From:	RILEY, Jim
To:	Shams, Mohamed; Marshall, Michael
Cc:	POLLOCK, Joseph; TSCHILTZ, Michael; MAUER, Andrew; BAUER, Scott; Bill Webster (william.webster@dom.com); Bradley, Jeff (Nuclear); Dave Schupp; Dean Hubbard (dmhubbard@duke-energy.com); Diane Aitken (diane.aitken@dom.com); Don Bentley (DBENTLE@entergy.com); GASPER, JOSEPH K; Geiger, Charlotte; George Attarian; RILEY, Jim; Giddens, John; greenrt@firstenergycorp.com; joe.bellini@aterrasolutions.com; Lingle, Ronnie; Lyter, Jay W:(GenCo-Nuc); Powell, Michael; Spink, Thomas E <tespink@tva.gov> (tespink@tva.gov); ZACHARIAH, Thomas
Subject:	[External_Sender] RE: Flooding MSA Template and Examples
Date:	Tuesday, February 16, 2016 4:02:17 PM
Attachments:	Plant G44 MSA with 2-9-16 template changes-Lyter updates 2-10-16.docx Plant G44 MSA with 2-9-16 template -Lyter updates 2-10-16 changes accept....docx PSL G 4 2 MSA Final Draft 2.10.docx

Mike, Mo;

In the message below I told you we would send the G.4.4, G.4.1 and G.4.2 examples last Friday. Unfortunately, all were not ready. I am attaching our revised G.4.4 example (both a clean version and a "track changes" that shows your comments) and the G.4.2 example. I will send the G.4.1 example as soon as it is completed.

Meanwhile, if you have any comments on our other examples, or on our template, please send them to me so we can work on resolution before our February 23rd webinar.

Thanks,

Jim Riley

NEI
W: (202) 739-8137
C: [redacted]
jhr@nei.org

From: RILEY, Jim
Sent: Tuesday, February 09, 2016 1:24 PM
To: Shams, Mohamed; Marshall, Michael
Cc: POLLOCK, Joseph; TSCHILTZ, Michael; MAUER, Andrew; BAUER, Scott; Bill Webster (william.webster@dom.com); Bradley, Jeff (Nuclear); Dave Schupp; Dean Hubbard (dmhubbard@duke-energy.com); Diane Aitken (diane.aitken@dom.com); Don Bentley (DBENTLE@entergy.com); GASPER, JOSEPH K; Geiger, Charlotte; George Attarian; Giddens, John; greenrt@firstenergycorp.com; joe.bellini@aterrasolutions.com; Lingle, Ronnie; Lyter, Jay W:(GenCo-Nuc); Powell, Michael; RILEY, Jim; Spink, Thomas E <tespink@tva.gov> (tespink@tva.gov); ZACHARIAH, Thomas
Subject: Flooding MSA Template and Examples

Mo, Mike;

I have attached the latest version of our MSA template that addresses all the comments we have received to date. The changes since the last version we sent you are shown in "Track Changes" mode. Our January 27th webinar identified some continuing concerns with our responses to your comments 9, 10, 35, and 36. I believe that the attached document resolves these comments in a manner that meets your request.

I look forward to your acceptance of this document and your comments on our G.3.A (PLANT DB=FLEX DB < MSFHI), G.3.B (PLANT DB < FLEX DB < MSFHI), and G.4.3 (AMS) examples that were sent to you on February 2nd.

I will send you a revised version of our G.4.4 (THMS) example that addresses your comments from last December, and an initial version of the G.4.1 (FLEX OK) and G.4.2 (MOD FLEX) examples this Friday. At this point you will have received all the documents that we plan to prepare to support the MSA effort.

We should be scheduling a follow-up meeting or webinar to close out the comments on all these examples in the near future. Please contact me with proposed dates once you have determined when your comments will be completed.

Thank you,

Jim Riley
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2016 Mitigating Strategies Assessments for Flooding
Documentation Requirements
(G.4.2 DRAFT)

Acronyms:

- MSFHI – Mitigating Strategies Flood Hazard Information (from the FHRR and MSFHI letter)
- FHRR – Flood Hazard Reevaluation Report
- DB – Design Basis
- AMS – Alternative Hazard Mitigating Strategies
- THMS – Targeted Hazard Mitigating Strategies
- MSL – Mean Sea Level
- PMP – Probable Maximum Precipitation
- FLEX DB – FLEX Design Basis (flood hazard)
- SWL – Still Water Level
- PMSS- Probable Maximum Storm Surge
- LIP – Local Intense Precipitation
- SWEL – Surface Water Elevation
- ELAP – Extended Loss of AC Power
- PSL – St Lucie Nuclear Plant
- RAB – Reactor Auxiliary Building

Definitions:

FLEX Design Basis Flood Hazard: The controlling flood parameters used to develop the FLEX flood strategies.

1. Summary

   The MSFHI provided in the PSL FHRR (Ref.1) has concluded that the Local Intense Precipitation (LIP) and hurricane induced Probable Maximum Storm Surge (PMSS) can challenge implementation of the FLEX strategies. The existing FLEX strategies for these events can be modified to address the impacts of the MSFHI. Other reevaluated flood hazard mechanisms (i.e.: tsunami, channel migrations/diversions, etc.), are bounded by the FLEX design basis and have no impact on the site.

   The MSFHI LIP flooding levels develop a depth above critical door sills for a limited period of time. Door seals are being updated and will be maintained to limit water intrusion (Ref. 2) and prevent challenge to the FLEX strategies. Personnel and equipment transport will be delayed during the flooding period. FLEX mitigation strategy timelines have been verified to not be challenged by the LIP affects (Ref. 4 & 5).

   The MSFHI Hurricane storm surge delays transportation of portable equipment beyond the period analyzed in the FIP submittal. The surge water level also challenges a remote permanently installed motor control center used the FLEX strategies.

   The FLEX response timeline has been modified and verified to ensure FLEX strategies can implemented to address the Probable Maximum Storm Surge with wave run-up (PMSS) generated by a hurricane storm surge (Ref. 4 & 5).

Alternatives to protect the challenged motor center from the storm surge are being tracked in the stations Corrective Action Program. NextEra Energy will continue the modification process once the MSA has been approved by the NRC.

The hardened FLEX equipment storage building and the power block are constructed at an elevation that exceeds the MSFHI results.

Ample hurricane warning time allows for a controlled shut down of the Reactor, implementation of storm preparation activities, and mobilizing additional on -site personnel and resources. Extended coping time, increased resources (personnel, fuel, water and equipment) and the reduced number of required FLEX activities during and after the storm lessen the challenge of the storm surge.

2. Documentation

2.1. NEI 12-06, Rev. 2, Section G.2 – Characterization of the MSFHI

Local Intense Precipitation (LIP)

Flood Height
The reevaluated LIP analysis, documented in the PSL FHRR (Ref.1), is for a suite of durations (1, 6, 12, 24, 48, 72 hours). The maximum flooding depth of accumulated water in the power block area is 3.20 ft.

Flood Event Duration
Based upon the LIP effect on Plant Internal Flooding evaluation (Ref.3) and FLEX deployment strategy (Ref. 4) the flood water maintains a depth above critical door sills for a maximum of 2.6hrs.

Relevant Associated Effects
The bounding calculated water level inside RAB 1 is 2.4 inches (Ref. 3). This value is acceptable as the bottom height of the critical equipment is at least 6 inches above the building floor (19.5 ft PSL-datum). The maximum volume of water conveyed to the lower levels (-0.5 ft PSL-datum) was evaluated to be on the order of 90,000 gallons. This value is also acceptable because the volume of water that can be safely accommodated in the lower level was previously calculated at 135,000 gallons (Ref 3).

For RAB 2 the bounding water level inside is 0.9 in. This value is deemed acceptable because the critical equipment bottom is at least 6 inches above the building floor (+19.5 ft PSL-datum). The volume of water conveyed downstairs to the lower levels (-0.5 ft PSL-datum) was evaluated to reach a maximum of 16,700 gallons. This amount of water can be safely accommodated within the lower levels because it is significantly less than the calculated safe maximum of 135,000 gallons (Ref 3).

Warning Time
An LIP event resulting from a Synoptic Storm (i.e. large frontal system) provides limited warning time; therefore, the FLEX deployment strategy was evaluated, and it was concluded that sufficient time margin exists to delay deployment until LIP flood waters have receded (Ref 3).

Probable Maximum Storm Surge (PMSS)

Flood Height

The reevaluated PMSS analysis, documented in the PSL FHRR (Ref.1), determined an SWL of 15.86' MSL (18.3 ft-PSL Datum). PMSS with wave run-up was also analyzed; however, waves dissipate before reaching the powerblock.

Flood Event Duration

Based upon the FHRR (Ref.1) and FLEX deployment strategy (Ref. 4 & 5) the flood water restricts FLEX equipment deployment for approximately 6 hrs.

Relevant Associated Effects

The flooding reevaluation determined that the maximum wave run-up occurs at the discharge canal and would result in overtopping of the steel sheet-piling barrier at the nose of the discharge canal, but this overtopping discharge volume is deemed insignificant. The reevaluated wave run-up analyses concluded the Powerblock is protected from wave run-up by the discharge canal steel sheet-piling barrier (Ref. 1). The FLEX equipment storage building is elevated and also protected. The storm surge does flood the redundant travel paths from the equipment storage building and the Powerblock for approximately 6 hours.

A remote motor control center, used to power some phase 1 FLEX equipment is constructed at 15.11' MSL which is 0.75' below the FLEX designed flood level.

Warning Time

Hurricane based events provide sufficient warning time (12-72 hrs) that allows the plant to be Shutdown to Mode 3, 4 or 5 (with Steam Generators available) at least 2 hrs prior to projected onset of hurricane force winds (Ref. 4).

2.2. NEI 12-06, Rev. 2, Section G.3 – Comparison of the MSFHI and FLEX DB Flood

Table 1a – Flood Causing Mechanism A (LIP) or Bounding Set of Parameters

Flood Scenario Parameter		Plant Current Design Basis	FLEX Design Basis Flood Hazard	MSFHI LIP	Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL)	19.5 ft. Plant Datum	See Note 1	Maximum Flood Depth 3.16' Unit 1 2.07' Unit 2	NB
	2. Max Wave Run-up Elevation (ft. MSL)	Not included	16.36' MSL 18.8' Plant Datum	See note 2	B
	3. Max Hydrodynamic /Debris Loading (psf)	Not included	See Note 3	See Note 3	NB
	4. Effects of Sediment Deposition/Erosion	Not included	See Note 4	See Note 4	B
	5. LIP associated effects	Not calculated	See Note 5	3.16 ft Unit 1 2.07 ft Unit 2	NB

	6. Concurrent Site Conditions	Not included	N/A	See Note 6	N/A
	7. Effects on Groundwater	Not included	N/A	N/A	N/A
Flood Event Duration	8. Warning Time (hours)	Not included	0	0	B
	9. Period of Site Preparation (hours)	Not included	0	0	B
	10. Duration of Significant Flooding (hours)	Not included	See Note 7	1.3	NB
	11. Period of Recession (hours)	Not included	See Note 7	2.6	NB
Other	12. Plant Mode of Operations	Not included	All	All	B
	13. Other Factors	Not included	-	-	-

Additional notes, 'N/A' justifications (why a particular parameter is judged not to affect the site), and explanations regarding the bounded/non-bounded determination.

1. MSFHI LIP water levels were not considered during the FLEX strategies and therefore are not bounded.
2. Wave run-up was evaluated for the spectrum of waves that can potentially impact PSL coincident with the PMSS event. LIP wave run-up is considered bounded by this analysis or N/A.
3. The FLEX DB did not consider hydraulic or debris loading due to LIP; therefore, the reevaluated LIP loading conditions is considered not bounded. Further evaluation (Ref. 8) concludes the FLEX strategies will not be challenged. The potential debris generation caused by the LIP event will be from unsecured materials located inside the plant Powerblock. Procedurally controlled housekeeping practices (Ref. 7) minimize the amount of material/debris that can be moved by LIP runoff. The flow velocities inside the Powerblock are low, minimizing the ability for waterborne projectiles to adversely affect plant and flood protection features.
4. The maximum velocities around the PSL site during the LIP/PMP generally occur throughout the canal. For scour and erosion to occur, the water velocity must be greater than permissible velocities for the ground cover materials (smooth asphalt 15 ft/s, rough asphalt 12ft/s and natural earth w/ vegetation 6 ft/s). The highest predicted velocities are located in areas already occupied by water, where runoff drains into a body of water or occur in remote places far outside the power block. Given that all velocities greater than 6 ft/s occur on asphalt and/or paved areas, and that the only area where velocities are greater than 12 ft/s occurs inside an existing pond, it was concluded qualitatively that scour/erosion from an LIP or PMP event is insignificant (Ref. 3).
5. The MSFHI LIP results were not considered in the FLEX strategies and therefore are not bounded. A Synoptic Storm provides limited warning time; therefore, the FLEX deployment strategy has been assessed to ensure sufficient time margin exists to delay deployment until LIP flood waters recede (Ref. 3). Penetrations that limit water intrusion into the Powerblock will be updated and maintained to ensure FLEX strategies are not challenged (Ref 8).
6. MSFHI LIP and hurricane storm surge hazards bound the flooding hazards at the site and do not occur simultaneously.
7. LIP results in approximately 2.6 hour duration of flooding including 1.3 hours of recessions. The period of flooding and recession was not considered in the FLEX

	strategies therefore it was considered not bounding. All FLEX strategy required actions can be completed indoors during this period of time. Equipment mobilization is not prohibited because transport is scheduled after the flood has receded prior to the time required by the original time-line (Ref. 5)

Table 1b – Flood Causing Mechanism A (PMSS) or Bounding Set of Parameters

Flood Scenario Parameter		Site Current Design Basis	FLEX Design Basis Flood Hazard	MSFHI Hurricane	Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL)	19.5 ft (Plant Datum)	17.2' (Plant Datum) 14.76' MSL	18.3' (Plant Datum) 15.86' MSL	NB See Note 1
	2. Max Wave Run-up Elevation (ft. MSL)	18.1 ft- plant island southeast corner 18.5 ft- south discharge canal 18.8 ft- north Unit 1 28.0 ft- north of discharge canal	18.8' (Plant Datum) 16.36' MSL	18.3' (Plant Datum) 15.86' MSL	B See Note 2
	3. Max Hydrodynamic/Debris Loading (psf)	Not considered	See Note 3	See Note 3	B
	4. Effects of Sediment Deposition/Erosion	Not considered	See Note 4	See note 4	B
	5. Other associated effects (Not including LIP)	See Note 5	N/A	N/A	B
	6. Concurrent Site Conditions	Not considered	No Impact	N/A	N/A
	7. Effects on Groundwater	Not considered	No Impact	N/A	N/A
Flood Event Duration	8. Warning Time (hours)	Not considered	12-72	12-72	B See Note 6
	9. Period of Site Preparation (hours)	Not considered	12-72	12-72	B See Note 6
	10. Duration of Significant Flooding (hours)	Not considered	3	7	NB See Note 7
	11. Period of Recession		2	4	NB See Note 7
Other	12. Plant Mode of Operations		Modes 3, 4 or 5	Modes 3, 4 or 5	B See Note 8
	13. Other Factors	-	-	-	-
	Additional notes, 'N/A' justifications (why a particular parameter is judged not to affect the site), and explanations regarding the bounded/non-bounded determination. 1. The travel paths between the FLEX storage building and the Powerblock flooded longer than the period considered for the FLEX strategies and therefore considered not bounded. 2. The CLB is exceeded, but the new levels are below the physical level of protection for critical plant equipment. The reevaluation includes a sea level rise of 0.20 ft for the				

	remainder of the current license. The available physical margin is 1.2 ft (19.5 ft – 18.3 ft = 1.2 ft) for still water and wave run-up. 3. The PMSS event does not result in Hydrodynamic/Debris Loading in Powerblock since the grade is located above the highest probable WSEL, there would be no threat of Hydrodynamic/Debris Loading that could impact safety-related structures in that area (Ref.1). For sections of the FLEX equipment deployment route that are located outside the Powerblock the FLEX DB accounted for debris removal time in the FLEX strategy (Ref. 5). 4. Debris and sedimentation accumulation resulting from a PMSS is expected to have the largest impact on the east side (ocean side) of the plant site due to wave run-up. Because the PSL Powerblock grade is located above the highest probable WSEL, there would be no threat of debris and sedimentation that could impact safety-related structures in that area. Since sections of the FLEX equipment deployment route are located outside the Powerblock the FLEX DB accounted for debris removal time in the FLEX strategy. 5. Tsunami flooding was not considered in the CLB. The tsunami maximum wave runup evaluation determined a surge elevation of EL +17.62 ft-PSL Datum. However, the available physical margin of 1.88 ft (19.5 ft –17.62 ft = 1.88 ft) remains during the event; therefore, the tsunami would not affect critical SSCs. 6. The preparation and time required for the MSFHI hurricane are unchanged and therefore bounded. Hurricane based events provide sufficient warning time to ensure the site is in a hardened state that is well prepared to cope with the events by having the site tanks filled with water, both units shut down and on-site resources augmented (Ref. 4). 7. The MSFFHI hurricane storm surge and recession is greater than the time considered in the FLEX strategies and is therefore considered not bounded. The increased period of storm surge delays the transport of the Portable FLEX equipment for up to 6 hours. FLEX strategy timelines have been adjusted and response margins verified acceptable (Ref. 5). 8. Hurricane based events provide sufficient warning time (12-72hrs) that allows the plant to be Shutdown to Mode 3, 4 or 5 (with Steam Generators available) at least 2 hrs prior to projected onset of hurricane force winds (Ref. 4).

2.3. NEI 12-06, Rev. 2, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI

2.3.1. NEI 12-06, Rev. 2, Section G.4.1 – Assessment of Current FLEX Strategies

The overall plant response strategies to an ELAP and loss of ultimate heat sink event using the current FLEX procedures, equipment and personnel can be implemented as described in the Final Implementation Plan provided the following modifications are implemented:

a. equipment deployment timelines are modified to accommodate the PMSS
b. key power block penetrations upgraded or verified sufficient to prevent water from challenging installed plant equipment for a LIP event
c. a flood barrier is constructed to protect a single motor control center from a PMSS.

2.3.1.1. Conclusions – Modify FLEX

NEI 12-06, Rev. 2, Section G.4.2 – Assessment for Modifying FLEX Strategies:

The existing FLEX mitigation strategies can be implemented with relatively minor modifications.

The MSFHI LIP event provides limited warning time and produces rainfall amounts that challenge the current FLEX mitigation strategies. LIP water levels exceed some critical door thresholds and channels in the equipment deployment roadways.

Door seals have been modified and will be maintained to ensure LIP water in-leakage will not challenge the existing FLEX strategies (Ref. 9). The current mitigation strategy timeline contains sufficient margin for local floodwaters to recede prior to the required deployment of FLEX equipment as described in the FIP.

Hurricane preparation activities as described in the FIP are unchanged. Hurricane warning times allow ample time for event preparation which includes maximizing inventories and resources. Existing procedures also require the reactor to be shut down in advance which extends the coping times and reduces the number of required FLEX activities during the event. (i.e. RCS cooldown, boration).

The MSFHI hurricane storm surge delays the portable equipment deployment. The most limiting mitigating strategy time constraint is the deployment of the FLEX 480V generators required to repower one battery charger on each unit. Existing battery management strategies extend life to 14 hours on Unit 2 and 21 hours on Unit 1 (Ref.6). The portable equipment deployment timeline has been modified to reflect the period needed for the hurricane flood water to recede and repowering batteries prior to voltage depletion (Ref 5).

The MSFHI hurricane storm surge also challenges a remote permanently installed motor control center used the FLEX strategies. Design alternatives are being tracked in the station Corrective Action Program and will be progressed once the NRC approves the stations MSA.

Additional on-site personnel provide more resources than previously used to demonstrate that equipment deployment activities meet timeline requirements and therefore the deployment activities will not require re-validation.
The surge water level also

2.4. References

1. FPL Letter L-2015-048 to NRC, FPL/St. Lucie Plant's Flooding Hazards Reevaluation for Information Pursuant to 10CFR50.54(f) Regarding Flooding Aspects of Recommendations 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, dated March 10, 2015 (ML15083A264)
2. PSL Preventive Maintenance Door Seal Inspection (PMs 82687 & 82688)
3. Enercon Report NEE-131-PR-001, Rev 0, Effects of Local Intense Precipitation (LIP) on Plant Internal Flooding Report, dated August 19, 2015
4. Eval PSL-ENG-SEMS-14-005 Rev 0, St. Lucie FLEX Final Integrated Plan Document (EC 284024)
5. FLEX MSFHI Hurricane and LIP Strategy time-lines
6. Calc FPL064-CAL-04 & -05, Rev0 Unit 1&2 Battery Load Shedding Strategy.
7. MA-AA-100-1008
8. LIP hydraulic and debris loading white paper.

9. Penetrations upgrades and maintenance procedures

2016 Mitigating Strategies Assessments for Flooding
Documentation Requirements
(DRAFT Plant G.4.4 Submittal)

Acronyms:

- MSFHI – Mitigating Strategies Flood Hazard Information (from the FHRR and MSFHI letter)
- FHRR – Flood Hazard Reevaluation Report
- DB – Design Basis
- AMS – Alternative Hazard Mitigating Strategies
- THMS – Targeted Hazard Mitigating Strategies
- FLEX DB – FLEX Design Basis (flood hazard)

Definitions:

FLEX Design Basis Flood Hazard: the controlling flood parameters used to develop the FLEX flood strategies.

1. Summary
   The FLEX DB flood strategy does not bound the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River were determined to be applicable flood-causing mechanisms at Example Power Station. The river height of this flood will require the units to be shutdown and cooled down to <212 F and the containment to be opened to flood the reactor cavities to maintain cold shutdown. Because of not fully maintaining the containment function a THMS is required. The LIP flood is not addressed in Example Power Station's CLB and was therefore determined to be not bounded by the plant's CDB flood. However, the FLEX DB includes the original reevaluation of the LIP flood.

2. Documentation

References:

1. NEI 12-06, Rev 2
2. FHRR Submittal
   - Enclosure 1 – LIP Report
   - Enclosure 2 – FHRR Report
   - Enclosure 3 – CD with pertinent site data
3. RAI Responses 1 (additional flood parameters)
4. RAI Responses 2 (updated LIP report)
5. RAI Responses 3 (additional site-specific PMP information)
6. MSFHI Letter
7. Warning Time Calculation and Procedures for LIP (per NEI 15-05)

2.1. Reference 1, Section G.2 – Characterization of the MSFHI

Characterization of the Mitigating Strategies Flood Hazard Information (MSFHI) is summarized in the Enclosure to Reference 6; the NRC's interim response to the flood hazard reevaluation submittal (Reference 2) and amended submittals (References 3, 4, and 5). A more detailed description of the MSFHI, along with the basis for inputs, assumptions, methodologies, and models, is provided in the following references:

- Local Intense Precipitation (LIP): See Reference 4.
- Flooding in Streams and Rivers: See Section 3 of Reference 2, Enclosure 2.
- Dam Breaches and Failures: See Section 3 of Reference 2, Enclosure 2.
- Storm Surge: See Section 3 of Reference 2, Enclosure 2.
- Seiche: See Section 3 of Reference 2, Enclosure 2.
- Tsunami: See Section 3 of Reference 2, Enclosure 2.
- Ice-Induced Flooding: See Section 3 of Reference 2, Enclosure 2.
- Channel Migration or Diversion: See Section 3 of Reference 2, Enclosure 2.
- Combined Effects (including wind-waves and run-up effects): See Section 3 of Reference 2, Enclosure 2.
- Other Associated Effects (i.e. hydrodynamic loading, including debris; effects caused by sediment deposition and erosion; concurrent site conditions; and groundwater ingress): See Reference 3.
- Flood Event Duration Parameters (i.e. warning time, period of site preparation, period of inundation, and period of recession): See Reference 3.

Storm surge, seiche, tsunami, ice-induced flooding, and channel migration or diversion (and associated NUREG/CR-7046 combined-effects flood scenarios) were either determined to be implausible or completely bounded by other mechanisms. Only LIP and the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River where determined to be applicable flood-causing mechanisms at Example Power Station. Parameters for these flood-causing mechanisms, including associated effects and flood event duration parameters, are described in detail in References 2 (Enclosure 2), 3, and 4 and summarized in Table 1. [Note that Example Power Station elected to provide a bounding set of MSFHI parameters, instead of individual parameters, in the enclosure.]

In Reference 6, the NRC concluded that the "reevaluated flood hazards information [i.e. MSFHI], as summarized in the [Reference 6] Enclosure [Summary Tables of Reevaluated Flood Hazard Levels], is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049" for Example Power Station. The information in the Reference 6 enclosure agrees with the elevation data in Table 1.

2.2. Reference 1, Section G.3 – Basis for Mitigating Strategies Assessment (FLEX Design Basis Comparison)

As discussed in Section 2.1, only LIP and the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River were determined to be applicable flood-causing mechanisms at Example Power Station.

The LIP flood is not addressed in Example Power Station's CLB so, therefore, was determined to be not bounded by the plant's CDB flood. However, the FLEX DB includes the original reevaluation of the LIP flood (Reference 2, Enclosure 1). The LIP flood was updated and submitted in Reference 4; which represents the MSFHI LIP flood. A comparison of the CDB, FLEX DB, and MSFHI for the LIP flood parameters is provided in Table 1.

The NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River includes two individual flood-causing mechanisms, flooding in rivers and streams and dam breaches and failures, plus wind-wave run-up. The flood hazard reevaluation showed that the stillwater elevations associated with flooding in rivers and streams and dam breaches and failures are bounded by the CDB flood. However, the reevaluated wind-wave run-up elevation for the H.1-combination is not bounded by the CDB flood. Other associated effects, including hydrodynamic and debris loads, effects of sediment deposition and erosion, concurrent site conditions, and groundwater ingress for the MSFHI are addressed in Reference 3. Hydrodynamic and debris loads are not addressed in Example Power Station's CLB so, therefore, was determined to be not bounded by the CDB flood. As indicated in Reference 3, effects of sediment deposition and erosion, concurrent site conditions, and groundwater ingress were determined to be bounded by the CDB flood. MSFHI food duration parameters are also provided in Reference 3. However, the FLEX DB incorporates many of the MSFHI flood parameters and, therefore, bounds the MSFHI flood, with the exception of period of inundation and recession. A comparison of the CDB, FLEX DB, and MSFHI for the H.1 combined-effects river flood is provided in Table 2.

As discussed above and indicated in Tables 1 and 2, the FLEX DB flood does not completely bound the MSFHI flood. Therefore, Example Power Station performed an evaluation of the FLEX strategy against the MSFHI flood parameters in accordance with Reference 1, Section G.4.1. See Section 2.3.1.1.

Table 1 – Local Intense Precipitation Flood Parameter Comparison

Flood Scenario Parameter		Plant's Current Design Basis	FLEX Design Basis	MSFHI	MSFHI Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. NAVD-88)	N/I	597.6	597.7	NB
	2. Max Wave Run-up Elevation (ft. NAVD-88)	N/I	N/A	N/A	N/A
	3. Max Hydrodynamic (lb/ft)/Debris Loading (lb)	N/I	250.2	263.7	NB
	4. Effects of Sediment Deposition/Erosion	N/I	See note	See note	B
	5. Other associated effects (identify each effect)	N/I	N/A	N/A	N/A
	6. Concurrent Site Conditions	N/I	See note	See note	B
	7. Effects on Groundwater	N/I	See note	See note	N/A
Flood Event Duration	8. Warning Time (hours)	N/I	See note	See note	B
	9. Period of Site Preparation (hours)	N/I	See note	See note	B
	10. Period of Inundation (hours)	N/I	2.2	2.3	NB
	11. Period of Recession (hours)	N/I	See note	See note	NB
Other	12. Plant Mode of Operations	N/I	Any	Any	B
	13. Other Factors	N/I	N/A	N/A	N/A

N/A = Not Applicable N/I = Not Included

The numbering of Notes below corresponds to the numbering of the line items in the Table above.

1. Elevation may vary around the site. MSFHI LIP flood represents the maximum flood elevation from Reference 4 at Door 1 of the Reactor Building. The FLEX DB for LIP was based on the original FHRR submittal (Reference 2, Enclosure 1); with the maximum occurring at Door 1 of the Reactor Building.
2. Consideration of wind-wave action for the LIP event is not explicitly required by NUREG/CR-7046 and is judged to be a negligible because of limited fetch lengths and flow depths.
3. The hydrodynamic and hydrostatic loads are included and determined as force per unit length of structure (lb/ft). To determine the force for the entire structure the loads need to be multiplied by the structure length. The loads vary but the maximum occurs at Door 3 of the Turbine Building. The debris load for the LIP event is assumed to be negligible due to the absence of heavy objects at the plant site and due to low flow velocity, the factors combination of which could lead to a hazard due to debris load. Additionally, the water depths around the buildings due to LIP are relatively shallow.
4. The flow velocities due to the LIP event are determined to be below the suggested velocities (USACE 1984) for the ground cover type (concrete and gravel) at the plant area. Therefore, significant erosion is not expected for the LIP flood. Similarly, the relatively low velocities and flow depths are not expected to have the power to transport sediment and cause significant deposition during the LIP flood.
5. None
6. High winds could be generated concurrent to a LIP event. However, manual actions are not required to protect the plant from LIP flooding so this concurrent condition is not applicable.
7. The majority of the plant area is paved or gravel. Also, the soil in the site area is generally characterized by the Natural Resources Conservation Service (NRCS) as sandy clay loam (Hydrologic Soil Group C). These land use and soil type features would limit the volume of rainfall infiltrated during a short-duration (1-hour) LIP event and groundwater seepage would likely be minimal.
8. FLEX DB LIP warning time procedures were developed in accordance with NEI 15-05. See Reference 7. The procedures define a consequential rainfall depth, monitoring trigger, and action trigger.
9. [Discuss period of site preparation (after entry into flood procedures and before flood waters reach site grade).] Site preparation is captured in the FLEX DB LIP warning time procedures, developed in accordance with NEI 15-05. See Reference 7. The procedures define a consequential rainfall depth, monitoring trigger, and action trigger.
10. Period of inundation above the permanent/passive protection levels. Varies throughout the site; maximum value shown.
11. Captured in the period of inundation.
12. None
13. None

Table 2 – NUREG/CR-7046, Appendix H, H.1 Combined-Effect Flood (floods caused by precipitation events plus hydrologic dam failure) Parameter Comparison for Example River

	Flood Scenario Parameter	Plant's Current Design Basis	FLEX Design Basis	MSFHI	MSFHI Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL 1912)	603.0	600.9	600.9	B
	2. Max Wave Run-up Elevation (ft. MSL 1912)	N/I	605.0	605.0	B
	3. Max Hydrodynamic (lb/ft)/Debris Loading (lb)	See note	4.1/480	4.1/480	B
	4. Effects of Sediment Deposition/Erosion	N/I	See note	See note	B
	5. Other associated effects (identify each effect)	N/A	N/A	N/A	N/A
	6. Concurrent Site Conditions	N/I	See note	See note	B
	7. Effects on Groundwater	See note	See note	See note	B
Flood Event Duration	8. Warning Time (hours)	See note	See note	See note	B
	9. Period of Site Preparation (hours)	96	96	172	B
	10. Period of Inundation (hours)	350	350	412	NB
	11. Period of Recession (hours)	See note	See note	See note	NB
Other	12. Plant Mode of Operations	All	All	All	B
	13. Other Factors	N/A	N/A	N/A	N/A

N/A = Not Applicable N/I = Not Included

The numbering of Notes below corresponds to the numbering of the line items in the Table above.

1. None
2. None
3. Debris load based on debris weights of 1,000 lbs. Barge impact determined to be not credible; see discussion in Reference 3.
4. The flow velocities due to a river flood are determined to be below the suggested velocities (USACE 1984) for the ground cover type (concrete and gravel) at the plant area. Therefore, significant erosion is not expected for the LIP flood. Also, hydraulic models show relatively low overbank velocities and stream power that is expected to only transport very fine particles with very low settling velocities. Therefore, deposition is expected to be minimal at the site. See discussion in Reference 3.
5. No additional associated effects identified.
6. High winds could be generated concurrent to a LIP event. However, the FLEX design considered 1-minute sustained wind-speeds of 45 mph (equivalent to a 100-year 1-minute sustained wind).
7. The CLB assumes that safety-related structures below site grade are protected from ingress to plant grade. Therefore, the river flood is not expected to surcharge groundwater and cause ingress below grade during a river flood. The MSFHI stillwater flood elevation is less than the CDB and FLEX DB flood elevation so no additional pressure head will be applied beyond the CDB flood.
8. River monitoring (every 2 hours) is triggered when a flood emergency is declared.
9. The CLB "Flood Emergency" procedure goes into effect when the actual river level exceeds elevation 586 ft MSL, as monitored by the gauge at the plant intake bay, or is predicted to exceed elevation 594 ft MSL in less than 96 hours. The MSFHI value is based on T=0 at the end of the rainfall event.
10. None
11. Period of recession captured in the period of inundation.
12. None
13. None

2.3. NEI 12-06, Rev. 2, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI

2.3.1. NEI 12-06, Rev. 2, Section G.4.1 – Assessment of Current FLEX Strategies

External Flood Hazard Assessment from OIP:
Per Plant G.4.4 UFSAR (Section 3.4.1), the maximum flood elevation is 603'-0" at the site. This is above the grade elevation (594-6"). The maximum flood elevation is a rising river level event that provides 96 hours of warning time. Therefore, time is available to relocate equipment and stage necessary measures to support plant response to rising water levels.

In accordance with NEI 12-06 section 6.2.1, Susceptibility to External Flooding, Plant G.4.4 screens in for an assessment for external flood hazard.

The current Plant G.4.4 FLEX strategies utilize a combination of Phase 1 (RCIC) and Phase 2 (portable pumps and generators) to maintain core cooling, containment and spent fuel pool cooling functions. The OIP and six month updates do not specifically list the strategy for a flood condition. Plant G.4.4 will utilize a flood abnormality procedure, "Flood Emergency" procedure, to address the MSFSHI riverine flooding event, including flood induced ELAP and LUHS (FLEX) events. This procedure will be initiated upon forecast of increasing river level by the National Weather Service or actual river level of >582 feet. During the warning time of 96 hours, Plant G.4.4 will shutdown both reactors, cool to cold shutdown (mode 4), remove the containment head, disassemble the reactor and flood the cavities to provide cooling and make up to the reactors. This strategy does not maintain the containment function.
Mitigation Strategies Flooding Hazard Information (MSFHI) for the most limiting flood hazard:

- Probable Maximum Flood
    - Combined effects: cool season PMP, 100-year snowpack, upstream dam failure and the effects of coincident wind wave activity
    - Maximum still water elevation is 8 feet above site grade
    - Maximum water elevation is 10 feet above site grade
    - Duration ~ 10 days
    - Warning time: Initiated by a flood forecast by NWS or River Level is greater than 582'. "Flood Emergency" procedure actions are triggered by actual river level greater than 586' or predicted to exceed plant grade in less than 96 hours.

2.3.1.1. Impacts of MSFHI

The MSFHI has been used in the evaluation of FLEX strategies.

Storage:
The FLEX / Flood equipment will be stored in different locations. Plant G.4.4 will have two storage locations, one robust building that is not protected for flood and one commercial building that is above the flood levels. The flood pump [Darley Model HE20V pump] will be relocated prior to the flood waters reaching grade level. In the event of a flood, the FLEX equipment from the robust building will be relocated to the upper commercial building.

Robustness of plant equipment:
No plant equipment will be required after flood water is at grade level. All plant equipment used for FLEX prior to being secured meets the requirements of robustness as defined in Appendix A.

Connection points:
There are no connections points for the flood strategy. Electrical power will be removed by plant personnel and water will be pumped to the open reactor cavity.

2.3.1.2. Conclusions

The current FLEX strategies were developed using the DB flood information per Plant G.4.4 UFSAR Section 3.4.1. The new MSFHI is slightly higher and therefore, the MSFHI is not bounded by the FLEX DB. The containment function will not be maintained and therefore a targeted mitigation strategy will be utilized.

The following summarizes all the applicable flooding hazards at Plant G.4.4 and the status of FLEX for each:

- LIP – FLEX works as designed
- Riverine – FLEX does not work as designed, the containments need to be open to implement the strategy.
- Combined effects (riverine plus dam failure) – FLEX does not work, THMS used as described in this document, the containment needs to be open to implement the strategy.

The current FLEX strategies were developed using the DB flood information per Plant G.4.4 UFSAR Section 3.4.1. The new MSFHI is slightly higher and therefore, the MSFHI is not bounded by the FLEX DB. The containment function will not be maintained and therefore a targeted mitigation strategy will be utilized. The river height of this flood will require the units to be shutdown and cooled down to < 212°F. This will also require opening the containment and flooding the reactors and reactor cavities to maintain cold shutdown. Because of not fully maintaining the containment function, a THMS is required.

2.3.2. NEI 12-06, Rev. 2, Section G.4.2 – Assessment for Modifying FLEX Strategies

Because of not fully maintaining the containment function, a THMS is required, therefore Section G4.2 is N/A.

2.3.3. NEI 12-06, Rev. 2, Section G.4.3 and G.4.4 – Assessment of Alternative and Targeted Hazard Mitigating Strategies

Because of not fully maintaining the containment function, a THMS is required. Attachment 1, "Plant G.4.4 Flood THMS" addresses the following:

- The sequence of events for the flood hazard(s);
- The detailed description of the mitigating strategies;
- A detailed list of equipment necessary for the mitigating strategies;
- A description of how the provisions in Sections 3, 6, and 11 of NEI 12-06, Rev. 2 have been addressed;
- Description of validation items that will need to be performed based on the changes.
- Justification for not maintaining the containment capability.

Sequence of events for the flood hazard:

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
1	- 96 hrs	Event Notification per “Flood Emergency” procedure	N	Plant at 100% power, “Flood Emergency” procedure is entered based on actual river level greater than 582’ or predicted to exceed plant grade in less than 96 hours.
2	- 96 hrs	Call out additional staff.	N	OCC staffed and reactor services called in for reactor disassembly.
3	- 96 hrs	Monitor river level.	N	Establishes response action
4	- 96 hrs	Secure from dry cask operation if in progress	N	Only necessary if in progress.
5	- 94 hrs	Initiate Unit 1 and Unit 2 shutdown	N	Both Units will be shut down concurrently and decay heat removed using the normal procedures as specified for the RHR system
7	- 94 hrs	Place mobile Makeup Demineralizer System in operation	N	Provide additional water as required.
8	- 93 hrs	Start setup portable pump (Darley pump) for Cavity and SFP makeup	N	Follow “Flood Emergency” procedure
9	- 87 hrs	Start removal of DW shield plugs	N	Per forced outage schedule
10	- 87 hrs	Both units achieve Mode 3	Y	Need to be in Mode 3 on both units for the pending Rx disassembly
11	- 85 hrs	Seal EDG Fuel Storage and plug IRSF pit lines	N	Prevent water entering diesel storage tank.
12	- 82 hrs	Mode 4, Cold Shutdown achieved on both units	Y	Need to be in Mode 4 to break primary containment and remove DW head.
13	- 82 hrs	Start water addition to Suppression Chambers through RHR system test lines per procedure.	N	
14	- 78 hrs	Shield plugs removed	N	Need plugs removed to remove DW head
15	- 76 hrs	Darley pump setup complete	N	This needs to be established prior to cavity flood
16	- 72 hrs	Transfer FLEX equipment to higher elevations above predicted flood levels	N	Protect FLEX equipment

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
17	- 72 hrs	Obtain DW samples	N	Preparation for DW head removal
18	- 72 hrs	Water addition to suppression chambers complete	N	
19	- 68 hrs	Set up to remove Unit 1 and Unit 2 DW head	N	Once in Mode 4, Cold Shutdown, DW head can be removed.
20	- 65 hrs	DW head removal set up complete	N	Need to be ready to remove DW head once Mode 4 has been established
21	- 62 hrs	Unit 1 DW head removed and stored	N	Need the DW head removed to remove Rx vessel head
22	- 59 hrs	Unit 2 DW head removed and stored	N	Need the DW head removed to remove Rx vessel head
23	- 35 hrs	Unit 1 Rx vessel head removed and stored	Y	This allows the cavity to be filled to maintain cold shutdown
24	- 24 hrs	Unit 2 Rx vessel head removed and stored	Y	This allows the cavity to be filled to maintain cold shutdown
25	- 22 hrs	Unit 1 and Unit 2 cavity filled	N	Allows for sufficient water above the core to maintain cold shutdown.
26	- 22 hrs	Darley pumps connected and alignment for reactor cavity make up.	N	Per “Flood Emergency” procedure
27	- 1 hr	Open plant doors on ground elevation.	N	Equalize loading on buildings.
28	0 hrs	ELAP occurs due to flood Directed by “Flood Emergency” procedure	N	EDGs and SBO DGs not protected from flood water
29	~2 min	Operating crew enters applicable EOPs and abnormal procedures for LOOP.	N	EOP “RPV Control” AOP “Loss of Offsite Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power”
30	~5 mins	Start de-energize station loads prior to water going above grade level	N	Personnel safety
31	~5 mins	DC load shedding initiated per AOP “Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power”	N	AOP “Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power”. Initiation of load shedding is not time critical – completion of load shedding is time critical.
32	30 mins	DC load shedding completed	Y	AOP “Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power.”

Attachment 1
Plant G.4.4 Flood THMS

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
33	30 mins	Complete de-energize station loads.	N	Personnel Safety
34	~60 mins	Control Room crew has assessed SBO and plant conditions and declares an Extended Loss of AC Power (ELAP) event.	N	This is not time critical. Plant G.4.4 will be in a flood condition prior to this declaration.
35	90 mins	FLEX DC load shed complete.	N	DC coping analysis assumes FLEX load shed is complete by 90 minutes.
36	24 hrs	Initial equipment from National SAFER Response Center becomes available.	N	Per NEI 12-06, Section 12 (NSRC).
37	24 -72 hrs	Continue to maintain critical functions of core cooling and SFP cooling. Utilize initial NSRC equipment in spare capacity.	N	Not time critical/sensitive since Phase 2 actions result in indefinite coping times for all safety functions.
38	10 days	Flood water subsides below grade level, start plant restoration.	N	Time based on recent MSFHI

A detailed description of the mitigating strategies:

Maintain Core Cooling:

The following actions will be initiated four days prior to the predicted arrival of a flood of elevation 594’6” or greater, with both Units being shut down and decay heat being removed using the normal procedures as specified for the RHR system. Flood stage levels on the Example River are predicted several weeks in advance by the U.S. Army Corps of Engineers. In the highly unlikely event that a maximum probable flood is predicted, the plant will be shut down and cooled four days prior to the predicted time at which water will go above plant grade elevation of 594.5’. This will reduce decay heat from the reactor to a level which can be removed by natural circulation cooling between the reactor and the reactor cavities and fuel storage pools. (reference UFSAR Section 3.4.1, “Flood Protection”).

Upon entry into “Flood Emergency” procedure, Plant G.4.4 will call out additional personnel as necessary to shutdown both reactors and once shutdown and cooled down, disassemble the reactors. Unit shutdown will commence within the first two hours of entry into the procedure. Operators will be briefed and start a normal unit shutdown per “Reactor Power Operations” procedure and “Normal Unit Shutdown” procedure. Both reactors will be shutdown in parallel.

A flood watch schedule will be established to monitor for rising river levels. Subsequent actions and decisions to continue with plant shutdown and disassembly will be based on the river rate of rise and level. An onsite mobile makeup demineralizer system will be placed in operation to fill the CCSTs and provide additional water to flood the reactor cavity. FLEX equipment from the lower FLEX storage area will be transferred to the FLEX storage building near the upper parking lot which is an elevated site not susceptible to the river flood. Specific flood equipment as listed in the equipment section will be obtained and staged in preparation for maintaining the reactor cavity water level once the units are shutdown and the cavities flooded.

Both units will enter mode 4 approximately 14 hours after entry into the "Flood Emergency" procedure or hour -82 per the time line. At this time, Unit 1's containment head will be removed and stored. After removal of the Unit 1 containment head, the staff will commence removal of the Unit 2 containment head. Both containment heads will be removed at hour -59 per the time line. Once both containment heads are removed, setup and removal of both reactor heads will commence. Both reactor heads will be removed and stored at hour -24 per the time line. After both reactor heads are removed, the reactor cavities will be filled. Under this condition, no heat removal nor related electrical power supply systems are needed. The recirculation loops will be isolated to prevent leakage from the pump seals limiting the water loss from the reactors. Units will be maintained in cold shutdown (<212°F) via natural circulation. Water level will be maintained in the normal cavity filled level.

Additionally, during the warning time period, other activities will occur. Both suppression chambers will be filled, the outdoor water storage tanks will be filled, sealing the EDG Fuel Storage tanks and plug drain lines in IRSF pit will be completed. The flood pumps (Darley pumps) will be connected and alignment for reactor cavity make up established. Since this is the same strategy as used for the design basis and FLEX flood response, no additional access provisions are required for the operators.

Ninety six (96) hours after "Flood Emergency" procedure initiation, water level is predicted to reach grade level. At this time, plant doors will be opened to ensure pressure is equalized. Power will be removed by de-energization of station loads. This will be designated as "Time 0". The operating crew will enter the applicable EOPs and abnormal procedures for LOOP. DC load shedding will commence and declaration of an ELAP will be made. The ELAP is caused when the plant staff removes power to the site per procedure. Since this is a planned evolution, all preparations will be complete and plant staff will be staged at key locations to implement the actions. Once DC load shed is complete, the operating crew will continue to maintain the critical functions of core cooling and spent fuel pool cooling until flood waters subside and recovery can be entered.

A detailed list of equipment necessary for the mitigating strategies:

- Portable Flood pump [Darley Model HE20V]
- Emergency Portable Pump 'A'
- Emergency Portable Pumps 'B'
- Emergency Portable Pumps 'C'
- Trash pumps in H building

- Two 10' sections of 4" suction hose with suction strainer
- Pump discharge hose, approximately 400 feet of 2 ½ inch fire hose for two pumps.
- Ten day supply of gasoline, 400 gallons of gasoline (approximately 40 gallons per day)
- Scaffolding
- FLEX Haul Vehicles
- Two boats with outboard motors, 50 gallons of gasoline, safety equipment
- Reactor and Containment disassembly equipment
    - Miscellaneous rigging equipment
    - Miscellaneous hand held tools
    - Reactor Stud De-Tensioners
    - Portable stairs

A description of how the provisions in Sections 3, 6, and 11 of NEI 12-06, Rev. 2 have been addressed:

- **Section 3 Establish Baseline Coping Capability**

The general criteria and initial plant conditions were reviewed during the development of the THMS. All applicable aspects of these sections have been incorporated into the THMS.
Section 3.2.1.3 was reviewed and since this is a specific BDB event, flood, some of the initial conditions do not apply.

3.2.1.3.1 "No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) at a plant site resulting from an external event that affects the off-site power system either throughout the grid or at the plant with no prospect for recovery of off-site power for an extended period. The LOOP is assumed to affect all units at a plant site." This is specific to a flood event. The LOOP will be caused when plant staff removes power from the site due to the flood conditions.

3.2.1.3.2. "All design basis installed sources of emergency on-site ac power and SBO alternate ac power sources are assumed to be not available and not imminently recoverable. Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available." The plant staff will induce the loss of power based on flood levels. Once the flood waters subside, actions will be initiated to recover on-site ac power. During the warning period Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available. After the plant staff initiates the ELAP, DC Power and AC power from buses fed by station batteries through inverters is assumed lost and is not required for the THMS strategy.

3.2.1.3.5. "Fuel for FLEX equipment stored in structures with designs which are robust for the applicable hazard(s) remains available." The plant staff will continue to protect fuel stored in the EDG storage tanks, but due to the flood, this fuel will not be accessible until the flood water subsides.

3.2.1.3.8. "Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design." All of the electrical distribution systems will be considered normally available until just before flood waters reach plant grade elevation (EL 595). At that point, operations personal de-energize station electrical loads including offsite power and onsite backup power (AC and DC).

Section 3.2.1.4, Reactor Transient – the units will be shut down and cooled down prior to the predicted arrival of a flood of elevation 594'6" or greater.

Section 3.2.1.5, Reactor Coolant Inventory Loss – the units will be shut down and cooled down prior to the predicted arrival of a flood of elevation 594'6" or greater. The coolant losses will be reduced as compared to the initial mitigating strategies assessment. The reactor recirculation pumps will be isolated which will isolate any leakage due to pump seal leakage. Loss due to evaporation is considered for make up to the reactor cavities.

Section 3.2.1.6, SFP Conditions – the units will be in a condition where the cavities and SFPs are connected. Make up to the SFPs will be via the Darley pump to the reactor cavities. All assumptions in this section for the SFP have been reviewed and apply to the development of the THMS.

Section 3.2.1.7, Event Response Actions – the response is based on the timeline established for the flood event. Additional plant staff will be available to complete all actions specified in the THMS. All principles in this section have been reviewed and are met by the THMS.

Section 3.2.1.8, Effects of Loss of Ventilation – the loss of ventilation has been considered in the development of the FLEX strategies. These considerations will apply for the THMS. The conditions and timing under which ventilation will be lost are unchanged as compared to the original FLEX strategy.

Section 3.2.1.9 Personnel Accessibility – areas requiring personnel access have been evaluated. Plant staff will be able to access upper areas of the reactor and turbine buildings during the event. Boats will need to be utilized in some areas of the site for access. This will not impede any actions in the THMS. Two boats with outboard motors will be stored at an area above the flood elevation.

Section 3.2.1.10, Instrumentation and Controls – all instruments and controls will be available for use during the warning period. After the plant staff removes power from the units, the only instruments required for mitigation will be SFP level. Readings can be obtained locally or via the SFPI.

Section 3.2.1.11, Containment Isolation Valves – all valves will be in the isolated position and do not require operation during the event.

Section 3.2.1.12, Qualification of Plant Equipment – prior to the flood water reaching plant grade, all plant equipment required for the THMS is qualified to current plant design. After the flood reaches grade and the staff removes power from the units, only portable equipment will be required.

Section 3.2.1.13, FLEX Analyses, Methodologies and Generic Topics – this section has been reviewed and applicable topics are incorporated in the development of the THMS.

Section 3.2.2, Minimum Baseline Capabilities
Phase 1 will be during the warning period. Plant equipment used to shut down and cool down the plant will be used. In addition to this equipment, refueling equipment will be used to disassemble the reactors and flood the reactor cavities. Phase 2 equipment consists of a portable make up pump, Darley pump, to supply make up water to the reactor cavities. Small generators will be available for use if required. The THMS does not require the use of portable generators during the event.
Phase 3 equipment from off site will be available and used for spares if required. An off-site staging area has been established for Phase 3 equipment. If required, the Phase 3 equipment can be transferred from the staging area to the plant using helicopters, boats or a combination of these means.
All aspects of section 3.2.2 were considered in the development of the site FLEX FSGs. The THMS will also incorporate the guidelines needed to support the development of other FSGs for a flood event. FSGs that will be used during the flood; control room vent/habitability, lighting, plant area ventilation, and deployment of spare equipment have been developed.

- **Section 6 Assess External Flooding Impact**

6.1 and 6.2: Section 6.1 of NEI 12-06 is information for the utility and has been reviewed. Section 6.2 review follows:
Plant G.4.4 is a not a dry site. Per section 6.2.2, characterization of the Applicable Flood Hazard was performed. This analysis is in section 1.1 of this submittal.

6.2.3.1 Protection of FLEX Equipment:

Plant G.4.4 will meet the following section for protection:
"6.2.3.2.1.1.c FLEX equipment can be stored below flood level if time is available and plant procedures/guidance address the needed actions to relocate the equipment. Based on the timing of the limiting flood scenario(s), the FLEX equipment can be relocated to a position that is protected from the flood, either by barriers or by elevation, prior to the arrival of the potentially damaging flood levels. This should also consider the conditions on-site during the increasing flood levels and whether movement of the FLEX equipment will be possible before potential inundation occurs, not just the ultimate flood height."

Plant G.4.4 will have two storage locations, one robust building that is not protected for flood and one commercial building that is above the flood levels. In the event of a flood, the FLEX equipment from the robust building will be relocated to the upper commercial building. Equipment required to implement the THMS will be relocated to the area of deployment, which is above the predicted flood levels. In the event the flood levels are above the predicted levels, the flood pump and related equipment can be moved to a higher location. Equipment is available to support the operation of the flood pump at a higher location.

6.2.3.2 Deployment of FLEX Equipment:

The equipment necessary for the strategy will be deployed prior to the flood waters reaching grade elevation. All of the necessary support equipment will also be staged prior to the predicted arrival of a flood of elevation 594'6" or greater. Per section 6.2.3.2.:
"1. For external floods with warning time, the plant may not be at power. In fact, the plant may have been shut down for a considerable time and the plant configuration could be established to optimize FLEX deployment. For example, the FLEX pump could be connected, tested, and readied for use prior to the arrival of the critical flood level. Further, protective actions can be taken to reduce the potential for flooding impacts, including cooldown, borating the RCS, isolating accumulators, isolating RCP seal leak off, obtaining dewatering pumps, creating temporary flood barriers, etc. These factors can be credited in considering how the baseline capability is deployed."

Plant G.4.4 units 1 and 2 will be shut down and cooled down to less than 212° F for at least 3 days prior to the predicted arrival of a flood of elevation 594'6" or greater. The Flood pump (Darley pump) will have been set up and readied for use.

"2. The ability to move equipment and restock supplies may be hampered during a flood, especially a flood with long persistence. Accommodations along these lines may be necessary to support successful long-term FLEX deployment."

Supplies for a duration of 10 days will be staged and available for use.

"3. Depending on plant layout, the ultimate heat sink may be one of the first functions affected by a flooding condition. Consequently, the deployment of the FLEX equipment should address the effects of LUHS, as well as ELAP."

Plant G.4.4 THMS will not require the use of the UHS equipment. The ELAP will be self-induced prior to the predicted arrival of a flood of elevation 594'6" or greater. Any power needs will be established prior to the ELAP.

"4. FLEX equipment will require fuel that would normally be obtained from fuel oil storage tanks that could be inundated by the flood or above ground tanks that could be damaged by the flood. Steps should be considered to protect or provide alternate sources of fuel oil for flood conditions. Potential flooding impacts on access and egress should also be considered."

The below ground fuel tanks will be protected prior to the predicted arrival of a flood of elevation 594'6" or greater. Fuel for the Darley pump for a 10 day duration will be staged near the pump.

"5. Connection points for FLEX equipment should be reviewed to ensure that they remain viable for the flooded condition."

The discharge of the Darley pumps will be directly into the reactor cavity. There are no connections required for the THMS. All fuel pool gates will be open and the reactor cavities connected to the fuel pool. This allows for discharging the output from the Darley pump into the fuel pool to maintain level in both reactor cavities.

"6. For plants that are limited by storm-driven flooding, such as Probable Maximum Surge or Probable Maximum Hurricane (PMH), expected storm conditions should be considered in evaluating the adequacy of the baseline deployment strategies."

This does not apply to Plant G.4.4.

"7. Since installed sump pumps will not be available for dewatering due to the ELAP, plants should consider the need to provide water extraction pumps capable of operating in an ELAP and hoses for rejecting accumulated water for structures required for deployment of FLEX strategies."

Water extraction will only be required once the flood waters subside. There will be small trash pumps and the FLEX pumps available for dewatering areas of the plant.

"8. Plants relying on temporary flood barriers should assure that the storage location for barriers and related material provides reasonable assurance that the barriers could be deployed to provide the required protection."

Plant G.4.4 does not rely on temporary flood barriers for the THMS.

"9. A means to move FLEX equipment should be provided that is also reasonably protected from the event."

The Darley pump is a small pump that can be moved by operators. This pump does not need a separate vehicle to transport the pump.

6.2.3.3 Procedural Interfaces

Plant G.4.4 has developed a procedure for flood, "Flood Emergency" procedure. This procedure incorporates all necessary actions for the THMS.

6.2.3.4 Considerations in Utilizing Off-site Resources

Plant G.4.4 will have a staging area designated for any off-site resources. This staging area is above the flood levels. Site access will be limited and the use of boats will be required to access various areas of the plant. Any additional pumps required for the THMS will be small and can be transported via boat to the location needed.

- **Section 11 Programmatic Controls**

11.1, Quality Attributes – the Darley is a commercially available pump. This pump was procured for use during floods.

11.2 Equipment Design – the Darley pump design basis has been reviewed. The pump will meet all performance requirements for the THMS. The pump curve is available for reference as an attachment in "Flood Emergency" procedure. All design factors in section 11.2 have been considered.

11.3 Equipment Storage – the Darley pump will be stored in the Protected Area Warehouse. The pump will be relocated prior to the predicted arrival of a flood of elevation 594'6" or greater.

11.4 Procedure Guidelines – all procedures developed for the THMS meet the guidelines specified in this section.

11.5 Maintenance and Testing – PMs have been established the Darley pump. These PMs fully meet the Utility program requirements. The Utility program was developed using EPRI guidance. For unavailability, the Darley will be added to the FLEX unavailability program and subject to the same unavailability controls as FLEX equipment.

11.6 Training – Operators and plant staff have been trained on "Flood Emergency" procedure. This is included in the Operator training program for periodic training per the training plan.

11.7 Staffing – additional staff will be called out prior to the event. The plant will be fully staffed to perform all tasks necessary to shut down and disassemble the units to the predicted arrival of a flood of elevation 594'6" or greater.

11.8 – Configuration Control – the THMS will be included in the FLEX program and subject to the same unavailability controls as FLEX equipment.

Validation items that will need to be performed:

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
10	- 87 hrs	Both units achieve Mode 3	Y	This will be validated using past refuel outage performance data.
12	- 82 hrs	Mode 4, Cold Shutdown achieved on both units	Y	This will be validated using past refuel outage performance data.
23	- 35 hrs	Unit 1 Rx vessel head removed and stored	Y	This will be validated using past refuel outage performance data.
24	- 24 hrs	Unit 2 Rx vessel head removed and stored	Y	This will be validated using past refuel outage performance data.
32	30 mins	DC load shedding completed	Y	DC load shedding has been validated for FLEX strategies. There are no new actions or environmental factors apply for this load shed, therefore, re-validation of this action is not required.

Justification for not maintaining the containment capability:

The function of the primary containment is to isolate and contain fission products released from the Reactor Primary System following a design basis Loss of Coolant Accident (LOCA) and to confine the postulated release of radioactive material. The primary containment consists of a drywell, which is a steel pressure vessel, enclosed in reinforced concrete, and a suppression chamber, which is a steel torus-shaped pressure vessel, connected by vent pipes. The primary containment surrounds the Reactor Primary System and provides an essentially leak tight barrier against an uncontrolled release of radioactive material to the environment.

The safety design basis for the primary containment is that it must withstand the pressures and temperatures of the limiting DBA without exceeding the design leakage rate. The DBA that postulates the maximum release of radioactive material within primary containment is a LOCA. In the analysis of this accident, it is assumed that primary containment is OPERABLE such that release of fission products to the environment is controlled by the rate of primary containment leakage.

In MODES 1, 2, and 3, a DBA could cause a release of radioactive material to primary containment. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations of these MODES. Therefore, primary containment is not required to be OPERABLE in MODES 4 and 5 to prevent leakage of radioactive material from primary containment.

In this configuration, there will be 490,000 gallons of water above each reactor core. The reactor recirculation system will be isolated preventing inventory loss due to normal pump seal leakage. The loss due to evaporation 4 days after shutdown will be approximately 50 gallons per minute per reactor. The reactors will be able to be maintained in cold shutdown for the duration of the event via natural circulation.

The THMS for Plant G.4.4 will require both units to be shut down and cooled down prior to the predicted arrival of a flood of elevation 594’6” or greater. Both units will be in Mode 4 prior to the removal of the containment heads.

2016 Mitigating Strategies Assessments for Flooding
Documentation Requirements
(DRAFT Plant G.4.4 Submittal)

Acronyms:

- MSFHI – Mitigating Strategies Flood Hazard Information (from the FHRR and MSFHI letter)
- FHRR – Flood Hazard Reevaluation Report
- DB – Design Basis
- AMS – Alternative Hazard Mitigating Strategies
- THMS – Targeted Hazard Mitigating Strategies
- FLEX DB – FLEX Design Basis (flood hazard)

Definitions:

FLEX Design Basis Flood Hazard: the controlling flood parameters used to develop the FLEX flood strategies.

1. Summary
   The FLEX DB flood strategy does not bound the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River where determined to be applicable flood-causing mechanisms at Example Power Station. The river height of this flood will require the units to be shutdown and cooled down to <212 F and the containment to be opened to flood the reactor cavities to maintain cold shutdown. Because of not fully maintaining the containment function a THMS is required. The LIP flood is not addressed in Example Power Stations CLB and was therefore determined to be not bounded by the plant's CDB flood. However, the FLEX DB includes the original reevaluation of the LIP flood.

2. Documentation

References:

1. NEI 12-06, Rev 2
2. FHRR Submittal
   - Enclosure 1 – LIP Report
   - Enclosure 2 – FHRR Report
   - Enclosure 3 – CD with pertinent site data
3. RAI Responses 1 (additional flood parameters)
4. RAI Responses 2 (updated LIP report)
5. RAI Responses 3 (additional site-specific PMP information)
6. MSFHI Letter
7. Warning Time Calculation and Procedures for LIP (per NEI 15-05)

2.1. Reference 1, Section G.2 – Characterization of the MSFHI

Characterization of the Mitigating Strategies Flood Hazard Information (MSFHI) is summarized in the Enclosure to Reference 6; the NRC's interim response to the flood hazard reevaluation submittal (Reference 2) and amended submittals (References 3, 4, and 5). A more detailed description of the MSFHI, along with the basis for inputs, assumptions, methodologies, and models, is provided in the following references:

- Local Intense Precipitation (LIP): See Reference 4.
- Flooding in Streams and Rivers: See Section 3 of Reference 2, Enclosure 2.
- Dam Breaches and Failures: See Section 3 of Reference 2, Enclosure 2.
- Storm Surge: See Section 3 of Reference 2, Enclosure 2.
- Seiche: See Section 3 of Reference 2, Enclosure 2.
- Tsunami: See Section 3 of Reference 2, Enclosure 2.
- Ice-Induced Flooding: See Section 3 of Reference 2, Enclosure 2.
- Channel Migration or Diversion: See Section 3 of Reference 2, Enclosure 2.
- Combined Effects (including wind-waves and run-up effects): See Section 3 of Reference 2, Enclosure 2.
- Other Associated Effects (i.e. hydrodynamic loading, including debris; effects caused by sediment deposition and erosion; concurrent site conditions; and groundwater ingress): See Reference 3.
- Flood Event Duration Parameters (i.e. warning time, period of site preparation, period of inundation, and period of recession): See Reference 3.

Storm surge, seiche, tsunami, ice-induced flooding, and channel migration or diversion (and associated NUREG/CR-7046 combined-effects flood scenarios) were either determined to be implausible or completely bounded by other mechanisms. Only LIP and the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River where determined to be applicable flood-causing mechanisms at Example Power Station. Parameters for these flood-causing mechanisms, including associated effects and flood event duration parameters, are described in detail in References 2 (Enclosure 2), 3, and 4 and summarized in Table 1. [Note that Example Power Station elected to provide a bounding set of MSFHI parameters, instead of individual parameters, in the enclosure.]

In Reference 6, the NRC concluded that the "reevaluated flood hazards information [i.e. MSFHI], as summarized in the [Reference 6] Enclosure [Summary Tables of Reevaluated Flood Hazard Levels], is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049" for Example Power Station. The information in the Reference 6 enclosure agrees with the elevation data in Table 1.

2.2. Reference 1, Section G.3 – Basis for Mitigating Strategies Assessment (FLEX Design Basis Comparison)

As discussed in Section 1.1, only LIP and the NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River where determined to be applicable flood-causing mechanisms at Example Power Station.

The LIP flood is not addressed in Example Power Stations CLB so, therefore, was determined to be not bounded by the plant's CDB flood. However, the FLEX DB includes the original reevaluation of the LIP flood (Reference 2, Enclosure 1). The LIP flood was updated and submitted in Reference 4; which represents the MSFHI LIP flood. A comparison of the CDB, FLEX DB, and MSFHI for the LIP flood parameters is provided in Table 1.

The NUREG/CR-7046, Appendix H, H.1 combined-effect flood (floods caused by precipitation events plus hydrologic dam failure and wind-wave run-up) for Example River includes two individual flood-causing mechanisms, flooding in rivers and streams and dam breaches and failures, plus wind-wave run-up. The flood hazard reevaluation showed that the stillwater elevations associated with flooding in rivers and streams and dam breaches and failures are bounded by the CDB flood. However, the reevaluated wind-wave run-up elevation for the H.1-combination is not bounded by the CDB flood. Other associated effects, including hydrodynamic and debris loads, effects of sediment deposition and erosion, concurrent site conditions, and groundwater ingress for the MSFHI are addressed in Reference 3. Hydrodynamic and debris loads are not addressed in Example Power Stations CLB so, therefore, was determined to be not bounded by the CDB flood. As indicated in Reference 3, effects of sediment deposition and erosion, concurrent site conditions, and groundwater ingress were determined to be bounded by the CDB flood. MSFHI food duration parameters are also provided in Reference 3. However, the FLEX DB incorporates many of the MSFHI flood parameters and, therefore, bounds the MSFHI flood, with the exception of period of inundation and recession. A comparison of the CDB, FLEX DB, and MSFHI for the H.1 combined-effects river flood is provided in Table 2.

As discussed above and indicated in Tables 1 and 2, the FLEX DB flood does not completely bound the MSFHI flood. Therefore, Example Power Station performed an evaluation of the FLEX strategy against the MSFHI flood parameters in accordance with Reference 1, Section G.4.1. See Section 2.3.1.1.

Table 1 – Local Intense Precipitation Flood Parameter Comparison

Flood Scenario Parameter		Plant's Current Design Basis	FLEX Design Basis	MSFHI	MSFHI Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. NAVD-88)	N/I	597.6	597.7	NB
	2. Max Wave Run-up Elevation (ft. NAVD-88)	N/I	N/A	N/A	N/A
	3. Max Hydrodynamic (lb/ft)/Debris Loading (lb)	N/I	250.2	263.7	NB
	4. Effects of Sediment Deposition/Erosion	N/I	See note	See note	B
	5. Other associated effects (identify each effect)	N/I	N/A	N/A	N/A
	6. Concurrent Site Conditions	N/I	See note	See note	B
	7. Effects on Groundwater	N/I	See note	See note	N/A
Flood Event Duration	8. Warning Time (hours)	N/I	See note	See note	B
	9. Period of Site Preparation (hours)	N/I	See note	See note	B
	10. Period of Inundation (hours)	N/I	2.2	2.3	NB
	11. Period of Recession (hours)	N/I	See note	See note	NB
Other	12. Plant Mode of Operations	N/I	Any	Any	B
	13. Other Factors	N/I	N/A	N/A	N/A

N/A = Not Applicable N/I = Not Included

The numbering of Notes below corresponds to the numbering of the line items in the Table above.

1. Elevation may vary around the site. MSFHI LIP flood represents the maximum flood elevation from Reference 4 at Door 1 of the Reactor Building. The FLEX DB for LIP was based on the original FHRR submittal (Reference 2, Enclosure 1); with the maximum occurring at Door 1 of the Reactor Building.
2. Consideration of wind-wave action for the LIP event is not explicitly required by NUREG/CR-7046 and is judged to be a negligible because of limited fetch lengths and flow depths.
3. The hydrodynamic and hydrostatic loads are included and determined as force per unit length of structure (lb/ft). To determine the force for the entire structure the loads need to be multiplied by the structure length. The loads vary but the maximum occurs at Door 3 of the Turbine Building. The debris load for the LIP event is assumed to be negligible due to the absence of heavy objects at the plant site and due to low flow velocity, the factors combination of which could lead to a hazard due to debris load. Additionally, the water depths around the buildings due to LIP are relatively shallow.
4. The flow velocities due to the LIP event are determined to be below the suggested velocities (USACE 1984) for the ground cover type (concrete and gravel) at the plant area. Therefore, significant erosion is not expected for the LIP flood. Similarly, the relatively low velocities and flow depths are not expected to have the power to transport sediment and cause significant deposition during the LIP flood.
5. None
6. High winds could be generated concurrent to a LIP event. However, manual actions are not required to protect the plant from LIP flooding so this concurrent condition is not applicable.
7. The majority of the plant area is paved or gravel. Also, the soil in the site area is generally characterized by the Natural Resources Conservation Service (NRCS) as sandy clay loam (Hydrologic Soil Group C). These land use and soil type features would limit the volume of rainfall infiltrated during a short-duration (1-hour) LIP event and groundwater seepage would likely be minimal.
8. FLEX DB LIP warning time procedures were developed in accordance with NEI 15-05. See Reference 7. The procedures define a consequential rainfall depth, monitoring trigger, and action trigger.
9. [Discuss period of site preparation (after entry into flood procedures and before flood waters reach site grade).] Site preparation is captured in the FLEX DB LIP warning time procedures, developed in accordance with NEI 15-05. See Reference 7. The procedures define a consequential rainfall depth, monitoring trigger, and action trigger.
10. Period of inundation above the permanent/passive protection levels. Varies throughout the site; maximum value shown.
11. Captured in the period of inundation.
12. None
13. None

Table 2 – NUREG/CR-7046, Appendix H, H.1 Combined-Effect Flood (floods caused by precipitation events plus hydrologic dam failure) Parameter Comparison for Example River

Flood Scenario Parameter		Plant's Current Design Basis	FLEX Design Basis	MSFHI	MSFHI Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL 1912)	603.0	600.9	600.9	B
	2. Max Wave Run-up Elevation (ft. MSL 1912)	N/I	605.0	605.0	B
	3. Max Hydrodynamic (lb/ft)/Debris Loading (lb)	See note	4.1/480	4.1/480	B
	4. Effects of Sediment Deposition/Erosion	N/I	See note	See note	B
	5. Other associated effects (identify each effect)	N/A	N/A	N/A	N/A
	6. Concurrent Site Conditions	N/I	See note	See note	B
	7. Effects on Groundwater	See note	See note	See note	B
Flood Event Duration	8. Warning Time (hours)	See note	See note	See note	B
	9. Period of Site Preparation (hours)	96	96	172	B
	10. Period of Inundation (hours)	350	350	412	NB
	11. Period of Recession (hours)	See note	See note	See note	NB
Other	12. Plant Mode of Operations	All	All	All	B
	13. Other Factors	N/A	N/A	N/A	N/A

N/A = Not Applicable   N/I = Not Included

The numbering of Notes below corresponds to the numbering of the line items in the Table above.

1. None
2. None
3. Debris load based on debris weights of 1,000 lbs. Barge impact determined to be not credible; see discussion in Reference 3.
4. The flow velocities due to a river flood are determined to be below the suggested velocities (USACE 1984) for the ground cover type (concrete and gravel) at the plant area. Therefore, significant erosion is not expected for the LIP flood. Also, hydraulic models show relatively low overbank velocities and stream power that is expected to only transport very fine particles with very low settling velocities. Therefore, deposition is expected to be minimal at the site. See discussion in Reference 3.
5. No additional associated effects identified.
6. High winds could be generated concurrent to a LIP event. However, the FLEX design considered 1-minute sustained wind-speeds of 45 mph (equivalent to a 100-year 1-minute sustained wind).
7. The CLB assumes that safety-related structures below site grade are protected from ingress to plant grade. Therefore, the river flood is not expected to surcharge groundwater and cause ingress below grade during a river flood. The MSFHI stillwater flood elevation is less than the CDB and FLEX DB flood elevation so no additional pressure head will be applied beyond the CDB flood.
8. River monitoring (every 2 hours) is triggered when a flood emergency is declared.
9. The CLB flood emergency procedure goes into effect when the actual river level exceeds elevation 586 ft MSL, as monitored by the gauge at the plant intake bay, or is predicted to exceed elevation 594 ft MSL in less than 96 hours. The MSFHI value is based on T=0 at the end of the rainfall event.
10. None
11. Period of recession captured in the period of inundation.
12. None
13. None

1.2.2.3. NEI 12-06, Rev. 1a, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI

1.2.1.2.3.1. NEI 12-06, Rev. 1a, Section G.4.1 – Assessment of Current FLEX Strategies

External Flood Hazard Assessment from OIP:
Per Plant G.4.4 UFSAR (Section 3.4.1), the maximum flood elevation is 603'-0" at the site. This is above the grade elevation (594-6"). The maximum flood elevation is a rising river level event that provides 96 hours of warning time. Therefore, time is available to relocate equipment and stage necessary measures to support plant response to rising water levels.

In accordance with NEI 12-06 section 6.2.1, Susceptibility to External Flooding, Plant G.4.4 screens in for an assessment for external flood hazard.

The current Plant G.4.4 FLEX strategies utilize a combination of Phase 1 (RCIC) and Phase 2 (portable pumps and generators) to maintain core cooling, containment and spent fuel pool cooling functions. The OIP and six month updates do not specifically list the strategy for a flood condition. Plant G.4.4 will utilize the current a flood abnormality procedure, PGOA 0010-16 "Flood Emergency" procedure, for all flooding events FLEX DB, to address the MSFSHI and current design basis flood riverine flooding event, including flood induced ELAP and LUHS (FLEX) events. This procedure will be initiated upon forecast of increasing river level by the US National Weather ServiceBureau or actual river level of >582 feet. During the warning time of 96 hours, Plant G.4.4 will shutdown both reactors, cool to cold shutdown (mode 4), remove the containment head, disassemble the reactor and flood the cavities to provide cooling and make up to the reactors. This strategy does not maintain the containment function.
Mitigation Strategies Flooding Hazard Information (MSFHI) for the most limiting flood hazard:

- Probable Maximum Flood
  - Combined effects: cool season PMP, 100-year snowpack, upstream dam failure and the effects of coincident wind wave activity
  - Maximum still water elevation is 8 feet above site grade
  - Maximum water elevation is 10 feet above site grade
  - Duration ~ 10 days
  - Warning time: Initiated by a flood forecast by NWS or River Level is greater than 582'. PGOA 0010-16 "Flood Emergency" procedure Aactions are triggered is by actual river level is greater than 586' or predicted to exceed plant grade in less than 96 hours.

1.2.1.1.2.3.1.1.

Impacts of MSFHI:
The MSFHI has been used in the evaluation of FLEX strategies.

Storage:
The FLEX / Flood equipment will be stored in different locations. Plant G.4.4 will have two storage locations, one robust building that is not protected for flood and one commercial building that is above the flood levels. The flood pump [Darley Model HE20V pump] will be relocated prior to the flood waters reaching grade level. In the event of a flood, the FLEX equipment from the robust building will be relocated to the upper commercial building.

Commented [JWL1]: 19. Page 2, Last Paragraph: It was difficult to determine which flood hazard FLEX DB flood, MSFHI, or both) was being discussed in this paragraph. It would helpful to consistently, explicitly refer to MSFHI and FLEX DB flood. (see Comment 2)

Commented [JWL2]: 30. Page 2, Last Paragraph, Fourth Sentence: The sentence refers to the "US Weather Bureau." Should this have been a reference to the "National Weather Service"?

Commented [JWL3]: 20. Page 3, First Paragraph, Fifth Sub-Bullet: A reference that describe the actions being taken or a descriptions of the action being taken should be provided.

Commented [JWL4]: 17. Page 3, Section 1.3.1.1, Storage: It would be helpful if a statement or reference is provided at beginning of section or elsewhere that clearly indicated whether equipment being discussed (e.g., flood pump) is or is not part of FLEX, modified FLEX, AMS, or THMS. It is unclear whether the flood pump discussed in this section is an existing FLEX pump. If the pump being described is one of the pumps listed in Attachment 1 under "a detailed list of equipment necessary for the mitigating strategies" then it would be helpful if the description is consistent within the document.

Robustness of plant equipment:
No plant equipment will be required after flood water is at grade level. All plant equipment used for FLEX prior to being secured meets the requirements of robustness as defined in Appendix A.

Connection points:
There are no connections points for the flood strategy. Electrical power will be removed by plant personnel and water will be pumped to the open reactor cavity.

~~1.2.1.2.~~2.3.1.2. Conclusions

The current FLEX strategies were developed using the DB flood information per Plant G.4.4 UFSAR Section 3.4.1. The new MSFHI is slightly higher and therefore, the MSFHI is not bounded by the FLEX DB. The containment function will not be maintained and therefore a targeted mitigation strategy will be utilized.

The following summarizes all the applicable flooding hazards at Plant G.4.4 and the status of FLEX for each:

- LIP – FLEX works as designed
- Riverine – FLEX does not work as designed, the containments need to be open to implement the strategy.
- Combined effects (riverine plus dam failure) – FLEX does not work, THMS used as described in this document, the containment needs to be open to implement the strategy.

The current FLEX strategies were developed using the DB flood information per Plant G.4.4 UFSAR Section 3.4.1. The new MSFHI is slightly higher and therefore, the MSFHI is not bounded by the FLEX DB. The containment function will not be maintained and therefore a targeted mitigation strategy will be utilized. The river height of this flood will require the units to be shutdown and cooled down to < 212°F. This will also require opening the containment and flooding the reactors and reactor cavities to maintain cold shutdown. Because of not fully maintaining the containment function, a THMS is required.

~~1.2.2.~~2.3.2. NEI 12-06, Rev. 2, Section G.4.2 – Assessment for Modifying FLEX Strategies

Because of not fully maintaining the containment function, a THMS is required, therefore Section G4.2 is N/A.

~~1.2.3.~~2.3.3. NEI 12-06, Rev. 1a, Section G.4.3 and G.4.4 – Assessment of Alternative and Targeted Hazard Mitigating Strategies

Because of not fully maintaining the containment function, a THMS is required. Attachment 1, "Plant G.4.4 Flood THMS" addresses the following:

- The sequence of events for the flood hazard(s);
- The detailed description of the mitigating strategies;
- A detailed list of equipment necessary for the mitigating strategies;
- A description of how the provisions in Sections 3, 6, and 11 of NEI 12-06, Rev. 2 have been addressed;
- Description of validation items that will need to be performed based on the changes.
- Justification for not maintaining the containment capability.

Attachment 1
Plant G.4.4 Flood THMS

Sequence of events for the flood hazard:

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
1	- 96 hrs	Event Notification per ~~PGOA 0010-16~~ "Flood Emergency" procedure	N	Plant at 100% power "Flood Emergency" procedure is entered based on actual river level greater than 582' or predicted to exceed plant grade in less than 96 hours.
2	- 96 hrs	Call out additional staff.	N	OCC staffed and reactor services called in for reactor disassembly.
3	- 96 hrs	Monitor river level.	N	Establishes response action
4	- 96 hrs	Secure from dry cask operation if in progress	N	Only necessary if in progress.
5	- 94 hrs	Initiate Unit 1 and Unit 2 shutdown	N	Both Units will be shut down concurrently and decay heat removed using the normal procedures as specified for the RHR system
7	- 94 hrs	Place mobile Makeup Demineralizer System in operation	N	Provide additional water as required.
8	- 93 hrs	Start setup portable pump (Darley pump) for Cavity and SFP makeup	N	Follow "Flood Emergency" procedure~~PGOA 0010-16~~
9	- 87 hrs	Start removal of DW shield plugs	N	Per forced outage schedule
10	- 87 hrs	Both units achieve Mode 3	Y	Need to be in Mode 3 on both units for the pending Rx disassembly
11	- 85 hrs	Seal EDG Fuel Storage and plug IRSF pit lines	N	Prevent water entering diesel storage tank.
12	- 82 hrs	Mode 4, Cold Shutdown achieved on both units	Y	Need to be in Mode 4 to break primary containment and remove DW head.
13	- 82 hrs	Start water addition to Suppression Chambers through RHR system test lines per PGOP 4100-11	N	
14	- 78 hrs	Shield plugs removed	N	Need plugs removed to remove DW head
15	- 76 hrs	Darley pump setup complete	N	This needs to be established prior to cavity flood
16	- 72 hrs	Transfer FLEX equipment to higher elevations above predicted flood levels	N	Protect FLEX equipment

Attachment 1
Plant G.4.4 Flood THMS

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
17	- 72 hrs	Obtain DW samples	N	Preparation for DW head removal
18	- 72 hrs	Water addition to suppression chambers complete	N	
19	- 68 hrs	Set up to remove Unit 1and Unit 2 DW head	N	Once in Mode 4, Cold Shutdown, DW head can be removed.
20	- 65 hrs	DW head removal set up complete	N	Need to be ready to remove DW head once Mode 4 has been established
21	- 62 hrs	Unit 1 DW head removed and stored	N	Need the DW head removed to remove Rx vessel head
22	- 59 hrs	Unit 2 DW head removed and stored	N	Need the DW head removed to remove Rx vessel head
23	- 35 hrs	Unit 1 Rx vessel head removed and stored	Y	This allows the cavity to be filled to maintain cold shutdown
24	- 24 hrs	Unit 2 Rx vessel head removed and stored	Y	This allows the cavity to be filled to maintain cold shutdown
25	- 22 hrs	Unit 1and Unit 2 cavity filled	N	Allows for sufficient water above the core to maintain cold shutdown.
26	- 22 hrs	Darley pumps connected and alignment for reactor cavity make up.	N	"Flood Emergency" ~~PGOA 0010-16~~ procedure
27	- 1 hr	Open plant doors on ground elevation.	N	Equalize loading on buildings.
28	0 hrs	ELAP occurs due to flood Directed by ~~PGOA 0010-16~~"Flood Emergency" procedure	N	EDGs and SBO DGs not protected from flood water
29	~2 min	Operating crew enters applicable EOPs and abnormal procedures for LOOP.	N	~~QGA 100~~EOP RPV Control ~~PGOA 6100-03~~AOP Loss of Offsite Power
30	~5 mins	Start de-energize station loads prior to water going above grade level	N	Personnel safety
31	~5 mins	DC load shedding initiated per ~~PGOA 6100-03~~AOP Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power procedure	N	~~QOA 6900-07~~AOP Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power. Initiation of load shedding is not time critical – completion of load shedding is time critical.

Attachment 1
Plant G.4.4 Flood THMS

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
32	30 mins	DC load shedding completed	Y	AOP Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric PowerQOA 6900-07
33	30 mins	Complete de-energize station loads.	N	Personnel Safety
34	~60 mins	Control Room crew has assessed SBO and plant conditions and declares an Extended Loss of AC Power (ELAP) event.	N	This is not time critical. Plant G.4.4 will be in a flood condition prior to this declaration.
35	90 mins	FLEX DC load shed complete.	N	DC coping analysis assumes FLEX load shed is complete by 90 minutes.
36	24 hrs	Initial equipment from National SAFER Response Center becomes available.	N	Per NEI 12-06, Section 12 (NSRC).
37	24 -72 hrs	Continue to maintain critical functions of core cooling and SFP cooling. Utilize initial NSRC equipment in spare capacity.	N	Not time critical/sensitive since Phase 2 actions result in indefinite coping times for all safety functions.
38	10 days	Flood water subsides below grade level, start plant restoration.	N	Time based on recent MSFHI

A detailed description of the mitigating strategies:

Maintain Core Cooling:

The following actions will be initiated four days prior to the predicted arrival of a flood of elevation 594'6" or greater, with both Units being shut down and decay heat being removed using the normal procedures as specified for the RHR system. Flood stage levels on the Mississippi River are predicted several weeks in advance by the U.S. Army Corps of Engineers. In the highly unlikely event that a maximum probable flood is predicted, the plant will be shut down and cooled four days prior to the predicted time at which water will go above plant grade elevation of 594.5'. This will reduce decay heat from the reactor to a level which can be removed by natural circulation cooling between the reactor and the reactor cavities and fuel storage pools. (reference UFSAR Section 3.4.1, "Flood Protection").

Upon entry into PGOA 0010-16"Flood Emergency" procedure, Plant G.4.4 will call out additional personnel as necessary to shutdown both reactors and once shutdown and cooled down, disassemble the reactors. Unit shutdown will commence within the first two hours of

Commented [JWL5]: 22. Page 8, First Paragraph, Last Sentence: For key assertions, like the one in this sentence, please, include a reference that contains the basis for the statement or provide a summary description of the basis.

entry into the procedure. Operators will be briefed and start a normal unit shutdown per PGGP 3-1, Reactor Power Operations and PGGP 2-1, Normal Unit Shutdown. Both reactors will be shutdown in parallel.

A flood watch schedule will be established to monitor for rising river levels. Subsequent actions and decisions to continue with plant shutdown and disassemebly will be based on the river rate of rise and level. The deployment and access is not affected by the higher level because…. An onsite mobile makeup demineralizer system will be placed in operation to fill the CCSTs and provide additional water to flood the reactor cavity. FLEX equipment from the lower FLEX storage area will be transferred to the FLEX storage building near the upper parking lot which is an elevated site not susceptible to the river flood. Specific flood equipment as listed in the equipment section will be obtained and staged in preparation for maintaining the reactor cavity water level once the units are shutdown and the cavities flooded.

Commented [JWL6]: 23. Page 9, First Paragraph (partial), Second Sentence: Since the table was not complete in the example, it was not clear if the river flood level was bounded by the FLEX DB flood. If it was not bound, a discussion should be included of deployment and access consideration should be provided, even if it is a discussion that states with explanation that deployment and access is not affected by higher flood level.

Both units will enter mode 4 approximately 14 hours after entry into ~~PGOA-0010-16~~"Flood Emergency" procedure or hour -82 per the time line. At this time, Unit 1's containment head will be removed and stored. After removal of the Unit 1 containment head, the staff will commence removal of the Unit 2 containment head. Both containment heads will be removed at hour -59 per the time line. Once both containment heads are removed, setup and removal of both reactor heads will commence. Both reactor heads will be removed and stored at hour -24 per the time line. After both reactor heads are removed, the reactor cavities will be filled. Under this condition, no heat removal nor related electrical power supply systems are needed. The recirculation loops will be isolated to prevent leakage from the pump seals limiting the water loss from the reactors. Units will be maintained in cold shutdown (<212°F) via natural circulation. Water level will be maintained in the normal cavity filled level.

Additionally during the warning time period, other activities will occur. Both suppression chambers will be filled, the outdoor water storage tanks will be filled, sealing the EDG Fuel Storage tanks and plug drain lines in IRSF pit will be completed. The flood pumps (Darley pumps) will be connected and alignment for reactor cavity make up established. Since this is the same strategy as used for the design basis and FLEX flood response, no additional access provisions are required for the operators.

Commented [JWL7]: 24. Page 9, Third Paragraph (complete): Since this is a strategy that is different than the one reviewed under Order EA-12-049, additional detail should be provided such as special access provisions for the operators.

Ninety six (96) hours after procedure initiation, water level is predicted to reach grade level. At this time, plant doors will be opened to ensure pressure is equalized. Power will be removed by de-energization of station loads. This will be designated as "Time 0". The operating crew will enter the applicable EOPs and abnormal procedures for LOOP. DC load shedding will commence and declaration of an ELAP will be made. The ELAP is caused when the plant staff removes power to the site per procedure. Since this is a planned evolution, all preparations will be complete and plant staff will be staged at key locations to implement the actions. Once DC load shed is complete, the operating crew will continue to maintain the critical functions of core cooling and spent fuel pool cooling until flood waters subside and recovery can be entered.

Attachment 1
Plant G.4.4 Flood THMS

A detailed list of equipment necessary for the mitigating strategies:

- Portable Flood pump [Darley Model HE20V]
- Emergency Portable Pump 'A'
- Emergency Portable Pumps 'B'
- Emergency Portable Pumps 'C'
- Trash pumps in H building
- Two 10' sections of 4" suction hose with suction strainer
- Pump discharge hose, approximately 400 feet of 2 ½ inch fire hose for two pumps.
- Ten day supply of gasoline, 400 gallons of gasoline (approximately 40 gallons per day)
- Scaffolding
- FLEX Haul Vehicles
- Reactor and Containment disassembly equipment
  - Miscellaneous rigging equipment
  - Miscellaneous hand held tools
  - Reactor Stud De-Tensioners
  - Portable stairs

A description of how the provisions in Sections 3, 6, and 11 of NEI 12-06, Rev. 1a have been addressed:

- **Section 3 Establish Baseline Coping Capability**

  The general criteria and initial plant conditions were review during the development of the THMS. All applicable aspects of these sections have been incorporated into the THMS.
  Section 3.2.1.3 was reviewed and since this is a specific BDB event, flood, some of the initial conditions do not apply.

  3.2.1.3.1 "No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) at a plant site resulting from an external event that affects the off-site power system either throughout the grid or at the plant with no prospect for recovery of off-site power for an extended period. The LOOP is assumed to affect all units at a plant site." This is specific to a flood event. The LOOP will be caused when plant staff removes power from the site due to the flood conditions.
  3.2.1.3.2. "All design basis installed sources of emergency on-site ac power and SBO alternate ac power sources are assumed to be not available and not imminently recoverable. Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available." The plant staff will induce the loss of power based on flood levels. Once the flood waters subside, actions will be initiated to recover on-site ac power ~~will be recovered~~. During the warning period Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available. After the plant staff initiates the ELAP, DC Power and AC power from buses fed by station batteries through inverters is assumed lost and is not required for the THMS strategy. ~~The dc buses along with ac power from buses fed by station batteries will be available during the event~~.

Commented [JWL8]: 25. Page 10, Section 3.2.1.3.2, Fourth Sentence: For key assertions, like the one in this sentence, please, include a reference that contains the basis for the statement or provide a summary description of the basis. (see Comment 22)

Commented [JWL9]: 1.1.1.1.26. Page 10, Section 3.2.1.3.2, Last Sentence: Since the table was not complete in the example, it was not clear if the MSFHI flood parameters were bounded by the FLEX DB flood parameters. If it was not bound, a justification should be included , if any, on dc buses along with ac power, even if it is a discussion that states with explanation that is not affected by higher flood level. (see Comment 23)

3.2.1.3.5. "Fuel for FLEX equipment stored in structures with designs which are robust for the applicable hazard(s) remains available." The plant staff will continue to protect fuel stored in the EDG storage tanks, but due to the flood, this fuel will not be accessible until the flood water subsides.
3.2.1.3.8. "Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design." All of the electrical distribution systems will be considered normally available until just before flood waters reach plant grade elevation (EL 595). At that point, operations personal de-energizing station electrical loads including offsite power and onsite backup power (AC and DC)."Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design." Some of the electrical distribution systems will not be available (site to indicate those buses that will be inundated with flood water). All electrical distribution systems located above elevation will remain available.

Section 3.2.1.4, Reactor Transient – the units will be shut down and cooled down prior to the predicted arrival of a flood of elevation 594'6" or greater.
Section 3.2.1.5, Reactor Coolant Inventory Loss – the units will be shut down and cooled down prior to the predicted arrival of a flood of elevation 594'6" or greater. The coolant losses will be reduced as compared to the initial mitigating strategies assessment. The reactor recirculation pumps will be isolated which will isolate any leakage due to pump seal leakage. Loss due to evaporation is considered for make up to the reactor cavities.
Section 3.2.1.6, SFP Conditions – the units will be in a condition where the cavities and SFPs are connected. Make up to the SFPs will be via the Darley pump to the reactor cavities. All assumptions in this section for the SFP have been reviewed and apply to the development of the THMS.
Section 3.2.1.7, Event Response Actions – the response is based on the timeline established for the flood event. Additional plant staff will be available to complete all actions specified in the THMS. All principles in this section have been reviewed and are met by the THMS
Section 3.2.1.8, Effects of Loss of Ventilation – the loss of ventilation has been considered in the development of the FLEX strategies. These considerations will apply for the THMS. The conditions and timing under which ventilation will be lost are unchanged as compared to the original FLEX strategy.
Section 3.2.1.9 Personnel Accessibility – areas requiring personnel access have been evaluated. Plant staff will be able to access upper areas of the reactor and turbine buildings during the event. Boats will need to be utilized in some areas of the site for access. This will not impede any actions in the THMS. (Site, need to describe location of boats for access. Also need to indicate the number of boats available and list these in the equipment section earlier in this document. Consideration of strategy timing needs to be described.)
Section 3.2.1.10, Instrumentation and Controls – all instruments and controls will be available for use during the warning period. After the plant staff removes power from the

units, the only instruments required for mitigation will be SFP level. Readings can be obtained locally or via the SFPI.
Section 3.2.1.11, Containment Isolation Valves – all valves will be in the isolated position and do not require operation during the event.
Section 3.2.1.12, Qualification of Plant Equipment – prior to the flood water reaching plant grade, all plant equipment required for the THMS is qualified to current plant design. After the flood reaches grade and the staff removes power from the units, only portable equipment will be required.
Section 3.2.1.13, FLEX Analyses, Methodologies and Generic Topics – this section has been reviewed and applicable topics are incorporated in the development of the THMS.
Section 3.2.2, Minimum Baseline Capabilities
Phase 1 will be during the warning period. Plant equipment used to shut down and cool down the plant will be used. In addition to this equipment, refueling equipment will be used to disassemble the reactors and flood the reactor cavities.
Phase 2 equipment consists of a portable make up pump, Darley pump, to supply make up water to the reactor cavities. Small generators will be available for use if required. The THMS does not require the use of portable generators during the event.
Phase 3 equipment from off site will be available and used for spares if required. An off-site staging area has been established for Phase 3 equipment. If required, the Phase 3 equipment can be transferred from the staging area to the plant using helicopters, boats or a combination of these means.
All aspects of section 3.2.2 were considered in the development of the site FLEX FSGs. The THMS will also incorporate the guidelines needed to support the development of other FSGs for a flood event. FSGs that will be used during the flood; control room vent/habitability, lighting, plant area ventilation, and deployment of spare equipment.

Commented [JWL10]: 27. Page 11, Section 3.2.2, Ninth Sentence: A discussion on how Phase 3 equipment will be transported from the staging area to the site should be provided.

- **Section 6 Assess External Flooding Impact**

6.1 and 6.2: Section 6.1 of NEI 12-06 is information for the utility and has been reviewed. Section 6.2 review follows:
Plant G.4.4 is a not a dry site. Per section 6.2.2, characterization of the Applicable Flood Hazard was performed. This analysis is in section 1.1 of this submittal.

6.2.3.1 Protection of FLEX Equipment:

Plant G.4.4 will meet the following section for protection:
"6.2.3.2.1.1.c FLEX equipment can be stored below flood level if time is available and plant procedures/guidance address the needed actions to relocate the equipment. Based on the timing of the limiting flood scenario(s), the FLEX equipment can be relocated to a position that is protected from the flood, either by barriers or by elevation, prior to the arrival of the potentially damaging flood levels. This should also consider the conditions on-site during the increasing flood levels and whether movement of the FLEX equipment will be possible before potential inundation occurs, not just the ultimate flood height."

Plant G.4.4 will have two storage locations, one robust building that is not protected for flood and one commercial building that is above the flood levels. In the event of a flood, the FLEX equipment from the robust building will be relocated to the upper commercial building. Equipment required to implement the THMS will be relocated to the area of deployment, which is above the predicted flood levels. In the event the flood levels are above the predicted levels, the flood pump and related equipment can be moved to a higher location. Equipment is available to support the operation of the flood pump at a higher location.

Commented [JWL11]: 28. Page 12, Section 6.2.3.1, Last Sentence and Page 13, third Paragraph, Only Sentence: If statement is included that equipment is being moved to higher location or more time , a discussion should be provided whether additional equipment (e.g., additional hose) is needed or will be staged.

6.2.3.2 Deployment of FLEX Equipment:

The equipment necessary for the strategy will be deployed prior to the flood waters reaching grade elevation. All of the necessary support equipment will also be staged prior to the predicted arrival of a flood of elevation 594'6" or greater. Per section 6.2.3.2.:
"1. For external floods with warning time, the plant may not be at power. In fact, the plant may have been shut down for a considerable time and the plant configuration could be established to optimize FLEX deployment. For example, the FLEX pump could be connected, tested, and readied for use prior to the arrival of the critical flood level. Further, protective actions can be taken to reduce the potential for flooding impacts, including cooldown, borating the RCS, isolating accumulators, isolating RCP seal leak off, obtaining dewatering pumps, creating temporary flood barriers, etc. These factors can be credited in considering how the baseline capability is deployed."

Plant G.4.4 units 1 and 2 will be shut down and cooled down to less than 212° F for at least 3 days prior to the predicted arrival of a flood of elevation 594'6" or greater. The ~~FLEX~~ Flood pump (Darley pump) will have been set up and readied for use.

"2. The ability to move equipment and restock supplies may be hampered during a flood, especially a flood with long persistence. Accommodations along these lines may be necessary to support successful long-term FLEX deployment."

Supplies for a duration of 10 days will be staged and available for use.

"3. Depending on plant layout, the ultimate heat sink may be one of the first functions affected by a flooding condition. Consequently, the deployment of the FLEX equipment should address the effects of LUHS, as well as ELAP."

Plant G.4.4 THMS will not require the use of the UHS equipment. The ELAP will be self-induced prior to the predicted arrival of a flood of elevation 594'6" or greater. Any power needs will be established prior to the ELAP.

"4. FLEX equipment will require fuel that would normally be obtained from fuel oil storage tanks that could be inundated by the flood or above ground tanks that could be damaged by the flood. Steps should be considered to protect or provide alternate sources of fuel oil for flood conditions. Potential flooding impacts on access and egress should also be considered."

The below ground fuel tanks will be protected prior to the predicted arrival of a flood of elevation 594'6" or greater. Fuel for the Darley pump for a 10 day duration will be staged near the pump.

"5. Connection points for FLEX equipment should be reviewed to ensure that they remain viable for the flooded condition."

The discharge of the Darley pumps will be directly into the reactor cavity. There are no connections required for the THMS. All fuel pool gates will be open and the reactor cavities connected to the fuel pool. This allows for discharging the output from the Darley pump into the fuel pool to maintain level in both reactor cavities.

"6. For plants that are limited by storm-driven flooding, such as Probable Maximum Surge or Probable Maximum Hurricane (PMH), expected storm conditions should be considered in evaluating the adequacy of the baseline deployment strategies."

This does not apply to Plant G.4.4.

"7. Since installed sump pumps will not be available for dewatering due to the ELAP, plants should consider the need to provide water extraction pumps capable of operating in an ELAP and hoses for rejecting accumulated water for structures required for deployment of FLEX strategies."

Water extraction will only be required once the flood waters subside. There will be small trash pumps and the FLEX pumps available for dewatering areas of the plant.

"8. Plants relying on temporary flood barriers should assure that the storage location for barriers and related material provides reasonable assurance that the barriers could be deployed to provide the required protection."

Plant G.4.4 does not rely on temporary flood barriers for the THMS.

"9. A means to move FLEX equipment should be provided that is also reasonably protected from the event."

The Darley pump is a small pump that can be moved by operators. This pump does not need a separate vehicle to transport the pump.

6.2.3.3 Procedural Interfaces

Plant G.4.4 has developed a procedure for flood, ~~PGOA-0010-16,~~" Flood Emergency" ~~P~~procedure. This procedure incorporates all necessary actions for the THMS.

6.2.3.4 Considerations in Utilizing Off-site Resources

Attachment 1
Plant G.4.4 Flood THMS

Plant G.4.4 will have a staging area designated for any off-site resources. This staging area is above the flood levels. Site access will be limited and the use of boats will be required to access various areas of the plant. Any additional pumps required for the THMS will be small and can be transported via boat to the location needed.

- **Section 11 Programmatic Controls**

  11.1, Quality Attributes – the Darley is a commercially available pump. This pump was procured for use during floods.
  11.2 Equipment Design – the Darley pump design basis has been reviewed. The pump will meet all performance requirements for the THMS. The pump curve is available for reference as an attachment in ~~PGOA 0010-16~~"Flood Emergency" procedure. All design factors in section 11.2 have been considered.
  11.3 Equipment Storage – the Darley pump will be stored in the Protected Area Warehouse. The pump will be relocated prior to the predicted arrival of a flood of elevation 594'6" or greater.
  11.4 Procedure Guidelines – all procedures developed for the THMS meet the guidelines specified in this section.
  11.5 Maintenance and Testing – PMs have been established the Darley pump. These PMs fully meet the ~~Exelon~~ Utility PM program requirements. The ~~Exelon~~ Utility program was developed using EPRI guidance. For unavailability, the Darley will be added to the FLEX unavailability program and subject to the same unavailability controls as FLEX equipment.

  Commented [JWL12]: 29. Page 14, Section 11.5, Last Sentence and Page 15, Section 11.8: Consider being more explicit regarding equipment that may be added to FLEX unavailability program. An explicit statement should be included whether the equipment will have the same unavailability controls as the FLEX equipment.

  11.6 Training – Operators and plant staff have been trained on ~~PGOA 0010-16,~~" Flood Emergency" ~~P~~procedure. This is included in the Operator training program for periodic training per the training plan.
  11.7 Staffing – additional staff will be called out prior to the event. The plant will be fully staffed to perform all tasks necessary to shut down and disassemble the units to the predicted arrival of a flood of elevation 594'6" or greater.
  11.8 – Configuration Control – the THMS will be included in the FLEX program and subject to the same unavailability controls as FLEX equipment.

  Commented [JWL13]: 29. Page 14, Section 11.5, Last Sentence and Page 15, Section 11.8: Consider being more explicit regarding equipment that may be added to FLEX unavailability program. An explicit statement should be included whether the equipment will have the same unavailability controls as the FLEX equipment.

Validation items that will need to be performed:

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
10	- 87 hrs	Both units achieve Mode 3	Y	This will be validated using past refuel outage performance data.
12	- 82 hrs	Mode 4, Cold Shutdown achieved on both units	Y	This will be validated using past refuel outage performance data.
23	- 35 hrs	Unit 1 Rx vessel head removed and stored	Y	This will be validated using past refuel outage performance data.
24	- 24 hrs	Unit 2 Rx vessel head removed and stored	Y	This will be validated using past refuel outage performance data.

Attachment 1
Plant G.4.4 Flood THMS

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
32	30 mins	DC load shedding completed	Y	DC load shedding has been validated for FLEX strategies. There are no new actions or environmental factors apply for this load shed, therefore, re-validation of this action is not required.

Justification for not maintaining the containment capability:

The function of the primary containment is to isolate and contain fission products released from the Reactor Primary System following a design basis Loss of Coolant Accident (LOCA) and to confine the postulated release of radioactive material. The primary containment consists of a drywell, which is a steel pressure vessel, enclosed in reinforced concrete, and a suppression chamber, which is a steel torus-shaped pressure vessel, connected by vent pipes. The primary containment surrounds the Reactor Primary System and provides an essentially leak tight barrier against an uncontrolled release of radioactive material to the environment.

The safety design basis for the primary containment is that it must withstand the pressures and temperatures of the limiting DBA without exceeding the design leakage rate. The DBA that postulates the maximum release of radioactive material within primary containment is a LOCA. In the analysis of this accident, it is assumed that primary containment is OPERABLE such that release of fission products to the environment is controlled by the rate of primary containment leakage.

In MODES 1, 2, and 3, a DBA could cause a release of radioactive material to primary containment. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations of these MODES. Therefore, primary containment is not required to be OPERABLE in MODES 4 and 5 to prevent leakage of radioactive material from primary containment.

In this configuration, there will be 490,000 gallons of water above each reactor core. The reactor recirculation system will be isolated preventing inventory loss due to normal pump seal leakage. The loss due to evaporation 4 days after shutdown will be approximately 50 gallons per minute per reactor. The reactors will be able to be maintained in cold shutdown for the duration of the event via natural circulation.

The THMS for Plant G.4.4 will require both units to be shut down and cooled down prior to the predicted arrival of a flood of elevation 594’6” or greater. Both units will be in Mode 4 prior to the removal of the containment heads.