U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants

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FILING INSTRUCTIONS

PAGES TO BE REMOVED			NEW PAGES TO BE INSERTED		
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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.4.2 FLOODS

REVIEW RESPONSIBILITIES

Primary - Structural & Geosciences Branch (ESGB)

Secondary - None

I. AREAS OF REVIEW

This section of the safety analysis report (SAR) identifies historical flooding (defined as occurrences of abnormally high water stage or overflow from a stream, floodway, lake, or coastal area) at the proposed site or in the region of the site. It summarizes and identifies the individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. It also covers the potential effects of local intense precipitation. Although topical information may appear in SAR Sections 2.4.3 through 2.4.7, the types of events considered and the controlling event are reviewed in this section.

The flood history and the potential for flooding are reviewed for the following sources and events. Factors affecting potential runoff (such as urbanization, forest fire, or change in agricultural use), erosion, and sediment deposition are considered in the review.

1. Stream flooding

    a. Probable maximum flood (PMF) with coincident wind-induced waves, considering dam failure potential due to inadequate capacity, inadequate flood-discharge capability, or existing physical condition.

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b. Ice jams, both independently and coincident with a winter probable maximum storm.

c. Tributary drainage area PMF potential.

d. Combinations of less severe river floods, coincident with surges and seiches.

2. Surges

a. Probable maximum hurricane (PMH) at coastal sites.

b. PMH wind translated inland and resulting wave action coincident with runoff-induced flood levels.

c. Probable maximum wind-induced (non-hurricane) storm surges and waves.

d. Combinations of less severe surges, coincident with runoff floods.

3. Seiches

a. Meteorologically induced in inland lakes (e.g., Great Lakes and harbors) and at coastal harbors and embayments.

b. Seismically induced in inland lakes.

c. Seismically induced by tsunami (seismic sea waves) on coastal embayments.

d. Combinations of less severe surges and seiches, coincident with runoff floods.

4. Tsunami

a. Near field, or local, excitation.

b. Far field, or distant, excitation.

5. Seismically induced dam failures (or breaches) and maximum water level at site from:

a. Failure of dam (or dams) during safe shutdown earthquake (SSE) coincident with 25-year flood.

b. Failure during operating basis earthquake (OBE) coincident with standard project flood (SPF).

c. Failure during other earthquakes, coincident with runoff, surge, or seiche floods where the coincidence is at least as likely as for 5.a and 5.b above.

6. Flooding caused by landslides

a. Flood waves.

b. Backwater effects due to stream blockage.

7. Ice loadings from water bodies

II. ACCEPTANCE CRITERIA

Acceptance criteria for this SRP section relate to the following regulations:

1. General Design Criterion 2 (GDC 2) as it relates to structures, systems, and components important to safety being designed to withstand the effects of hurricanes, floods, tsunami, seiches.

2. 10 CFR Part 100 as it relates to identifying and evaluating hydrologic features of the site.

To meet the requirements of the hydrologic aspects of GDC 2 and 10 CFR Part 100, the following specific criteria are used:

For SAR Section 2.4.2.1 (Flood History): The potential flood sources and flood response characteristics identified by the staff's review (described in Review Procedures) are compared to those of the applicant. If similar the applicant's conclusions are accepted. If, in the staff's opinion, significant discrepancies exist, the applicant will be requested to provide additional data, reestimate the effects on the plant, or revise the applicable flood design bases, as appropriate.

For SAR Section 2.4.2.2 (Flood Design Considerations): The applicant's estimate of controlling flood levels is acceptable if it is no more than 5% less conservative than the staff's independently determined (or verified) estimate. If the applicant's SAR estimate is more than 5% less conservative, the applicant should fully document and justify its estimate of the controlling level. On the other hand, the applicant may accept the staff's estimate and redesign applicable flood protection.

For SAR Section 2.4.2.3 (Effects of Local Intense Precipitation): The applicant's estimates of local probable maximum precipitation (PMP) and the capacity of site drainage facilities (including drainage from the roofs of buildings and site ponding) are acceptable if the estimates are no more than 5% less conservative than the corresponding staff's assessment. Similarly, conclusions relating to the potential for any adverse effects of blockage of site drainage facilities by debris, ice, or snow should be based upon conservative assumptions of storm and vegetation conditions likely to exist during storm periods. If a potential hazard does exist (e.g., the elevation of ponding exceeds the elevation of plant access openings), the applicant should document and justify his local PMP basis and analysis and redesign any affected facilities.

Appropriate sections of the following documents are used by the staff to determine the acceptability of the applicant's data and analyses in meeting the requirements of GDC 2 and 10 CFR Part 100. Regulatory Guide 1.59 provides guidance for estimating the design basis for flooding considering the worst single phenomenon and combinations of less severe phenomena. Regulatory Guide 1.29 identifies the safety-related structures, systems, and components, and Regulatory Guide 1.102 describes acceptable flood

protection to prevent the safety-related facilities from being adversely affected. Publications of the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Soil Conservation Service (SCS), Corps of Engineers, applicable State and river basin authorities, and other similar agencies are used to verify the applicant's data relating to hydrologic characteristics and extreme events in the region. SRP Sections 2.4.3 through 2.4.7 discuss methods of analysis to determine the individual flood-producing phenomena.

III. REVIEW PROCEDURES

Construction permit (CP) stage reviews are carried out under this SRP section to evaluate the significance of the controlling flood level with regard to the plant design basis for flood protection. At the operating license (OL) stage, a brief review is carried out to determine if new information has become available since the CP review and to evaluate the significance of the new information with regard to the plant design basis for flood protection. New information might arise, for instance, from the occurrence of a new maximum flood of record in the site region, from identification of a source of major flooding not previously considered, from construction of new dams, from flood plain encroachments, or from advances in predictive models and analytical techniques. If the CP-stage evaluation of flooding potential has been carefully done, all sources of major flooding should have been considered and any new floods of record should fall well within the design basis. Improvements in calculational methods may occur, but generally will be concerned with increased accuracy in stream flow and water level predictions rather than with substantive changes in the flows and levels predicted. Where the OL review reveals that the controlling flood level differs more than 5% less conservatively from the CP evaluation, any supplemental provisions needed in the flood protection design basis should be directed toward early warning measures and procedures for ensuring safe shutdown of the plant or toward minor structural modification to accommodate the design flood level.

For SAR Section 2.4.2.1 (Flood History): The staff will review publications of the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Soil Conservation Service (SCS), Corps of Engineers, applicable State and river basin agencies, and others to ensure that historical maximum events and the flood response characteristics of the region and site have been identified. Similar material, in addition to applicant-supplied information, will be reviewed to identify independently the potential sources of site flooding.

For SAR Section 2.4.2.2 (Flood Design Considerations): The potential flood levels from consideration of the worst single phenomenon and combinations of less severe phenomena are identified in accordance with SRP Sections 2.4.3 through 2.4.7 and the controlling flood level is selected. The controlling flood level is compared with the proposed protection levels to ensure that the safety-related facilities will not be adversely affected. If appropriate, additional provisions for flood protection will be imposed to ensure adequate protection of the safety-related facilities.

For SAR Section 2.4.2.3 (Effect of Local Intense Precipitation): The staff's estimates of flooding potential are based on PMP estimates from

the appropriate hydrometeorological reports and similar NOAA publications. The staff's estimates are compared with the applicant's estimates to determine conformity to Acceptance Criteria in subsection II of this SRP section. Runoff models, such as the unit hydrograph if applicable, or other runoff discharge estimates presented in standard texts, are used to estimate discharge on the site drainage system. Where generalized runoff models are used, coefficients used for the site and region are compared to information available at documented locations to evaluate hydrologic conditions used in determining the probable maximum flood for the site drainage system. Potential ponding on the site is also determined.

The above reviews are performed only when applicable to the site or site region. Some items of review may be done on a generic basis.

IV. EVALUATION FINDINGS

For CP reviews, the findings will consist of a statement indicating the completeness of the identification of site flood characteristics and flood design bases in compliance with 10 CFR Part 100 and GDC 2. For OL reviews, the flood history will be updated if necessary, with special attention to any new flood of record. Sample statements for CP reviews follow:

> The maximum flood known to have occurred on the A River was in 1796. The peak discharge at B City, Montana, was estimated to be 360,000 cubic feet per second (cfs). The applicant estimated that a comparable flood would produce water surface elevation at the site of 116 feet MSL. The maximum flood during the period since records were maintained (1883) at B City was 350,000 cfs and occurred on October 3, 1929. These floods occurred prior to construction of several upstream dams. Flood flows are now regulated by C and D Reservoirs as well as by upstream hydropower plants.
>
> The applicant has estimated potential flooding from rainfall over the E River basin upstream from the site. The probable maximum flood (PMF), the upper level of flooding the staff considers to be reasonably possible, was estimated to produce a flow of 5,000,000 cfs near the city of F. This estimate was made by using 165% of the Corps of Engineers project design flood (PDF) estimate of 3,030,000 cfs at the same location, as modified by upstream flood control reservoirs. The 3,030,000 cfs project design flood flow is estiimated to be partially diverted to the leveed G and H floodways upstream of the site, with 1,500,000 cfs continuing downstream within the levee system past the plant site. The applicant concluded that the PMF could result in overtopping of levees and flooding of the river valley well upstream from the site, thereby causing generally low level flooding in the plant area. The upstream levee overtopping and resulting valley flow during such an event would reduce the flow in the main levee channel adjacent to the site to levels equal to or less than those that would exist during a PDF. We conclude that the combination of a runoff-type flood less severe than a PMF, but more severe than a PDF, and a coincident levee break in the vicinity of the site could occur before water approaches levee grade upstream. A failure or levee breach, when the levee is full to design capacity (3 feet below the top of the levee adjacent to the site plus the

effects of any coincident wind-generated wave activity), would result in a higher water surface at the plant than a PMF spread over the valley as a result of levee failures upstream. At our request, the applicant evaluated various modes of levee failure in the vicinity of the plant. One of the conditions postulated is that of a flood, approaching the severity of a PMF, causing a massive failure of the upstream left bank levee along the G floodway, resulting in flooding around the plant, coincident with a failure of the levee adjacent to the plant site. The applicant estimated the resulting water level at the plant would reach elevation 22.5 feet MSL for this case. The case of an instantaneous levee failure adjacent to the plant, with no upstream levee failure, resulted in an estimated water level of 24.6 feet MSL.

Based upon this evaluation, the staff concludes that, in order to meet the requirements of General Design Criterion 2 and 10 CFR Part 100 with respect to potential hydrologic events, the applicant should design for the conditions associated with the 24.6 feet MSL water level.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

The provisions of this SRP section apply to reviews of construction permit (CP), operating license (OL), and Preliminary Design Approval (PDA) applications docketed after the effective date of issuance of this revision to SRP Section 2.4.2.

VI. REFERENCES[1]

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 100, "Reactor Site Criteria."

3. "Surface Water Supply of the United States,"[2] U.S. Geological Survey.

[1]References for PMP estimates, time distribution, etc., are in SRP Section 2.4.3.

[2]"Surface Water Supply" is a continuing series of water discharge measurements by the USGS and others. It is not practical to list all the volumes (called "Water-Supply Papers") that are available. Numerous State and local authorities maintain river discharge, lake level, and tide data.

4. "Tide Tables," National Oceanic and Atmospheric Administration (similar situation as identified in footnote 2).

5. Reports of Great Lakes levels by National Ocean Survey, National Oceanic and Atmospheric Administration.

6. Corps of Engineers records maintained in District and Division Offices, Coastal Engineering Research Center, and Waterways Experiment Station.

7. Regulatory Guide 1.29, "Seismic Design Classification."

8. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants."

9. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

10. ANSI N170, "Standards for Determining Design Basis Flooding at Power Reactor Sites."

11. "Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian for Areas to 400 Square Miles and Durations to 24 Hours," Technical Paper No. 38, U.S. Weather Service, NOAA (1960).

12. Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants."

13. "Probable Maximum Precipitation Estimates, - United States East of the 105th Meridian," Hydrometeorological Report No. 51, National Oceanic and Atmospheric Administration, National Weather Service, June 1978.

14. "Application of Probable Maximum Precipitation Estimates, - United States East of the 105th Meridian, "Hydrometeorological Report No. 52, National Oceanic and Atmospheric Administration, National Weather Service, August 1982.

15. "Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates, - United States East of the 105th Meridian," Hydrometeorological Report No. 53, National Oceanic and Atmospheric Administration, National Weather Service, April 1980.

16. "Probable Maximum Precipitation Estimates, - United States Between the Continental Divide and the 103rd Meridian," Hydrometeorological Report No. 55, National Oceanic and Atmospheric Administration, National Weather Service (Corps of Engineers and Bureau of Reclamation), March 1984.