular section (Table 3.2-2). The staff found that, for the same water surface elevation, 583.43 ft (177.8 m), as estimated by the licensee, the cross section flow area will be reduced by 15 percent from a rectangular to a semi-trapezoidal section at cross section B.

The extent of drainage area defined by the licensee for analysis at cross section B approximately follows the 581.5 to 582 ft (177.2 to 177.4 m) contour lines (Figure 3.2-2). The runoff generated from this area could flow to the west or east. As stated in FHHR, the concrete barriers erected since the initial issuance of the operating license could restrict surface drainage from leaving the site in the north and south directions. Thus, the licensee concluded, and the staff agrees, that it is reasonable to assume that no flow occurs across the north and south sections for the analysis. The licensee's analysis also included a conservative assumption that all runoff from the onsite drainage area of 34 acres flows towards the west of the site to cross section B. However, under this assumption, the resulting maximum water surface elevation at cross section B would slightly exceed the current design-basis flood elevation of 583.5 ft (177.9 m) because the actual cross section in the semi-trapezoidal shape has the less section area for flow to pass compared to the section in rectangular shape assumed by licensee.

In order to have a more realistic evaluation, staff reviewed the site aerial photography image combined with the ground surface elevation contours provided by the licensee. As shown in Figure 3.2-2, the area east (east is located on the right-hand side of Figure 3.2-2) of the main building structures has less restriction for flow across the site and the flow from this area could directly discharge to the Lake Erie. On the basis of the contour map and building locations, staff identified a more realistic drainage area of 27 acres from which flow will mostly go to the west across cross section B. The drainage area for analysis along cross section B is shown in Figure 3.2-2 as the shaded area.

Staff applied the Rational Method for estimation of flow from the drainage area identified above and calculated the maximum water surface elevation by using Manning's equation with an assumption of semi-trapezoidal shape representing cross section B. The other parameters in Manning's equation, such as Manning's roughness coefficient (n) and slope (S) entering to cross section B, remain the same in the staff's calculation as in the licensee's. The results are summarized in Table 3.2-2. The resulting maximum water surface elevation at cross section B is 583.44 ft (177.83 m), which is below the acceptance criterion of 583.5 ft (177.9 m). As a comparison, the results from the licensee's analysis for cross section B are also listed in Table 3.2-2.

3.2.3 LIP and Associated Site Drainage Conclusions

On the basis of an independent review and of the licensee's assertion that the elevation of the door sills are above plant grade, the staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage would not exceed the elevation of the door sills.

3.3 Streams and Rivers

In its FHRR, the licensee incorporated by reference the stream flooding analysis performed for the Fermi Unit 3 COL. The licensee stated that since Fermi 2 and Fermi 3 are located on the same site and in close proximity of each other, both would be subject to the same flooding hazards.

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding from streams and rivers is 586.6 ft (178.8 m). The current design-basis hazard for flooding from streams and rivers is 579.1 ft (176.5 m). The FHRR considered three stream flooding scenarios and selected the scenario which includes a 25-year flood combined with a probable maximum surge, wind wave activity, and a maximum lake level. This scenario resulted in a flood elevation of 586.6 ft (178.8 m). The current design-basis hazard for the same combined effects (stream flooding plus the maximum lake level and storm surge) is 586.9 ft (178.9 m).

The information incorporated by reference in the FHRR identifies Swan Creek as being about 1 mi (1.6 km) northeast of the site, Stony Creek, about 3 mi (5 km) southwest, the River Raisin about 6 mi (9.6 km) southwest, and the Huron River about 5.75 mi (9.25 km) north. The staff determined that except for Swan Creek, the other streams were far enough away from the site and would not cause flooding at the site even under the most severe flooding conditions. Therefore, only the flooding potential of Swan Creek was analyzed further.

In addition to the information provided in the FHRR, the staff reviewed information incorporated by reference from the Fermi 3 COL to analyze the potential for flood the Fermi 2 site by Swan Creek, as discussed in the sections below.

3.3.1 PMF on Swan Creek

The major flooding potential identified by the licensee is associated with Swan Creek. Swan Creek is located north of the Fermi site (as depicted in Figure 3.2-3). Swan Creek experiences maximum flow rates in the spring and minimum flow rates in the summer. Swan Creek watershed has an area of approximately 106 $mi^2$ (275 $km^2$). Swan Creek is the main outlet for this watershed and a minor tributary of the western basin of Lake Erie. The licensee reported that currently Swan Creek is ungauged and there is no recorded flow data in reference to historical storm events.

Flooding analysis on Swan Creek is based on the runoff generated from the Swan Creek watershed which was estimated using historical flow rates estimated by the Michigan Department of Environmental Quality.

3.3.2 Combined events with PMF

The primary stream flooding potential for Fermi 2 is identified to be flooding from Swan Creek. The analysis incorporated by reference from the Fermi 3 COL considered the following three alternatives that combine multiple effects as defined in ANSI/ANS-2.8-1992 (ANSI/ANS, 1992):

- Alternative I -
    - One-half PMF or 500-year flood, whichever is less, plus
    - Surge and seiche from worst regional hurricane or windstorm with wind wave activity, plus
    - 100-year or maximum controlled level of waterbody, whichever is less.

  The calculated flood level for Alternative I is 580.6 feet (177.0 m), 2.4 feet (0.7 m) below plant grade.

- Alternative II -
    - PMF, plus
    - 25-year Surge and seiche with wind wave activity, plus
    - 100-year or maximum controlled level of waterbody, whichever is less.

  The calculated flood level for Alternative II is 579.5 feet (176.6 m), 3.5 feet (1.1 m) below plant grade.

- Alternative III -
    - 25-year flood, plus
    - Probable maximum surge and seiche with wind wave activity, plus
    - 100-year or maximum controlled level of waterbody, whichever is less.

  The calculated flood level for Alternative III is 586.6 ft (178.8 m); which is 0.3 ft (0.1 m) below the current design bases flood level of 586.9 ft (178.9 m).

The staff reviewed the information provided in the FHRR including the HEC-RAS model developed by the licensee. The licensee constructed a HEC-RAS model with an inflow from the 25-yr flood in Swan Creek and the downstream boundary at 586.6 ft (178.8 m), including the 100-year lake water level plus probable maximum surge height, and determined the maximum water surface elevation at a cross section that extends from Swan Creek to the west side of the Fermi 2 site was 586.6 ft (178.8 m). The staff's review confirmed that the third alternative is the controlling PMF at the site with a water surface elevation of 586.6 ft (178.8 m). The flooding analysis also considered the effect of snowmelt, but the results showed that the water surface elevation is not sensitive to the snowmelt scenario.

The reevaluated hazard presented in the FHRR for flooding in streams and rivers is based on scenarios that assume the probable maximum storm surge as part of the streamflow flooding analysis. Therefore, the NRC staff compared this reevaluated hazard against the current design-basis for storm surge. The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from streams and rivers is bounded by the current design-basis for storm surge.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to failure of dams and onsite water control/storage structures does not inundate the site. This flood-causing mechanism is described in the licensee's current design-basis.

The licensee stated that the Swan Creek watershed, in which the Fermi site is located, contains no dams upstream or downstream and therefore flooding due to dam failure would not affect the site. Additionally, there are no water control structures erected on the Fermi site with the potential to fail or cause potential flooding. In addition, the staff reviewed the recent database by revisiting the USACE National Inventory of Dams on December 18, 2013, and verified that there are no dams within the Swan Creek watershed (USACE, 2013).

In summary, the staff confirmed the licensee's conclusion that the PMF from dam failure flooding alone could not inundate the site. The staff confirmed that the reevaluated hazard for flooding from the failure of dams and onsite water control/storage structures is bounded by the current design-basis flood hazard.

## 3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to storm surge is 591.7 ft (180.4 m) for the 5.4-ft (1.6-m) waves. This flood-causing mechanism is described in the licensee's current design-basis. The current design-basis hazard for site flooding due to storm surge (with wave runup) is elevation 593.0 ft (180.7 m) for the Category I reactor/auxiliary building and elevation 598.0 ft (182.3 m) for the RHR complex.

### 3.5.1 Identification of Environmental Conditions for Model Input

The licensee discussed meteorological winds and parameters for the probable maximum windstorm (PMWS) from which it calculated the probable maximum surge. Section 7.2.2.3.1 of ANSI/ANS-2.8-1992 (ANSI/ANS, 1992) recommends the set of parameters for the Great Lakes region in lieu of a detailed meteorological study for the area. Though the Fermi 2 site is sheltered from the predominant direction of squalls in the region, the licensee analyzed a worst-case scenario with assumptions of an 8-millibar pressure jump and a 65-knot speed. The maximum surge would be 5.6 ft (1.7 m) under the worst-case scenario at the Fermi 2 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 (3.1 m) derived from analysis of storm surge induced by PMWS.

The licensee stated that the analysis of probable maximum surge and seiche flooding was performed using the STWAVE and ACES computer models and conservative inputs and assumptions. Consistent with Section 9.2.3.1 of ANSI/ANS-2.8-1992 (ANSI/ANS, 1992), the licensee used a combination of flood causing events to provide an adequate design bases for a shore location at the Fermi 2 site, either the probable maximum surge and seiche with wind-wave activity or the 100-year or maximum controlled level of Lake Erie, whichever is less. The licensee chose to use the 100-year lake level.

The staff verified 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 (ANSI/ANS, 1992). The staff also verified the licensee'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 calculated a 100-year lake elevation of 574.7 ft (175.2 m) NAVD88, which is lower than the licensee value of 575.1 ft (175.3 m) NAVD88.

The staff verified the bathymetric data for Lake Erie and used the information to model parameters. The staff reviewed the historical data for seiche in Lake Erie and confirmed its effect is less than impact of surge under PMWS in the site area.

The staff reviewed the licensee's conclusion that sedimentation and erosion do not impact safety related water since Lake Erie is not used for safety related cooling. In RAI 3 (NRC, 2014a) the staff asked the licensee to provide the reference or source for the equation used to calculate the stability of a submerged breakwater. The staff reviewed the licensee's response (Conner, 2014a), which included the reference for the equation.

The licensee provided detailed descriptions of the probable maximum surge flood analysis. In applying their storm surge analysis, the key parameters that affect storm surge are the fetch length, water depth, and coefficients under the PMWS condition. The staff verified the longest straight line fetch length from the Fermi 2 site across Lake Erie is a distance of 96.2 miles (155 km).

3.5.2 Estimating Storm Surge Using Computer Models

The Fermi 2 wave runup analysis considered waves approaching from the northeast and the east and also considered site specific aspects of the plant layout, including the presence of other buildings and the security barrier to the north of the plant. The licensee calculated the wave runup using the Automated Coastal Engineering System (ACES) model. The licensee developed two profiles to describe the nearshore and shallow onshore areas. The licensee noted several assumptions inherent in the ACES model that provide a conservative determination of wave runup and overtopping. The licensee examined several points that were closest to shore to determine the highest waves generated and concluded that the highest waves generated from the northeast have a height of 12.3 ft (3.75 m) with a peak spectral period of 11.1 sec, and waves from the east had a wave height of 11.58 ft (3.53 m) with a wave period of 11.1 sec.

The licensee simulated wave transmission across the nearshore and onshore areas using the standard water wave equations provide in the USACE Coastal Engineering Manual (CEM) (CEM; USACE, 2003). The licensee's calculations of wave transmission across the nearshore and onshore areas considered the effects of changes in wave length, breaking waves due to shallow depths; the security barrier which would act as a submerged breakwater; and wave diffraction. Table 3.5-1 provides the calculated wavelengths associated with various points in Lake Erie.

For the breaking wave height calculations, the licensee used the procedures in the CEM (USACE, 2003), the results of which for breaking wave heights at the toe of the seawall, at the security barrier and the buildings are shown in Table 3.5-2. The licensee calculated the final wave runup by considering three diffraction scenarios: (1) no diffraction, (2) diffraction, and (3) the impact of the security barrier. The licensee assumed that the security barrier will act as a submerged breakwater and its effect on the waves is calculated by applying a reduction factor based on the CEM.

The licensee calculated the wave runup at the Fermi 2 SSCs from the ACES model using input from the STWAVE wave characteristics. The licensee used the wave characteristics calculated for the buildings as inputs to the ACES model to calculate wave runup for the case of no diffraction and no effect from the security barrier. Table 3.5-3 summarizes the diffraction and runup results for waves approaching from the east.

The licensee noted that waves approaching the site from any direction north of east will cross over the security barriers which would act as a submerged breakwater, before reaching the buildings. The licensee stated that the ACES model cannot simulate submerged breakwaters and therefore used the applicable CEM equations for the security barrier analysis. Table 3.5-4 summarizes the results of the licensee analysis conducted to determine the effects of the barrier.

The staff reviewed the approaches, methodology, and selected models and formulas used by the licensee for simulating wave set up, transmission, run-up, and breaking across the defined shore profile. For the Fermi 2 reevaluated wave runup, the staff reviewed the applicable methodology provided in the USACE CEM (USACE, 2003). The staff reviewed the wave run-up analysis and notes that the licensee used the present-day guidance and methodology as requested in the 50.54(f) letter.

As described in the Fermi 2 UFSAR, Revision 18, Sections 2.4.5.6.3 and 2.4.5.6.2 (DTE, 2012b), the licensee stated that the critical static pressure and thrust occur under the broken wave conditions, whereas the critical dynamic pressure and thrust occur under the breaking wave conditions for an assumed slope of 20:1 and the minimum wave periods of 3.4 to 4.5 sec. The licensee's calculated wave pressure and forces against the reactor building and RHR Complex are based on both 3 ft (0.9 m) and 5.4 ft (1.6 m) wave heights; which correspond to wave runup elevations of 593 ft (180.7 m) and 598 ft (182.3 m). As shown in Table 3.5-4, the licensee's maximum calculated transmitted wave height is 2.13 ft (0.65 m) at the buildings and the maximum wave runup elevation is 591.7 ft (180.4 m). Therefore, the licensee concluded that the calculated pressures and forces used in the Fermi 2 UFSAR, Revision 18 (DTE, 2012b) for structural design in the current licensing basis are more conservative than the reevaluated values.

The staff reviewed the licensee's calculated wave pressure, forces, and runup elevations, as well as the maximum calculated transmitted wave height. The staff agrees with the licensee's conclusion that the calculated pressures and forces used in the Fermi 2 UFSAR, Revision 18 (DTE, 2012b) for structural design in the current licensing basis are more conservative than the reevaluated values.

The licensee calculated the stability of a submerged breakwater, the results of which are shown in Table 3.5-5. The licensee stated that the diameters of the rocks on the seawall are in the range of 3 to 4 ft (0.9 to 1.2 m). Therefore, the licensee concluded that the shore protection barrier would be protected from erosion during the postulated flood. The licensee performed additional sensitivity analyses using the ACES model and the wave characteristics defined at the toe of the slope. The licensee also considered the stability of the seawall when the stillwater level is just at the top of the seawall. The licensee calculated that the wave height would be 7.44 ft (2.27 m) and the wave period is 11.1 sec. The licensee stated that the above analyses are conservative because the seawall would be submerged during the maximum flood event. The licensee assumed that waves would break on the face of the revetment, which is the area most subject to damage. For the postulated flood condition, the licensee concluded that the entire seawall would be underwater, and therefore not subject to the full force of the breaking waves associated with this water depth. In addition, the licensee concluded that during a lesser surge event, the seawall might not be submerged; but for that condition, the wave height would be less than the 9.49 ft (2.89 m) used in this analysis. The licensee stated that the extent of predicted damage to the seawall described in the analyses is consistent with that described in the Fermi 2 UFSAR, Revision 18, Section 2.4.5.7 (DTE, 2012b). The licensee also noted that damage to the shore barrier will not enable waves larger than 5.4 ft (1.65 m) to break against Category I structures because of their distance inland. Finally, the licensee stated that their Technical Requirements Manual requires that the shore barrier be inspected annually and after major storms.

The licensee determined the impact forces from debris striking the structure walls at the breaking wave velocity and considered the effect on the SSCs important to safety from debris and water-borne projectiles during the postulated wind-driven surge event. Using the methodology in the American Society of Civil Engineers (ASCE) 7-10 (ASCE, 2010) to determine the loads from debris or water borne projectiles based on a 2,000 pound (907 kg) projectile assumed to impact the structure at the wave velocity, the licensee's resultant loads were compared to the loads for which the structures are designed (tornado missiles) to ensure that the design can accommodate water borne projectiles. The licensee stated that the results demonstrate that loads from the waterborne debris plus hydrodynamic loads are less than the loads for which the structures are designed. Therefore, the licensee concluded that the structures are capable of handling the postulated loads.

The staff found that the licensee considered the effect to the SSCs important to safety from debris and water-borne projectiles during the postulated wind-driven surge event. The staff noted that the licensee compared the resultant loads to those for which the structures are designed (tornado missiles) to ensure that the design can accommodate water borne projectiles. Therefore, the staff agrees with the licensee's conclusion that the analysis results demonstrate that loads from the waterborne debris plus hydrodynamic loads are less than the loads that the structures are designed for.

The Fermi 2 wave runup analysis considers waves approaching from the northeast and the east and also considered site specific aspects of the plant layout including the presence of other buildings and the security barrier to the north of the plant. The highest runup elevation was calculated to be 591.7 ft (180.3 m). Runup elevations cited in the USFAR for the Fermi 2 plant ranges from 593 ft to 598 ft (181 m to 182 m). Therefore, the licensee's results are less than the wave runup elevations in the current design-basis. The staff also notes that the licensee considered waterborne projectiles, and that the load from waterborne debris and hydrodynamic loading is less than the design load of the structures.

### 3.5.3 Storm Surge Conclusions

The resulting maximum predicted still water elevation for this combination of flood causing events is 586.6 ft (178.8 m), which is 0.3 ft (0.09 m) below the stillwater flood level of 586.9 ft (178.9 m). Additionally, it is below the current design-basis elevation of 593.0 ft (180.7 m) for the Category I reactor/auxiliary building and elevation 598.0 ft (182.3 m) for the RHR complex. The staff determined that due to the topography of the site and the nearby vicinity, during the probable maximum surge event, the stillwater elevation would extend well inland to the west of the site. The staff reviewed the licensee's surge determinations and verified the height of the surge by checking the licensee's references (USACE, 2009 and USACE, 1984).

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge is bounded by the current design-basis flood hazard.

3.6 Seiche

The licensee reported in the FHRR that the reevaluated hazard, including associated effects for site flooding from seiche, does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The licensee stated in its FHRR, by reference to the Fermi 3 COL FSAR, 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."

The staff reviewed the information provided in the FHRR and its references and agreed with the licensee's conclusion that resonance is not a concern at the site during PMWS occurrence. The licensee also stated that historic records in the area indicated that the maximum recorded rise was 6.3 ft (1.9 m) and the maximum recorded fall was 8.9 ft (2.7 m) for the period of 1941 to 1981. The staff verified the information provided by the licensee regarding the historical occurrence of seiche at the Fermi 2 site.

In summary, the staff confirmed the licensee's conclusion that the PMF from seiche alone could not inundate the site. The staff confirmed that the reevaluated hazard for flooding from seiche is bounded by the current design-basis flood hazard.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding from tsunami does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design basis.

Based on the history of the area, the licensee stated that local seismic disturbances resulted in minor excitations in Lake Erie. No tsunami flooding has been recorded on Lake Erie. The licensee concluded that there are no potential tsunamis or tsunami-like waves which could affect safety-related structures or components at Fermi 2.

To verify licensee's conclusion, the staff searched the National Geophysical Data Center (NGDC, 2014) tsunami database and found two historical events: one in the northern end of Lake Erie and the other near the Detroit River. Further investigation by the licensee into additional information regarding historic records in the area indicated that the recorded historical events were only minor disturbances or seiches and no actual tsunamis are evident. The staff agrees with the interpretation that historical records do not show any evidence of prior tsunami on Lake Erie.

In summary, the staff confirmed the licensee's conclusion that the PMF from tsunami alone could not inundate the site. The staff confirmed that the reevaluated hazard for flooding from tsunami is bounded by the current design-basis flood hazard.

## 3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated PMF, including associated effects, due to an ice-induced event does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design basis.

The licensee stated that the emergency cooling system for Fermi 2 is provided by the ultimate heat sink, which does not rely on water sources external to the plant and is not affected by ice conditions. The licensee reviewed the USACE ice jam database (USACE, 2012) for historical occurrences of ice jams on Swan Creek and found no historic ice jams on Swan Creek in the database. Also, the licensee stated that no ice jams were observed on Swan Creek over the period from 1957 to the present, during which time the licensee managed the Fermi site.

To verify the licensee's response, the staff searched the USACE ice jam database and found no evidence of an historical ice jam on Swan Creek (USACE, 2012). However, the description of the ice jam database is limited to waterways that have USGS gaging stations (USACE, 2012) and the staff noted that there are no continuously recording USGS gaging stations on Swan Creek. The licensee stated that there have been no ice jams on Swan Creek since 1957; although the gaging station on the River Raisin to the south has recorded several ice jams since that time as recorded in the ice jam database and in local media sources. Although there are no USGS gaging stations on Swan Creek, the staff found no personal or media accounts of flooding on Swan Creek due to ice jams during this time period. Therefore, the staff agrees with the licensee's conclusion that ice jams are not likely to contribute to flooding in Swan Creek.

In summary, the staff confirmed the licensee's conclusion that the PMF from ice-induced flooding alone could not inundate the site. The staff confirmed that the reevaluated hazard for ice-induced flooding of the site is bounded by the current design basis flood hazard.

## 3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding from channel migrations or diversions does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The licensee stated that the geology and topography of the Swan Creek watershed are not conducive to large scale landslides that could cause a channel diversion. The licensee stated that although the banks of Swan Creek do experience small failures, they would not be large enough to divert Swan Creek. The licensee also determined that it is unlikely that an ice jam would occur on Swan Creek and cause a diversion. The licensee also stated that no manmade or natural diversions were observed over the period from 1957 to the present, during which time the licensee has managed the Fermi 2 site. The staff reviewed the licensee's findings and agrees that channel diversions or migrations are unlikely to affect the site.

In summary, the staff confirmed the licensee's conclusion that the PMF from channel migrations or diversions could not inundate the site. The staff confirmed that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the current design-basis flood hazard.

## 4.0 INTEGRATED ASSESSMENT AND ASSOCIATED HAZARD DATA

The staff confirmed that the reevaluated hazard results for all reevaluated hazard mechanisms are bounded.

The reevaluated hazard for LIP does not exceed the current design-basis for the Fermi 2 site. The flood elevation related to this hazard does exceed the site grade by 1.4 ft (0.42 m). However, since the LIP flood elevation remains below the door sill elevation of 583.5 ft (177.9 m), it would not result in adverse flooding of Class I structures.

The FHRR states that the reevaluated hazard, including associated effects, for site flooding from streams and rivers is elevation 586.6 ft (178.8 m). The current design-basis hazard for flooding from streams and rivers is less than elevation 582 ft (177 m), which is 1 ft (0.3 m) below plant grade (elevation 583 ft (177.7 m)) and 1.5 ft (0.45 m) below the door sills (elevation 583.5 ft (177.9 m)). The FHRR considered the stream and river flooding with a maximum lake level under a storm surge condition, which results in a flood elevation of 586.6 ft (178.8 m). The current design-basis for storm surge employs the same combination of effects (stream flooding plus the maximum lake level and storm surge). The current design-basis flood elevation for storm surge is 586.9 ft (178.9 m). The staff considers this hazard to be bounded by the storm surge analysis. T

The staff therefore concludes that an Integrated Assessment is not necessary.

## 5.0 CONCLUSION

The NRC staff reviewed the information provided for the reevaluated flood-causing mechanisms of Fermi 2. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, staff confirmed the licensee's conclusions that (a) the reevaluated hazard results for each reevaluated flood-causing mechanism are bounded by the current design-basis flood hazard, and (b) an Integrated Assessment is not necessary. The NRC staff has no additional information needs at this time with respect to Enclosure 2.

## 6.0 REFERENCES

ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

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- NRC, 2007, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition", NUREG-0800, 2007.

- NRC, 2009, "Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America", NUREG/CR-6966, March 2009, ADAMS Accession No. ML091590193.

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- NRC, 2011c, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

- NRC, 2011d, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

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- NRC, 2012a, letter from Eric Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, March 12, 2012, ADAMS Accession No. ML12053A340.

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- NRC, 2014a. Email from Thomas Wengert, Project Manager – Fermi-2, Office of Nuclear Reactor Regulation, to Alan I Hassoun, DTE Electric Company (DTE) regarding Fermi 2 – Draft RAI Concerning Flood Hazard Reanalysis Report. February 28, 2014. ADAMS Accession No. ML14063A000.

- NRC, 2014b, Staff Assessment of Flooding Walkdown Report, June 18, 2014, ADAMS Accession No. ML14143A235.

- NRC, 2014c. Fermi 2 – Request for Additional Information Regarding Fukushima Lessons Learned – Flooding Hazard Reanalysis Report. June 19, 2014. ADAMS Accession No. ML14168A565.


6.2 Codes and Standards


- ANSI/ANS (American National Standards Institute/American Nuclear Society), 1992, ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites," American Nuclear Society, LaGrange Park, IL, July 1992.


6.3 Other References:


- American Society of Civil Engineers (ASCE) 2010, "Minimum Design Loadings for Buildings and Other Structures," July 10, 2010.

- Conner, 2013, Letter NRC-13-0013 to NRC from J. Todd Conner (DTE) dated March 8, 2013, Subject: "DTE Electric Submittal of Flooding Hazard Reevaluation Report in Response to March 12, 2012 Information Request Regarding Flood Protection Evaluations," ADAMS Accession No. ML13070A199.

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- USACE, 2013, "National Inventory of Dams", accessed from http://nid.usace.army.mil, accessed on December 18, 2013.

**Table 2.2-1: Flood-Causing Mechanisms and Corresponding Guidance**

| Flood-Causing Mechanism | SRP Section(s) and JLD-ISG |
|---|---|
| LIP and Associated Drainage | SRP 2.4.2<br>SRP 2.4.3 |
| Streams and Rivers | SRP 2.4.2<br>SRP 2.4.3 |
| Failure of Dams and Onsite Water Control/Storage Structures | SRP 2.4.4<br>JLD-ISG-2013-01 |
| Storm Surge | SRP 2.4.5<br>JLD-ISG-2012-06 |
| Seiche | SRP 2.4.5<br>JLD-ISG-2012-06 |
| Tsunami | SRP 2.4.6<br>JLD-ISG-2012-06 |
| Ice-Induced | SRP 2.4.7 |
| Channel Migrations or Diversions | SRP 2.4.9 |

**Notes:**

SRP is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)

JLD-ISG-2012-06 is the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a)

JLD-ISFG-2013-01 is the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b)

**Table 3.0-1: Summary of Controlling Flood-Causing Mechanisms**

| Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation* | ELEVATION, ft (m) NYMT |
|---|---|
| LIP and Associated Drainage | 583.4 (177.8) |
| Storm Surge | 586.9 (178.9) |

***Flood Height and Associated Effects as defined in JLD-ISG-2012-05.**

**Table 3.1.2-1: Current Design Basis Flood Hazard**

| Flooding Mechanism | Stillwater Elevation, ft (m) NYMT | Associated Effects, ft (m) | Current Design Basis (CDB) Flood Elevation, ft (m) NYMT | Reference |
|---|---|---|---|---|
| LIP and Associated Drainage | Less Than 582 (177) | Not Discussed in CDB | Less Than 582 / 583.5* (177 / 177.9) | FHRR Section 3.1 |
| Streams and Rivers | 579.1 (176.5) | Not Discussed in CDB | 579.1 (176.5) | FHRR Section 3.2 |
| Failure of Dams and Onsite Water Control/Storage Structures | N/A | N/A | N/A | FHRR Section 3.3 |
| Storm Surge | 586.9 (178.9) | 11.1 (3.4) due to wave run-up | 593.0 (180.7) to 598.0 (182.3) | FHRR Section 3.4 |
| Seiche | N/A | N/A | N/A | FHRR Section 3.5 |
| Tsunami | N/A | N/A | N/A | FHRR Section 3.6 |
| Ice-Induced | N/A | N/A | N/A | FHRR Section 3.7 |
| Channel Migrations or Diversions | N/A | N/A | N/A | FHRR Section 3.8 |

***Fermi 2 UFSAR, Revision 18 is unclear as to the actual CDB. Site grade elevation is 583.0 ft, whereas the door sills are at an elevation of 583.5 ft**

**Table 3.2-1: Summary of parameters at three on-site cross sections**

| On-Site Cross Section (See Figure 3.2-1) | Drainage Area (acre) | Unobstructed width, ft (m) | Slope | Base elevation, ft (m), Plant Datum | Peak runoff, $ft^3/s$ ($m^3/s$) | Max water surface elevation, ft (m), Plant Datum |
|---|---|---|---|---|---|---|
| A | 43 | 692 (210.9) | 0.0019 | 582 (177.4) | 3844 (108.9) | 583.4 (177.8) |
| B | 34 | 463 (141.1) | 0.0024 | 582 (177.4) | 3040 (86.1) | 583.4 (177.8) |
| C | 3 | 219 (66.8) | 0.0024 | 582.5 (177.5) | 268 (7.6) | 583 (177.7) |

**Table 3.2-2: Results of the Reevaluated LIP Analysis for the Onsite Drainage Area at Cross Section B (See Figure 3.2-2)**

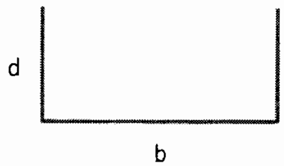
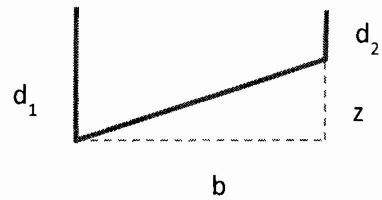
| | Licensee Results | NRC Staff Results | |
|---|---|---|---|
| **Total flow from drainage area** | Intensity (I) = 89.4 in./hr (227 cm/hr)<br>Drainage area (A) = 34 acres<br>Runoff, Q = IA = 3,040 $ft^3/s$ (86.1 $m^3/s$) | Intensity (I) = 89.4 in./hr (227 cm/hr)<br>Drainage area (A) = 34 acres<br>Runoff, Q = IA = 3,040 $ft^3/s$ (86.1 $m^3/s$) | Intensity (I) = 89.4 in./hr (227 cm/hr)<br>Drainage area (A) = 27 acres<br>Runoff, Q = IA = 2,414 $ft^3/s$ (68.4 $m^3/s$) |
| **Manning Eq.** | $Q = (1.486/n)\ AR^{2/3}\ S^{1/2}$ n=0.2 S=0.0024 | | |
| **Cross section length (b)** | Unobstructed Section Length = 463 ft (141 m) | | |
| **Cross section geometry** | **Rectangular Cross Section**<br><br> | **Semi-Trapezoidal Cross Section**<br><br> | |
| **Cross section flow area (A)** | Area: A = bd<br>d = 1.43 ft (0.44 m)<br>A = 660.77 $ft^2$ (61.38 $m^2$) | Area: A = b $(d_1+d_2)/2$<br>$d_1$ = 2.03 ft (0.62 m)<br>$d_2$ = 0.83 ft (0.25 m), z = 1.2 ft (0.37 m)<br>A = 661 $ft^2$ (61.4 $m^2$) | Area: A = b $(d_1+d_2)/2$<br>$d_1$ = 1.84 ft (0.56 m)<br>$d_2$ = 0.64 ft (0.20 m), z = 1.2 ft (0.37 m)<br>A = 575.6 $ft^2$ (53.5 $m^2$) |
| **Hydraulic radius (R)** | Wetted perimeter:<br>P = b + 2d = 465.85 ft (141.99 m )<br>R = A/P = 1.42 ft (0.43 m) | Wetted perimeter:<br>$P = (b^2 + z^2)^{1/2} + d_1 + d_2$ = 465.86 ft (141.99 m)<br>R = A/P = 1.42 ft (0.43 m) | Wetted perimeter:<br>$P = (b^2 + z^2)^{1/2} + d_1 + d_2$ = 465.49 ft (141.88 m)<br>R = A/P = 1.24 ft (0.38 m) |
| **Calculated flow Q via cross section** | Q = 3040 $ft^3/s$ (86.1 $m^3/s$) | Q = 3040 $ft^3/s$ (86.1 $m^3/s$) | Q = 2414 $ft^3/s$ (68.4 $m^3/s$) |
| **Base elevation of cross section** | 582 ft (177.4 m) | 581.6 ft (177.3 m) (at d1 location)<br>582.8 ft (177.6 m) (at d2 location) | 581.6 ft (177.3 m) (at d1 location)<br>582.8 ft (177.6 m) (at d2 location) |
| **Water surface elevation** | = 582 + d = 583.43 ft (177.82 m) | = 581.6 + $d_1$ = 583.63 ft (177.89 m) | = 581.6 + $d_1$ = 583.44 ft (177.83 m) |
| **CDB Flood Elevation** | 583.5 ft (177.85 m) | | |

**Table 3.3-1: Results of Storm Surge Hazard Reevaluations for Three Alternatives Evaluated in Fermi 2 Flood Analyses**

| Combined Events | Licensee Results | | NRC Staff Results | |
|---|---|---|---|---|
| **Flood Scenario** | **Result for Individual Event** | **Resulting Fermi Flood Elevation, ft (m), Plant Datum** | **Result for individual Event** | **Resulting Fermi Flood Elevation, ft (m), Plant Datum** |
| Alternative I: | | | | |
| • 500-yr flood in Swan Creek | 5,000 $ft^3/s$ (142 $m^3/s$) | | 5,000 $ft^3/s$ (142 $m^3/s$) | |
| • largest observed surge in Lake Erie | 4.0 ft (1.2 m) | 580.6 (177.0) | 4.0 ft (1.2 m) | 580.3 (176.9) |
| • 100-year elevation of Lake Erie | 576.3 ft (175.6 m) | | 576.3 ft (175.6 m) | |
| Alternative II: | | | | |
| • PMF in Swan Creek | 113,200 $ft^3/s$ (3,200 $m^3/s$). | | 134,000 $ft^3/s$ (3,790 $m^3/s$). | |
| • 25-yr surge in Lake Erie | 3.2 ft (0.98 m) | 580.35 (176.9) | 3.2 ft (0.98 m) | 582.7 (177.6) |
| • 100-yr elevation of Lake Erie | 576.3 ft (175.6 m) | | 576.3 ft (175.6 m) | |
| Alternative III: | | | | |
| • 25-yr flood in Swan Creek | 3100 $ft^3/s$ (88 $m^3/s$) | | 3100 $ft^3/s$ (88 $m^3/s$) | |
| • Probable maximum surge or seiche in Lake Erie | 10.3 ft (3.14 m) | 586.6 (178.8) | 10.3 ft (3.14 m) | 586.6 (178.8) |
| • 100-yr elevation of Lake Erie | 576.3 ft (175.6 m) | | 576.3 ft (175.6 m) | |

**Table: 3.5-1 Wavelengths (FHRR Table 3.4-1)**

| Location | Depth, ft (m) | Wave length, ft (m) |
|---|---|---|
| Deepwater | N/A | 631 (192.3) |
| STWAVE point | 19.2 (5.9) | 267 (81.4) |
| Seawall | 15.9 (4.8) | 245 (74.7) |
| Barrier | 4.6 (1.4) | 134 (40.8) |
| Buildings | 3.6 (1.1) | 119 (36.3) |

**Table 3.5-2: Breaking Wave Heights (FHRR Table 3.4-2)**

| Location | Depth, ft (m) | Wave Height, ft (m) |
|---|---|---|
| Seawall | 15.9 (4.8) | 9.49 (2.89) |
| Barrier | 4.6 (1.4) | 2.84 (0.87) |
| Buildings | 3.6 (1.1) | 2.24 (0.68) |

**Table 3.5-3: Wave Runup Elevations for Wave Diffraction (FHRR Table 3.4-3)**

| Parameter | RHR Complex | Reactor Building |
|---|---|---|
| Incident Wave Height ft (m) | 2.24 (0.68) | 2.24 (0.68) |
| Incident Wave Period (sec) | 11.1 | 11.1 |
| Modified Wave Height ft (m) | 1.0 (0.3) | 0.9 (0.27) |
| Runup from Modified Wave ft (m) | 2.0 (0.6 ) | 1.9 (0.57) |
| Elevation of Runup ft (m) | 588.6 (179.4) | 588.5 (179.3) |

**Table 3.5-4: Wave Runup Elevations Accounting for Security Barrier (FHRR Table 3.4-4)**

| Parameter | Both Structures |
|---|---|
| Incident Wave Height, ft (m) approaching barrier | 2.84 (0.87) |
| Incident Wave Period (sec) | 11.1 |
| Transmission Coefficient (Ct) | 0.75 |
| Transmitted Wave Height, ft (m) | 2.13 (0.65) |
| Wave Runup, ft (m) | 5.1 (1.55) |
| Elevation of Runup, ft (m) | 591.7 (180.4) |

**Table 3.5-5: Stability of Submerged Breakwater Results (FHRR Table 3.4-5)**

| s | N*s | $D_{50}$ ft (m) |
|---|---|---|
| 2 | 7.783 | 2.1 (0.64) |
| 5 | 8.659 | 1.8 (0.55) |
| 8 | 9.439 | 1.8 (0.55) |

**Figure 2.2.4-1: Flood Event Duration**

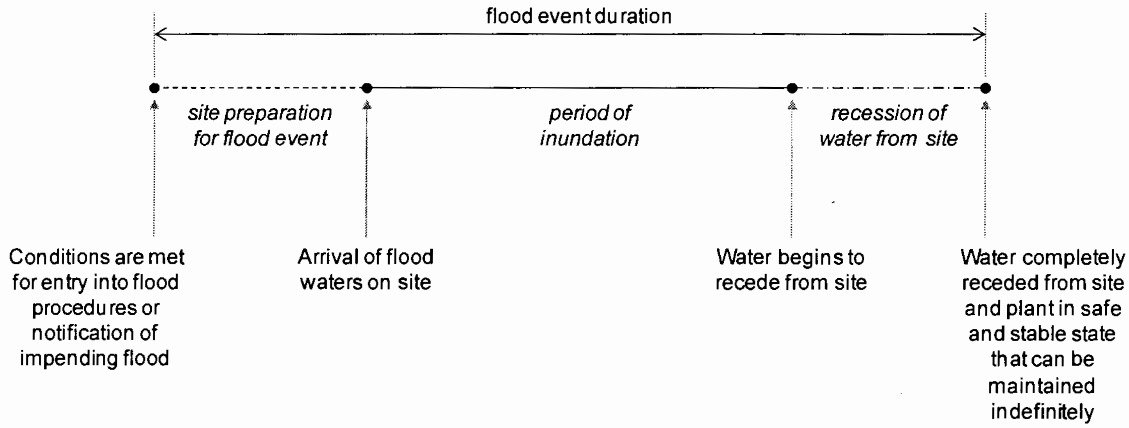


**Figure 3.2-1: Site Map Showing Structures, Ground Surface Contour, Location of Cross Sections A, B, and C.**

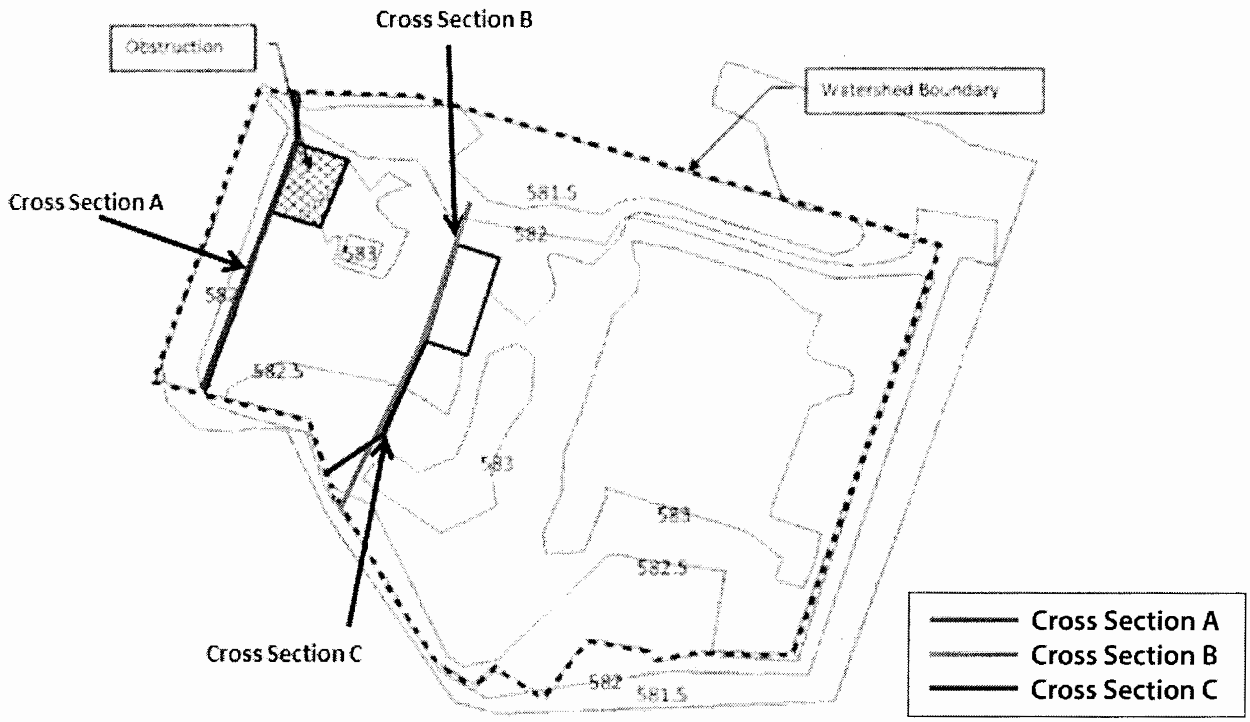


**Figure 3.2-2: Site Map Showing Structures, Ground Surface Contour, Location of Cross Section B and Drainage Areas for Cross Section B.**

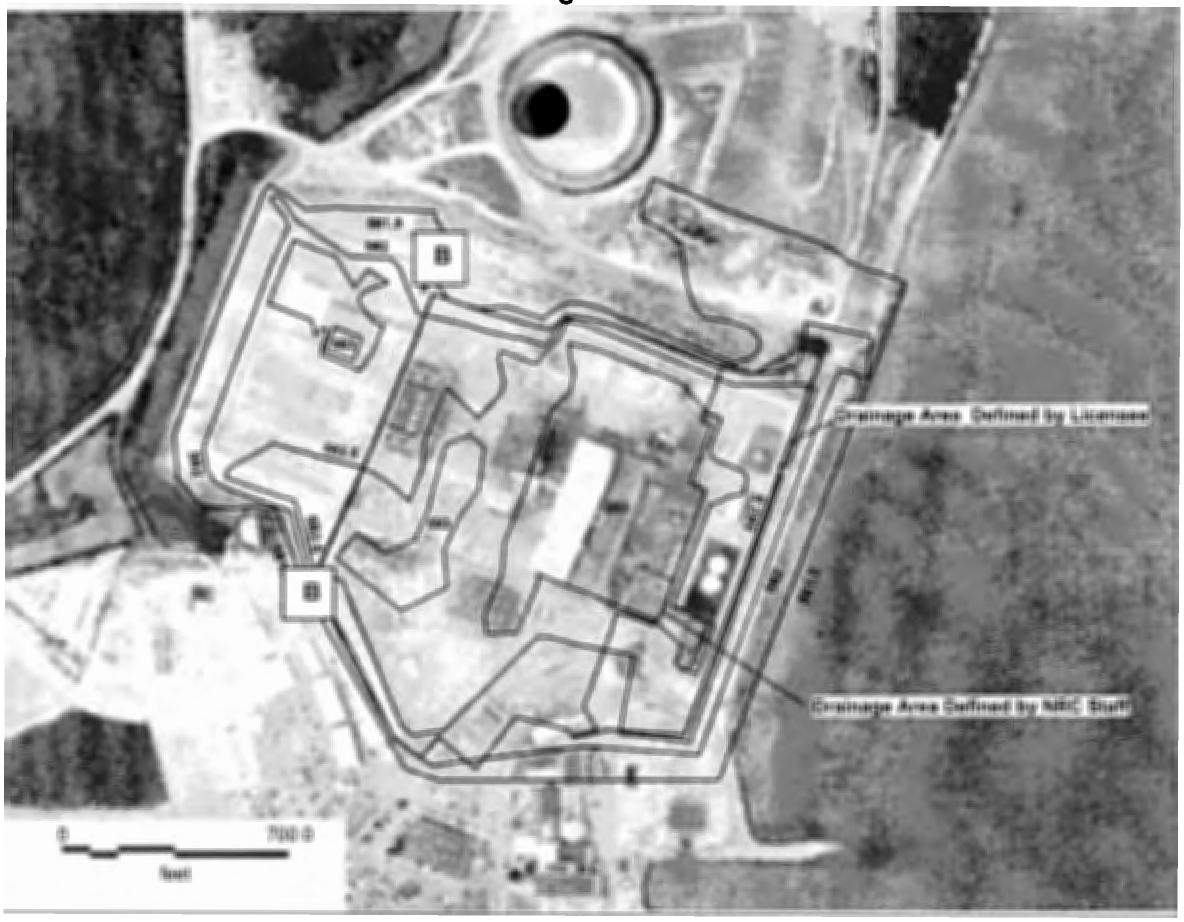
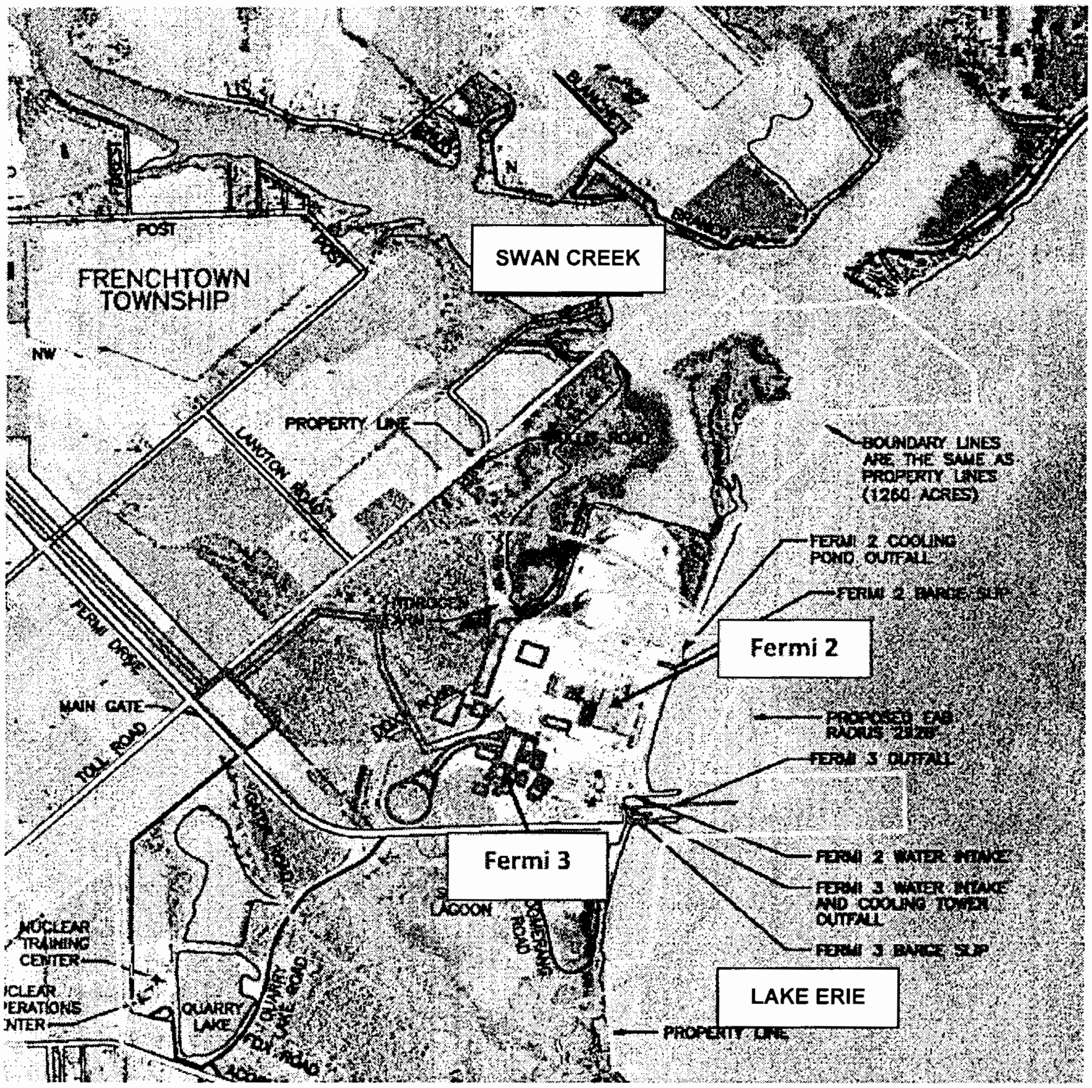


**Figure 3.2-3: Fermi Site Showing Proximity of Proposed Fermi 3 to Existing Fermi 2 (FHRR Figure 1)**



If you have any questions, please contact me at (301) 415 2915 or e-mail at Victor.Hall@nrc.gov.

Sincerely,

*/RA/*

Victor Hall, Senior Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-341

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Hazard Reevaluation Report

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