Entergy

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GNRO-2014/00005

January 9, 2014

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

SUBJECT: Grand Gulf Nuclear Station Request for Additional Information Regarding Flooding Hazard, dated December 11, 2013
Grand Gulf Nuclear Station, Unit 1
Docket No. 50-416
License No. NPF-29

REFERENCES:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident; dated March 12, 2012, (Accession No. ML12073A348).

2. Required Response 2 for Near-Term Task Force Recommendation 2.1: Flooding - Hazard Reevaluation Report dated March 11, 2013, (Accession No. ML13071A457).

Dear Sir or Madam:

Entergy Operations, Inc. is providing, in the Attachment, the response to the Reference 2 Request for Additional information (RAI).

This letter contains no new Regulatory Commitments. If you have any questions or require additional information, please contact Jeffery A. Seiter at 601-437-2344.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 9th day of January, 2014.

Sincerely,

Thomas Coutu for K.J. Mulligan.

KJM/jas

Attachment: Response to Request for Additional Information
Enclosure: 1 Compact Disc (CD) of Data Files
cc: (see next page)

A001
NRR

cc: U.S. Nuclear Regulatory Commission
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Attachment to

GNRO-2014/00005

Response to Request for Additional Information

The format for the Requests for Additional Information (RAI) responses below is as follows. The RAI is listed in its entirety as received from the Nuclear Regulatory Commission (NRC) with background, issue and request subparts. This is followed by the Grand Gulf Nuclear Station (GGNS) RAI response to the individual question.

RAI No. 3.1-1, Design Basis Flood Hazard:
NRC staff noted that the current design basis flood levels, which are identical to the current licensing basis levels listed on the Table 4.1-1 of the FHRR, are different from the design basis flood levels used in structural and flood protection analyses listed on the Table 3.4-1 of the FSAR (2012). Therefore the licensee is requested to clarify the current design basis flood levels described in the Section 2.2 of FHRR with those provided in the FSAR.

Response:

FHRR Table 4.1-1 values for CLB elevations are taken from Section 2.4 of the FSAR. Section 2.3.1 of the FHRR details the FSAR source section for each CLB elevation.

2.3.1 Flooding Mechanisms
Flooding hazard evaluations for GGNS include a screening for the following flood mechanisms (GGNS, 2012a, Section 2.4.3):
1. Local Intense Precipitation (LIP) – 133.25 ft (GGNS, 2012a, Section 2.4.3.5.3)
2. Probable Maximum Flood (PMF) on Rivers and Streams
a. Mississippi River – 103 ft (GGNS, 2012a, Section 2.4.3.5.1)
b. Stream A – 128.93 ft (GGNS, 2012a, Section 2.4.3.5.2)
c. Stream B – 132.8 ft (GGNS, 2012a, Section 2.4.3.5.2)
3. Coincident Wind-Wave Activity
a. Mississippi River – 108.8 ft (GGNS, 2012a, Section 2.4.3.6)
4. Dam Failures (Screened Out)
5. Surge and Seiche Flooding (Screened Out)
6. Tsunami Flooding (Screened Out)
7. Ice Effect Flooding (Screened Out)
8. Cooling Water Canal and Reservoir Flooding (Screened Out)
9. Channel Diversions (Screened Out)

RAI No. 3.2-2, LIP Flooding:
Section 3.1.2.1.2 of the FHRR describes that the culverts modeled in FLO-2D were conservatively assumed to be 50-percent blocked either by adopting a half of the diameter for the Culvert #1 or by reducing the depth-discharge relationships for other culverts. The licensee is requested to provide an explanation of how a 50-percent reduction in the depth-discharge relationship represents a 50-percent blockage in a culvert. Also, provide a description of the culvert features (e.g., diameter, slope, invert elevation, roughness condition, upstream/downstream conditions, etc.) and how these culverts were modeled in the CulvertMaster calculation and FLO-2D in the local intense precipitation flood analyses.

Response:

Specific requirements for the methodology for accounting for blockage to culverts is not provided by NUREG CR-7046, other than that contained in Appendix B.2 which shows an approach for a blockage to open drainage channels. Culverts at the GGNS which were modeled as functioning under the LIP condition are all covered by plant procedures which address the monitoring and clearing of debris. However, to conservatively acknowledge the potential for debris to accumulate during an intense runoff event, the capacities of these culverts were reduced in the model. A description of the culvert names, locations and features has been attached in Enclosure 1 (Folder RAI 3.2-2) to this response. The rationale and methodology for accounting for such blockage at each culvert is as follows:

Culvert 1 – This is a large (15-foot diameter) corrugated metal pipe (CMP) culvert. Culvert 1 was modeled in FLO-2D as a 10.6 feet diameter culvert instead of a 15 feet diameter culvert. The 10.6 feet diameter culvert has an opening area 88.3 square feet, which is 50-percent of the opening area of the actual 15 feet diameter culvert of 177 square feet. The culvert upstream and downstream invert elevations were also set at 4.4 feet (15 – 10.6 feet) above the actual invert elevations. This method was selected because for this culvert, which serves the large Stream B channel, the expected mechanism of blockage is large debris hanging on the edges of the culvert.

Culverts 8A, 9A, and 11 – Culverts 8A and 9A are CMP culverts. Culvert 11 is a concrete box culvert. All three of these culverts are 4 feet high and are protected by security screens. Blockage at these culverts was modeled by reducing the flow capacity of the culverts by a factor of 0.5. A depth-to-discharge relationship was developed using the actual culvert geometry and the CulvertMaster computer program. The flow rate at each point on the depth-to-discharge relationship was reduced by one-half to create the "blocked" rating curve which was then used as input to the FLO-2D hydrodynamic model as assigned rating tables. This method was selected because the expected mechanism of blockage for these culverts is accumulation of small material (such as leaf litter, etc.) on the entire face of the security screens, thus generally reducing the effective flow capacity but maintaining the invert elevation and overall dimensions of the culvert. At these culverts, the stated 50 percent blockage represents a 50 percent reduction in effective flow capacity for the culverts as modeled in the two-dimensional hydrodynamic model.

A one half reduction in capacity (or diameter) was selected as a reasonable approach because the culverts are routinely cleared (by procedure) and have security screens / trash racks which would mitigate extreme blockages or effectively increase invert elevations.

RAI No. 3.2-3, LIP Flooding:

The licensee is requested to provide high resolution, digital versions of Figures 3.1-2 through 3.1-5 of the licensee's FHRR. Also, provide a detailed digital map showing the location of hydraulic structures (e.g., culverts, channels, levees/barriers, etc.) that were used in the FLO-2D modeling in the local intense precipitation flood analyses.

Response:

Appendix E (located in Enclosure 1, Folder RAI 3.2-3) of the Local Intense Precipitation Calculation (AREVA Document No. 32-9195573-000) contains large high resolution versions of the figures requested. Additionally, Figures 4 and 5 located in Enclosure 1 (Folder RAI 3.2-3) of the same calculation show locations of hydraulic structures used in the FLO-2D model.

RAI No. 3.2-4, LIP Flooding:
The licensee is requested to provide (1) a description of the methods used to construct grid-based elevation input in FLO-2D from point-based elevation measurements, (2) a brief description of the likely magnitude of the errors (e.g., measurement and interpolation errors) associated with these grid-based elevations, and (3) a discussion of the related uncertainty associated with the onsite flood level estimations.

Response:

1. The topographic survey performed in November of 2012 for GGNS was required to meet the ASPRS Class I Accuracy Standard, with +/- 1 ft horizontal accuracy, +/- 0.33 ft RMSe vertical accuracy for contours and +/- 0.17 ft RMSe vertical accuracy for spot elevations and DTM points, at well-defined points. Additional designated critical structures and locations with respect to site flooding impacts were identified and surveyed with a vertical accuracy of +/- 0.1 ft. The methodology of the topographic survey was aerial photogrammetric mapping of the site with sufficient photo-identifiable control points for calibration meeting the mapping standard, and conventional ground survey loops for the critical structures and locations. FLO-2D grid element elevation data is based on imported digital terrain (DTM) points based on the topographic survey of the site that were added to the working region. Interpolation methods available in FLO-2D include:
   - Using a user specified minimum number of closest DTM points within the vicinity of a grid element to compute the grid elevation;
   - Using a user specified radius of interpolation which defines a circle around each grid element node to select DTM points for use in computing the grid element elevation; and
   - Using an inverse distance weighting formula exponent to assign elevations to the grid element from the DTM points.
2. Model grid elevations cannot be more accurate than the survey they are based upon. Therefore model grid elevations have a minimum level of uncertainty of +/- 0.1 feet. A minimum of two closest DTM points within the vicinity of a grid element was used in computing grid elevations. The density of spot elevations on the DTM provided for adequate coverage for each grid element. Interpolated grid elevations at all critical points were spot checked against the survey elevations and adjustments were made as needed. Model interpolation errors are therefore believed to be very minimal.
3. Uncertainty regarding onsite flood elevations is generally limited to the level of accuracy of the site survey. The nature of the two dimensional flow model is such that the impact of potential inaccuracy in the elevation of any single grid element is generally mitigated by the surrounding grid elements. LIP results were computed as maximum water surface depths, which was then compared to the known height of flood protection at critical elements, thus reducing uncertainty related to potential issues with elevation datum normalization.

RAI No. 3.2-5, LIP Flooding:
The licensee is requested to discuss how the vehicle barrier system was incorporated in the FLO-2D modeling in the local intense precipitation analyses.

Response:

From FHRR Section 3.1.2.1.2:

The Vehicle Barrier System (VBS) was modeled using the levee structure component in FLO-2D and designed flow pathways within the VBS were modeled as 30-percent blocked (AREVA Document No. 32-9195573-000). There are three types of designed flow pathways in the VBS:

1. 0.6 feet diameter Polyvinyl Chloride (PVC) pipes;

2. 5 feet wide by 1 foot high openings in series (125 total); and

3. 16 feet wide by 2 feet high openings in series (7 total).

The smallest of the openings (0.6 feet diameter PVC pipes) were assumed to be completely blocked based on guidance in NUREG/CR-7046 Section 3.2.2. Both the 5 feet wide by 1 foot high and the16 feet wide by 2 feet high openings in the VBS were modeled using the hydraulic structure component in FLO-2D.

The area within the VBS at GGNS is completely impervious and contains minimum natural sources of vegetation such as trees, brush, or other vegetation that may block culverts. Also, since the area within the VBS does not contain channelized flow, depths and flow velocities are unlikely to be sufficient to transport debris that could result in significant blockages of the VBS openings. However, the VBS openings that were included in FLO-2D were conservatively assumed to be 30 percent blocked based on the security screens in place at each opening. The depth-discharge relationship for each of the modeled openings in the VBS was calculated using CulvertMaster. The calculated discharges were reduced by 30-percent. Tailwater effects were modeled in FLO-2D. The head (depth) used in FLO-2D was the difference in water surface elevations inside and outside of the VBS at each opening.

RAI No. 3.2-6, LIP Flooding:
The licensee is requested to provide electronic versions of the input files used for the FLO-2D modeling in the local intense precipitation analyses.

Response:

Electronic versions of the input files used for FLO-2D (AREVA Document No. 32-9195573-000) are included in Enclosure 1 (Folder RAI 3.2-6).

RAI No. 3.3-1, River and Stream Flooding:
The licensee is requested to provide the relationship between Manning's roughness coefficient (nvalue) and observed land cover used for the FLO-2D modeling in the Stream A and Stream B flood analyses.

Response:

The PMF calculation for Stream A and Stream B utilized separate hydrology and hydraulic models. A hydrology model was created using HEC-HMS to develop PMF hydrographs. These hydrographs were then input into a FLO-2D two-dimensional hydrodynamic model which was used to calculate water surface elevations in the channel and surrounding flood plains. The relationship between Manning's roughness coefficient (n-value) and observed land cover/ material composition of the watersheds and channels for Stream A and Stream B used in the FLO-2D model were developed based on guidance contained in the FLO-2D Reference Manual. Land use/ land cover information was obtained from the United States Geological Survey National Land Cover Database 2006 Land Cover. These relationships are given below:

NLCD 2006 CODE	NLCD DEFINITION	MANNING'S N
11	Water	0.025
12	Perennial Ice Snow	0.05
21	Low Intensity Residential	0.1
22	High Intensity Residential	0.08
23	Commercial/Industrial/Transportation	0.06
24	Developed High Intensity	0.05
31	Bare Rock/Sand/Clay	0.08
41	Deciduous Forest	0.4
42	Evergreen Forest	0.6
43	Mixed Forest	0.5
51	Dwarf Scrub	0.35
52	Shrub/Scrub	0.4
71	Grasslands/Herbaceous	0.35
72	Sedge/Herbaceous	0.35
73	Lichens	0.35
74	Moss	0.35
81	Pasture/Hay	0.3
82	Cultivated Crops	0.25
90	Wood Wetlands	0.1
95	Emergent Wetlands	0.1

Stream	Material composition / Land cover	n-value
Stream A	Open ground / natural unlined channel	0.04
Stream B	Concrete	0.02

RAI No. 3.3-2, River and Stream Flooding:
The licensee is requested to provide electronic versions of the input files for HEC-HMS and HEC-RAS models in the river and stream flooding analyses.

Response:

The input files for river and stream flooding analysis have been included in Enclosure 1 (Folder RAI 3.3-2). Models are included for the Mississippi River (HEC-RAS), Bayou Pierre (HEC-HMS and HEC-RAS), and Streams A and B (HEC-HMS). The FLO-2D model for Streams A and B have been included in Enclosure 1 (Folder 3.2-6).

RAI No. 3.3-3, River and Stream Flooding:
NRC staff noted that the licensee did not address all potential Bayou Pierre basin flooding mechanisms except the river flooding caused by probable maximum precipitation. Staff's review of the FHRR noted that the Bayou Pierre basin may have the potential to flood the Grand Gulf nuclear plant facilities if the divide between Bayou Pierre and the plant site is eroded or the Bayou Pierre River downstream from the site would potentially become blocked by a landslide. Therefore, the licensee is requested to provide an analysis of the potential effects of Bayou Pierre floods on the Grand Gulf nuclear plant facilities considering combinations of appropriate flood causing mechanisms, including probable maximum precipitation, dam failure, channel migrations and divisions, and landslide blockage on the Bayou Pierre basin.

Response:

Dam Failure

Bayou Pierre floods resulting from the Probable Maximum Precipitation has been addressed in the FHRR Section 3.2. Based on the United States Army Corps of Engineers National Inventory of Dams (NID) database, there are about 53 dams within the Bayou Pierre watershed. The total maximum storage of all the dams in the Bayou Pierre watershed is estimated to be about 17,011 acre-feet. The tallest dam within the watershed is 48 feet. The peak breach outflow from a hypothetical dam with a height of the tallest dam within the watershed and storage equal to the total maximum storage of all the dams in the watershed will be approximately 96,500 cfs. The estimated peak breach outflow is only about 13 percent of the calculated Bayou Pierre PMF. The calculated PMF maximum elevation on Bayou Pierre as reported in the FHRR is 130.7 feet and about 44 feet lower than the Bayou Pierre watershed divide elevation of 175 feet near GGNS. Upstream dam failure within the Bayou Pierre watershed is therefore unlikely to overtop the Bayou Pierre watershed divide at GGNS and cause flooding at GGNS. The NID dams within the Bayou Pierre watershed and the estimation of the peak breach outflow is attached in Enclosure 1 (Folder RAI 3.3-3). This conservative method of peak breach outflow estimation is based on guidance contained in JLD-ISG-2013-01 - Interim Staff Guidance Japan Lessons-Learned Project Directorate - Guidance For Assessment of Flooding Hazards Due to Dam Failure.

Channel Migration, Diversion and Landslide

Bayou Pierre is in a drainage sub-basin (confluencing with the Mississippi River) which is separate from that of the GGNS site. The nearest segment of the current Bayou Pierre channel is approximately 6,600 ft from the GGNS protected area, and approximately 3,500 ft from the watershed divide. The general bank elevation of Bayou Pierre near the site is approximately 60

ft NGVD29 and the typical low elevation of the watershed divide is approximately 175 ft NGVD29. In order to impact the site, the Bayou Pierre channel in the vicinity of GGNS would need to migrate 3,500 ft horizontally to erode/modify approximately 115 vertical ft of the watershed divide between the site and the Bayou Pierre basin.

A review and comparison of USGS maps from 1939 to 2012 indicate that no significant migration of the Bayou Pierre channel in the vicinity of the GGNS site has occurred during that time period (USGS, 1939; USGS, 1963a; USGS, 1963b, USGS, 1986; USGS, 2012a; USGS, 2012b; and USGS, 2012c). As a result, channel migration of Bayou Pierre is not considered to be significant.

The width of the Bayou Pierre flood plain limits the potential for landslide blockage of the basin which could impact the site. The narrowest portion of the Bayou Pierre floodplain in the vicinity of the site is near the intersection of the Bayou Pierre floodplain with the Mississippi River floodplain, and is approximately 3,500 ft wide (USGS, 2012c). Slope failure of the watershed divide could potentially lower the divide between the site and the Bayou Pierre basin. However, it is judged that there is sufficient physical vertical (45 ft during the PMF) and lateral margin between the site and both the watershed divide and the current Bayou Pierre channel that no impact is anticipated for the GGNS site. Based on the height and width of the Bayou Pierre floodplain with respect to the watershed divide, landslides are not considered a credible source of flooding impact to the site.

References

USGS, 1939. Louisiana – Mississippi, Lorman Quadrangle, Grid Zone "C", Army Map Service, U.S. Army, 1939.

USGS, 1963a. Port Gibson Quadrangle, Mississippi – Clairborne Co., 7.5 Minute Series (Topographic), U.S. Department of the Interior, Geological Survey, 1963.

USGS, 1963b. Willows Quadrangle, Mississippi, 7.5 Minute Series (Topographic), U.S. Department of the Interior, Geological Survey, 1963.

USGS, 1986. Widows Creek Quadrangle, Mississippi - Louisiana, 7.5 Minute Series (Topographic), U.S. Department of the Interior, Geological Survey, 1986.

USGS, 2012a. Port Gibson Quadrangle, Mississippi – Clairborne Co., 7.5 Minute Series, U.S. Geological Survey, 2012.

USGS, 2012b. Willows Quadrangle, Mississippi, 7.5 Minute Series, U.S. Geological Survey, 2012.

USGS, 2012c. Widows Creek Quadrangle, Mississippi - Louisiana, 7.5 Minute Series, U.S. Geological Survey, 2012.

RAI No. 3.3-4, River and Stream Flooding:
The licensee addressed local intense precipitation flooding in Section 3.1 of the FHRR and PMP induced river floods on Stream A and Stream B on Section 3.2 of the FHRR: However the FHRR did not analyze a combined flooding event of the three flood-causing mechanisms. A combined event of local intense precipitation flooding and floods on Stream A and Stream B could occur because (1) the two stream basins and the onsite drainage area are adjacent each

other and small enough to apply a single probable maximum precipitation scenario, and (2) the onsite drainage could be affected by floods on Stream A and Stream B as the invert elevations of onsite drainage culverts discharging to the streams are lower than the estimated flood levels on Stream A and Stream B. Therefore, the licensee is requested to provide an analysis of the local intense precipitation flooding associated with PMP based floods on both Stream A and Stream B to determine a potentially larger onsite flood hazard. The licensee also is requested to provide electronic versions of the input files used for hydrologic simulations, if any, in relation to this RAI.

Response:

A combined event of local intense precipitation flooding and floods on Stream A and Stream B was not analyzed in the FHRR because:

- Appendix H of CR-7046 and ANS2.8 do not specify LIP to be combined with other events.
- The LIP is defined as a 1 sq.mi. event and the watershed areas of Stream A and B are a total of 3.4 sq. mi., which is greater than this limit. Thus, precipitation amounts over the total watershed would be expected to be slightly lower than those used in the LIP analysis.
- PMF on Streams A and B was calculated, including the site as contributory area as noted in Section 3.2 of the FHRR.

Lag times in Stream A and B are 1.5 hours and 0.7 hours respectively. Therefore, the peak elevations from the site (which would experience peak flood elevations immediately as it is largely impervious and has minimal lag time) and the streams would occur separately. Because the hydrograph peaks are out of phase, the maximum water surface elevations within the GGNS plant site resulting from LIP are not expected to be influenced by upstream watershed inflow to Stream A and Stream B.

RAI No. 4.0-1, Integrated Assessment:

(1) The NRC staff noted from the Table 4.1-1 of the FHRR that the reevaluated site flood levels exceed the corresponding design basis flood levels, triggering an Integrated Assessment. Therefore, the licensee is requested to confirm that an integrated assessment will be submitted within two years of the submittal of the FHRR. The licensee should also clarify which flood hazard mechanisms will be included in the Integrated Assessment.

(2) The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated floods hazard is not bounded by the current design basis. The licensee is requested to provide the applicable flood event duration parameters (see definition and Figure 6 of the Guidance for Performing an Integrated Assessment, JLD-ISG-2012-05) associated with mechanisms that trigger an Integrated Assessment. This includes (as applicable) the warning time the site will have to prepare for the event, the period of time the site is inundated, and the period of time necessary for water to recede off the site for the mechanisms that are not bounded by the current design basis. The licensee is also requested to provide a basis for the flood event duration parameters. The basis for warning time may include information from relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers).

Response:

(1) An Integrated Assessment will be submitted within two years of the FHRR submittal. Local Intense Precipitation is the controlling flood for Grand Gulf Nuclear Station and will be included in the Integrated Assessment. Flooding on Rivers and Streams, Dam Breaches and Failures, and Combined Effects are at or below site grade of 132.5'. They will be included in the Integrated Assessment Report however will be a simplified process as protection is provided by natural terrain.

(2) The LIP was never a part of the CLB for Grand Gulf Nuclear Station therefore this triggered the need for performing an Integrated Assessment. Other events which caused the flood levels to exceed the CLB will also be addressed in the Integrated Assessment. Grand Gulf Nuclear Station is only inundated by Local Intense Precipitation. Warning time of 24 hours is used from prediction of 12 inches of rain from the national weather service and site preparation is governed by Off-Normal Event Procedure 05-1-02-VI-2 "Hurricanes, Tornados and Severe Weather". Section 3.1.2.1.4 and Figures 3.1-6 through 3.1-19 in the FHRR provide the location, elevation and duration from beginning of the event until water has receded from the site.

RAI No. 4.0-2, Integrated Assessment:
The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. The licensee is requested to provide a brief summary of the flood height and associated effects (as defined in Section 9 of JLD-ISG-2012-05) that trigger an Integrated Assessment. This includes the following quantified information for each mechanism (as applicable):

- Flood height
- Wind waves and runup
- Hydrodynamic loading, including debris,
- Effects caused by sediment deposition and erosion (e.g., flow velocities, scour),
- Concurrent site conditions, including adverse weather,
- Groundwater ingress, and
- Other pertinent factors.

Response:

Grand Gulf Nuclear Station is only inundated by Local Intense Precipitation. Warning time of 24 hours is used from prediction of 12 inches of rain from the national weather service and site preparation is governed by Off-Normal Event Procedure 05-1-02-VI-2 "Hurricanes, Tornados and Severe Weather". Section 3.1.2.1.4 and Figures 3.1-6 through 3.1-19 in the FHRR provide the location, elevation and duration from beginning of the event until water has receded from the site.

Enclosure 1 to

GNRO-2014/00005
Compact Disc (CD) of Data Files