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

May 24, 2016

Mr. Brian D. Boles
FirstEnergy Nuclear Operating
Company
c/o Davis-Besse NPS
5501 N. State Route 2
Oak Harbor, OH 43449-9760

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF FIRSTENERGY NUCLEAR OPERATING COMPANY'S FLOOD HAZARD REEVALUATION REPORT SUBMITTAL RELATED TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR: DAVIS-BESSE NUCLEAR POWER STATION, UNIT 1 (CAC NO. MF3721).

Dear Mr. Boles:

The purpose of this letter is to provide you with the final audit report, which summarizes and documents the U.S. Nuclear Regulatory Commission's (NRC) regulatory audit of FirstEnergy Nuclear Operating Company's (FENOC, the licensee) Flood Hazard Reevaluation Report (FHRR) submittal related to the Near-Term Task Force Recommendation 2.1-Flooding for Davis-Besse Nuclear Power Station, Unit 1 (Davis-Besse). By letter dated July 6, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15181A011), the NRC informed you of the staff's plan to conduct a regulatory audit of FENOC's FHRR submittal for Davis-Besse. The audit was intended to support the NRC staff review of the licensee's FHRR and the subsequent issuance of an interim hazard letter and staff assessment documenting the staff's review. The audit was conducted on July 20, 2015 and was performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195). The details of this audit report have been discussed with Mr. Phil Lashley of your staff.

If you have any questions, please contact me at (301) 415-3809 or by e-mail at Juan.Uribe@nrc.gov.

Sincerely,

Juan Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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AUDIT REPORT BY THE OFFICE OF NUCLEAR REACTOR REGULATION FOR THE AUDIT OF FIRSTENERGY NUCLEAR OPERATING COMPANY'S FLOOD HAZARD REEVALUATION REPORT SUBMITTAL RELATED TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR: DAVIS-BESSE NUCLEAR POWER STATION, UNIT 1

DOCKET NO. 50-346

BACKGROUND AND AUDIT BASIS

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

By letter dated March 11, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14070A108), FirstEnergy Nuclear Operating Company's (FENOC, the licensee) submitted its Flood Hazard Reevaluation Report (FHRR) for Davis-Besse Nuclear Power Station, Unit 1 (Davis-Besse). The NRC staff has completed a regulatory audit of the licensee to better understand the development of the FHRR. Specifically, the audit sought to allow staff to better understand analyses (and supporting documentation) for areas such as: selection of model input(s) and parameters, calculations and methodologies, geographical characteristics and plant topography, among others. This audit report is completed in accordance with the guidance set forth in NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082900195).

By letter dated September 3, 2015 (ADAMS Accession No. ML15239B212), the NRC staff issued an interim hazard letter, which summarized its review of the re-evaluated flood-causing mechanisms described in the FHRR.

Enclosure

AUDIT LOCATION AND DATES

The audit was completed as described below:

- July 20, 2015, from 2:00pm to 4:00pm- webinar session

AUDIT TEAMS:

Title	Team Member	Organization
Team Leader, NRR/JLD	Juan Uribe	NRC
Branch Chief, NRO/DSEA	Christopher Cook	NRC
Technical Lead	Laura Quinn-Willingham	NRC
Technical Support	Mike Lee	NRC
	Colin Keller	FENOC
	John Sabo	FENOC
	Tom Gulvas	FENOC
	Mike Sobota	FENOC
	Jon Hook	FENOC
	Steve Osting	FENOC
	Phil Lashley	FENOC
	Ray Sacramo	FENOC Contractor
	Lana Lawrence	FENOC Contractor
	Anubhav Gaur	FENOC Contractor

DOCUMENTS AUDITED

Attachment 1 to this report details the documents that were reviewed by the NRC staff, in part or in whole, as part of this audit. The documents were located in an electronic reading room during staff review. The documents, or portions thereof, that were used by the NRC staff as part of the technical analysis and/or as reference in the completion of the staff assessment, may be requested from the licensee and docketed for completeness of the record, as necessary.

AUDIT ACTIVITIES

In general, the audit activities consisted mainly of the following actions:

- Review background information on site topography and geographical characteristics of the watershed.
- Review site physical features and plant layout.
- Understand the selection of important assumptions and parameters that were the basis for evaluating the individual flood causing mechanisms described in the 50.54(f) letter.
- Review model input/output files to computer analyses, such as the Hydrologic Engineering Center (HEC)-River Analysis System (RAS) and HEC- Hydrologic Modeling System (HMS) to have an understanding of how modeling assumptions were programmed and executed.

Attachment 2 to this report contains Table 1, which provides more detail and summarizes specific technical topics (and resolution) of important items that were discussed and clarified during the audit. The items discussed in Table 1 may be referenced/mentioned in the staff assessment in more detail.

EXIT MEETING/BRIEFING:

On July 20, 2015, the NRC staff closed out the discussion of the technical topics described above. There were no open or unresolved items.

Attachments:
1. List of References
   Reviewed by the NRC staff
2. Information Needs
   Discussed During Audit-Security Related Information

ATTACHMENT 1
LIST OF DOCUMENTS AUDITED BY THE STAFF

Calculation Package C-CSS-020.13-010.
Calculation Package C-CSS-020.13-012

Table 1- Davis-Besse Information Needs
Audit/Post-Audit Summary
Audit of July 20, 2015

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
1	**Local Intense Precipitation – LIP Duration** Evaluation of the effects of flooding of local intense precipitation on water surface elevations at the Davis-Besse site is requested in the 50.54 letter. Based on the staff's reviews of submitted FHRRs to date, it has been observed that when using transient rainfall runoff models, probable maximum precipitation (PMP) events having longer durations than the PMP events considered in the FHRR may result in the higher LIP flood elevations and longer periods of inundation, and that PMP events having shorter durations than the PMP events considered in the FHRR may result in (potentially significantly) shorter warning times and likewise result in consequential LIP flood elevations (e.g., flood elevations above the openings to plant structures). It is requested that the licensee describe the controlling scenario(s) for evaluation as part of the Integrated Assessment (see NRC, 2012c) using a range of rainfall durations associated with the LIP hazard events (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs) and various rainfall distributions (e.g., a center-weighted and other distributions in addition to a front-loaded distribution). The PMP values estimated from HMR Nos. 51 and 52 should also be presented. This should include a sensitivity analysis to identify potentially limiting scenarios with respect to plant response when considering flood height, relevant associated effects, and flood event duration parameters for LIP events.	The licensee noted that the 1-hr, 1-mi2 LIP event fully covers the contributing drainage area for the Davis-Besse Nuclear Power Station (DBNPS). Therefore, the evaluation of this storm event is deemed to be in accordance with NUREG/CR-7046 regulatory guidance, as described above. In addition, because of the high rainfall intensity during the first hour of the storm event, the amount of water available for a longer duration storm event would be minimal compared to the first hour. The licensee further noted DBNPS power block area is mostly flat but elevated compared to the surrounding areas. It was noted that surface water flow around the power block is generally not restricted. Consequently, the licensee stated that the controlling rainfall parameter affecting the maximum water depths is the rainfall intensity as compared to the cumulative volume. The licensee also stated, that the longer duration rainfall event would have the same peak intensity as the 1-hour event. Therefore, the licensee concluded that the maximum water surface elevations around the power block buildings due to the longer rainfall event are not expected to have an appreciable change. In closing, the licensee also stated that the 1-hr PMP event temporal distribution used in the calculation is the same as the temporal distribution of the LIP event presented as a case study in NUREG/CR-7046, Appendix B, Figure B-5 (front-loaded precipitation event). No directions are presented in any regulatory guidance related to variable temporal distribution of the LIP event. In summary, the licensee responded that the evaluation of the effects of the LIP was performed using the appropriate rainfall event (per regulatory guidance) for the purposes of the FHRR. The licensee also stated that warning time is not relevant at the DBNPS because the plant does not rely on any manual actions to protect the plant against the LIP flood. Therefore, no additional sensitivity modeling is warranted.

		The staff concluded that the information provided by the licensee was sufficient to address the information need request.
2	**Local Intense Precipitation – Runoff from Buildings** Evaluation of the effects of flooding of local intense precipitation on water surface elevations at the IPEC site is requested in the 50.54 letter. In connection with that evaluation, ANSI/ANS-2.8-1992, Section 11.4 recommends that building runoff used in LIP flood assessment allow evaluation of worst case roof drainage. The DBNPS FHRR does not include analysis of alternative points of roof drainage that would maximize flood elevations adjacent to points of access and egress at safety-related structures, systems and components (SSCs). In this regard, the licensee has previously stated that there was an error in the FHRR concerning the modeling of rainfall falling on rooftops in the LIP analysis. The staff requests that the licensee to describe how drainage from facility roofs as represented in FLO-2D® analyses is consistent with the guidance in ANSI/ANS-2.8-1992, Section 11.4.	The licensee noted that it relied on the FLOW-2D® modeling option that allows all the precipitation falling on building roofs to also contribute to overland runoff. There are no precipitation loses due to rainfall being retained on building rooftops. The licensee stated that this modeling approach is conservative because it generates a larger amount (volume) of precipitation that, in turn, produces a larger runoff volume and, ultimately, higher water surface elevations. Consequently, the licensee concluded that the approach used in its LIP calculation to model roof drainage corresponds to the worst case scenario for the treatment of roof drainage, as required by ANSI/ANS-2.8-1992, Section 11.4. In regards to the staff information need statement "... the DBNPS FHRR does not include analysis of alternative points of roof drainage that would maximize flood elevations adjacent to points of access and egress at safety-related SSCs...," the licensee noted that no alternative points of roof drainage were developed or analyzed based on certain modeling decisions. First, as noted above, the licensee assumed that all meteoritic falling on DBNPS roof structures was conservatively assumed to find its way to the powerblock yard. Second, the licensee also noted that roof pitch orientations were selected (in the east-west direction) so as to maximize overland runoff volumes in that particular direction – another modeling conservatism given the nature of the topography of the site. For these reasons, the licensee again expressed the view that the approach used in its LIP calculation to model roof drainage corresponds to the worst case of roof drainage scenario, as required by ANSI/ANS-2.8-1992, Section 11.4. The staff concluded that the licensee's approach was reasonable and had met the general intent of ANSI/ANS-2.8-1992. As such, the staff concluded that the information provided by the licensee was sufficient to address the information need request.

3	**Streams and Rivers** Evaluation of the effects of flooding of streams and rivers on water surface elevations at the DBNPS site is requested in the 50.54 letter. In connection with that evaluation, the licensee relied on a figure illustrating the location of basins and storm centers of precipitation events used in the FHRR riverine flood analysis. The specific figure in question is Figure 4.2.1 of Calculation Package C-CSS-020.13-010. It is requested that the licensee provide an electronic version of Figure 4.2.1 of Calculation C-CSS-020.13-010 on the docket so that the staff might reference it in its FHRR 2.1 staff assessment.	The licensee agreed to submit the requested figure on the docket to support the development of the staff assessment. The staff concluded that the information provided by the licensee was sufficient to address the information need request.
4	**Streams and Rivers – Probable Maximum Flood (PMF)** Evaluation of the effects of flooding of streams and rivers on water surface elevations at the DBNPS site is requested in the 50.54 letter. In connection with that evaluation, the licensee evaluated flooding of the Toussaint River to determine the PMF and the resulting flood water surface elevations at the DBNPS site; the Toussaint River is the principal feature of hydrologic interest for the purposes of the FHRR analysis of the PMF scenario at the site. Since the Toussaint River is ungauged and has no historical data, the licensee supplemented their inputs for the HEC-HMS model using data from the nearby Portage River. The choice of hydraulic parameters used in the HEC-HMS can impact the flood characteristics estimated for the DBNPS site. In the matter of model calibration, the staff is	The licensee noted that the models used to analyze a PMF for the Toussaint River were not calibrated. Instead, conservative modeling parameters were selected by the licensee for implementation in both the HEC-HMS and the HEC-RAS models. The selection of conservative modeling parameters were observed by the licensee to result in higher water surface elevations at the DBNPS site as compared to a more realistic modeling parameters that would have been defined from model calibration. The licensee further noted that the calculational approach it employed corresponds to the Hierarchical Hazard Assessment (HHA) approach discussed in NUREG/CR-7046, Section 2. Citing from NUREG/CR-7046, the licensee noted that the HHA is a progressively refined, stepwise estimation of the site-specific hazards that evaluates the safety if the SSCs with the most conservative plausible assumptions consistent with available data. The licensee further noted that HHA starts with the most conservative simplifying assumptions that maximize the hazard from the probable maximum event. If the site is not inundated, no further refinement in the model is needed. If the level of assessed hazard results

	aware of a report prepared by the State of Ohio's EPA entitled "Total Maximum Daily Loads for the Toussaint River Watershed from April through October 2004." This report includes monitoring data for the Toussaint River at the Rocky-Ridge Road location, which is within the modeled portion of the watershed that was not used in the FHRR analysis. The staff requests the licensee to explain why the Ohio EPA report was not used in connection with the calibration of the HEC-HMS model for the Toussaint River.	in an adverse effect, then a more site-specific hazard assessment should be performed for the probable maximum event. For the PMF event on the Toussaint River, the licensee reported that the most conservative plausible assumptions were used and the site was not inundated. Therefore, in the licensee's judgment, no refinement, such as model calibration, was required for the purposes of the FHRR. The licensee did note that the only modeling parameter where Portage River data was used, was in the evaluation of base flow. The base flow is the average discharge in the stream that should be present prior to PMF occurrence. Because no long-term historical data for flows in the Toussaint River are available (the river is not gaged), the licensee used Portage River data. It was noted that the Ohio EPA report cited by the staff used a similar approach – Portage Rive gage information was used to calibrate the Portage River hydrologic model and then the determined hydrologic relationships of Portage River were applied to the Toussaint River. In the licensee's view, this confirms that the calculation approach (using Portage River information for Toussaint River) is appropriate and acceptable. The staff concluded that the information provided by the licensee was sufficient to address the information need request.
5	**Streams and Rivers – Manning's Coefficient** Evaluation of the effects of flooding of streams and rivers on water surface elevations at the DBNPS site is requested in the 50.54 letter. In connection with that evaluation, the licensee relied on a single value of the Manning's n coefficient that was applied uniformly over the full extent of the watershed modeling domain. However, in reality, the surface of the watershed is not uniform in terms of surface character and it varies spatially. As a consequence, the output of the HEC-RAS model, including the estimated flood elevation, can vary depending on the value of the Manning's coefficient selected.	The licensee noted that the Manning's roughness coefficients were selected based on the characteristics of the streams and floodplains in the vicinity of the DBNPS site. The characteristics (e.g., land cover) were obtained from standard data sources such as National Land Cover Database (NLCD) and verified by imagery from general mapping and imagery sources. The licensee noted that the floodplain along the entire length of the Toussaint River is 70 percent to 83 percent cultivated crops. Therefore, a uniform Manning coefficient along the entire reach was considered to be appropriate. The most conservative (highest) value from the applicable range for the cultivated crops was used in the calculation. This corresponds to the HHA approach discussed in NUREG/CR-7046 where the most conservative applicable assumptions should be used and if the site is not flooded, no refinement is needed. For the stream itself,

	It is also requested that the licensee provide justification that a uniform Manning's roughness coefficient value applied over the entire model reach is a reasonable modeling assumption. In connection with this request, the licensee should perform a parametric sensitivity analysis by adjusting Manning's n values (within acceptable range for surfaces, but less conservative than the preferred value used in the FHRR) and discuss the sensitivity of the estimated flood elevation to the variations in the magnitude of the parameter.	the licensee noted that variable Manning's n-values were used for upstream and downstream reaches of the Toussaint River. The variable Manning's coefficients were selected based on the stream segment characteristics (e.g., top width of the stream). Conservative Manning's coefficients were selected from the suggested range in order to maximize the water levels, which is consistent with the HHA approach discussed earlier. The licensee further noted that Manning's coefficients were selected using the well-known engineering reference (Open Channel Hydraulics, Chow 1959) based on the specific parameters of the streams and floodplain. Therefore, the licensee stated that the approach used in the calculation was appropriate. Lastly, the licensee expressed the view that conservative values were utilized in the calculation to maximize the results of the PMF event. Because the maximized PMF event does not result in the flooding at the site, the licensee suggested that no refinement of the modeling parameters was needed. Therefore, the staff's information need request that "... the licensee should perform a parametric sensitivity analysis by adjusting Manning's n values (within acceptable range for surfaces but less conservative [emphasis added by the licensee] than the preferred value used in the FHRR)... " is not within the recommended guidance provisions in the licensee's view. The staff concluded that the information provided by the licensee was sufficient to address the information need request.
6	**Ice Dams and Ice Jams** Evaluation of the effects of flooding of streams and rivers on water surface elevations at the DBNPS site is requested in the 50.54 letter. In the FHRR, the licensee described the potential for site flooding as a result of ice jams in the vicinity of the DBNPS site. Based on the FHRR analysis, the licensee concluded that the current design-basis bounds this particular flood hazard. Calculation Package C-CSS-020.13-012 has a series of	In reference to Calculation Package C-CSS-020.13-012, the licensee noted that the first step to assess the effects of the ice jam is to create a condition with the stream blocked by the ice jam, which was done and the results shown in Figure 4.1.4. With the stream completely blocked by the ice jam, the maximum water surface elevation upstream of the blockage was determined to be 575.60 ft-NAVD88. As the most conservative approach, the licensee observed that the ice dam is set to fail when the water level is maximized (i.e. the dam breach is triggered when the water level reaches 575.60 ft-NAVD88). After the ice dam failure, the licensee

	figures and other information regarding ice-induced flooding on pages 4 through 6. Figure 4.1.4 shows the case of an ice dam at the Highway 2 bridge (cross section 9904), presumably under Alternative 2 PMF conditions. In this case, the water surface elevation (WSE) is 575.60 ft-NAVD88. The text describes this elevation as the maximum water surface elevation (WSE) calculated using HEC-RAS under ice jam conditions and the WSE at which an ice dam breach is triggered. Figure 4.1.5 shows the same cross section location with the bridge conservatively assumed to be removed. The WSE illustrated on the figure is 575.55 ft-NAVD88. Figure 4.1.6 tabulates results following the dam break at cross section 7432, which is downstream and in line with DBNPS. The WSE is 575.14 ft-NAVD88. In the FHRR, the maximum WSE following a dam breach is given as 575.12 ft-NAVD88. The licensee is requested to clarify whether there was any misrepresentation of the information described above. The licensee was also asked to describe and elaborate on the analysis illustrated on the Figure 4.1.5 of the FHRR, including the situation (location, timing) that provides a WSE of 575.55 ft-NAVD88. Clarify the inconsistence in maximum WSE following an ice dam breach presented in the FHRR (575.12 ft-NAVD88) versus the maximum WSE on the calculation package of 575.14 ft-NAVD88.	reported that the maximum water level upstream of the ice dam was estimated to be 575.55 ft-NAVD88. The licensee acknowledged that the FHHR's WSE value of 575.12 ft-NAVD88 associated with the dam breach is a typographical error, and that the correct value is 575.14 ft-NAVD88 (consistent with the calculation package, as described above). Lastly, for the scenario with the stream entirely blocked by the ice jam, the licensee reported that the maximum WSE at the CR2 bridge cross section (XS 9904) is equal to 575.60 ft-NAVD88 and occurred on January 3, 2000, at time 08:45. For the scenario with the ice jam failure, the licensee reported that the maximum headwater stage at CR2 bridge cross section occurred on January 3, 2000, at time 09:00. The staff concluded that the information provided by the licensee was sufficient to address the information need request.

If you have any questions, please contact me at (301) 415-3809 or by e-mail at Juan.Uribe@nrc.gov.

Sincerely,

/RA

Juan Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-346

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