July 27, 2012

MEMORANDUM TO: Ronaldo Jenkins, Branch Chief
LB3 Projects Branch
Division of New Reactor Licensing
Office of New Reactors

FROM: Tekia Govan, Project Manager ***/RA/***
LB3 Projects Branch
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: AUDIT SUMMARY APRIL 2012 FOR THE FERMI 3 COMBINED LICENSE APPLICATION SEISMIC ANALYSIS

By letter dated September 18, 2008, Detroit Edison Company (Detroit Edison) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a combined license (COL) for Fermi 3. As part of its review, the Structural Engineering Branch conducted an audit of calculations associated with the Request for Additional Information (RAI) Letter Number 70. The RAI is related to the site-specific seismic analysis and structural design of seismic Category I structures, as described in the Fermi 3 COL Application Sections 3.7 and 3.8. The audit was held April 23 through 27, 2012 at the offices of General Electric Hitachi in Wilmington, North Carolina. Enclosed are the April 2012 audit summary, a list of the NRC and Detroit Edison team members who participated in the audit, and a list of the calculation documents reviewed by the NRC staff.

CONTACT: Tekia Govan, NRO/DNRL
301-415-6197

Docket No.: 52-033

Enclosures: As stated

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SUBJECT: SEISMIC ANALYSIS REGULATORY AUDIT SUMMARY FOR THE FERMI 3 COMBINED LICENSE APPLICATION

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FERMI 3 COMBINED LICENSE APPLICATION:

SUMMARY OF APRIL 2012 AUDIT OF SEISMIC ANALYSIS

1. Background

The scope of the Technical Audit was the review of calculations associated with Request for Additional Information (RAI) Letter No. 70, related to the site-specific seismic analysis and structural design of seismic Category I structures, as described in the Fermi 3 Combined License Application final safety analysis report (FSAR) Sections 3.7 and 3.8. The audit was held on April 23 through 27, 2012 in the offices of General Electric Hitachi Nuclear Energy, 3901 Castle Hayne Road, Wilmington, NC 28401. The review team consisted of Tom Tai, NRC Project Manager; Manas Chakravorty, NRC Technical Reviewer; Carl Costantino (Brookhaven National Laboratory [BNL]); and Manuel Miranda (BNL).

2. Audit Summary

Representatives from the U.S. Nuclear Regulatory Commission (NRC), Detroit Edison (DTE), GEH, Black & Veatch (B&V), and Brookhaven National Laboratory (BNL) were present during the audit. A list of attendees at the meeting is provided in Enclosure 2.

After introductions and a review of the agenda, NRC staff made some introductory remarks regarding the audit background, scope, and objectives. Following these remarks, DTE presented a brief overview of the calculations prepared in support of the response to RAI Letter No. 70; in particular, the calculations relating to the site response analyses and the soil structure interaction (SSI) analyses.

Next, the staff conducted a detailed review of selected portions of the calculations made available by DTE, GEH, and B&V (see Enclosure 3). The staff noted that the calculations associated with the SSI analyses (designated as SER-DTF-002 through SER-DTF-008 in Enclosure 3) only provided summaries of the analyses performed but not the complete documentation of these analyses. In addition, calculations SER-DTF-006 and SER-DTF-008 were only available in draft form.

As a result of the review, several issues were identified as needing further clarification and, possibly, additional analysis/design work. These issues were discussed with DTE, GEH and B&V. Details of the discussions are given in the following section.

The audit concluded with an exit meeting that summarized the discussions and the disposition of the issues raised during the audit, which are summarized in Table 1. DTE indicated it will supplement its response to RAI Letter No. 70 as indicated in Table 1.

Detailed Discussions

Extent of the Geotechnical Investigation and Uncertainty/Variability of Geotechnical Data

B&V provided a brief presentation of the geotechnical investigation performed in accordance with Regulatory Guide (RG) 1.132, which is documented in Fermi FSAR Tier 2, Sections 2.5.1 and 2.5.4 (in particular Figs. 2.5.4-215 through 222). B&V indicated that they consider the site to be “well investigated” per Standard Review Plan (SRP) Section 3.7.2. B&V further indicated that this issue had been previously addressed under RAI Letter No. 16, Question 02.05.04-7, which is currently resolved. As such, the strain iterated soil profiles (LB, BE, UB) developed for the SSI analysis are consistent with a minimum coefficient of variation (COV) of 50 percent for the site material properties.

The staff noted that, for the Bass Islands Group, there seemed to be a shear wave velocity data outlier that is significantly lower than the rest of the data points. In addition, there appeared to be a lack of data in the suspension log used to establish the lower limits of the Salina F layer.

B&V explained that the revised LB strain iterated profile captures the measured site uncertainty. The revised profile was established on the basis of a minimum COV of 50 percent for the site material properties (see response to RAI Question 3.7.1-6).

DTE indicated that it would supplement its response to RAI 3.7.1-6 to explain the variability of Bass Island Group data and the uncertainty in the data for the Salina F layer shown in the calculations, and how it is taken into account in the development of the revised strain iterated soil profiles.

<u>QUAD4MU Site Response Analysis</u>

The staff reviewed the calculations associated with the two-dimensional site-response analysis of the soil layers, including concrete fill, underlying the fire water service complex (FWSC). The QUAD4MU code was used in these calculations. This code follows the equivalent-linear approach used in standard site-response analysis codes (e.g., SHAKE); however, the solution is obtained in the time domain using a two-dimensional FE mesh, not in the frequency domain. Well-known issues with such time-domain FE codes include the appropriate modeling of damping (hysteretic vs. viscous), as well as the appropriate lateral extent and boundary conditions of the FE model to avoid spurious wave reflections.

The reviewed calculations included a sensitivity study that considered increasing the lateral extent of the FE model (100, 250, 600, and 700 ft). The study concluded that a horizontal width of 600 ft was sufficient to eliminate spurious wave reflections from the lateral boundaries. However, the basis of the sensitivity study was the dynamic response of a node close to the lateral boundary.

The staff did not consider this an appropriate basis for comparison because a node close to the lateral boundary is not relevant to the computation of the FWSC foundation input response spectra (FIRS). To validate the analysis performed, the staff indicated that an acceptable alternative approach would be to consider a node at the top of the concrete fill. A comparison of response spectra computed at this node for the increasing lateral extent of the FE model (100, 250, 600, and 700 ft) would indicate whether the computed FWSC FIRS is sufficiently insensitive to any spurious wave reflections at the lateral boundaries, while capturing the desired two-dimensional effects.

DTE indicated that it would supplement its response to RAI 03.07.01-3 to provide the additional information.

Weak Scaling of Time Histories for Site Response Analysis using the RASCALS code (RAI 02.05.02-18)

The staff indicated that the RAI response shows some deviations between mean response spectra of individually scaled time histories and target DE response spectra. The deviations above 50 Hz for cases LF-DEH 10^{-5} and 10^{-6} may not be inconsequential. B&V explained that motions in this frequency range are not used to define the LF site amplification factors so the deviations are not significant. The reason for this is that the LF amplification function provides complete information only up to 2.5 Hz and partial information between 2.5 Hz and 5 Hz, so the LF information above 50 Hz is not used.

This explanation clarifies the explanation given in FSAR Tier 2, Section 3.7.1.1.4.2 and resolves this issue.

Minimum Horizontal Input for SSI Analysis (RAI 03.07.01-8)

The staff indicated that it does not agree with the RAI response that, since the FIRS themselves may be broad band spectra and have PGA values that are greater than 0.1g, these FIRS are sufficient to meet the requirements in 10 CFR Part 50, Appendix S, for minimum horizontal ground motion at the foundation level.

However, the staff also recognized that the RG 1.60 spectral shape is not strictly applicable to the site-specific conditions at the Fermi site. The staff indicated that the median Newmark-Hall spectral shape for rock sites scaled to 0.1g PGA (NUREG/CR-0098) is an acceptable alternative to the RG 1.60 spectral shape for the site-specific conditions at the Fermi site, which can be used to meet the requirements in 10 CFR Part 50, Appendix S.

Since the comparison plots provided in Figure 1 of the RAI indicate that the RB/FB and CB FIRS bound the median NUREG/CR-0098 spectral shape for rock sites scaled to 0.1g PGA, the staff concludes that the RB/FB and CB FIRS meet the requirements in 10 CFR Part 50, Appendix S, for minimum horizontal ground motion at the foundation level.

DTE indicated that it would supplement its response and modify the FSAR to explain why the minimum horizontal input requirements are met by NUREG/CR-0098 spectral shape for rock sites and not by the FIRS themselves.

Durability of Backfill Materials

In light of the aggressiveness of the groundwater at the site, the staff raised the issue of the durability requirements for the backfill material at the site.

B&V indicated that durability requirements for the backfill are included in FSAR Tier 2, Section 2.5.4.5.1 “Source and Quantities of Backfill and Borrow Materials”, which includes a specification of testing for soundness of aggregate using sulfate soundness per ASTM C88 and Los Angeles abrasion tests per ASTM C131 and ASTM C535. FSAR Tier 2, Section 2.5.4.5.1 also indicates that testing for chemical and static properties are performed on all proposed engineering backfill materials.

The staff finds that the testing requirements in the FSAR address the concerns regarding durability of the backfill material and no further action is needed from DTE.

ITAAC for Backfill Material

The staff noted an apparent discrepancy between the responses to RAI Letter Nos. 70 and 71, regarding the ITAAC for backfill material (Table 2.4.2-1). The staff indicated that the ITAAC for backfill material as specified in RAI Letter No. 70 should remain.

DTE explained that both RAI responses will be implemented and they are not contradictory. It was explained that, due to the different timing of these RAI responses, the markups did not appear in identical form.

Design for Hurricane Wind and Hurricane Missiles

In light of RG 1.221, issued in 2011, the staff has requested that the applicant update the site characteristic values in the Fermi FSAR to include new site characteristics called “Hurricane Wind Speed” and “Hurricane Missile Spectra” (RAI Letter No. 73, Question 02.03.01-20). As a related matter, the staff requested DTE to explain whether the loads from site-specific hurricane winds and hurricane-generated missiles per RG 1.221 were bounded by the loads considered in the ESBWR DCD; in particular, for the site-specific hurricane missiles considered in the design of RTNSS systems and RTNSS-related structures identified in ESBWR DCD Appendix 19A.

ESBWR DCD, Tables 19A-3 and 19A-4, and ESBWR DCD Tier 2, Table 2.0-1, Footnote (3), indicate that the tornado missile design criterion is not applicable to seismic Category NS and seismic Category II buildings that house RTNSS equipment. In this latter case, a hurricane missile criterion is specified such that barriers are designed for impact from missiles generated by Category 5 hurricanes (wind speed of 195 mph, 3-second gust). The missile spectrum and missile velocities are in accordance with SRP Section 3.5.1.4, Revision 2 with tornado wind speed substituted with hurricane wind speed.

DTE explained that a response to RAI Letter No. 73, Question 02.03.01-20 was submitted in April 3, 2012. The staff reviewed the response and found that it did not address the issue of site-specific hurricane missiles considered in the design of RTNSS systems and RTNSS-related structures.

DTE explained that for hurricane missile design, following SRP Section 3.5.1.4, Revision 2, the missile velocities associated with the three missile types (1800 kg automobile, 125 kg pipe, and 1” dia. solid sphere) are taken as 35 percent of the assumed 195 mph hurricane wind; that is, 35%x195mph=68 mph. This is specified in GEH internal document ESBWR Missile Protection Design Specification SR3-1-A40-TRD-004, Revision 0, Table 1.

DTE also explained that, assuming the most conservative estimate of the RG 1.221 design-basis hurricane wind speed at the Fermi site, 130 mph, missile velocities associated with the three missile types in RG 1.221 are: 66 mph for the 1800 kg automobile, 49 mph for the 125 kg pipe, and 42 mph for the 1” dia. solid sphere. Since conservative estimates of site-specific missile velocities computed in accordance with RG 1.221 are bounded by the corresponding ESBWR DCD hurricane missile criterion (68 mph), it was concluded that the ESBWR DCD hurricane missile criterion is bounding for the Fermi site. The above criterion is only applicable to seismic Category NS and seismic Category II buildings that house RTNSS equipment.

This explanation clarifies the ESBWR DCD design criterion for RTNSS systems and RTNSS-related structures and resolves this issue.

Alkali-Silica Reaction in Concrete

NRC Information Notice (IN) 2011-20, dated November 18, 2011, informs of the occurrence of alkali-silica reaction (ASR)-induced concrete degradation of a seismic Category I structure at the Seabrook Station NPP. The IN indicates that ASR-induced degradation occurred even though concrete testing per ASTM standards C289 and C295 was specified in the Seabrook Station FSAR. It is explained that the tests described in ASTM C227 and C289 may not accurately predict aggregate reactivity when dealing with late or slow-expanding aggregates containing strained quartz or micro-crystalline quartz; updated ASTM testing standards C1260 and C1293 are more appropriate in this regard.

Since it appears that the Fermi FSAR does not reference updated ASTM testing standards C1260 and C1293, either directly or through ACI 349-01 or the ASME code (2004 edition), during a telephone conference held on March 29, 2012, the staff asked DTE to explain the measures that are implemented in the FSAR to prevent the problems described in IN 2011-20. In particular, whether testing in accordance with updated ASTM C1260 and C1293 will be performed during construction.

DTE explained that letter NRC3-12-0012 was submitted in April 5, 2012 in which it commits to testing concrete aggregate for seismic Category I and RTNSS structures in accordance with ASTM testing standards C1260-07 and 1293-08b. The staff reviewed the letter and found that it addressed the concerns regarding ASR.

ACI 349-06 vs 349-01

DTE explained that the Fermi FSAR will be modified to reference the 2001 Edition of ACI 349 to be consistent with the ESBWR DCD. A supplemental RAI response will be provided to document this change.

Design of Seismic Category II Structures

DTE confirmed that the only seismic Category II structures at the Fermi site are the Turbine Building, Radwste Building, Auxiliary Diesel Building, and Service Building. There are no other site specific Category II structures.

GEH explained the ESBWR DCD approach to the standard design of seismic Category II structures. The DCD ITAAC clearly specifies the DCD criteria for the seismic design of these structures (seismic input, generic profiles, SSI analysis including SSSI effects, if applicable, etc.). The Fermi ITAAC is applicable only to those seismic Category II structures (i.e., TB, RWB, SB) for which it is not possible to meet the DCD requirements for backfill, and a site-specific SSI analysis is needed to demonstrate that the standard design is adequate. There is surface-founded seismic Category II structures (i.e., ADB) for which the Fermi ITAAC may not be applicable, which is why the Fermi ITAAC are written in conditional language.

The staff indicated that the Fermi FSAR does not clearly state whether the seismic Category II structures are always supported on bedrock or concrete fill. As written, it appeared that certain seismic Category II structures were supported on granular backfill.

DTE indicated that it would provide a supplementary RAI response to clearly indicate that all seismic Category II structures are supported on bedrock or concrete fill.

Seismic Stability of Seismic Category I Structures

The staff reviewed the stability calculations for the FWSC (147483.51.9053; see Enclosure 3) and RB/FB and CB (SER-DTF-006; see Enclosure 3), with emphasis on the calculations of factors of safety against sliding.

The review of the calculations for the FWSC identified a concern regarding the calculation of the factor of safety against sliding, reported in Fermi FSAR Section 3.8.5 as 15. The staff found that the factor of safety against sliding was computed on the basis of the shear friction resistance of the concrete fill underlying the structure, which will contain shear friction reinforcement. Since the design of the shear friction reinforcement will not be performed until the detailed design phase, the value reported in the FSAR is an upper bound based on ACI code formulas and not a lower bound as required by SRP Section 3.8.5. The staff indicated that an acceptable approach to address this issue would be to modify the FSAR to specify a minimum 10 percent design margin for the design of shear friction reinforcement.

DTE indicated that it would provide a supplemental RAI response to clarify that the factor of safety against sliding of 15 is actually an upper bound, and to specify a minimum 10 percent design margin for the design of shear friction reinforcement to ensure the minimum factor of safety is at least 1.1.

The review of the calculations for the RB/FB and CB found that the stability calculations were performed in accordance with the methodology described in ESBWR DCD Section 3.8.5. The computed factors of safety indicate a substantial margin relative to the minimum requirements in SRP Section 3.8.5. However, the computations are all based on the results of the site-specific SSI analyses for the RB/FB and CB. As indicated below, the staff has several concerns regarding these SSI analyses.

SSI Analysis

The staff reviewed the calculations associated with the licensing-basis analysis (i.e., no backfill) of the RB/FB and CB, as well as draft versions of the SSI analysis that does consider backfill (SER-DTF-002 through 008; see Enclosure 3).

The staff noted that the calculations associated with the SSI analyses only provided summaries of the analyses performed but not the complete documentation of these analyses. Since these calculations were performed by GEH in Japan, on-site representatives of GEH could not address all the detailed technical questions by the staff.

Regarding the SSI analysis (licensing basis analysis; i.e., no backfill) documented in SER-DTF-006, the staff requested GEH to provide the following additional information:

- Structural model including damping used, which should be consistent with the relative stress level of the structural elements. If SSE damping is used, provide the technical basis for this.

- Modeling of floor diaphragms in the structural model, which is not shown in the calculations. This information was shown to the staff but needs to be documented.

- Plots of Fourier amplitude/power and cumulative Fourier power spectra for the input in-column motions, in order to identify the relative power of the input between 25 and 50 Hz.

- Confirm all SSI analyses consider the seismic input in both plus and minus directions.

- Plots of transfer functions identified as having spikes, with clear representation of computed values and interpolated values, in order to judge numerical accuracy.

- Clarify why toe bearing pressures reported in GEH Calculation 002 and 006 are the same if the inputs are different (Tables 7-3, 7-4, B-7, and B-8).

- Plots of wall pressures for RB and CB.

- Explain applicability of DCD mesh sensitivity study (for the excavated soil) to the Fermi site-specific conditions, especially if certain analyses only consider frequencies up to 25 Hz. Staff noted brick elements having aspect ratio 1(vertical):4(horizontal); what is the frequency transmission characteristics for such elements?

Regarding the SSI analysis with backfill included, documented in SER-DTF-008, the staff identified the following issues:

- Superseded soil profiles were used.

- Superseded time-histories were used.

- The SASSI2000 Subtraction Method was utilized instead of the Direct Method.

- Based on the layer thickness of the excavated volume, it appeared that the SSI model is not capable of transmitting frequencies greater than 25 Hz.

Regarding the use of the SASSI2000 Subtraction Method (SM) vs. the Direct Method (DM):

- DTE indicated a DM-vs.-SM method validation study will be provided using the CB 3D model with backfill included. The model may have frequency transmission characteristics adequate up to 25 Hz only.

- Staff indicated that this validation study needs to provide a comparison of (a) wall pressures on both backfill and bedrock/concrete fill portions, (b) ISRS, and (c) amplified FIRS in adjacent nodes in the soil (used to assess SSSI effects).

- The validation study should use updated soil profiles and time histories. Use of BE soil profile is adequate.

- In all cases, the effect of the backfill and the SSSI effects need to be differentiated in order to address RAIs 03.07.02-6, 03.07.02-8, and 03.08.05-4.

- Since only the CB is being used for validation, staff needs to review the computed transfer functions obtained using the DM and SM with the backfill, to assess potential impact on the RB analysis, which is not part of the validation study.

- Staff indicated an acceptable alternative to using the SM would be to perform a 2D slice-type analysis in either the time or frequency domain. Details of such an alternative 2D analysis were discussed with DTE, GEH, and B&V.

Regarding SSSI effects:

- DTE to respond to outstanding RAI. Any analysis based on the SM requires independent validation using the DM. For the RB acting on the CB, staff indicated the kinematic approach proposed by GEH may not capture inertial effects on wall pressures. The staff indicated that an acceptable approach to address this issue would be to compute the relative movement of the RB and CB walls towards each other, and to assess the magnitude of this movement relative to the distance between the two structures.

DTE indicated it will supplement its response to RAI Letter No. 70 to provide the information requested by the staff, which was not available during the audit, and to provide the results of the additional analyses discussed above.

<u>Concrete fill under FWSC and surrounding other Seismic Category I and II Structures</u>

Since the concrete fill will have a compressive strength of 4500 psi and the only reinforcement specified in the FSAR is for shear friction under the FWSC, the staff raised the issue of potential thermal cracking of the concrete during construction. Another concern was the potential presence of undetected voids of a certain size in the bedrock underlying the concrete fill, and whether the concrete fill would be capable of spanning such voids if unreinforced.

DTE indicated that it would supplement its response to RAI 03.08.05-5 to provide the following additional information to address the staff's concerns:

- Specific measures that will be implemented to control thermal cracking. The staff reviewed a proposed FSAR markup and found it acceptable.

- Specific criteria to be used during detailed design to determine whether thermal reinforcement needs to be provided.

- Clarification of which edition of ACI 207R is being referenced in the FSAR.

- Reference to other applicable standards for mass concrete construction (e.g., ACI 207.1R, 207.4, 211.1) in the FSAR.

- Explanation that voids under concrete fill are not a concern because of the chemical composition/geological characteristics of the dolomite bedrock and groundwater, and also because of actual conditions observed on the bedrock surface.

<u>Seismic Lateral Pressures on Sidewalls of Seismic Category I Structures</u>

The staff reviewed the calculations associated with the computation of seismic lateral pressures using the Ostadan-White method and the ASCE 4-98 method. The staff did not find any technical issues; however, it was noted that these methodologies are applicable to homogeneous soils only, such as the backfill surrounding the structures, and not to the bedrock.

DTE indicated it will provide a response to the outstanding RAI to address staff's concerns regarding lateral wall pressures on both backfill and bedrock/concrete fill portions; in particular, whether the design of embedded sidewalls is adequate to resist the large lateral pressures expected at the top of rock elevation for the licensing basis SSI analysis (i.e., no backfill).

The staff indicated that the RAI response should include plots of wall pressures for RB and CB for the licensing basis SSI analysis (i.e., no backfill) and for the SSI analyses that include backfill and SSSI (if applicable). Any analysis based on the subtraction method requires independent validation using the direct method. The structural integrity of the walls will need to be verified if there are exceedance with respect to the pressures in the DCD.

TABLE 1

Summary and disposition of issues raised during the audit

RAI Letter No. 70 Question	Issue	Disposition
03.07.01-6, 03.07.02-8, and 03.08.05-4	SSI analysis (licensing basis analysis; i.e., no backfill)	Provide additional information: • Structural model including damping used, which should be consistent with the relative stress level of the structural elements. If SSE damping is used, provide the technical basis for this. • Modeling of floor diaphragms in the structural model, which is not shown in the calculations. This information was shown to the staff but needs to be documented. • Plots of Fourier amplitude/power and cumulative Fourier power spectra for the input in-column motions, in order to identify the relative power of the input between 25 and 50 Hz. • Confirm all SSI analyses consider the seismic input in both plus and minus directions. • Plots of transfer functions identified as having spikes, with clear representation of computed values and interpolated values, in order to judge numerical accuracy. • Clarify why toe bearing pressures reported in GEH Calculation 002 and 006 are the same if the inputs are different (Tables 7-3, 7-4, B-7, and B-8). • Plots of wall pressures for RB and CB. • Explain applicability of DCD mesh sensitivity study (for the excavated soil) to the Fermi site-specific conditions, especially if certain analyses only consider frequencies up to 25 Hz. Staff noted brick elements having aspect ratio 1(vertical):4(horizontal); what is the frequency transmission characteristics for such elements?

03.07.01-3 or 01-4	Validation of Quad4 analysis	Supplemental response to provide response spectra computed at the center node at top of the concrete fill, for various widths of the analysis model, which demonstrate that the chosen width of 600 ft adequately represents the lateral boundary conditions. Also provide a discussion on the envelope function used and its impact on the design margin.
03.07.01-5	Disturbance of the material outside the diaphragm wall	NRC to assess if there is a need to evaluate the disturbance of the material outside the diaphragm wall, and evaluate whether it could cause an increase in the PBSRS as well as its potential impact on the SSI analysis.(*)
03.07.01-6	Variability/uncertainty in geotechnical data for Bass Island Group and Salina F	Supplemental response to explain variability of Bass Island Group data and the uncertainty in the data for Salina F shown in the calculations.
03.07.01-8	Minimum horizontal input for SSI	Supplemental response to provide FSAR markup that indicates minimum horizontal input requirements are met by NUREG/CR-0098 spectral shape for rock sites. Markup reviewed during audit is OK.
03.07.02-5	ITAAC Commitments for seismic Category II structures	Supplemental response that clearly explains the design intent (i.e., generic DCD Cat. II design to be performed for DCD profiles and DCD seismic input, to address DCD ITAAC commitments), and FSAR markup with indication that all seismic Category II structures will be founded on bedrock or concrete fill, not on engineered granular backfill, similarly to seismic Category I structures.
03.07.02-6	Embedment effects on SSI response	DTE to respond to outstanding RAI. Any analysis based on the subtraction method requires independent validation using the direct method.
03.07.02-7	Direct vs. Subtraction method of SASSI2000	• DTE indicated a direct method-vs.-subtraction method validation study will be provided using the CB 3D model with backfill included. The model may have frequency transmission characteristics adequate up to 25 Hz only. • Staff indicated that this validation study needs to provide a comparison of (a) wall pressures on both backfill and bedrock/concrete fill portions, (b) ISRS, and (c)

		amplified FIRS in adjacent nodes in the soil (used to assess SSSI effects). • Validation study should use updated soil profiles and time histories. Use of BE soil profile is adequate. • In all cases, the effect of the backfill and the SSSI effects need to be differentiated in order to address RAIs 03.07.02-6, 03.07.02-8, and 03.08.05-4. • Since only the CB is being used for validation, staff needs to review the computed transfer functions obtained using the direct and subtraction methods with the backfill, to assess potential impact on the RB analysis, which is not part of the validation study. • Staff indicated an acceptable alternative to using the subtraction method would be to perform a 2D slice-type analysis in either the time or frequency domain.
03.07.02-8	SSSI effects between RB/FB and CB, and between CB and FWSC	DTE to respond to outstanding RAI. Any analysis based on the subtraction method requires independent validation using the direct method. For the RB acting on the CB, staff indicated the kinematic approach proposed by GEH may not capture inertial effects on wall pressures.
03.08.05-1	ACI 349-01 vs. 06	Supplemental response to provide FSAR markup that indicates that ACI 349-01 will be used, consistent with ESBWR DCD.
03.08.05-2	Sliding factor of safety for FWSC	Supplemental response to provide FSAR markup that clarifies that the stated factor of safety of 15 is actually an upper bound; to ensure the minimum factor of safety is at least 1.1, a minimum 10 percent design margin needs to be specified for the design of shear friction reinforcement.
03.08.05-3	SSSI effects and pressures transferred to concrete fill between RB/FB and CB	RAI response reviewed by NRC and not accepted; RAI to be subsumed under 03.08.05-4.
03.08.05-4	Information regarding lateral pressures (backfill and bedrock)	• Part (a) was reviewed and there are no further issues; Part (b) was reviewed and not accepted; Parts (c) and (d) are dependent on the

		SSI and SSSI analyses which are outstanding. • DTE to provide response to RAI to address staff's concerns regarding lateral wall pressures on both backfill and bedrock/concrete fill portions; in particular, whether the design of embedded sidewalls is adequate to resist the large lateral pressures expected at the top of rock elevation for the licensing basis SSI analysis (i.e., no backfill). • The RAI response should include plots of wall pressures for RB and CB for the licensing basis SSI analysis (i.e., no backfill) and for the SSI analyses that include backfill and SSSI. • Any analysis based on the subtraction method requires independent validation using the direct method.
03.08.05-5	Concrete fill under FWSC and surrounding other Cat I and II structures	Supplemental response to provide FSAR markup that indicates the following: • Specific measures that will be implemented to control thermal cracking. Markup reviewed during audit is OK. • Specific criteria to be used during detailed design to determine whether thermal reinforcement needs to be provided. • Clarification of which edition of ACI 207R is being referenced. • Reference to other applicable standards for mass concrete construction (e.g., ACI 207.1R, 207.4, 211.1). • Explanation that voids under concrete fill are not a concern because of the chemical composition/geological characteristics of the dolomite bedrock and groundwater, and also because of actual conditions observed on the bedrock surface.

(*) Subsequent to the audit, the staff determined that no further action was needed.

NRC Audit – Fermi 3 SSI Analysis

Name	Company
Tom Tai	USNRC
Manas Chakravorty	USNRC
Manuel Miranda	BNL (for NRC)
Peter Smith	DTE
Mike Brandon	DTE
Ryan Pratt	DTE
David Harwood (via phone)	DTE
Nick Latzy (via phone)	DTE
James Moore (via phone)	DTE
Suzanne Hanna (via phone)	DTE
Ed Meyer	Black & Veatch
Brandon Gomer	Black & Veatch
Steven Thomas (via phone)	Black & Veatch
Bob Youngs	AMEC Environment & Infrastructure (for Black & Veatch)
Mark Colby	GEH

Brian Johnson	GEH
Sujit Niogi	GEH
R. Taylor Blake	GEH
Walter (Skip) Schumitsch	GEH
Patricia Campbell	GEH
Brian Thomas	NRC
Curtis Branter	GEH

List of Calculations Available and Reviewed during the Audit

Calculation No.	Rev	Title	Objective	Related Calculation
147483.51.9005	0	Dynamic Engineering Properties	To determine the dynamic engineering properties of subsurface materials at the Fermi site.	
147483.51.9006	0	Static Engineering Properties	To determine the static engineering properties of subsurface materials at the Fermi site.	
147483.51.9021	0	Computation of Rock PSHA.	To perform updated PSHA for hard rock conditions.	9020, 9022
147483.51.9022	2	Site Response and Determination of SSE Spectra.	To perform site specific response to develop the transfer functions from the hard rock PSHA results to the Fermi site conditions and develop GMRS and FIRS response.	9021
147483.51.9046	3	Development of SSI Input.	To develop ground motions and site properties in SSI analysis for Fermi 3 site.	
147483.51.9051	4	Development of Input Motions for SSI	To develop in-column acceleration motions at the RB/FB and CB elevations for input to SSI analyses.	9022, 9046
147483.51.9053	0	Fire Water Service Complex Sliding Resistance		
147483.51.9054	0	Calculations in Support of Response to RAI 02.05.02-17.	To study the impact of the randomization of the shear-wave velocity correction model and compare with the impact of a fully correlated model at Fermi-3.	02.05.02-17

Calculation No.	Rev	Title	Objective	Related Calculation
147483.51.9056	1	Calculations in Support of Response to RAI 03.07.01-03.	To compare seismic response of 2-D case of fill concrete with surrounding engineered granular backfill to 1-D case of fill concrete and develop scaling ratio (2-D/1-D) to develop FWSC FIRS.	03.07.01-03 QUAD4
147483.51.9057	0	Calculations in Support of Response to RAI 03.07.01-05.	To explain why it is appropriate to define the PBSRS and FIRS for the RB/FB and CB on the basis of a 1-D column of backfill material.	03.07.01-05
147483.51.9060	0	Lateral Earth Pressure Response for RAI 03.08.05-4a		03.08.05-4a
147483.51.9061	1	Calculations in Support of Response to RAI 03.07.01-04.	To show the effect of updated fill concrete properties on site amplification for the FWSC.	03.07.01-04
SER-DTF-002	1 (6/3/11)	DTE Fermi-3 ESBWR SSI Analysis Report	Report site specific seismic SSI analysis of the RB/FBC, and CB	
SER-DTF-003	1 (8/11/11)	DTE Fermi-3 ESBWR SSI Analysis Using SASSI DM for CB	Provide additional/confirmatory SSI analysis for the CB	
SER-DTF-004	1 (11/18/11)	DTE Fermi-3 ESBWR SSI Analysis Using SASSI DM for RB/FB Complex	Provide additional/confirmatory SSI analysis for the RB/FB Complex	
SER-DTF-006	1 (draft) (4/24/11)	DTE Fermi-3 ESBWR SSI Analysis Using SASSI DM for RB/FB Complex and CB	Report site specific seismic SSI analysis of the RB/FBC, and CB	
SER-DTF-007	0 (2/29/12)	Shimizu Response to DTE Fermi 3 NRC RAI 03.07.02-7 (Item 1), 03.08.05-2 (Item a), 03.08.05-3, and 03.08.05-4 (Item b)	03.07.02-7 03.08.05-2 03.08.05-3 03.08.05-4	

Calculation No.	Rev	Title	Objective	Related Calculation
SER-DTF-008	B (4/17/12)	Shimizu Response to NRC RAI 03.07.02-6, 03.07.02-8, and 03.08.05-4 (Item c)	03.07.02-6 03.07.02-8 03.08.05-4	