



**U.S. NUCLEAR REGULATORY COMMISSION**  
**STANDARD REVIEW PLAN**  
**OFFICE OF NUCLEAR REACTOR REGULATION**

**2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING**

**REVIEW RESPONSIBILITIES**

Primary - Hydrologic & Geotechnical Engineering Branch (HGEB)

Secondary - None

**I. AREAS OF REVIEW**

In this section of the safety analysis report (SAR) the hydrometeorological design basis is developed to determine the extent of flood protection required for safety-related plant systems. The areas of review include the characteristics of the assumed probable maximum hurricane or other probable maximum wind storms and the techniques, methodologies, and parameters used in the determination of the design surge and/or seiche. Antecedent water levels, storm tracks, methods of analysis, coincident wind-generated wave action and wave runup on safety-related structures, potential for wave oscillation at the natural periodicity, and the resultant design bases for surge and seiche flooding are also reviewed.

**II. ACCEPTANCE CRITERIA**

HGEB acceptance criteria for this SRP section are based on meeting the requirements of the following regulations:

1. General Design Criteria 2 (GDC 2) as it relates to structures, systems, and components important to safety being designed to withstand the effects of hurricanes and seiches.
2. 10 CFR Part 100 as it relates to evaluating the hydrologic characteristics of the site.

Specific criteria necessary to meet the relevant hydrologic requirements of GDC 2 and 10 CFR Part 100 are as follows:

If it has been determined that surge and seiche flooding estimates are necessary to identify flood design bases, the applicant's analysis will be considered complete

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**USNRC STANDARD REVIEW PLAN**

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

and acceptable if the following areas are addressed and can be independently and comparably evaluated from the applicant's submission.

1. All reasonable combinations of probable maximum hurricane, moving squall line, or other cyclonic wind storm parameters are investigated, and the most critical combination is selected for use in estimating a water level.
2. Models used in the evaluation are verified or have been previously approved by the staff.
3. Detailed descriptions of bottom profiles are provided (or are readily obtainable) to enable an independent staff estimate of surge levels.
4. Detailed descriptions of shoreline protection and safety-related facilities are provided to enable an independent staff estimate of wind-generated waves, runoff, and potential erosion and sedimentation.
5. Ambient water levels, including tides and sea level anomalies, are estimated using NOAA and Corps of Engineers publications as described below.
6. Combinations of surge levels and waves that may be critical to plant design are considered, and adequate information is supplied to allow a determination that no adverse combinations have been omitted.
7. If Regulatory Guide 1.59, Position 2, is elected by the applicant, the design basis for flood protection of all safety-related facilities identified in Regulatory Guide 1.29 must be shown to be adequate in terms of time required for implementation of any emergency procedures. The applicant must also demonstrate that all potential flood situations that could negate the time and capability to initiate flood emergency procedures are provided for in the less severe design basis selected.

This section of the SAR may also state with justification that surge and seiche flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

Hydrometeorological estimates and criteria for development of probable maximum hurricanes for east and Gulf coast sites, squall lines for the Great Lakes, and severe cyclonic wind storms for all lake sites by the Corps of Engineers, National Oceanic and Atmospheric Administration (NOAA), and the staff are used for evaluating the conservatism of the applicant's estimates of severe windstorm conditions, as discussed in Regulatory Guide 1.59. The Corps of Engineers and NOAA criteria require variation of the basic meteorological parameters within given limits to determine the most severe combination that could result. The applicant's hydrometeorological analysis should be based on the most critical combination of these parameters.

Data from publications of NOAA, the Corps of Engineers, and other sources (such as tide tables, tide records, and historical lake level records) are used to substantiate antecedent water levels. These antecedent water levels must be as high as the "10% exceedence" monthly spring high tide plus a sea level anomaly based on the maximum difference between recorded and predicted average water levels for durations of two weeks or longer for coastal locations or the 100-yr recurrence interval high water for the Great Lakes. In a similar manner, the storm track, wind fields, effective fetch lengths, direction of approach, timing and frictional surface and bottom effects are evaluated by independent

staff analysis to assure that the most critical values have been selected. Models used to estimate surge hydrographs that have not previously been reviewed and approved by the staff are verified by reproducing historical events, with any discrepancies in the model being on the conservative (i.e., high) side.

Criteria and methods of the Corps of Engineers as generally summarized in Reference 32 are used as a standard to evaluate the applicant's estimate of coincident wind-generated wave action and runup.

Criteria and methods of the Corps of Engineers and other standard techniques are used to evaluate the potential for oscillation of waves at natural periodicity.

Criteria and methods of the Corps of Engineers (Ref. 32) are used to evaluate the adequacy of protection from flooding, including the static and dynamic effects of broken, breaking, and nonbreaking waves. Regulatory Guide 1.102 provides further guidance on flood protection. Regulatory Guide 1.125 provides guidance for using physical models in assessing flood protection.

### III. REVIEW PROCEDURES

The staff will evaluate the applicant's analysis, including all of the assumptions, techniques, and models used. If satisfied with their technical soundness and applicability to the problem, the staff's evaluation will be focused on the conservatism of parameters used by the applicant.

If not satisfied with the applicant's techniques, the staff will perform a simplified analysis of the controlling surge and seiche flooding level (coincident with wind-generated wave activity) and the resulting effects (static and dynamic) to the safety-related facilities using simplified calculational procedures or models with demonstrably conservative coefficients and assumptions. If the applicant's estimates of critical water level are no more than 5% less conservative than the staff's estimates,\* staff concurrence will be stated. If the applicant's estimates are more than 5% less conservative, the analysis is repeated using more realistic techniques. The staff will develop a position based on the analysis; resolve, if possible, differences between the applicant's and staff's surge and seiche flooding design basis; and write the SER input accordingly. The specific review procedures are described below and outlined in Figure 2.4.5-1.

In general, the conservatism of the applicant's estimates of flood potential from surges and seiches is judged against the criteria indicated in subsection II above and as discussed in Regulatory Guide 1.59. If the site is not near a large body of water the staff findings may be prepared a priori. Methods of the Corps of Engineers and National Oceanic and Atmospheric Administration (NOAA) (HUR 7-97 and amendments) are used to develop the critical probable maximum hurricane (PMH) parameters for the site. The Corps of Engineers model SURGE (or other verified models) may be used to estimate the maximum surge stillwater elevations at coastal sites. Coincident wind-generated waves and runup are estimated from publications by the Corps of Engineers (Ref. 32). Reports of NOAA and the Corps of Engineers are used to estimate probable maximum wind fields over the Great Lakes. Models such as Platzmann's, or other verified models, may be used to estimate the maximum surge or seiche stillwater elevation

\*Based on the difference between normal water levels and the flood event.

for Great Lakes sites; coincident wind-generated waves and runup are estimated as above.

Two-dimensional models (References 17, 28, and 44) include seiching effects. Seiching potential is evaluated using one-dimensional models by comparing the natural period of oscillation (resonance) of the water body with the estimated meteorologically-induced wave periods. Resonance of a water body may be calculated by the methods presented in Reference 32 or standard texts. Generally, a demonstration that the water body cannot generate or sustain waves of the required period for resonance is satisfactory to discuss the possibility of damaging seiching. Similarly, seismically induced seiching is precluded if the natural period of oscillation of the water body is dissimilar from the period of precluded seismic excitation. Coordination with the Geosciences Branch (GB) to determine the controlling seismic parameters may be required. If resonance is possible, the maximum seiche must be considered in the selection of the critical flood design bases.

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 construction permit (CP) reviews the findings will summarize the applicant's and staff's estimates of critical water level (including wind-generated wave levels) at the site. If the estimates meet the criteria (described in subsection II above), staff concurrence will be stated. If the applicant's estimates do not meet the criteria in subsection II above, and the proposed plant may be adversely affected, a statement requiring use of the staff's estimates for the design basis will be made. If the flood conditions do not constitute a design basis, the statement will so indicate.

For operating license (OL) reviews of plants which have received detailed reviews during the CP review, the CP conclusions will be referenced. However, a review will be made to assure that protection against the design-basis water level conditions established in the CP review has been properly implemented. In addition, a review of surge and seiche history since the CP review will be made. Any new information or improvements in predictive models will be noted. If no detailed CP review was undertaken, this fact will be indicated in the OL findings.

If Regulatory Guide 1.59, Position 2, is elected by the applicant for protection, a statement describing lesser design bases will be included in the findings with the staff conclusion of adequacy.

A sample statement for an OL review follows:

The design basis hurricane-induced high and low stillwater levels were established during the CP review at elevations 22.0 feet MSL and -7.5 feet MSL, respectively. These levels are based upon the estimated water levels, exclusive of wave action, that would occur during passages of a probable maximum hurricane (PMH) to the south and north, respectively, of the plant. At the request of the staff, the applicant analyzed the wave conditions on safety-related facilities that could accompany the 22 foot MSL surge level. The results of these analyses indicate the most severe wave action would be restricted to the canal, and that high ground levels would

limit wave heights in the vicinity of exposed safety-related buildings, except the service water intake, to 1.6 feet. For the intake, the applicant has estimated waves 3 feet high. The resulting wave runup levels were estimated to reach a maximum elevation of 28.3 feet MSL on the intake, and 25.6 feet MSL on other exposed buildings.

The staff concludes that the plant design meets the requirements of General Design Criterion 2 and 10 CFR Part 100 with respect to surge and seiche flooding. The bases for this conclusion is that the intake structure and the other exposed plant buildings are designed to withstand wave runup to 29.0 feet MSL and 26.0 feet MSL respectively, which are above the maximum calculated wave runup levels discussed above.

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees 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.

## VI. REFERENCES

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23. V. A. Myers, "Characteristics of United States Hurricanes Pertinent to Levee Design for Lake Okeechobee, Florida," Hydrometeorological Report 32, U.S. Weather Bureau (1954).

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Figure 2.4.5-1  
STANDARD REVIEW PLAN SECTION 2.4.5

