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

June 1, 2018

Mr. John Dent, Jr.
Vice President-Nuclear and CNO
Nebraska Public Power District
Cooper Nuclear Station
72676 648A Avenue
P.O. Box 98
Brownville, NE 68321

SUBJECT: COOPER NUCLEAR STATION – STAFF ASSESSMENT OF THE RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM RE-EVALUATION (CAC NO. MF4712; EPID L-2014-JLD-0057)

Dear Mr. Dent:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information under Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated September 30, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16279A426), Nebraska Public Power District (NPPD, the licensee) responded with a revised response to this request for Cooper Nuclear Station (Cooper). This replaced in its entirety the response submitted on February 3, 2015 (ADAMS Accession No. ML15041A523).

By letter dated May 6, 2015 (ADAMS Accession No. ML15125A060), the NRC notified NPPD of the staff's plan to perform a regulatory audit of Cooper's supporting calculations of the Flood Hazard Reevaluation Report. The technical audit was performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195). A summary of the regulatory audit was issued by letter dated December 4, 2017 (ADAMS Accession No. ML17310A290).

By letter dated December 22, 2015 (ADAMS Accession No. ML15355A416), the NRC staff sent the licensee a summary of the staff's review of the licensee's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the December 22, 2015, letter.

Enclosure 1 transmitted herewith contains Security-Related Information and Critical Electric Infrastructure Information (CEII). When separated from Enclosure 1, this document is decontrolled.

As stated in the letter, the reevaluated flood hazard results for the following mechanisms were not bounded by the Cooper current design basis (CDB) flood hazard: local intense precipitation, streams and rivers, failure of dams and onsite water control/storage structures, ice-induced flooding, and channel migration/diversion.

The NRC staff notes that for the flood-causing mechanisms that are not bounded by the CDB, the licensee also submitted a revised mitigation strategies assessment (MSA) dated December 12, 2017 (ADAMS Accession No. ML17355A110), which has been reviewed by the NRC staff and the results were documented separate from this assessment (ADAMS Accession No. ML18040A653).

In addition, NPPD is expected to submit an integrated assessment consistent with the process described by NRC letter dated September 1, 2015, "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML15174A257). The NRC staff will provide its assessment of the Cooper integrated assessment in a separate letter.

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

Sincerely,

Juan F. Uribe, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosures:
1. Staff Assessment of Flood Hazard Reevaluation Report (non-public)
2. Staff Assessment of Flood Hazard Reevaluation Report (public)

Docket No. 50-298

cc w/encl 2: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

COOPER NUCLEAR STATION

DOCKET NO. 50-298

1.0 INTRODUCTION

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

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating the Flood Hazard Reevaluation Report (FHRR) deadlines for each plant. On May 11, 2012, the NRC staff issued its prioritization of the FHRRs (NRC, 2012c).

By letter dated February 3, 2015 (NPPD, 2015a), Nebraska Public Power District (NPPD, the licensee) provided the FHRR for Cooper Nuclear Station (Cooper). This FHRR was revised by letter dated September 29, 2016 (NPPD, 2016). The NRC staff conducted a site audit, which was documented in a separate audit report (NRC, 2017a).

On December 22, 2015 (NRC, 2015b), the NRC issued an interim staff response (ISR) letter to the licensee. The purpose of the ISR letter is to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012c) and the additional assessments associated with NTTF Recommendation 2.1-Flooding. The ISR letter also made reference to this staff assessment, which documents NRC staff's basis and conclusions. The flood hazard mechanism values presented in the letter's enclosures were based on FHRR, Revision 0 (NPPD, 2015a) and identified information to be provided in FHRR, Revision 1 (NPPD, 2016). Therefore, the values provided in this staff assessment may differ from those in the ISR letter's enclosure as they reflect the information provided in FHRR, Revision 1 (NPPD, 2016), which was submitted following the issuance of the ISR (NRC, 2015b).

As mentioned in the ISR letter, the reevaluated flood hazard results for the local intense precipitation (LIP), streams and rivers, failure of dams, ice-induced flooding, and channel migration/diversion flood-causing mechanisms are not bounded by the plant's current design basis (CDB) hazard. Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 (NRC, 2015a), Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2016b), the NRC staff anticipates that for LIP, the licensee will perform and document a focused evaluation to assess the impact of the LIP hazard on the site and evaluate and implement any necessary programmatic, procedural or plant modifications to address this hazard exceedance. Additionally, for the streams and rivers, dam failure, ice-induced flooding, and channel migration/diversion flood-causing mechanisms, the NRC staff anticipates that the licensee will submit (a) a revised integrated assessment or (b) a focused evaluation confirming the capability of existing flood protection or implementing new flood protection consistent with the process outlined in COMSECY-15-0019 (NRC, 2015a) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

Additionally, for any reevaluated flood hazards that are not bounded by the plant's CDB hazard, the licensee was expected to develop any flood event duration (FED) and associated effects (AE) parameters currently not provided in the FHRR to conduct the mitigating strategies assessment (MSA) and focused evaluations or revised integrated assessments. By letter dated April 27, 2017, the licensee submitted its MSA which provided the AE and FED parameters (NPPD, 2017). The MSA is being reviewed by the NRC staff and the results will be documented separate from this assessment.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section of the staff assessment describes present-day regulatory requirements that are applicable to the FHRR.

Sections 50.34 (a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4) of 10 CFR, describe the required content of the preliminary and final safety analysis reports, including a discussion of the plant site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the final safety analysis report.

General Design Criterion 2 in Appendix A of 10 CFR Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without the loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines "design bases" as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design, which each licensee is required to develop and maintain. These values may be: (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (b) requirements derived from an analysis (based on calculation, experiments, or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for site applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21 (d)).

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter requested, in part, that licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews. By letter dated February 3, 2015 (NPPD, 2015a), NPPD provided the 50.54(f) response letter (the FHRR) for Cooper. This FHRR was revised by letter dated September 29, 2016 (NPPD, 2016).

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Enclosure 2 of the 50.54(f) letter discusses the flood-causing mechanisms for the licensee to address in the FHRR (NRC, 2012a). Table 2.2-1 lists the flood-causing mechanisms that the licensee should consider, and the corresponding Standard Review Plan (SRP) (NRC, 2007) section(s) and applicable ISG documents containing acceptance criteria and review procedures.

2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. Guidance document JLD-ISG-2012-05 (NRC, 2012d), defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- Wind waves and runup effects
- Hydrodynamic loading, including debris
- Effects caused by sediment deposition and erosion
- Concurrent site conditions, including adverse weather conditions
- Groundwater ingress
- Other pertinent factors

2.2.3 Combined Effects Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a "combined effects flood." It should also be noted that for the purposes of this staff assessment, the terms "combined effects" and "combined events" are synonymous. Even if some or all of the individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, Areas of Review (NRC, 2007)). Attachment 1 of the 50.54(f) letter describes the "combined effect flood" as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992) as follows:

> For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined (per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992), then the NRC staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding are plausible combined events and should be considered.

2.2.4 Flood Event Duration

Flood event duration was defined in JLD-ISG-2012-05 (NRC, 2012d), as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 illustrates flood event duration.

2.2.5 Actions Following the Flood Hazard Reevaluation Report

For the sites where the reevaluated flood hazard is not bounded by the CDB flood hazard elevation for any of the flood-causing mechanisms, the 50.54(f) letter (NRC, 2012a) requests licensees and construction permit holders to:

- Submit an interim action plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard; and
- Perform an integrated assessment to: (a) evaluate the effectiveness of the CDB (i.e. flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration.

If the reevaluated flood hazard is bounded by the CDB flood hazard for all flood-causing mechanisms at the site, licensees are not required to perform an integrated assessment. COMSECY-15-0019 (NRC, 2015a) outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with LIP hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation. As part of the focused evaluation, licensees will assess the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural or plant modifications to address this hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either a focused evaluation or a revised integrated assessment (NRC, 2015a and NRC, 2016b).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of the Cooper site. The licensee conducted the flood hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

While performing its review, the NRC staff identified the need to clarify and expand upon the information provided in the FHRR in order to complete its evaluation. As a result, the NRC informed the licensee of the staff's plan to conduct a regulatory audit of the licensee's FHRR submittal by letter dated May 6, 2015 (NRC, 2015a). During the audit, the NRC transmitted multiple information needs to the licensee to which the licensee responded via conference calls, and by making available calculation packages to the NRC staff via an electronic reading room (ERR). As part of the audit, the NRC staff also requested and received electronic copies of the requested input/output files to review and understand how modeling assumptions were programmed and executed. The specific information needs (technical topics and resolutions) that were discussed and clarified during the audit are summarized in the NRC Audit Summary Report (NRC, 2017a) and discussed in the appropriate sections below.

The NRC staff notes that it did not rely directly on these calculation packages in its review; and that the information reviewed during the audit was found only to expand upon and clarify the information already provided in the Cooper FHRRs, and so are not docketed or cited. For the instances in which information was revised or updated, the licensee submitted several addenda and revisions to the FHRR which are docketed and referenced in this staff assessment.

3.1 Site Information

The 50.54(f) letter includes the SSCs important to safety in the scope of the hazard reevaluation. The licensee included pertinent data concerning these SSCs in the FHRR (NPPD, 2015a). Based on NRC staff's review of the FHRR, the NRC staff sought additional clarifying information. The licensee provided this clarifying information during the audit. This information is summarized in the NRC staff's audit report (NRC, 2017a). Enclosure 2 (Recommendation 2.1: Flooding), "Requested Information, Hazard Reevaluation Report," Item a, describes site information to be contained in the FHRR. The NRC staff reviewed and summarized this information as follows.

3.1.1 Detailed Site Information

The FHRR (NPPD, 2015a) described the site-specific information related to the flood hazard evaluation. The Cooper site is located on the west bank of the Missouri River between the villages of Brownville and Nemaha, Nebraska, approximately 100 miles (mi) north-northwest of Kansas City, Kansas and 55 mi south-southeast of Omaha, Nebraska. At approximately 2,619 mi in length, the Missouri River is the longest river in the United States draining an area of approximately 529,000 square miles (mi^2). [[redacted].]]

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In this assessment, the majority of elevations and flood depths are given relative to either the MSL (also referred to as Plant Datum) or the North American Vertical Datum of 1988 (NAVD88). In summary, NAVD88 is equal to Plant Datum elevation plus 0.37 ft. Conversely, MSL levels correspond to NAVD88 elevations minus 0.37 ft. When other Datums are used, they are specified accordingly.

[[redacted].]]

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The licensee describes in the FHRR the natural topography of the site, which is relatively flat with only a few feet of relief. However, natural bluffs are present to the west of the site, approximately 1 mi from the Missouri River. [[redacted].]]

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3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-2. The licensee described the CDB with respect to both flow rate and flood elevation. The licensee discussed a study by the [[redacted].]] The licensee stated that the probable maximum precipitation (PMP) for the Cooper site area is 23.5 inches in a 24-hour period. The licensee noted that storm surge, seiche and tsunami were not discussed in

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the CLB, but stated that these three flooding mechanisms can be screened out for the Cooper site. The CLB does not quantify ice-induced flooding and considered channel migration not credible at the Cooper site. The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.3 Flood-Related Changes to the Licensing Basis

The licensee stated that there have been no significant changes to the licensing basis with respect to flooding or flood protection. However, the licensee noted that procedures have been enhanced and the implementation of protective actions has changed since licensing with engineered flood barriers replacing the original sandbag barriers (NPPD, 2015a). The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.4 Changes to the Watershed and Local Area

The licensee stated in the FHRR that the Missouri River was wider and further east at the time the Cooper site was licensed. The licensee also noted that changes in land use and land cover were included in the FHRR analysis performed. Finally, the licensee noted that the addition of the vehicle barrier system at the Cooper site was incorporated in the LIP analysis, as discussed in Section 3.2 of this staff assessment. The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

(CEII) The licensee stated that the Class I structures at the Cooper site were designed for a hydraulic load equivalent to a [[redacted].]] The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.6 Additional Review Details to Assess the Flood Hazard

The licensee provided additional information and references to the NRC staff during the audit, as previously discussed in Section 3.0 of this staff assessment. The information audited is documented in the corresponding audit report (NRC, 2017a).

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Other parts of the 50.54(f) letter asked the licensee to report any relevant information from the results of the plant walkdown activities.

By letter dated November 27, 2012 (NPPD, 2012), as supplemented by letters dated November 21, 2013 (NPPD, 2013), January 31, 2014 (NPPD, 2014a), and December 10, 2014 (NPPD, 2014b), NPPD submitted the Flooding Walkdown Report for the Cooper site. On June 24, 2014 (NRC, 2014a), the NRC staff issued its assessment of the Walkdown Report, which documented its review of that licensee action and concluded that the licensee's implementation of the flooding walkdown methodology met the intent of the 50.54(f) letter.

3.2 Local Intense Precipitation

The licensee reported in its FHRR that the reevaluated flood hazard for LIP and associated site drainage is based on a stillwater-surface elevation of 903.9 ft. MSL. This flood-causing mechanism is not discussed in the CDB.

3.2.1 Probable Maximum Precipitation Depths

In the FHRR, Section 2.1.1 describes the LIP PMP depths determined for the Cooper site. The licensee stated that the precipitation used in the analysis is the 1-hour (h), 1-mi^2 PMP at the Cooper site derived from the National Ocean and Atmospheric Administration (NOAA) National Weather Service (NWS) Hydrometeorological Report (HMR) 51 (NOAA, 1978) and HMR 52 (NOAA, 1982). In the FHRR, Table 2.1-1 summarizes the PMP depths and intensities for various durations.

3.2.2 Drainage Areas and Local Drainage Parameters

The licensee noted that the Cooper site is relatively flat without well-defined flow paths, although drainage does flow away from the Central Building Complex in all directions. Openings between jersey barriers and Kontek concrete block barriers were not considered flow paths for the LIP analysis. Figure 3.2-1 shows the four drainage areas, Zones A, B, C and D, considered in the analysis. The licensee noted that Zone A is on the eastern side of the Cooper site and drains to the eastern boundary of the site into the Missouri River, while Zone B on the northern part of the site drains to the east side of the northern boundary overtopping security barriers. Zone C is on the south side of the main plant area and drains over the southern edge of the site near the discharge canal to the Missouri River, and Zone D to the western side of the site drains to the south after ponding in the west due to installed security barriers with some additional runoff flow into Zones B and C.

3.2.3 Peak Discharges

The licensee used the Kerby Equation (Gupta, 2001) to estimate the time of concentration for each zone in order to determine the peak runoff. The licensee stated that the surface in the main plant area is mostly gravel and concrete or asphalt-paved, and therefore assumed a Manning's roughness coefficient of 0.02. Using the estimated times of concentration and the corresponding PMP values, the licensee estimated the applicable PMP intensity. The licensee used the rational method and a conservative runoff factor of 1.0 to estimate peak runoff for each zone.

3.2.4 Hydraulic Model Setup

The licensee performed Hydrologic Engineering Center-River Analysis System (HEC-RAS) runs for each zone and characterized site features and flow obstructions in cross-sections used in the analysis. The licensee conservatively estimated the Manning's roughness coefficient of 0.030 to account for both the gravel and asphalt-paved site conditions, as well as minor obstructions. The licensee considered the critical depth as the downstream boundary condition for all Zones; for Zone B this accounts for flow over security barriers assumed to be acting as a weir while for the remaining zones this accounts for flow transition from the flat main plant area, over the boundary and down a steep slope. [[redacted].]] The licensee modeled onsite temporary trailers as complete obstructions and determined they have a negligible effect on the PMP water levels.

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The licensee computed the maximum water levels in each zone with and without cross flows between zones. Zone D had the highest water elevation without considering cross flows. However, when cross flows were considered, Zones B, C, and D had nearly equal maximum water levels. The licensee also considered maximum velocity in each zone using HEC-RAS under subcritical flow conditions. The results indicated that supercritical flow conditions are possible in Zones B and D. Although both zones have potential for site erosion due to the supercritical flows, the licensee concluded the supercritical flows would not affect any safety-related facilities at the Cooper site.

3.2.5 Effect of Local Intense Precipitation

The licensee reported that the maximum estimated water level due to LIP is 903.9 ft. NAVD88, which is equal to the finished flood elevation. Because of the shallow depth and short duration, the licensee did not consider the effect of wind waves in its LIP analysis. Additionally, the licensee did not consider debris loading or transportation due to the lack of debris sources in the main plant area at the Cooper site.

3.2.6 Nuclear Regulatory Commission Staff Assessment

The NRC staff reviewed the HEC-RAS model inputs used by the licensee, such as the precipitation timing and amounts found in HMRs 51 and 52.

The NRC staff also examined how the licensee modeled the site subbasins using zones based on the local topography in the immediate vicinity of the plant. The NRC staff also verified various aspects of the licensee's HEC-RAS model such as cross section geometries and hydraulic parameters such as Manning roughness coefficients. The NRC staff also performed confirmatory model runs using the licensee's input files.

3.2.7 Conclusion

The NRC staff confirmed the licensee's conclusion that the flood hazard from LIP and associated site drainage is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for LIP and associated site drainage for the Cooper site.

3.3 Streams and Rivers

The licensee reported in its FHRR that the reevaluated flood hazard for streams and rivers is based on a maximum water level of 904.1 ft. NAVD88 for the other SSCs and 908.4 ft. NAVD88 for the intake structure at the Cooper site (NPPD, 2016).

This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for streams and rivers is based on a maximum water level of 905.4 ft. NAVD88 for other SSCs and 909.6 ft. NAVD88 for the intake structure. The licensee noted that assessing the hydrologic conditions in the Missouri River at the Cooper site in order to determine the PMF is complex due to the large size of the Missouri River watershed. [[redacted]]

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3.3.1 Probable Maximum Precipitation

The licensee estimated the PMP for the Platte River Basin and adjoining reaches of the Missouri River, notably two Lower Basins (Fort Calhoun and Cooper). The licensee delineated the basins by defining watershed boundaries and the aerial extent of surface water drainage to the Cooper site. Figure 2.2-3 in the FHRR shows the delineated basin outline.

The licensee considered three PMP alternatives selecting the most conservative alternative for further analysis. The selected alternative is the mean monthly (base) flow, median soil moisture, antecedent or subsequent rain (the lesser of rainfall equal to 40 percent of the PMP and a 500-year rainfall), PMP, and waves induced by the 2-year wind speed applied along the critical direction. The licensee used NOAA Atlas 14 (NOAA, 1982) to obtain the 500-year, 72-h rainfall value, which when applying the 40 percent PMP results in about half the rainfall volume of the 500-year, 72-h storm. This event would precede the PMP event by three days, which the licensee noted is both meteorologically reasonable and consistent with ANSI/ANS-2.8-1992.

The licensee used NOAA's NWS HMRs 51 and 52 (NOAA, 1978 and 1982) to determine the PMP storm depth, spatial distribution, centering, and orientation pattern for the 72-h storm period. [[redacted]] The licensee used HMR 51 (NOAA, 1978) to obtain the all-season precipitation values at all four storm centers for basins ranging from 10 to 20,000 mi^2 for the 6-, 12-, 24-, 48-, and 72-h durations. The licensee selected basin sizes of 20,000-, 15,000-, 10,000-, and 6,500-mi^2 to develop the envelopment curves while also generating the maximum precipitation volume. The 20,000-mi^2 basin yielded the highest precipitation volume for all but the fourth center in which the 15,000-mi^2 basin had the highest precipitation volume. Finally, the licensee distributed the

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storm-area-averaged PMP over the drainage basin and developed precipitation depths for each storm area and 6-h temporal distribution period.

3.3.2 Probable Maximum Precipitation Runoff Hydrographs

The licensee used the HEC – Hydrologic Modeling System (HMS) hydrologic model for the Missouri River between [[redacted].]] To validate the HEC-HMS model, the licensee computed the Nash-Sutcliffe efficiency (NSE) model coefficient, which assesses the predictive power of a model's ability to reproduce observed data. The licensee also determined the Pearson correlation coefficient (r), which measures the linear relationship between the measured and computed discharge. The models are considered validated when the NSE coefficient was greater than 0 and/or the r coefficient was greater than 0.7. Based on the validation, the licensee concluded that the computed hydrographs are a good fit to measured values with respect to peak discharge, volume and timing, particularly given the magnitude of the historic storm used and the size and coarseness of the model.

[redacted]

In addition to the antecedent storm with the PMP, the licensee also considered the PMP and a subsequent storm. In the FHRR, Figures 2.2-5 and 2.2-6 present the four PMF positions with 40 percent antecedent storm and hydrographs with 40 percent subsequent PMP. The licensee concluded that the 40 percent PMP followed by 3 days of no precipitation, and then the PMP resulted in the highest peak flow at the Cooper site.

3.3.3 Water Level Determinations

To simulate the water level resulting from the combined PMF event, the licensee used a modified HEC-RAS (USACE, 2010b) model previously developed and calibrated by the USACE, converted to a steady-state model and calibrated to the 100-year flood event by the Federal Emergency Management Agency (FEMA) (NPPD, 2016). The NRC staff considers the licensee's use of a previously developed FEMA HEC-RAS model with modifications to be appropriate.

(~~CEII~~) The one-dimensional (1-D) HEC-RAS model covers a [[redacted].]] An unsteady HEC-RAS model simulation was used to predict PMP hydrograph translation and attenuation, with the results used as input to a reach-scale two-dimensional (2-D) TUFLOW FV hydraulic model of approximately 46 mi in length. The TUFLOW FV model was used to predict the complicated interaction between the river channel and overbank areas in order to estimate flow distributions near the Cooper site, and to predict WSELs and velocities at the Cooper site resulting from the combined PMF event (NPPD, 2016). The NRC staff considers the licensee's use of the HEC-RAS hydraulic model and subsequent refinement using a TUFLOW FV hydraulic model to be appropriate.

The unsteady HEC-RAS model was developed by validating the model input and gage data from the historic 2011 flood event and making model parameter changes as needed to replicate observed discharges, stages, and timing. Each PMF flow scenario was evaluated using the HEC-RAS model and used to establish inflow discharge hydrographs at River Mile (RM) 556.2 and outflow rating curve(s) at RM 510.0 for use as TUFLOW FV model boundary conditions. The model generated an upstream inflow hydrograph, upstream flow distribution, and downstream stage hydrograph for use in the TUFLOW FV model (NPPD, 2016). The upstream location at RM 556.2 was selected since it is sufficiently upstream of the Cooper site, a tie-back levee, and a major confluence. The downstream location at RM 510.0 was selected since it is approximately 5 mi downstream of Federal levee alignments and is in a relatively straight river reach 20 mi downstream of the Cooper site (NPPD, 2016).

(~~CEII~~) In developing the unsteady HEC-RAS model, the licensee made several assumptions. With approximately [[redacted].]] The NRC staff considers the licensee's HEC-RAS hydraulic model application and use of simulation output as input to a TUFLOW FV hydraulic model to be appropriate.

To test model sensitivity of the TUFLOW FV model upstream and downstream boundary locations, the licensee varied the Manning's roughness coefficients within 20 percent. The resulting analysis revealed insignificant sensitivity of PMF timing and magnitude at the 2-D model upstream boundary location when changing the Manning's roughness coefficient. However, the licensee found the PMF timing and magnitude at the TUFLOW FV model downstream boundary condition to be sensitive to the selected Manning's roughness coefficient, thus highlighting the importance of Manning's roughness coefficient selection (NPPD, 2016).

(~~CEII~~) Stage and discharge measurements taken during the 2011 flood events at several USGS stream gages were used by the licensee to estimate inflow boundary conditions for 14 tributaries within the HEC-RAS model. [[redacted].]] The NRC staff considers the licensee's HEC-RAS hydraulic model sensitivity analysis and validation to be appropriate.

(~~CEII~~) [[redacted]]] The NRC staff considers the licensee's HEC-RAS hydraulic modeling results to be appropriate.

3.3.3.1 Two-Dimensional (2-D) Hydraulic Modeling (TUFLOW FV)

To improve the spatial and temporal refinement of the PMF simulation, the licensee developed a TUFLOW FV 2-D hydraulic model of the Missouri River near the Cooper site (NPPD, 2016). When compared to a 1-D model such as HEC-RAS, a 2-D model can provide additional information such as lateral variations in WSELs, depths, and velocities across the Cooper site during the PMF. Erosion, sedimentation, and debris effects were also evaluated by the licensee using the TUFLOW FV model. The TUFLOW FV model domain simulated a roughly 46-mi stretch of the Missouri River from north of Hamburg, Iowa (RM 556.2) to north of Craig, Missouri (RM 510.0). The TUFLOW FV model development involved creating a digital elevation model of surface roughness characteristics, an appropriate flexible computational mesh with levee crests defined, and boundary conditions from the HEC-RAS unsteady model. The TUFLOW FV model extended laterally to cover the Missouri River valley but was not extended beyond the valley profile (e.g., the major Nishnabotna River valley tributary was not modeled to reduce potential floodwater storage without significantly affecting water levels).

The licensee validated the TUFLOW FV model using gage data and high-water marks from the 2011 flood event. The TUFLOW FV simulated water levels were less than 1 ft. below the observations, which the licensee found reasonable for a reach-scale model (NPPD, 2016). Additionally, the licensee performed sensitivity analyses of the upstream and downstream boundary conditions with no major sensitivities found. Additional information on these parameters can be found in Section 2.2.3.3.1 of Revision 1 to the FHRR (NPPD, 2016).

The NRC staff considers the licensee's development and validation of the TUFLOW FV hydraulic model to be appropriate.

~~(CEII)~~ [[redacted].]]

The peak WSEL in the main channel was 902.8 ft. NAVD88 near the intake structure. The peak WSEL at the Cooper site was 903.3 ft. NAVD88 at the upstream side of the plant on the main channel side of the levee. In the FHRR, Table 2.2-9 summarizes the grade elevation, maximum WSEL, maximum velocity and maximum depth as determined from the 2D model.

3.3.4 Combined Effects

In the FHRR, Section 2.2.4 describes the licensee determination of the total water level, including wind and wave effects, for the predicted maximum stillwater level from the Missouri River PMF. The licensee used the USACE Coastal Engineering Manual (CEM) (USACE, 2008) to convert the annual extreme-mile wind speed to a 1-h duration wind speed, and then to 10-, 15-, and 20-minute wind speed durations. To determine the wind-driven waves, the licensee used the "Windspeed Adjustment and Wave Growth" module in the Automated Coastal Engineering System (ACES) in the Coastal Engineering Design and Analysis System (CEDAS) (Veri-Tech, 2014). The licensee used ACES to model the wind approaching along the longest and deepest fetch to determine the controlling significant wave height at each point. The licensee stated that the fetch with the larger wave height was considered the controlling fetch. The licensee then calculated wind setup along the controlling fetch, which was added to the PMF stillwater elevation and subsequently used in wave runup and associated effects calculations.

The licensee used both the CEM (USACE, 2008) and FEMA guidelines (FEMA, 2007) for wave runup calculations. The wave runup from the west was 1.4 ft. resulting in a maximum water elevation of 902.9 ft. NAVD88, which the licensee does not expect to reach the critical building complex. Runup from the north was 0.5 ft. resulting in a maximum water elevation of 904.1 ft. NAVD88 thus indicating the area may be exposed to runup from wind waves. However, the licensee noted that flood protection barriers extend to an elevation of 906.4 ft. NAVD88 thereby protecting the main building complex. For the intake structure, the licensee determined a vertical extent of runup to elevation 908.4 ft. NAVD88, which is the equivalent of a PMF stillwater elevation of 903.0 ft. NAVD88 and 5.4 ft. runup.

3.3.5 Associated Flooding Impacts

The licensee discussed the associated flooding impacts related to the PMF on the Missouri River, including overtopping, erosion and sedimentation, hydrodynamic forces and debris and impact loads. [[redacted].]] The remaining associated effects are discussed in Section 4.3 of this staff assessment.

(~~CEII~~)

3.3.6 Nuclear Regulatory Commission Staff Assessment

3.3.6.1 Probable Maximum Flood Development

The NRC staff reviewed the methodology, parameter values, and alternatives used by the licensee to develop the PMF for the Cooper site. The NRC staff found that the methods used by the licensee were consistent with current guidance and were applied in a reasonable manner. As part of the audit, the NRC staff questioned the level of conservatism in the selection of Alternative 1 for the development of the PMF. Alternative 1 did not appear to consider contributions from snow melt. [[redacted].]] The NRC staff found the licensee's response to be sufficient to resolve the information needs request.

(~~CEII~~)

3.3.6.2 Water Level Determinations

The NRC staff reviewed the models submitted by the licensee. In its review, the NRC staff requested additional clarification regarding the interface between the HEC-RAS and TUFLOW FV models (NRC, 2017a). Specifically the NRC staff requested clarification regarding the upstream and downstream locations of the interfaces, and how both hydrodynamic effects and model differences would affect the TUFLOW FV modeling results. In response, the licensee stated that the boundaries of the TUFLOW FV model are placed where the flow is primarily 1-D and are located far enough away from the site such that model boundary effects would not affect model flows at the site. The licensee also performed model runs to investigate two different boundary conditions: 1) all flow in the floodplains, and 2) all flow in the main channel area. The licensee found that most of the flow would be conveyed in the floodplain and decided that full floodplain conditions were most appropriate. In a related information need (NRC, 2017a), the NRC staff requested that the licensee provide a comparison from two different modeling scenarios: 1) model runs (PMF and dam breach) with original boundary location and 2) model runs (PMF and dam breach) with extended boundary location. The licensee provided the information to the NRC staff through the ERR for review during the audit. The information demonstrated a negligible effect on the WSEL at the Cooper site, and the responses were sufficient to resolve and clarify these information needs.

Additional information needs were resolved during the audit and are documented in the audit summary report (NRC, 2017a).

3.3.7 Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from streams and rivers is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit either a focused evaluation or revised integrated assessment for flooding from streams and rivers.

3.4 <u>Failure of Dams and Onsite Water Control/Storage Structures</u>

The licensee reported in its FHRR that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is based on a stillwater-surface elevation [[redacted]]] This flood-causing mechanism is discussed in the licensee's CDB, but no PMF elevation was reported for the Cooper site.

~~(CEII)~~

3.4.1 Background

The NRC staff reviewed the flooding hazard from failure of dams and onsite water control or storage structures against the relevant regulatory criteria based on present-day methodologies and regulatory guidance. During its review, the NRC staff sought additional clarifications during an audit dated May 19, 2015, (NRC, 2017a). Specifically, the information needed was a comparison of the reevaluated flood hazard relative to the CDB. The information was provided and documented as part of the audit report (NRC, 2017a).

As a part of the review, the licensee also submitted two Addendums to the FHRR; Addendum A by letter dated July 31, 2015 (NPPD, 2015b), and Addendum B by letter dated October 31, 2015 (NPPD, 2015c). Finally, in order to provide additional information relative to the final TUFLOW FV modeling results, and to consolidate the information on the previous Addendums, the licensee submitted Revision 1 to the Cooper FHRR by letter dated September 29, 2016 (NPPD, 2016). The additional information provided in these FHRR addendums and FHRR Revision 1 is discussed in the appropriate sections below.

(CEII) [[redacted]]

3.4.2 Dam Screening

The licensee followed the JLD-ISG-2013-01, Revision 0 (NRC, 2013b) to evaluate the flooding effects at the Cooper site due to upstream dam failure and performed a dam screening analyses in order to identify inconsequential dams whose failure would not induce flooding beyond the dam owner's property. Additional screening analysis was used to identify noncritical dams whose failure would likely have negligible flooding impacts at the Cooper site. The remaining potentially critical dams were further screened to assess which may be noncritical or critical. Following the ISG, the cumulative effects from all noncritical dams were used and applied in addition to the critical dam failures (NPPD, 2016).

(CEII) [[redacted]]] The NRC staff determined that the licensee properly identified upstream dams for additional evaluation during the screening process. Therefore, the NRC staff considers the licensee's use of JLD-ISG-2013-01, Revision 0 (NRC, 2013b) and the dam screening results to be appropriate.

3.4.3 Modeling Dam Failure

3.4.3.1 Hydrologic Modeling (HEC-HMS)

To simulate dam failure hydrographs, the licensee modified the HEC-HMS model developed for PMF modeling. All sub-basins were removed from the previous PMF model, and hypothetical dams were added at the location of drainage confluences. Further modifications were made to conservatively remove several routing reaches between the hypothetical dams and the Missouri River (NPPD, 2016). The NRC staff considers the licensee's selection of HEC-HMS for hydrologic modeling to be appropriate.

To estimate breach parameters for breach bottom width and breach formation time, the licensee used equations for rectangular breaches of earthen dams documented in the United States Bureau of Reclamation (USBR) Assistant Commissioner Engineering and Research (ACER) Technical Memorandum No. 11 (USBR, 1988). (CEII) [[redacted]

[redacted].]]

(CEII) [[redacted].]]

(CEII) [[redacted].]] The NRC staff considers the licensee's selection of dam failure scenarios to be appropriate.

3.4.3.2 One-Dimensional (1-D) Hydraulic Modeling (HEC-RAS)

The licensee modified the PMF HEC-RAS model discussed in Section 3.3.3 to route the dam breach hydrographs and compute peak water levels at the Cooper site due to dam failure. The results from the 1-D HEC-RAS simulation were used as input to a 2-D TUFLOW FV model for refined analysis of water levels, depths, and velocities (NPPD, 2016).

(CEII) [[redacted].]] The NRC staff considers the licensee's application of the HEC-RAS model for the hypothetical dam failure analysis, results, and conclusions to be appropriate.

(CEII) [[redacted].]] The NRC

staff considers the licensee's HEC-RAS dam failure simulation results based on boundary conditions from the USACE results, to be appropriate.

3.4.3.3 Two-Dimensional (2-D) Hydraulic Modeling (TUFLOW FV)

~~(CEII)~~ [[[redacted].]]

~~(CEII)~~ [[[redacted].]]

~~(CEII)~~ [[[redacted].]]

Additional information needs are documented in the audit summary report (NRC, 2017a). The NRC staff considers the licensee's 2-D hydraulic modeling results to be appropriate.

3.4.3.4 Combined Effects: PMF with Hydrologic Dam Failure

(CEII) [[redacted]]

The NRC staff considers the licensee's dam failure combined effects calculation results to be appropriate.

3.4.4 Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from failure of dams and onsite water control or storage structures is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit either a focused evaluation or revised integrated assessment for flooding from failure of dams and onsite water control or storage structures.

3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated flood hazard for storm surge is negligible. This flood-causing mechanism is described in the licensee's CDB, but is screened out as a potential flood-causing mechanism.

The licensee stated that the Cooper site is located inland and away from any large body of water for which storm surge flooding would apply. Accordingly, the licensee screened out storm surge as a credible flood-causing mechanism at the Cooper site.

The NRC staff noted that the Cooper site is located more than 200 mi away from any coastline or large body of water which could produce a storm surge. Accordingly, the NRC concludes that storm surge is unlikely to occur at or near the Cooper site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge would not inundate the Cooper site. Therefore, the NRC staff determined that flooding from storm surge does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.6 Seiche

The licensee reported in its FHRR that the reevaluated hazard for seiche does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is discussed in the licensee's CDB, but is screened out as a potential flood-causing mechanism.

The licensee noted that the riverine setting at the Cooper site is too narrow and meandering to develop a seiche and its oscillation propagation. The licensee also noted that the river geometry near the Cooper site limits the height of any potential seiche and will cause the rapid attenuation of seiche oscillations. Accordingly, the licensee screened out seiche as a credible flood-causing mechanism at the Cooper site.

The NRC staff reviewed the Cooper site and nearby river geometry and concludes that the narrow Missouri River channel and the shallowness of the river near the Cooper site would preclude the development and propagation of a seiche. Therefore, the NRC staff concludes that seiche is unlikely to occur at or near the Cooper site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche would not inundate the Cooper site. Therefore, the NRC staff determined that flooding from seiche does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.7 Tsunami

The licensee reported in the FHRR that the reevaluated hazard for tsunami does not inundate the plant site but did not report a PMF elevation. This flood-causing mechanism is discussed in the licensee's CDB but was screened out as a credible flood-causing mechanism.

The licensee stated that the Cooper site is not susceptible to oceanic tsunamis due to its inland location. Therefore, the licensee screened out tsunami as a credible flood-causing mechanism. The NRC staff noted that although the FHRR mentions several tsunamigenic sources, including seismic, landslide and volcanic, none of the sources are discussed in detail. However, the NRC staff also noted that the Cooper site is not located near a body of water capable of generating and propagating a tsunami. Therefore, the NRC staff concludes that tsunami is unlikely to occur at the Cooper site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding from tsunami does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated flood hazard for ice-induced flooding is 896.8 ft. NAVD88 for upstream breach of an ice dam and 896.9 ft. NAVD88 for a downstream ice jam resulting in backwater at the Cooper site. This flood-causing mechanism is discussed in the licensee's CDB, but no flood elevation was reported.

The licensee stated that it used the hierarchical hazard assessment approach to evaluate the effects of ice-induced flooding at the Cooper site. The licensee consulted the USACE National Ice Jam Database (USACE, 2017a) to identify the most severe historical ice jam event, which was an April 23, 1881, event 200 mi upstream of the Cooper site in Sioux City, Iowa. This maximum ice jam event had an estimated ice dam height of 21.8 ft. corresponding to a river flood stage of 1,079.5 ft. relative to the National Geodetic Vertical Datum of 1929 (NGVD29). The largest downstream ice jam event occurred December 29, 1972 and it was an approximately 14.5 ft. high occurrence, near Rulo, Nebraska (which is about 35 mi downstream from the Cooper site). This was equivalent to a stage of approximately 858 ft. NGVD29. The licensee analyzed the effect of an upstream breach of an ice dam at Sioux City, Iowa and the backwater effects from a downstream ice jam at Rulo, Nebraska, and concluded that the peak WSEL was 896.8 ft. NAVD88 and 898.9 ft. NAVD88, respectively. The licensee concluded that the maximum ice-induced flood level is still below the minimum floor elevation of 903.9 ft. NAVD88 for all safety-related facilities. Because ice-induced flooding does not exceed the site grade, the licensee considered ice-induced flooding to be bounded by the CLB.

The NRC staff independently consulted the USACE National Ice Jam Database and confirmed that the largest upstream event was the 1881 event in Sioux City, Iowa and the largest downstream event was the 1972 event in Rulo, Nebraska. The NRC staff noted that the peak WSEL calculated from these maximum events are reasonable.

Although the licensee concluded that the reevaluated hazard for ice-induced flooding is bounded by the CLB flood hazard at the Cooper site, the NRC staff determined that because ice-induced flooding is not included in the CDB, ice-induced flooding is not bounded by the CDB at the Cooper site. Therefore, the NRC staff expects that the licensee will submit either a focused evaluation or revised integrated assessment for ice-induced flooding.

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard for channel migrations or diversions does not inundate the plant site, but did not report a maximum flood elevation. This flood-causing mechanism is discussed in the licensee's CDB, but no maximum flood elevation was reported.

The licensee stated that although it is not possible to postulate a probable maximum channel diversion event, it is possible to determine whether a channel has the tendency to meander towards or away from the Cooper site. The licensee noted that, historically, the Missouri River was a meandering alluvial river with large amounts of sediment and seasonal variations in flow that would erode sediment from the bed and banks. [[redacted].]]

~~(CEII)~~

The licensee also considered the potential for future channel migration and diversion by reviewing regional topographic evidence. The licensee concluded that future meandering beyond what would be expected during a flood event is not expected due to [[redacted]]] The licensee considered soil survey data but noted that soil erosivity near the Cooper site was not evaluated. The licensee also noted that channel diversion due to an ice jam is possible.

~~(CEII)~~

The licensee also discussed the experience from the 2011 flood at the Cooper site, which is the flood of record since the USACE system of dams and levees was constructed. The 2011 flood included several incidents of overtopping and breaching of levees upstream of the Cooper site. At the Cooper site, the licensee noted that the flood waters inundated the floodplain in areas where the Missouri River once meandered but remained within the levees. However, there was some overbank flooding that resulted in erosion.

The licensee evaluated channel erosion potential using an allowable velocity approach (USACE, 1994). Using the allowable velocities for the soil types in the vicinity of the Cooper site and velocities predicted using HEC-RAS, the licensee concluded that there is potential for erosion and diversion. Finally, the licensee determined the human-induced changes to channel diversion are not applicable because any plans [[redacted].]]

~~(CEII)~~

[[redacted].]]

~~(CEII)~~

The NRC staff considered the location of the Cooper site and the historical meanderings of the Missouri River when reviewing the potential for flooding due to channel migrations or diversions. The NRC staff noted that while there is a historical record of channel migrations, these occurred prior to the construction of the systems of dams and levees currently in place. The NRC staff also noted that any channel migration of the Missouri River into an old meander will have minimal effect on the flood elevation at the CNS site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit either a focused evaluation or revised integrated assessment for channel migrations or diversions.

4.0 REEVALUATED FLOOD HEIGHT, EVENT DURATION AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CDB

4.1 Reevaluated Flood Height for Hazards Not Bounded by the CDB

Section 3 of this staff assessment documents the NRC staff's review of the licensee's flood hazard water height results. Table 4.1-1 contains the maximum flood height results, including waves and runup, for flood mechanisms not bounded by the CDB. The NRC staff agrees with the licensee's conclusion that LIP, flooding from streams and rivers, failure of dams and onsite water control/storage structures, ice-induced flooding and flooding from channel migrations or diversions are the flood-causing mechanisms not bounded by the CDB.

The NRC staff anticipates that the licensee will submit a focused evaluation for LIP. For the streams and rivers, dam failure, ice-induced and channel migration or diversion flood-causing mechanisms, the NRC staff anticipates the licensee will perform either a focused evaluation or an integrated assessment. By letter dated April 27, 2017 (NPPD, 2017), the licensee provided its MSA. The NRC staff's review of the information provided in the MSA was documented in a separate staff assessment (NRC, 2017b).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The NRC staff reviewed the information provided in NPPD's 50.54(f) responses (NPPD, 2015a; NRC, 2017a) regarding the FED parameters needed to perform the additional assessments of plant response for flood-causing mechanisms not bounded by the CDB. The FED parameters provided in the FHRRs for the flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1. The NRC staff reviewed the FED parameters provided by the licensee's revised FHRR response (NPPD, 2016) and determined that they are reasonable for use in future assessments of plant response.

In addition to the FED information in the FHRRs, the licensee submitted the MSA (NPPD, 2017), which included additional FED parameters and information associated with the five controlling scenarios. The NRC staff's assessment of the MSA and the additional FED parameters will be documented in a separate staff assessment.

4.3 Associated Effects for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided by in NPPD's 50.54(f) response (NPPD, 2015a) regarding the AE parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The licensee presented the AE parameters associated with the unbounded flood-causing mechanisms directly related to maximum total water height, such as wave and runup in Section 3.10 of the FHRR (NPPD, 2015a). The AE are summarized in Table 4.3-1.

~~(CEII)~~ [[redacted].]]

For AE parameters noted as minimal or not applicable, the NRC staff confirms the licensee's FHRR AE parameter results are reasonable for use in additional assessments. By letter dated April 27, 2017, the licensee submitted the MSA (NPPD, 2017), which included additional AE parameters for the four controlling scenarios. The NRC staff's review and conclusions regarding the AE parameters provided in the MSA are documented in a separate staff assessment (NRC, 2017b).

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirms that the reevaluated flood hazard information defined in Section 4 is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter, COMSECY-15-0019 (NRC, 2015a), and the associated guidance.

5.0 CONCLUSION

The NRC staff reviewed the information provided for the reevaluated flood-causing mechanisms at the Cooper site. Based on the review of the above available information provided in NPPD's 50.54(f) response (NPPD, 2015a), the NRC staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, NRC staff confirmed the licensee's conclusions that (1) the reevaluated flood hazard results for local intense precipitation, streams and rivers, failure of dams, ice-induced flooding, channel migrations and diversions are not bounded by the CDB flood hazard, (2) additional assessments of plant response would need to be performed for local intense precipitation, flooding from streams and rivers, failure of dams, ice-induced flooding and channel migrations and diversions, and (3) the reevaluated flood-causing mechanism information is appropriate input to the additional assessments of plant response, as described in 50.54(f) letter and COMSECY-15-0019, and associated guidance. The NRC staff has no additional information needs at this time with respect to the NPPD's 50.54(f) response.

6.0 REFERENCES

Notes: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

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SUBJECT: COOPER NUCLEAR STATION – STAFF ASSESSMENT OF THE RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (CAC NO. MF4712; EPID L-2014-JLD-0057) DATED June 1, 2018

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