The Detroit Edison Company
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10 CFR 52.79

January 29, 2010
NRC3-10-0007

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

References: 1) Fermi 3
Docket No. 52-033
2) Letter from Ilka T. Berrios (USNRC) to Jack M. Davis (Detroit Edison), "Request for Additional Information Letter No. 19 Related to the SRP Sections 2.4.2, 2.4.3, 2.4.5, 2.4.6 and 2.4.13 for the Fermi 3 Combined License Application," dated December 8, 2009

Subject: Detroit Edison Company Response to NRC Request for Additional Information Letter No. 19

In Reference 2, the NRC requested additional information to support the review of certain portions of the Fermi 3 Combined License Application (COLA). The responses to these Requests for Additional Information (RAIs) are provided as Attachments 1 through 5 of this letter. Information contained in these responses will be incorporated into a future COLA submission as described in the RAI response.

If you have any questions, or need additional information, please contact me at (313) 235-3341.

I state under penalty of perjury that the foregoing is true and correct. Executed on the 29th day of January, 2010.

Sincerely,

Peter W. Smith, Director
Nuclear Development – Licensing & Engineering
Detroit Edison Company

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NRO

Attachments: 1) Response to RAI Letter No. 19 (Question No. 02.04.02-4)
2) Response to RAI Letter No. 19 (Question No. 02.04.03-2)
3) Response to RAI Letter No. 19 (Question No. 02.04.03-3)
4) Response to RAI Letter No. 19 (Question No. 02.04.05-5)
5) Response to RAI Letter No. 19 (Question No. 02.04.05-6)
6) Response to RAI Letter No. 19 (Question No. 02.04.05-7)
7) Response to RAI Letter No. 19 (Question No. 02.04.05-8)
8) Response to RAI Letter No. 19 (Question No. 02.04.06-1)
9) Response to RAI Letter No. 19 (Question No. 02.04.13-9)

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Bruce Olson, NRC Fermi 3 Environmental Project Manager (w/o attachments)
Fermi 2 Resident Inspector (w/o attachments)
NRC Region III Regional Administrator (w/o attachments)
NRC Region II Regional Administrator (w/o attachments)
Supervisor, Electric Operators, Michigan Public Service Commission (w/o attachments)
Michigan Department of Environmental Quality, Radiological Protection and Medical Waste Section (w/o attachments)

Attachment 1
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4068)

RAI Question No. 02.04.02-4

NRC RAI 02.04.02-4

To meet the requirements of 100.20(c) and 52.79(a)(1)(iii) and to support the staff's review of the application, the staff requests additional information concerning the erosion protection measures to be used for the slopes of the Fermi 3 elevated area. The staff requests the following:

1. *calculations of the potential maximum velocity of runoff from the 8 percent slopes during the PMP at the site*

2. *detailed information on specific erosion protection measures designed to resist erosion under the maximum predicted water velocities.*

Response

The calculation of the potential maximum velocity of runoff from the 8 percent slopes during the PMP and the specific erosion protection to be provided are discussed below.

Determination of Potential Maximum Velocity of Runoff from the 8 percent slopes

The potential maximum velocity is determined on the 8% slopes of the "elevated area" based on the flow rate corresponding to the local Probable Maximum Precipitation (PMP). This is conservative as it is the highest flow rate that the site could experience, and would be bounding for lesser but more typical precipitation events. The surface cover is one of the factors that dictate the runoff velocity. For the initial determination of the velocity, the surface cover is assumed to be "smooth earth." This is conservative as it results in a lower roughness coefficient and therefore higher velocities. A local PMP flow rate and velocity is determined for each of the sub-basins (sub-basins S1, S2, S3, N1, and N2 are shown on FSAR Figure 2.4-217). Erosion protection will then be specified based on the highest predicted velocity.

The probable maximum flow (Q) for each of the sub-basins is determined using the Rational Equation.

$Q = C*I*A$ Equation 1 (same as that provided in FSAR Section 2.4.2.3)

Where:

C = Rational Coefficient, unitless
I = Rainfall Intensity, in/hr
A = Sub-Basin Area

Manning's equation is used to calculate the normal depth of flow down the 8% slope of the "elevated area." Manning's equation is as follows:

$$Q = \frac{1.49}{n} A \left(\frac{A}{P}\right)^{\frac{2}{3}} S^{\frac{1}{2}}$$ Equation 2 (same as that shown in FSAR Section 2.4.2.3)

Where:

Q = flow rate from Equation 1, cfs
n = Manning's Roughness Coefficient, unitless
A = flow area, ft^2
  = b * y
b = bottom width, ft
y = normal depth, ft
P = wetted perimeter, ft
  = b + 2 * y
S = slope, ft/ft

The bottom width is assumed to be the outside edge of the sub-basin at the top of the 8% slope. This is conservative as the width is wider at the bottom of the sloped area than at the top.

Using the area determined using Equation 2 and the flow rate determined using Equation 1, the velocity is determined using the following:

V = Q/A   Equation 3

Where:

V = Velocity, ft/s
Q = Flow, ft^3/s
A = Flow Area, ft^2

Based on the above method, the velocities for each of the sub-basins are summarized in Table 1, below.

Table 1

Sub-Basin ID	V (ft/s)
S1	4.73
S2	5.64
S3	4.26
N1	4.77
N2	4.03

Sub-basin S2 has the largest velocity based on a high flow rate coupled with the smallest outside edge at the top of the 8% slope. Erosion control will be specified based on the velocity determined for sub-basin S2. To be conservative, all other sloped areas will use equivalent erosion control measures.

Erosion Protection

As discussed in the response to RAI 02.04.02-1, submitted in Detroit Edison letter NRC3-09-0027 (ML092790561), dated September 30, 2009, erosion control measures for the 8% slope of the elevated area will be consistent with design practices included in "The Guidebook of Best Management Practices (BMP) for Michigan Watersheds." The BMP for Michigan Watersheds provides information useful for specifying the erosion control method(s) based on the predicted runoff velocity. As shown above in Table 1, the maximum predicted velocity during a PMP storm event is 5.64 ft/s (based on a final surface of smooth earth); which is greater than the maximum allowable velocity for this soil texture. Figure 1 below, Table 1 of the Stabilized Outlets BMP shows that the maximum allowable velocity for graded loam to gravel is 5 ft/s. To reduce the velocity and prevent erosion, multiple erosion control measures could be incorporated. Grass surfacing would change the n value in Equation 2 above, and reduce the velocity to 4.47 ft/s. Exhibit 4 of the Grass Waterways BMP (Figure 2 below) shows that the permissible velocity for soil established by sod is between 5 and 6 ft/s. As the maximum velocity is less than the permissible velocity, grass surfacing would be an acceptable erosion control measure. Riprap is another erosion control measure that could be used. Using the velocity and depth calculated for sub-basin S2, a D50 of 0.25 feet would be required according to Exhibit 3 of the Riprap BMP (Figure 3). The erosion control measures discussed in this response describe possible measures that could be used. Erosion control measures are not limited to the possible options discussed in this response.

FIGURE 1, The Guidebook of BMPs for Michigan Watersheds, SO-3

Table 1

Maximum Allowable Velocities for Various Soils

Soil Texture	Maximum Allowable Velocity (ft/sec)
Sand and sandy loam	2.5
Silt loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel, graded loam to gravel	5.0
Cobbles	5.5
Shale	6.0

Source: Connecticut Guidelines for Soil Erosion and Sediment Control, Connecticut Council for Soil and Water Conservation, 1985.

FIGURE 2, The Guidebook of BMPs for Michigan Watersheds, GW-9

Exhibit 4

Permissible Velocity (V_i)*

		Erosion Resistant		Easily Eroded
	Slope Range	Established by Seeding	Established by Sod	
Kentucky bluegrass Smooth brome Tall fescue	0- 5 5-10 over 10	4 3 3	6 5 5	3.5 2.5 2.5
Grass mixtures Reed canarygrass Orchard grass	0- 5** 5-10**	4 3	6 5	3.5 2.5
Lespedeza Redtop Alfalfa Red fescue	0-5***	4	6	2.5

* Use velocities between 5 and 6 feet per second only where good covers and proper maintenance can be obtained.

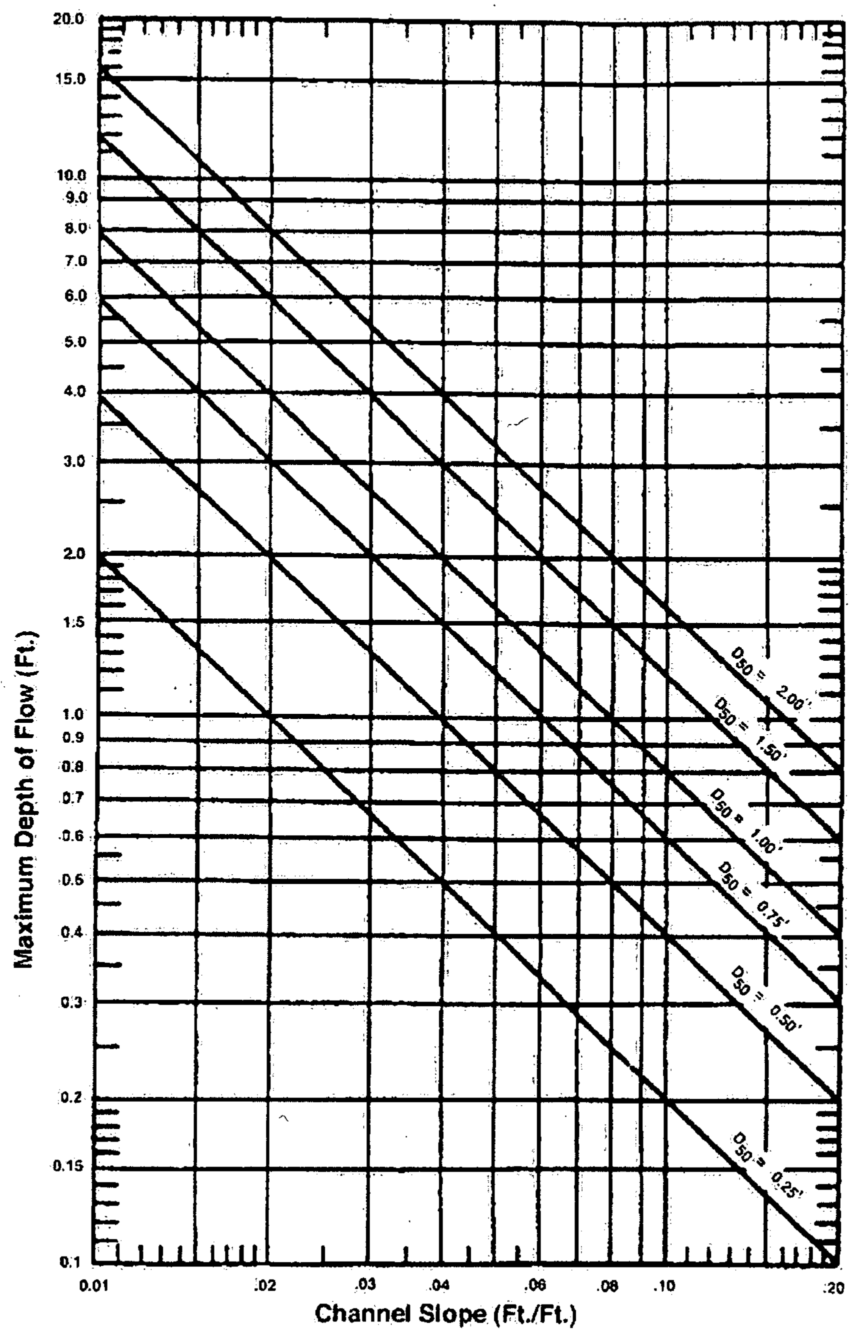
** Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

*** Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

FIGURE 3, The Guidebook of BMPs for Michigan Watersheds, RIP-14

Exhibit 3

Maximum Depth of Flow for Riprap-Lined Channels



Source: Design of Stable Channels with Flexible Linings, Hydraulic Engineering Circular No. 15, Federal Highway Administration, 1975, as copied from the Rhode Island Soil Erosion and Sediment Control Handbook.

Proposed COLA Revision

The response to RAI 02.04.02-1, submitted in Detroit Edison letter NRC3-09-0027 (ML092790561), dated September 30, 2009, included a mark-up for the FSAR to discuss erosion control measures. This previously provided mark-up will be clarified as shown on the attached pages to specify that erosion control measures will be based on the local PMP storm event. The other changes represented by the attached markup are described in the response to RAI 02.04.02-1, submitted in Detroit Edison letter NRC3-09-0027 (ML092790561), dated September 30, 2009.

Markup of Detroit Edison COLA
(following 2 pages)

The following markup represents how Detroit Edison intends to reflect this RAI response in the next submittal of the Fermi 3 COLA Revision 2. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be different than presented here.

18.10 hectares (44.72 acres)

This total area is ~~17.83 hectares (44.05 acres)~~. Due to the minimal 0.6 percent slope within the 10.51 hectare (25.96 acre) N3 area, the storm-runoff from the local PMP storm could create a backwater scenario due to the storm runoff leaving the 8 percent slope of the safety related area at a higher velocity than the 0.6 percent slope of the N3 drainage area. Using the rational method, the corresponding runoff for this area is ~~86.8~~ m^3/s ~~(3,066~~ cfs). For this discharge, Manning's equation predicts a runoff depth of ~~0.78 m (2.55 ft)~~, using the channel characteristics described above. This depth is the local PMP runoff ~~water level~~.

88.1

3112

0.79 m (2.59 ft)

Add Insert 3 Here

Given that the existing plant grade is at elevation 177.3 m (581.8 ft) NAVD 88, the most conservative water level due to PMP runoff at the Fermi 3 site is approximately ~~178.1 m (584.4 ft)~~ NAVD 88. The nominal Fermi 3 plant grade of safety related structures is 179.6 m (589.3 ft) NAVD 88. Therefore, the Fermi 3 nominal plant grade elevation is approximately ~~4.5 m (4.9 ft)~~ above the local PMP runoff flood level. Accordingly, no safety related structures will flood due to PMP runoff.

178.2m (584.67)

1.4m (4.5ft)

Add Insert 4 Here

EF3 COL 2.0-14-A

2.4.3 Probable Maximum Flood on Streams and Rivers

This section determines the PMF of the Swan Creek Watershed, which is located hydrologically above Fermi 3. The guidance of ANSI/ANS-2.8-1992, which is the latest available standard, was used in determining the PMF (Reference 2.4-235).

The Swan Creek Watershed is shown on Figure 2.4-208 (Reference 2.4-260). It has a drainage area of approximately 275 km^2 (106 mi^2). Swan Creek, the main outlet for this watershed and a minor tributary of the western basin of Lake Erie, is located approximately 1.6 km (1 mi) northeast of Fermi 3. Swan Creek is currently ungauged. Consequently, there is no recorded flow data pertaining to historical storm events. However, historical flow rates have been estimated by the Michigan Department of Environmental Quality (MDEQ). The lowest 95 percent and 50 percent exceedance, the harmonic mean, and the 90-day once in 10-year flow (90Q10) for Swan Creek are estimated to be 0, 0.08, 0.13, and 0.03 m^3/s (0, 2.8, 4.6, and 0.9 cfs), respectively. Monthly 50 percent and 95 percent exceedance flows and monthly mean flows are shown on Table 2.4-215.

The MDEQ has estimated Swan Creek's flow rates during typical storm events using the Drainage-Area Ratio (DAR) method on Plum Brook

Insert 4

To prevent erosion on the 8% slopes of the elevated area, a storm water collection system will be designed to collect the runoff before it has a chance to reach the slopes. Figure 2.4-215 shows the conceptual storm water collection plan. The runoff will be collected in drop inlets where it will make its way to an outfall pipe at the north canal. Therefore the only runoff that the slopes will see is from direct rainfall onto the slopes. The slope area is small which will result in a small runoff. The small runoff spread over the length of the boundary of the elevated area will result in very low velocities. Erosion does not occur at very low velocities. [START **COM** FSAR-2.4-002] Detailed design will incorporate best industry practices included in "The Guidebook of Best Management Practices for Michigan Watersheds" to provide added erosion protection to the slopes, even though they are receiving very little runoff. These practices include mulching, seeding, sodding, soil management, trees, shrubs, and ground covers. [END **COM** FSAR-2.4-002]

To be conservative, erosion protection methods selected will be based on runoff velocities for a local PMP condition not taking credit for the storm water drains.

Attachment 2
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4069)

RAI Question No. 02.04.03-2

NRC RAI 02.04.03-2

In accordance with 100.20(c) and 52.79(a)(1)(iii) and to support the staff's review of the application, the NRC staff requests that the applicant provide 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 ANSI/ANS-2.8-1992 guidelines indicate that the Alternative I should include the "surge and seiche resulting from the worst regional hurricane or windstorm."

Response

Regarding Alternative I, ANSI/ANS-2.8-1992, Section 9.2.3.2, states that the following combination of events should be considered:

(1) One-half PMF or 500-yr flood, whichever is less.
(2) Surge and seiche from the worst regional hurricane or windstorm with wind-wave activity.
(3) 100-yr or maximum controlled level of water body, whichever is less.

The bases for the combinations of flood causing scenarios specified in ANSI/ANS-2.8-1992 are described in Section 9.2 as follows:

> "The following combinations of flood-causing events are considered to have an exceedance probability of less than 1 x 10^{-6} and shall be used, if they apply, as design flood bases for power reactor plants."

As described in FSAR Section 2.4.3.3 (page 2-444), the analysis for Alternative I was performed using the 500-yr flood for Swan Creek combined with the 100-yr water level for Lake Erie and the surge and seiche from the worst regional windstorm with wind-wave activity. For Alternative I the 100-year surge for the month of December was used in this analysis. The calculated 100-year storm surges vary by month and range from 1.6 ft in August to 4.0 feet in December. The exceedance probability of the combination of events used in the Fermi 3 analysis to satisfy Alternative I in ANSI/ANS-2.8-1992, Section 9.2.3.2 is:

= 500 year flood * 100 year lake level * 100 year storm induced lake level increase

$$=\left(\frac{1}{500yr}\right)*\left(\frac{1}{100yr}\right)*\left(\frac{1}{100yr}\right)=2x10^{-7}\,peryear$$

The exceedance probability of this event combination is less than 1 x 10^{-6} sited in ANSI/ANS-2.8-1992, Section 9.2, as the bases for the event combinations.

Using the 100-year storm surge of 4.0 feet, the predicted water surface elevation for Alternative I was 579.4 ft NAVD88 (580.6 ft PD, plant datum). This represents a 0.3 ft rise over the still water surface elevation in Lake Erie for this condition which would be 579.1 ft NAVD88 (580.3 ft PD). This is 6.0 feet below the still water level predicted for Alternative III, 585.4 ft NADV88 (586.65 feet PD). FSAR Section 2.4.5.3.2.4 indicates that for Alternative III the safety related features would not be impacted by high water levels even with the addition of wave activity. Therefore, it can be concluded that the safety related features would also not be impacted by high water levels under the Alternative I scenario because water levels would be 6.0 ft less than in Alternative III.

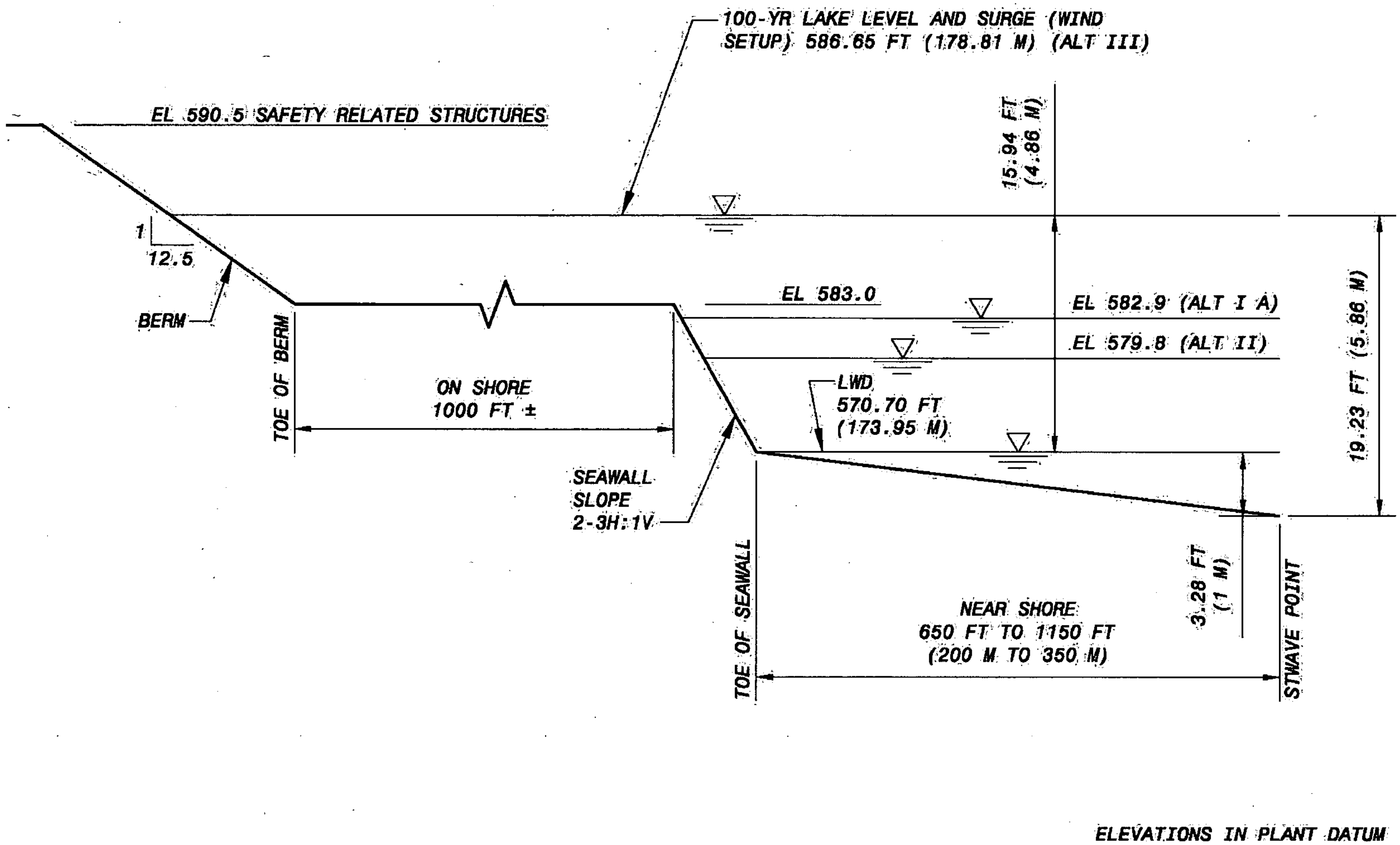
If a seiche of 6.3 was used in the Alternative I analysis, the predicted water surface elevation would be approximately 581.7 ft NAVD88 (582.9 PD). This is 3.7 ft below the still water level predicted for Alternative III (586.65 PD). As discussed above, FSAR Section 2.4.5.3.2.4 indicates that for Alternative III the safety related features would not be impacted by high water levels even with the addition of wave activity. Therefore, it can be concluded that even if a seiche of 6.3 feet is used, the safety related features would not be impacted by high water levels under the Alternative I analysis, including the higher surge elevation scenario, because water levels would be 3.7 ft less than the Alternative III analysis.

Figure 1 shows the still water elevations for all three alternatives. On Figure 1 the seiche height of 6.3 feet was used in place of the 100-year storm surge of 4.0 ft for Alternative I (identified as Alternative IA on the attached figure).

Proposed COLA Revision

None.

Figure 1
Still Water Elevations for Alternatives IA, II and III



Attachment 3
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4069)

RAI Question No. 02.04.03-3

NRC RAI 02.04.03-3

The staff has reviewed FSAR Section 2.4.3.6, Coincident Wind and Wave Activity. In accordance with 100.20(c) and 52.79(a)(1)(iii), the NRC staff requests 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 should provide the details on determination of critical wind direction and speed, calculation of possible wind-wave activities, and evaluation of potential impacts of wind wave run-up on the plant safety design.

Response

The potential for wave action to cause flooding of the safety related features was considered for all alternatives. The approach was to first examine the effects of waves for the worst case scenario which was Alternative III. The results of that analysis were described in Section 2.4.5 of the FSAR. For Alternative III the wave runup was calculated to be 3.0 ft. This height in addition to the still water elevation of 586.7 PD (plant datum) means runup would reach an elevation of 589.7 ft PD about 0.8 ft below the elevation of Fermi 3 safety related facilities.

For Alternative II the still water level at the site was calculated to be 578.6 ft NAVD88 or 579.8 ft PD. This elevation is about 3.2 ft below the elevation of the top of the seawall at the site. Assuming the same wave characteristics as the maximum wave calculated from the STWAVE modeling, the wave would have a height of 12.37 ft and a period of 11.1 seconds. Because of the lower water depth, the wave will break as it moves towards shore. At the toe of the seawall where the water depth would be 9.1 ft, the breaking wave height would be 5.5 ft. In this case the seawall does not extend high enough above the waves for ACES to calculate a meaningful run-up value. The top of the waves would be about 0.4 ft below the seawall so there would definitely be water from the waves splashing up onto the onshore area behind the seawall. However, the elevation of the safety features is 7.5 ft above this area and therefore would be well above the influence of the waves.

A similar analysis can be conducted for Alternative I. Assuming a seiche height of 6.3 ft, the still water level for this alternative would be 581.7 ft NAVD88 or 582.9 ft PD which is just below the top of the seawall. The breaking wave height at the toe of the seawall would be 7.4 ft. Calculating a wave runup value for this situation where the water level is essentially at the top of the seawall is not appropriate. However, the top of the waves would be about 3.6 ft higher than the elevation of the onshore area and therefore a significant amount of water would wash onto the onshore area. The elevation of the safety feature is 7.5 ft above the onshore area. Based on this information it was concluded that wave activity would not have any impact on safety features for alternatives I or II.

It should also be noted that in the above calculations and those presented in the FSAR it was assumed that the wave period would not change as waves moved onshore. Although it is generally believed that wave periods decrease as waves move onshore, according to the Coastal

Engineering Manual (FSAR Reference 2.4-250) there is no widely accepted method for determining changes in wave period. This is a conservative assumption because longer period waves have longer wave lengths, higher breaking wave heights and larger wave run-up values.

Proposed COLA Revision

None.

Attachment 4
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4073)

RAI Question No. 02.04.05-5

NRC RAI 02.04.05-5

To meet the requirements of 10 CFR Part 52 and 10 CFR Part 100 and to support the staff's review of the application, the staff requests that 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.

Response

According to the ANSI/ANS-2.8-1992 standards, Section 7.2.3.1, "A moving squall line should be considered for the locations along Lake Michigan where significant surges have been observed because of such a meteorological event. The possible region of occurrence includes others of the Great Lakes". The standard further defines the conditions to be used in the analysis which include a pressure jump of 8 mbar within a 10 nautical mile width of the squall lines with a 65 knot wind. In addition, the squall line should move at the resonant speed of the surge.

References listed in the ANSI standard for use in evaluating a moving squall line include a series of three papers published in the Monthly Weather Review (Platzman, G.W. 1965, Irish, S.M. 1965 and Hughes, L.A. 1965). These three papers focused on the prediction of surges in the Southern Basin of Lake Michigan. The first paper presented the results of a numerical model that predicted surge height and time of arrival at various shore locations. The numerical model used in the analysis was described in a previous publication by Platzman (1958). The second paper was a case study comparing the results of the numerical model with data from a large surge attributed to a moving squall line. The third paper described an operational scheme for predicting surges associated with squall lines in Lake Michigan.

In the Great Lakes area, most of the analyses of storm surges due to moving squall lines have been in Lake Michigan. As reported by Platzman (1965) most of the moving squall lines in this region move in a northwest to southeast direction. The effect of the pressure gradient and wind stress acting on the water surface produces a surface disturbance similar to a solitary wave. The maximum amount of energy is supplied to the water surface when the propagation of the squall line is approximately equal to the speed of waves in the lake. The speed of waves in the lake is dependent on the water depth. In Lake Michigan the resonant speed is about 57 knots (~65 mph) while in the Lake Erie, the resonant speed is much less; about 26 knots or 30 mph (Donn 1959). Fast moving squall lines have on several occasions produced storm surges in the range of 6 to 8 ft in Lake Michigan. These same storms would not produce significant storm surges in Lake Erie because the storm would move over the water surface too quickly for a solitary wave to form.

Donn (1959) reported on storm surges, associated with a moving squall line, which affected Lake Huron and Lake Erie in 1952. The squall line moved across Lake Huron with a propagation speed of about 65 mph producing shoreline surge of up to 2.2 ft. The storm traveled in a southeasterly direction over Lake Erie such that the storm front was parallel to the axis of the lake. Records at Cleveland indicated that the pressure jump was about 0.1 in (about 3.4 mbar) with winds of 20 to 30 mph. The storm slowed as it moved across Lake Erie to a propagation speed of about 27 mph, consistent with the Lake Erie resonant speed (Donn 1959). It is likely that a resonant transfer of energy occurred and a solitary wave was generated in Lake Erie, a storm surge of 1.7 ft was observed in Cleveland. According to Platzman (1965) the displacement of the water surface is proportional to the magnitude of pressure jump. Extrapolating the 1.7 ft storm surge associated with a pressure jump of 3.4 mbar recorded at Cleveland in 1952, to the 8 mbar pressure jump condition defined in the ANSI standard, the expected storm surge would be about 4 ft.

The Fermi site is sheltered from the predominant direction of squalls moving through this region of the Great Lakes. To generate the greatest storm surge the squall line would have to move in a southeast to northwest direction, opposite to the direction in which they are observed to travel. The most likely situation in which surge from a squall line could affect the Fermi site would be from surge reflected back from the southeastern shoreline. The reflected waves would attenuate as they moved across the lake.

Platzman (1965) presented tables of results for four locations in Lake Michigan that summarized the results of storm surge due to the pressure difference and due to surface stress. The results were scaled to a pressure rise of 0.01 in. (0.34 mbar) and a wind speed of 10 knots. In this way the results can be used to determine the amplitude of the storm surge for a variety of pressure jumps and wind speeds. The highest storm surges were predicted for South Haven and were predicted to occur when the squall line was moving southeasterly with propagation speed of 60 knots. At this direction and speed the squall line would move over the deepest portion of southern Lake Michigan at a speed close to the resonant speed of the surge.

Although the results presented in Platzman (1965) are site specific and do not directly apply to the Fermi site the potential effect of a squall line with an 8 mbar pressure jump, 65 knot winds moving at the resonant speed was determined. Based on the figures for South Haven, the maximum surge due to the atmospheric pressure change would be 2.6 ft. The maximum surge due to wind stress would be 3.0 ft for a total rise of 5.6 ft. The historical data and research have indicated that storm surges in Lake Michigan are much greater than those generated in Lake Erie primarily because of the differences in lake size and depth but also due to the orientation of the lakes with respect to the primary direction of propagation of the squalls. Therefore, the conditions listed in the ANSI standard, which would produce a 5.6 ft storm surge in Lake Michigan would produce a much smaller surge in Lake Erie.

Based on historical data and analyses of storm surges conducted for Great Lakes areas it can be concluded that a storm surge from the prescribed conditions could produce a water level rise of up to a few feet. As discussed in FSAR Section 2.4.5, the surge used in the flood analysis was 10.3 feet and therefore the surge from a moving squall line would be much less than the condition used in the analysis.

References

Donn, W.L., "The Great Lakes Storm Surge of May 5, 1952," *Journal of Geophysical Research*, vol 64, No. 2 Feb. 1959, pp. 191-198.

Hughes, L. A. "The Prediction of Surges in the Southern Basin of Lake Michigan. Part III. "The Operational Basis for Prediction," *Monthly Weather Review*, vol 93, No. 5, May 1965, pp. 275-281

Irish S.M. "The Prediction of Surges in the Southern Basin of Lake Michigan. Part II. "A Case Study of the Surge of August 3, 1960," *Monthly Weather Review*, vol 93, No. 5, May 1965, pp. 275-281

Platzman, G.W. "A Numerical Computation of the Surge of 26 June 1954 on Lake Michigan," *Geophysica*, vol. 6, No. 3-4, 1958, pp. 407-438.

Platzman, G.W. "The Prediction of Surges in the Southern Basin of Lake Michigan. Part I. "The Dynamical Basis for Prediction," *Monthly Weather Review*, vol 93, No. 5, May 1965, pp. 275-281

Proposed COLA Revision

None

Attachment 5
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4073)

RAI Question No. 02.04.05-6

NRC RAI 02.04.05-6

To meet the requirements of 10 CFR Part 52 and 10 CFR Part 100 and to support the staff's review of the application, the staff requests that the applicant provide the following: (1) descriptions of the limitations 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 on the derivation of the key parameters of fetch length and water depth used in the Bretschneider method, and (4) a table of results presented in applicant's calculation package.

Response

1. Limitations of the Bretschneider Method
The Bretschneider method was based on original work done by Bretschneider that examined storm surges from hurricanes. Bretschneider expanded the work to include classifications of other water bodies. The general classifications included; enclosed lakes and reservoirs, off coast or continental shelf, and coastlines and open bays and estuaries. In the classification of lakes and reservoirs, the following types are addressed; rectangular channel with constant depth, regular in shape, somewhat irregular in shape, and very irregular in shape. The method can be improved for lakes with varying depths by segmenting the lake and making calculations for each segment. This approach was used in developing the wind set-up calculations for Fermi 3. This method is not recommended for lakes that are very irregular in shape, for these cases Bretschneider recommends that statistical analysis of winds and wind set-up be used. No other limitations are noted.

2. Rationale for Choosing the Bretschneider Method
The Coastal Engineering Manual does not recommend any specific methods for calculating storm surge. The Bretschneider method was selected because it was considered to be the most appropriate method for this location. Two other methods that could have been used include the Zeider Zee formula and the Sibul Method. The Zeider Zee formula was developed for fjords which are long, narrow and deep. This method can overestimate storm surge in shallow water such as the western basin of Lake Erie. The Sibul method was also considered however, the wind set-up predicted by the Sibul method was significantly smaller and therefore less conservative than that of the Bretschneider method.

To verify that the wind set-up predicted by the Bretschneider method was conservative and reasonable, the predicted value was compared to measured storm surges in Lake Erie. According to the Corps of Engineers Detroit District, the 100-yr storm surge for December at the Fermi site is 3.9 ft (Reference 2.4-245). During other months of the year the 100-yr storm surge are less than 3.9 ft. In addition, according to the NOAA web site, (Reference 2.4-228) the maximum water level during the period of record was 576.22 (IGLD 85) or 576.48 (NAVD 88). This was recorded on April 9, 1998 at 1400. This value was 3 ft above the average monthly water level for April, 1998. The maximum recorded water level is 9 ft below the water level used in the flood calculations. The period of record for verified data at the Fermi 3 site is January 1, 1970 through August 1, 2009. Based on the applicability of the Bretschneider method for enclosed water bodies, and comparison of the predicted wind set-up to observed values, this method provides a conservative estimate of wind set-up.

3. Derivation of Parameters

The key parameters that affect storm surge are the fetch length, water depth, wind speed, and coefficients used to calculate wind stress, and bottom stress. The Bretschneider method uses straight line fetches and therefore the longest straight line fetch distance was used in the calculations. This distance was calculated to be 154,781 m. Using this method several options are available for calculating storm surge in enclosed basins including options for a constant or irregular depth. The option that accounted for an irregular depth was used in the calculations. The fetch length was divided into 10 segments and the average depth within each segment was calculated. The average depths ranged from 8.7 m, closest to shore, to 23.2 m with an overall average depth of 16.2 m. If the average depth were used in the calculations instead of the variable depth for each segment, the calculated storm surge would be 0.4 ft smaller. A wind speed of 100 mph was used in the calculations. The coefficients used in the equations were derived by the Corps of Engineers based on studies conducted at Lake Okeechobee.

4. Table of Results

The table of results from the calculation file is presented below (Table 1). Figure 1 is included to illustrate variables that were used. The table lists the calculated values for each of the 10 segments along the transect of the lake. The stress parameter is calculated according to the equation listed under Note A and is a function of wind speed, fetch length and water depth. The ratio of wind set-up (S) to water depth (h) was interpolated from values presented in tables provided in FSAR Reference 2.4-257. The specific values for stress parameter and ratio (S/h) used in the interpolation are listed in the table below and marked as the high and low values.

TABLE 1, Calculation File Results

Notes	Parameter											
	Wind Set-up Calculations											
	Bretschneider Method											
	Calculations for		**X / l = 1**									Check using lake average
Notes	**Parameter**	**100 mph wind**										
	Depth (m)	**18.87**	**22.86**	**23.12**	**21.30**	**15.88**	**10.86**	**12.05**	**11.01**	**8.72**		**16.17**
	K	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033		0.0000033
	U (ft/s)	147	147	147	147	147	147	147	147	147		147
	F (ft)	56424	56424	56424	56424	56424	56424	56424	56424	56424		507812
	g (ft/sec2)	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2		32.2
	D or h ft	61.91	75.00	75.85	69.88	52.10	35.63	39.53	36.12	28.61		53.05
A	Stress	0.032	0.022	0.022	0.025	0.046	0.098	0.080	0.095	0.152		0.398
B	Stress (low)	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201		0.39
	S/h (low)	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097		0.184
	Stress (high)	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209		0.423
	S/h (high)	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101		0.199
C	S/h	0.013	0.008	0.007	0.009	0.019	0.045	0.036	0.044	0.072		0.188
	ΔS (ft)	0.79	0.57	0.55	0.65	1.01	1.62	1.43	1.60	2.07		9.95
	S (ft) cum	0.8	1.4	1.9	2.6	3.6	5.2	6.6	8.2	10.3		9.9
	Notes											
	A	Stress Parameter =		kU^2F / gD^2								
	B	From Table 5.2 (Ippen, 1966) relating S/h, etc. to stress parameter										
		Values for stress parameters that bracket the calculated value										
	C	Interpolated value of S/h, etc. from values presented in B										

FIGURE 1, Bretschneider Method Variables

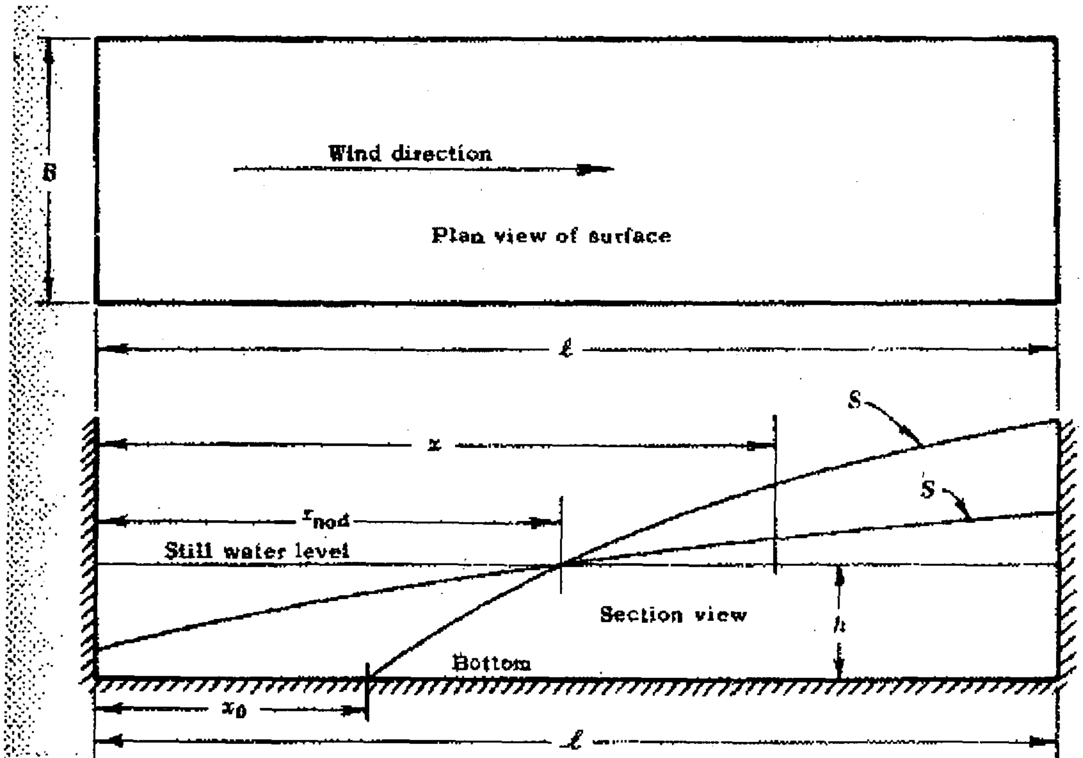


FIG. 5.1. Rectangular channel of constant depth.

Proposed COLA Revision

None

Attachment 6
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4073)

RAI Question No. 02.04.05-7

NRC RAI 02.04.05-7

To meet the requirements of 10 CFR Part 52 and 10 CFR Part 100 and to support the staff's review of the application, the staff requests that the applicant provide a map showing the distribution of wave height overlain on the contours of the bathymetric map of Lake Erie. According to section of 7.3.5 of ANSI/ANS-2.8-1992, "Results of the computation of the probable maximum surge hydrograph in graphical presentation" should be addressed.

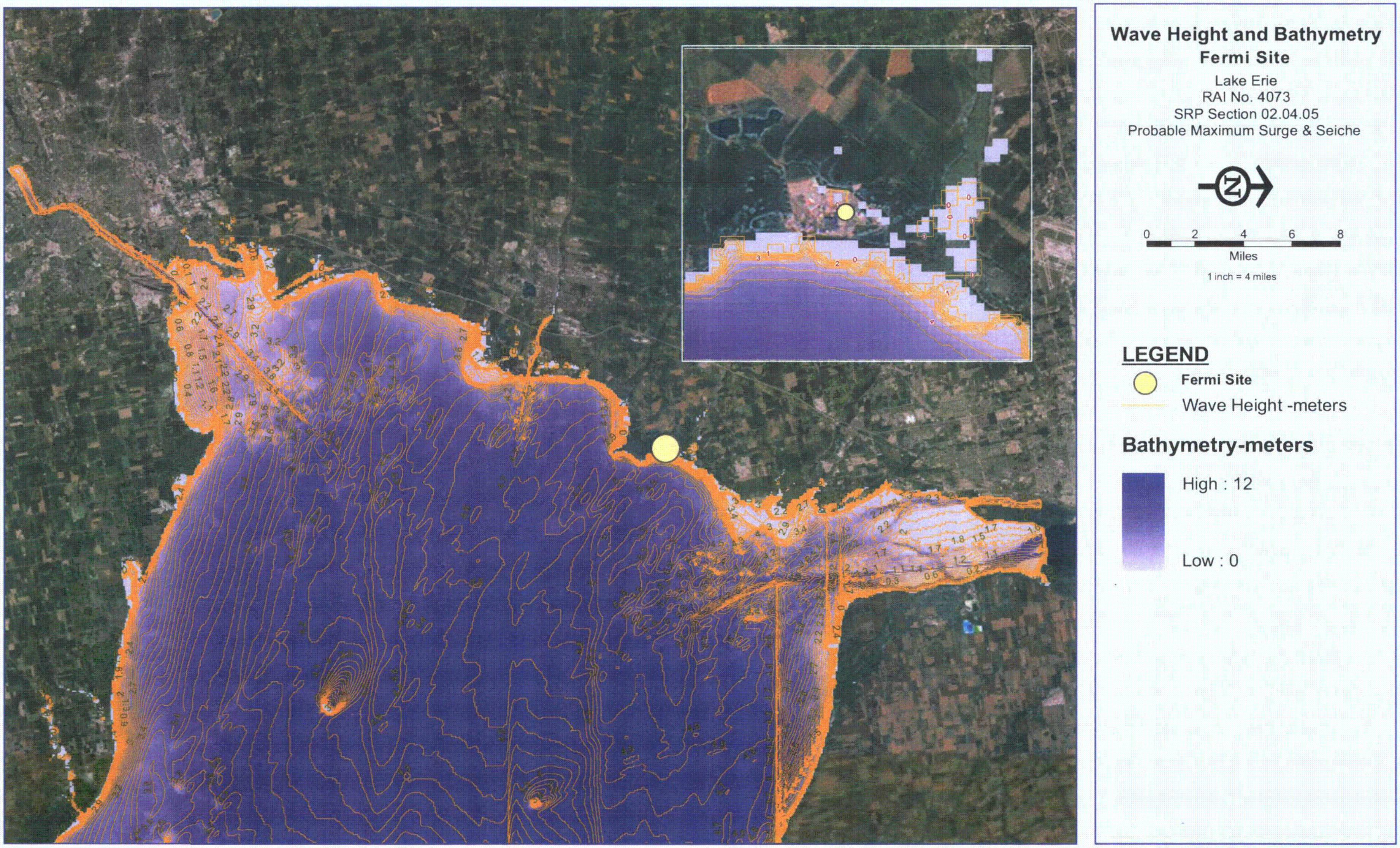
Response

Figure 1 provides the contours of the wave height distribution overlain on the bathymetric map of Lake Erie from NOAA (NOAA Great Lakes Environmental Research Laboratory, http://www.glerl.noaa.gov/data/char/bathymetry.html). The wave height contours were prepared using the results from the STWAVE analysis. Wave heights are in meters and the contours have 0.1 meter accuracy.

Proposed COLA Update

None.

Figure 1


Wave Height and Bathymetry
Fermi Site
Lake Erie
RAI No. 4073
SRP Section 02.04.05
Probable Maximum Surge & Seiche
N
0
2
4
6
8
Miles
1 inch = 4 miles
LEGEND
Fermi Site
Wave Height -meters
Bathymetry-meters
High : 12
Low : 0

Attachment 7
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4073)

RAI Question No. 02.04.05-8

NRC RAI 02.04.05-8

To meet the requirements of 10 CFR Part 52, and 10 CFR Part 100 and to support the staff's review of the application, the staff requests that the applicant provide the following:

1. *Revise FSAR Table 2.4-224, Breaking Wave Heights, to show correct and consistent values of wave height in meter and feet, respectively, and*
2. *Use graphs to illustrate the shore profile (from STWAVE point to the Fermi 3 safety structure), 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.*

Response

(1) Table 2.4-224 will be modified to show the correct values for wave heights in feet. The table will be modified to be as shown below.

Location	Depth		Wave Height	
	(m)	(ft)	(m)	(ft)
Seawall	4.85	15.9	2.89	9.5
Berm	1.11	3.65	0.68	2.2

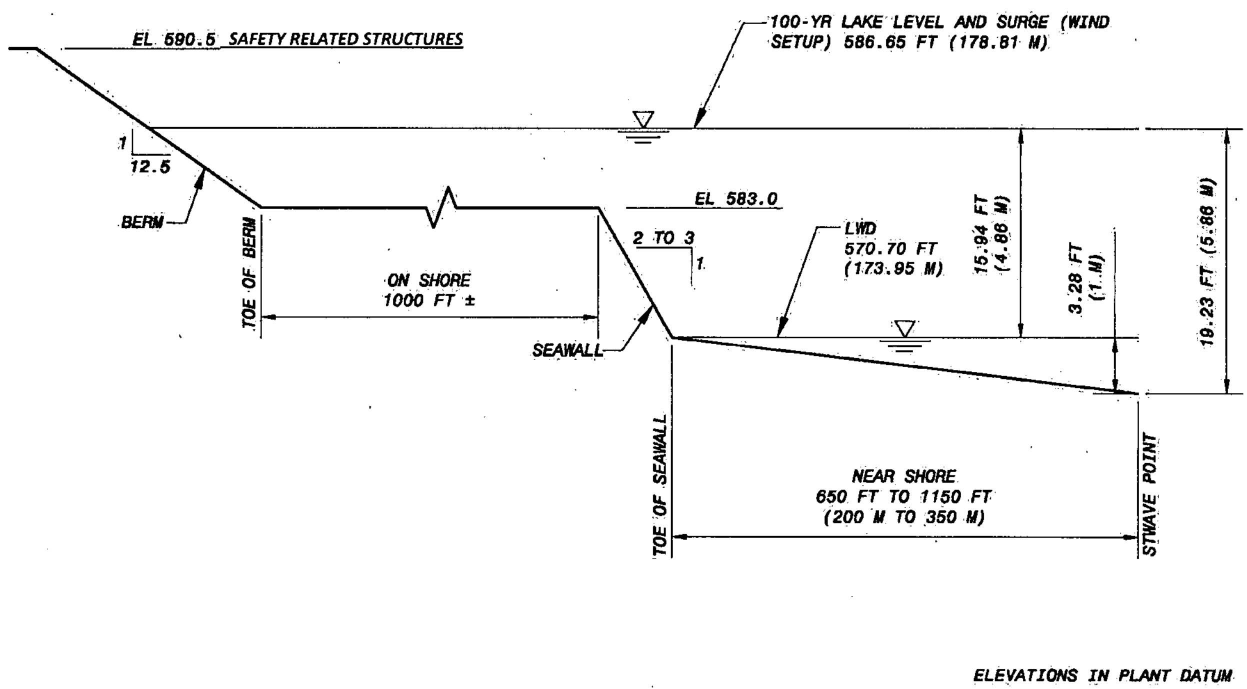
(2) Graphs are provided below, that indicate wave characteristics at three locations across the shore, at the toe of the seawall, at the toe of the berm, and the final run-up on the berm. These graphs show the still water level, wave height, wave length, and run-up characteristics. In addition to the graphical presentation, the values of the wave characteristics are summarized below for each location.

Figure 1 presents a cross section showing a transect between the Fermi 3 site to the grid point. Ground elevations and the still water surface water elevation are shown using the Fermi Plant Datum (PD). Note that because of the horizontal distances included on Figure 1 it is not to scale. However, slopes, elevations and distances are noted on Figure 1. The areas shown on Figure 1 can be described as:

- Nearshore – the area from 3.3 ft depth (MLW) to 0 ft depth (MLW). This area is between the points used to describe the waves at the shore (from STWAVE model) to the base of the seawall. The area is about 650 ft (200 m) to 1,150 ft (350 m) wide with a slope of about 200 H: 1 V.
- Seawall – the area of onshore protection from an elevation of 570.7 ft (173.95 m) to 583 ft (177.7 m) with a slope of 3H: 1V to 2H: 1V.

- Onshore - the area immediately behind the seawall. This area is approximately flat with a width of about 1,000 ft
- Berm – area between the onshore flat area and the project site. This area has a slope of about 12.5 H:1V with smooth slopes. Although there is a flat area within this area it ends at an elevation of 590.5 ft.

Figure 1



The steps used to calculate the wave runup were discussed in Section 2.4.5.3.2 and included:

1. Selected wave height and period based on STWAVE results (H_{mo} = 3.77 m, T_p = 11.1 sec
2. Simulated wave transmission across the nearshore area.
3. Calculated breaking wave characteristics (wave length and height) at two locations – the toe of the sea wall (H = 2.89 m) and the toe of the berm (H = 0.68 m).
4. Calculated the wave runup on the berm using the wave characteristics for the toe of the berm and structure height and water depth shown on the attached figure.

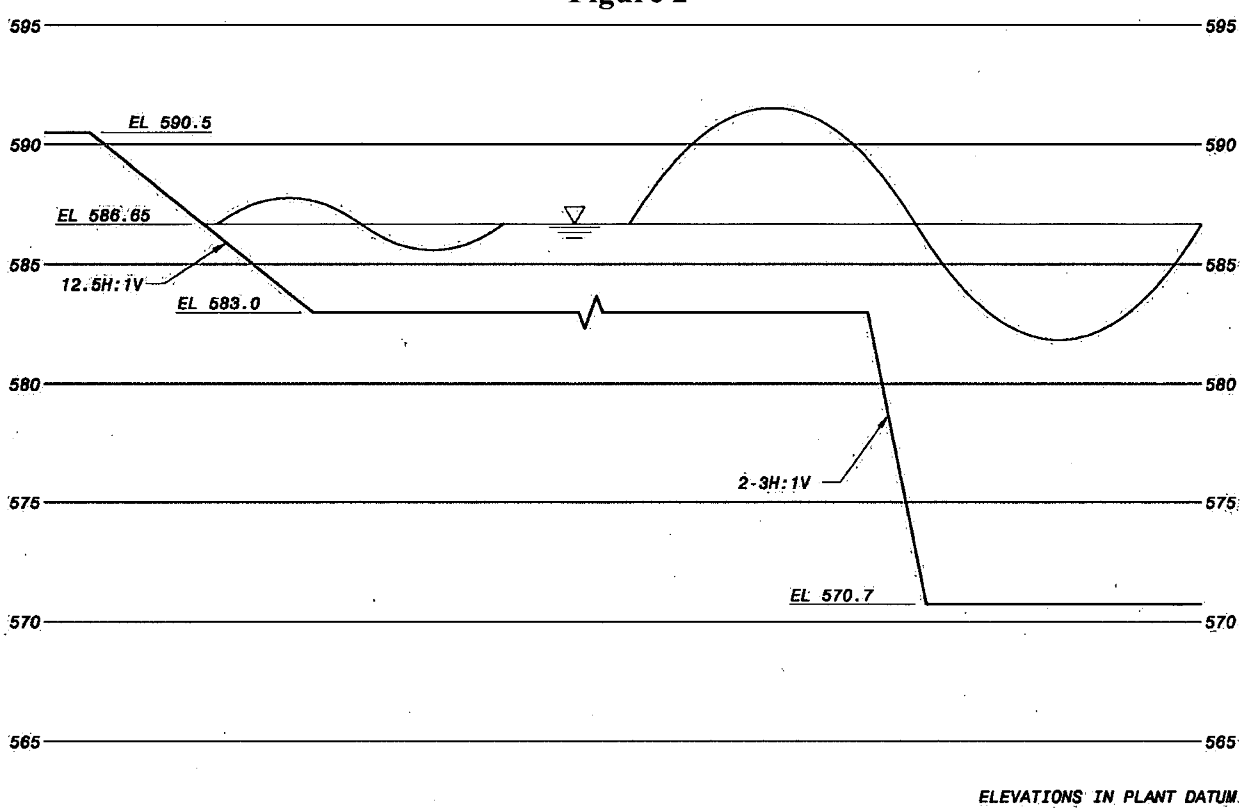
Water depths, wave heights and wave lengths at three locations are summarized on the following table.

Location	Water Depth		Wave Height		Wave Length	
	(m)	(ft)	(m)	(ft)	(m)	(ft)
STWAVE Point	5.85	19.2	3.77	12.4	81.4	267
Seawall (toe)	4.85	15.9	2.89	9.5	74.6	245
Berm (toe)	1.11	3.65	0.68	2.2	36.2	119

The wave lengths may appear to be excessively long especially for waves that have broken. This is due to the assumption that the wave period does not change. As stated in the FSAR this is a conservative assumption that was made because there is no widely accepted method for calculating how the wave period decreases. As an example if the wave period was 4 seconds instead of 11.1 seconds the wave length at the berm would be 12.5 m (41 ft).

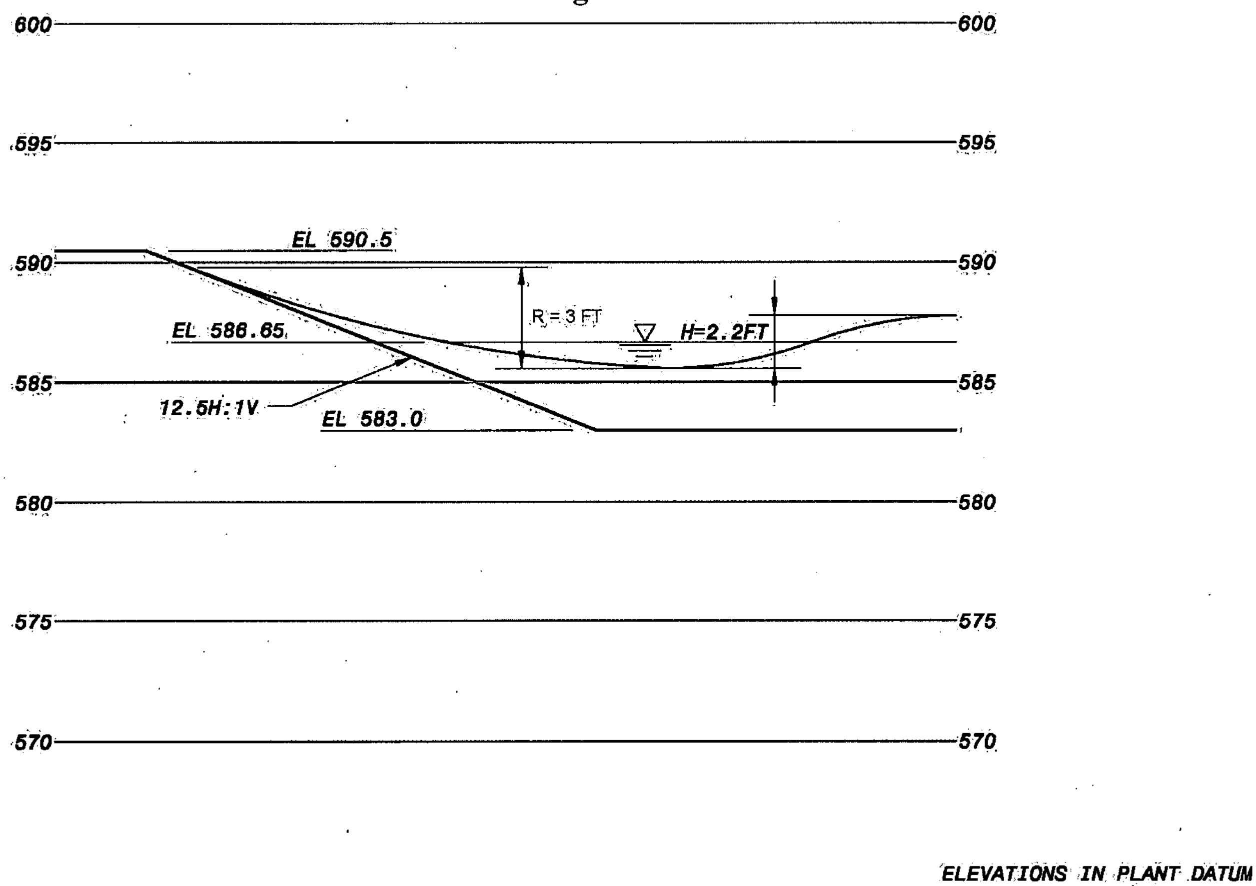
Figure 2 below shows the waves at the seawall and the berm. The vertical exaggeration on this figure is about 10 to 1.

Figure 2



Wave runup was predicted to be 3.01 ft. Wave runup is shown on Figure 3 below. The vertical exaggeration on the figure is about 5 to 1.

Figure 3



Proposed COLA Revision

A mark-up for FSAR Table 2.4-224 to correct the wave heights (in feet) is attached.

Markup of Detroit Edison COLA
(following page)

The following markup represents how Detroit Edison intends to reflect this RAI response in the next submittal of the Fermi 3 COLA Revision 2. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be different than presented here.

Table 2.4-224 Breaking Wave Heights [EF3 COL 2.0-16-A]

	Depth		Wave Height	
Location	**(m)**	**(ft)**	**(m)**	**(ft)**
Seawall	4.85	15.9	2.89	~~2.89~~ 9.5
Berm	1.11	3.65	0.68	~~0.68~~ 2.2

Attachment 8
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4074)

RAI Question No. 02.04.06-1

NRC RAI 02.04.06-1

To meet the requirements of 10 CFR Part 52, and 10 CFR Part 100 and to support the staff's review of the application, the staff requests that the applicant conduct a thorough search for historical tsunamis in the area. Based on the search results, the applicant should provide an analysis to evaluate whether a tsunami may occur in the area and its potential impacts, if any. NRC staff has conducted an initial search and found two historical events: one in the northern end of Lake Erie and the other near the Detroit River.

Response

The National Oceanographic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC) maintains a historical tsunami database which catalogs tsunami events (http://www.ngdc.noaa.gov/hazard/hazards.shtml). As described on the NGDC website,

> "The NGDC tsunami database is a listing of historical tsunami source events and runup locations throughout the world that range in date from 2000 B.C. to the present. The events were gathered from scientific and scholarly sources, regional and worldwide catalogs, tide gauge reports, individual event reports, and unpublished works. There are currently over 2,000 source events in the database with event validities >0 (0=erroneous entry). The global distribution of these events is 63% Pacific Ocean, 21% Mediterranean Sea, 5% Atlantic Ocean, 4% Caribbean Sea, 6% Indian Ocean, and 1% Black Sea. There are over 13,000 runup locations where tsunami effects were observed. The global distribution of these locations is 82% Pacific Ocean, 2% Atlantic Ocean, 2% Caribbean Sea, 4% Mediterranean, 9% Indian Ocean, and <1% in the Red Sea and Black Sea."

The NGDC tsunami database can be searched using various parameters, such as source region, tsunami validity and runup region. In the NGDC database, the Great Lakes (including Lake Erie) are located in the Region titled "East Coast of the United States and Canada." A search of the NGDC database for runup attributed to a Tsunami in the "East Coast of the United States and Canada" Region identified a total of 48 such occurrences. This total of 48 such events includes all of the runup events identified for this region, without consideration of the validity of the event. Of these 48 events, six are attributed to the Great Lakes. Two of the six events attributed to the Great Lakes are in Lake Erie and one in the Detroit River. For these three events (two in Lake Erie and one in Detroit River), the NGDC database provides only anecdotal information regarding the source, runup, and impacts.

A refined search of the database was performed for runup attributed to a Tsunami in the "East Coast of the United States and Canada" by including the Tsunami validity code in the search parameters. The NGDC database uses a validity code of -1 to 4, where the validity codes are defined as follows:

Tsunami Event Validity Codes

Validity Code	Definition
4	Definite Tsunami
3	Probable Tsunami
2	Questionable Tsunami
1	Very Doubtful Tsunami
0	Event that only caused a seiche or disturbance in an inland river
-1	Erroneous entry

As shown in the above table, events with validity codes of 0 and -1 are not considered to be tsunami related. Searching the database based on a validity code greater than 0 for the same region identified 30 events. This is conservative as it includes all events that are even categorized as a "Very Doubtful Tsunami" (Validity Code = 1). Based on this search, none of the identified 30 events were recorded as occurring in the Great Lakes. That is, the six events previously noted as identified in the Great Lakes are assigned a validity code of 0 in the NGDC database.

Thus, based on the historical information in the NGDC database the Fermi site is not in an area that has experienced valid tsunami events. This is further substantiated by information from the State of Ohio Geological Survey (http://www.dnr.state.oh.us/geosurvey/faq/tsunami/tabid/8341/Default.aspx). Based on available information, the State of Ohio Geological Survey concludes that it is very unlikely that Lake Erie would experience a tsunami. This conclusion is based on the absence of historical large earthquakes in the Lake Erie region, a low probability of vertical displacement of the lake bed during a seismic event, the relatively shallow depth of Lake Erie, and the very gentle bottom profile of Lake Erie (particularly in the western and central basins). There are recorded instances of so-called "rogue" waves that have suddenly swamped a comparatively small area of Lake Erie shoreline. None of these events have been associated with earthquakes and all have been confined to a local area of shoreline. It is thought that they are caused by local but intense atmospheric disturbances. Large waves generated by surge or seiche events at the Fermi site are considered in FSAR Section 2.4.5

It is not anticipated that a tsunami event will affect safety-related structures or components at Fermi 3.

<u>Proposed COLA Update</u>

A proposed mark-up for FSAR Section 2.4.6 is included to provide additional discussion for the conclusion that the Fermi site will not be impacted by a tsunami event.

Markup of Detroit Edison COLA
(following 4 pages)

The following markup represents how Detroit Edison intends to reflect this RAI response in the next submittal of the Fermi 3 COLA Revision 2. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be different than presented here.

Figure 2.4-230. The analysis of wave run-up determined that waves could not directly impact Fermi 3.

2.4.5.4 Resonance

Resonance generated by waves can cause problems in enclosed water bodies, such as harbors and bays, when the period of oscillation of the water body is equal to the period of the incoming waves. However, the Fermi site is not located in an enclosed embayment. The full exposure to Lake Erie during PMWS conditions, plus the flat slopes surrounding the site area, 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.

2.4.5.5 Sedimentation and Erosion

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. The slope to Fermi 3 is appropriately designed to preclude significant erosion during the postulated storm surge.

2.4.5.6 Protective Structures

The storm surge and wave run-up results in waves that will break on the berm that is between the onshore flat area and the Fermi 3 elevation of 179.5 m (589.0 ft) IGLD 85 or 179.6 m (589.3 ft) NAVD 88. The analyses of the wave run-up indicate that the waves will not overtop the slope and impact Fermi 3. Therefore, additional protection is not needed.

EF3 COL 2.0-17-A

Insert 1 Here

2.4.6 Probable Maximum Tsunami

Observed similar phenomena

~~The Fermi site is located in an area of the United States designated as having potentially minor seismic activity. Any tsunami activity in Lake Erie could only be generated by local seismic disturbances. 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 low-amplitude seiches that could occur would be of negligible concern to~~

~~the site (Reference 2.4-258).~~ These events are further discussed in Subsection 2.4.5.

Therefore, there are no potential tsunamis ~~or tsunami-like waves~~ which could affect safety-related structures or components at Fermi 3.

EF3 COL 2.0-18-A

2.4.7 Ice Effects

The emergency cooling system for Fermi 3 is provided by the Ultimate Heat Sink (UHS) which does not rely on water sources external to the plant and is not affected by ice conditions. This is further described in Subsection 9.2.5. Therefore, there are no safety-related systems, structures, or components impacted by ice formations.

EF3 COL 2.0-19-A

2.4.8 Cooling Water Canals and Reservoirs

As described in Subsection 2.4.1, Fermi 3 uses a natural draft cooling tower for rejecting heat from the CIRC. The Plant Service Water System (PSWS) rejects heat from station heat loads via the CIRC or the two Auxiliary Heat Sink (AHS) mechanical draft cooling towers. Make-up water for the CIRC and PSWS cooling towers are supplied from Lake Erie. Blowdown discharge from the CIRC is returned to Lake Erie via a discharge pipe outfall into the lake.

The Ultimate Heat Sink (UHS) for Fermi 3 is described in Subsection 9.2.5. The IC/PCCS pools contain a separate water supply in place during Fermi 3 operation for safety-related cooling in the event that use of the UHS is required. Lake Erie is not used for safety-related water withdrawal for Fermi 3.

Discussion of the probable maximum flood (PMF) level at the site is provided in Subsection 2.4.3. The effects of probable maximum surge and seiche flooding and ice effect flooding are addressed in Subsection 2.4.5 and Subsection 2.4.7, respectively.

As described above, cooling water canals and reservoirs are not used for safety related functions by Fermi 3. Therefore, the water level effects due to failures of such structures are not applicable to Fermi 3.

Insert 1

The National Oceanographic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC) maintains a historical tsunami database which catalogs tsunami events (Reference 2.4-2XX). The data in the NGDC database was filtered to exclude invalid events. Based on this filtering, no tsunami events were identified in the Great Lakes.

Furthermore, valid tsunami events in Lake Erie are considered unlikely based on the absence of historical large earthquakes in the Lake Erie region, a low probability of vertical displacement of the lake bed during a seismic event, the relatively shallow depth of Lake Erie, and the very gentle bottom profile of Lake Erie (particularly in the western and central basins).

2.4-293 Konikow, L. F., and J. D. Bredehoeft, Computer Model of Two-Dimensional Solute Transport and Dispersion in Ground Water, Chapter C2, Book 7, Techniques of Water-Resources Investigations of the United States Geological Survey, 1978.

2.4-2XX National Geophysical Data Center Historical Tsunami Record, National Oceanic and Atmospheric Administration, Website: http:www.ngdc.noaa.gov/hazard/hazards.shtml

Attachment 9
NRC3-10-0007

Response to RAI Letter No. 19
(eRAI Tracking No. 4075)

RAI Question No. 02.04.13-9

NRC RAI 02.04.13-9

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, the staff requests additional information related to the RESRADOFFSITE 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 Kd values to calculate leaching rates. For radionuclides with large Kd values (e.g. Co-60), this means that very little of the contamination would be leached from the soil and enter the groundwater. Please either provide a justification for the modeling approach that was used, or else perform and discuss RESRAD-OFFSITE simulations in which the contaminants enter the groundwater without delay, for example by specifying the rate of leaching from contaminated soil.*

2. *Please provide additional information regarding the well pumping rate used in the simulation. The value of about 5,000 m^3/yr is based on an agricultural scenario, and appears to be unreasonably large for a residential well. Either provide an explanation for the choice of this rate, or else provide and discuss a simulation that uses a more reasonable pumping rate consistent with a residential well.*

3. *Please provide additional information, in "risk-informed" terms, regarding the uncertainty in the estimates of radionuclide concentrations at the receptor points. This might for example include sensitivity and/or uncertainty analyses.*

Response

The following response addresses the three items as numbered in the request above. The results of the analysis show that the radionuclides predicted at the closest off site well and Lake Erie are less than the 10 CFR 20, Appendix B, Table 2, Column 2 limits. Meeting 10 CFR 20 limits at the closest off site well and Lake Erie demonstrates that the radiological consequences of a postulated failure of one of the equipment drain collection tanks are also acceptable for larger distances from the radwaste building. 10 CFR 20, Appendix B, Table 2 imposes additional requirements when the identity and concentration of each radionuclide in a mixture are known. In this case, the ratio present in the mixture and the concentration otherwise established in 10 CFR 20 for the specified radionuclides not in a mixture must be determined. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity"). The sum of fractions approach has been applied to the radionuclide concentrations for both pathways. The sums of fractions for the mixtures at the closest off site well and at Lake Erie are less than unity. The RESRAD OFFSITE analyses presented below are characterized by the sum of the fractions calculated from the RESRAD OFFSITE simulation output.

1. Leaching Rates

As discussed in the Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009, the RESRAD-OFFSITE code is used to analyze the postulated accidental release of radioactive liquid effluents to the groundwater. For the analysis, the assumed release is one of the equipment drain collection tanks with a tank capacity of 140 m^3 (37,000 gal) and radionuclide concentrations as given in DCD Table 12.2-13a. These tanks are located on the lowest level of the Radwaste Building (level B2F), which has a floor elevation of approximately 540 feet NAVD88 (FSAR Figure 2.5.4-204). One of the tanks is postulated to rupture, and 80 percent of the liquid volume (112 m^3 or 29,600 gal) is assumed to be released following the guidance provided in BTP 11-6. Following tank rupture, it is conservatively assumed that a pathway is created that allows the entire 112 m^3 to exit the Radwaste Building instantaneously and to enter the groundwater (unconfined aquifer). The volume of 112 m^3 is modeled in RESRAD-OFFSITE as a volume of contaminated soil 56 m^2 by 2 m deep. The assumption of instantaneous release to the groundwater following tank rupture is conservative because it requires failure of the floor drain system, plus it ignores the barriers presented by the basemat concrete and the steel liners incorporated into the tank cubicles of the Radwaste Building, which is seismically designed. It should also be recognized that level B2F of the Radwaste Building is well below the water table. Piezometric head contour maps presented in FSAR Figure 2.4-246 through Figure 2.4-249 indicate that the ambient water table in the vicinity of the Radwaste Building is approximately 567 feet NAVD88, or 27 ft above the Radwaste Building floor elevation. If the basemat or exterior walls of the Radwaste Building and associated steel liners were to fail simultaneously, groundwater would flow into the Radwaste Building, precluding the release of liquid effluents out of the building. Only if the interior of the Radwaste Building was flooded to a level higher than the surrounding groundwater would there be a pathway for liquid effluents to be released out of the building and to the groundwater. Hence, the assumption of an accidental release of liquid effluents from the Radwaste Building to groundwater is extremely conservative, given the design features of the Radwaste Building intended to prevent an accidental release and the hydrogeologic conditions at the site.

In the RESRAD-OFFSITE model, the contaminants leach from the contaminated zone to the groundwater. The rate at which the contaminants leach from the contaminated zone is a function of the leach rate. For the RESRAD-OFFSITE model, the user can specify a leach rate for each radionuclide or (per Footnote 1 at the bottom of Page 2-4 of NUREG/CR-6937) "if the user does not input a leach rate, RESRAD-OFFSITE will estimate a leach rate by equating the initial release rate to the equilibrium desorption release rate, computed using the user-specified distribution coefficient of the radionuclide in the region of primary contamination." For the Fermi 3 analysis, the approach of RESRAD-OFFSITE calculating the leach rate based on the distribution coefficient in the region of primary contamination was used. Distribution coefficients were determined based on laboratory testing for specific radionuclides. The distribution coefficients were determined for nine locations on site, representing the general area of postulated initial contamination and the flow path to the off-site well to the west and Lake Erie to the east. The distribution coefficients selected for each radionuclide for the RESRAD-OFFSITE analysis represent the minimum value regardless of the location. For most of the radionuclides the minimum value for the distribution coefficients used in the analysis were measured well away from the postulated release location. For example, for cobalt (Co) the minimum measured distribution coefficient was 640 cm^3/g. The distribution coefficients measured at locations representative of the initial area of contamination are on the order of 1,500 to 3,000 cm^3/g.

As an additional confirmation of the methods used, specific leach rates were determined based on site specific parameters, including the distribution coefficients, at the area of the release. Table 1 provides a comparison of the leach rates determined using the site specific parameters at the release location vs. those determined in RESRAD-OFFSITE.

Table 1, Leach Rate Comparison

Radionuclide	Leach Rate Determined Using Release Location Parameters (yr^{-1})
Mn	2.343E-04
Fe	3.238E-02
Co	7.259E-05
Zn	1.379E-03
Sr	2.126E-03
Y	1.213E-05
Ru	4.292E-04
Ag	2.102E-02
Cs	1.975E-04
Ce	3.335E-05

The leach rates determined using parameters indicative of the release location were input into the RESRAD-OFFSITE model for the case where the release is to Lake Erie. The total sum of the fractions was computed as 6.02E-02, or approximately a factor of five less than the total sum of the fractions of 0.3 reported in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009.

Therefore, to summarize, using the distribution coefficients to determine the leach rate is acceptable based on the following.

- The conservatisms applied in the assumed immediate release of the tank contents to the bedrock. That, based on the building design and the physical site parameters, such an immediate release would not occur.

- The distribution coefficients used in the analysis represent minimum measured values regardless of the location to determine conservative leaching rates. Calculating leach rates based on parameters indicative of the postulated release location shows that the methods using the leach rates calculated by RESRAD-OFFSITE are conservative.

- For using RESRAD-OFFSITE following the guidance in NUREG/CR-6937, allowing RESRAD to determine the leach rates based on the distribution coefficients, is an acceptable approach.

2. Well Pumping Rates

The well pumping rate that was used in the analysis provided in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009, is representative of an agricultural scenario. A sensitivity analyses was performed with a reduced well pumping rate representative of a residential scenario. For this scenario, the total well pumping rate was based on four individuals in a dwelling, 510 liters/year/person to account for consumption by humans, and 210 liters/day/person used in the dwelling for other purposes. The RESRAD-OFFSITE model for the release towards the well was run with this reduced well pumping rate. The results were essentially the same as with the higher well pumping rate, and the sum of the fractions for both scenarios totals 4.29E-01. This sensitivity case demonstrates that the results are insensitive to the well pumping rate.

3. Uncertainty in the Estimates of Radionuclide Concentrations at the Receptor Points

Detroit Edison has implemented a progressive approach in the development of FSAR Section 2.4.13 as provided in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009. This approach is summarized as follows:

- The ESBWR DCD, Section 15.3.16, provides an evaluation of the consequences of a liquid-containing tank rupture in the Radwaste Building. As discussed in DCD Section 15.3.16, based on the provisions included in the design, the analyses of the postulated release of the radioactive liquid from tanks in the Radwaste Building is not included. As stated in DCD Section 15.3.16.3:

  > "The liquid pathway is not considered because of the mitigation capabilities of the Radwaste Building to mitigate the liquid release. General Design Criterion (GDC) 60 is met, as the release of radioactive materials in this case is suitably controlled."

  FSAR, Revision 0, Section 2.4.13, credited these same design provisions discussed in the DCD for demonstrating that measures consistent with NRC Branch Technical Position (BTP) 11-6 were incorporated into the design to preclude accidental release of liquid effluents. Based on the design provisions precluding the release from occurring, an analysis of the postulated release was not included in Revision 0 of the FSAR.

- FSAR Revision 1, Section 2.4.13, incorporated a very conservative transport analysis to estimate the radionuclide concentrations at the receptor. The analysis was performed by a relatively simple straight line flow path model. The model determined the transport time from the source to the receptor. The concentration at the receptor was determined based on the initial concentrations, the decay constants for the radionuclides and the transport time. Mechanisms such as dispersivity and distribution coefficients were not credited in the analysis. The results from the analysis indicated that concentrations of several radionuclides could exceed the associated limit in 10 CFR Part 20. Similar to FSAR Revision 0, Revision 1 to Section 2.4.13 concluded that, based on design features provided in the Radwaste Building, a postulated liquid release to the environment at Fermi 3 is mitigated in a manner consistent with regulatory guidance.

- As described in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009, the rigor applied in the analysis was further increased. For specific radionuclides, laboratory testing was performed to determine distribution coefficients. A model for the site analysis was developed using the RESRAD-OFFSITE computer code. The model was run using the measured distribution coefficients coupled with conservative inputs and assumptions. The results from this refined analysis indicate that the limits specified in 10 CFR Part 20 are satisfied for Fermi 3. Conservative assumptions and inputs that are significant to the RESRAD-OFFSITE analysis are:

    - Distribution coefficients used in the analysis were determined based on laboratory testing for specific radionuclides. The distribution coefficients were determined for nine locations on site, representing the general area of postulated initial contamination and the flow path to the off-site well to the west and Lake Erie to the east. The distribution coefficients selected for each radionuclide for the RESRAD-OFFSITE analysis represent the minimum value regardless of the location. Minimum values were used in the analysis to account for potential uncertainties associated with the potential variability of the subsurface conditions. Using the minimum distribution coefficient for each radionuclide maximizes the predicted result at the receptor.

    - Travel time for groundwater movement from the Radwaste Building to the off-site well and to Lake Erie is determined using the following relationship:

$$t = \frac{x}{V} = \frac{x}{KI/\theta}$$

Where: t = time to move distance x (yr)
x = distance of contaminant movement (m)
V = average interstitial groundwater velocity (m/yr)
K = hydraulic conductivity (m/yr)
I = hydraulic gradient
θ = effective porosity

The postulated release from the Radwaste Building is into the Bass Islands formation. The maximum average hydraulic conductivity for the Bass Islands is 767 meters/year per FSAR Section 2.4.12.2.4.2. To provide a conservative analysis, the RESRAD-OFFSITE analysis used the hydraulic conductivity of

197,719 corresponding to the Rock Fill. This is conservative as it is results in a much shorter travel time.

Sensitivities for critical parameters were considered as described below.

- Hydraulic Conductivity – A sensitivity case was run where the hydraulic conductivity used was representative of the Bass Islands aquifer; actual location of the postulated release. This sensitivity case also set all of the radionuclide distribution coefficients to zero. Lake Erie was used as the receptor for this sensitivity. The results from this sensitivity case indicated essentially no radionuclide concentrations at the receptor. The results from this sensitivity clearly show the significance in the conservatism of using the hydraulic conductivity for the Rock Fill in the analysis. If the actual measured distribution coefficients were used with this sensitivity case, the results would have been even lower.

- Distribution Coefficients – A sensitivity case was run where the mean values for the distribution coefficients were used in lieu of using the minimum measured values. These mean values are shown in Table 2.

Table 2, Mean Kd Value

Sample	Mn	Fe	Co	Zn	Sr	Y	Ru	Ag	Cs	Ce
						cm3/g				
MW-381D-KD	605	2.99	2,074	76.9	58.6	19,329	509	3.28	1,536	5,092
MW-381D-KD (Duplicate sample, same location)	799	2.88	1,795	40	56	18,119	373	2.58	1,579	4,575
MW-383D-KD	423	2.93	1,319	56.8	14.5	11,535	197	0.41	1,323	5,289
MW-384D-KD	394	3.02	640	45.1	0.44	3,183	42.9	960	1,518	10,422
MW-386D-KD	823	10.1	2,472	146	188	21,946	574	2.12	1,951	9,666
RW-C3-KD	971	7	3,134	165	107	18,762	530	10.8	1,152	6,821
CB-C1-KD	869	6.36	2,919	26.1	397	7,366	449	579	1,422	6,666
CB-C1-KD (Duplicate sample, same location)	751	6.28	3,128	101	376	19,418	730	582	1,715	6,867
EB/TSC-C2-KD	588	4.2	2,089	16.7	72.6	18,698	265	348	1,862	6,528
RB-C7-KD	681	4.4	1,513	105	33.1	17,519	303	624	1,238	5,894
RB-C4-KD	651	4.65	2,238	51.5	53.6	19,455	301	625	1,078	6,389
Average	**687**	**4.98**	**2,120**	**75.5**	**123**	**15,939**	**389**	**340**	**1,489**	**6,746**

Using these mean values for the distribution coefficients, the sum of the fractions is 4.26E-02, or approximately a factor of ten lower than the results presented in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009, using the minimum distribution coefficient values. This demonstrates the relative significance of the conservatisms implemented in the analysis by using the minimum distribution coefficient values.

- Other Parameters – Other less significant parameters (e.g., total porosity) were varied to ensure that the results of the analyses were conservative. The results confirm that the analyses presented in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009, are conservative.

The results from the analysis can be further examined to analyze the uncertainty in the estimates of the radionuclide concentrations at the receptor. From the analysis results, the more significant contributors can be identified. These more significant contributors along with the associated distribution coefficients are summarized in the Table 3.

Table 3, Significant Nuclide Contributors at Receptor (Off Site Well)

Nuclide	Max Concentration / 10 CFR 20 Limit	Distribution Coefficient
Ba-140	7.91E-02	0
Cr-51	4.00E-02	0
Fe-55	9.38E-03	2.88
La-140	8.02E-02	0
Nb-95	7.38E-03	0
P-32	8.91E-03	0
Sr-89	8.78E-03	0.44
Sr-90	1.15E-01	0.44
Te-129m	5.55E-02	0
Zr-95	9.42E-03	0
Total	**4.14E-01**	

The total sum of the fractions at the receptor (Off Site Well) is 4.29E-01 in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009. Thus, the above nuclides account for more than 95% of the total. As shown in the Table 3, with the minimum measured distribution coefficients used in the analysis, the significant contributors are those nuclides that have very small or no associated distribution coefficient. This shows that the distribution coefficients are an important part of the analyses. As previously discussed, the minimum measured values for the distribution coefficients were used in the analysis to be conservative.

Conclusions

As discussed previously, the design of the ESBWR includes appropriate specific measures to preclude the postulated release to the groundwater from occurring. Given these design measures, the probability of the initiating event is very low. Furthermore, based on actual groundwater elevation, the postulated immediate release of the contaminants from the Radwaste Building to the environment is physically precluded, further reducing the probability of this event from occurring.

To demonstrate the conservatisms, analyses were performed assuming that the initiating event occurs. For this very low probability event, conservative inputs and assumptions (e.g., high value for hydraulic conductivity, low values for distribution coefficients) were used in the analysis to account for potential uncertainties in the subsurface conditions. Even with these very conservative assumptions the results at the receptor are less than the 10 CFR Part 20 limits. Sensitivities have been performed on key parameters (hydraulic conductivity, distribution coefficients) that support the conservatism of the analysis presented in Detroit Edison letter NRC3-09-0026 (ML092470230), dated September 1, 2009.

Proposed COLA Update

None.