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APR 7 1980

NOTE TO: G. Bagchi, Chief
Structural Engineering Branch
Division of Reactor Safety Research

FROM: H. Schierling
Accident Analysis Branch, DSE, NRR

SUBJECT: RESEARCH REVIEW GROUP ON FLOOD HAZARDS AND FLOODING EFFECTS

I have reviewed the material you provided in your memo of March 20, 1980. In addition to specific comments on the proposed research program which appear as notes in the margin of the document, as attached, I have the following general comments.

(1) In the "Background" section of the proposed program it should be stated that the effort is in response to the NRR research request of October 26, 1977 and the specific "Information Needs" of that request should be identified. Without referencing or incorporating the NRR request the purpose of the prpposed program as currently written is not obvious.

(2) A major item in the NRR research requestiis the identification and assessment of methodologies for applying probabilistic methods (see Information Needs of NRR memo). This importance however is not sufficiently recognized and addressed in the section "Scope of Work" of the proposed program. There is much emphasis placed on selecting plant sites and performing a flood evaluation without first identifying, reviewing or developing the appropriate probabilistic methods for the evaluation. The approach described in Part A of that section is not sufficiently structured for a research program.

(3) It is not obvious how the "Expected Results" will be obtained from the proposed "Scope of Work". The proposed program should demonstrate how a specific work activity will lead to a specific result.

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Attachment:
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BACKGROUND

The assumption and underlying practice in this subject area is that a nuclear power plant hardened against the most severe flooding conditions reasonably probable is adequate to protect the public health and safety. Potential flooding conditions are analyzed deterministically using techniques and procedures evolved from practice by other Federal agencies (primarily the Corps of Engineers, NOAA, FPC, and the Bureau of Reclamation). Furthermore, these techniques and procedures consider the range of causative mechanisms, including tropical storms, large and small-scale extra tropical precipitation and wind storms, geoseismic activity and dam failures. No assessment is made of the probability of the flood conditions postulated. Furthermore, no evaluation is made of the likelihood of failure of flood protection, the consequences of failure, the residual risks inherent in inadequate flood condition/flood protection criteria, or the degree of conservatism associated with the present methodology.

Primary concerns regarding current probabilistic techniques include the following:

A single measure of an event outcome, such as water level or discharge, is generally used as an indicator of event magnitude. No differentiation is made as to the cause of the event, however, and experience indicates that a flood record contains events caused by at least two completely different phenomena (e.g., tropical and extra tropical storms). A typical flood record may not contain a large enough sample of floods caused by each type of event to be representative. Furthermore, even if a flood record is not considered composed of mixed events, the representativeness of a relatively short-term record for prediction of very low likelihood events may be questionable.

How should the confidence limits be selected in order to (1) minimize the residual error in estimates of event magnitudes, and correspondingly, (2) minimize the range of event likelihood?

If likelihood estimates are made using dependent and independent components of event magnitude (e.g., rainfall magnitude, areal distribution of rainfall, ground wetness, etc.), how are individual component confidence limits reconciled to minimize the residual error in estimates of the outcome magnitude and outcome of likelihood?

Flood protection requirements vary considerably from site to site. For example, if all safety-related facilities are located above design basis flood levels, no flood protection provisions are required. Many sites fall in this category; others do not. Prior to the issuance of Regulatory Guide (R.G.) 1.102, flood protection provisions at those sites susceptible to flooding often include many provisions requiring emergency actions to provide external water barriers. With the advent of R.G. 1.102, hardened protection has been the staff goal such that water barriers are permanently in place. Based upon this history, designs and costs of providing flood protection vary considerably from site to site.

It is well known that the recommendations made by the Federal agencies listed above include factors of safety carefully prescribed for all and every type of hydraulic and protective structure on rivers and for most types of coastal structures. These factors of safety must be assessed and their probabilistic significance determined, if possible.

To assess the overall risk, it has been consistently concluded that a plant accommodating a design basis flood condition (which could be caused by a severe precipitation, dam failure, hurricane, wave action, or seismically induced event) is adequate. No detailed assessment has been made of the overall risk of a severe flood for which either flood protection is inadequate, or for the likelihood and consequences of a failure of design flood protection. Both of these situations should be assessed to assure that (1) flood protection requirements are adequate, and (2) residual risks are appropriately minimized.

SCOPE OF WORK

Several plants will be selected and the main elements of this study are: A. Probabilities of Exceedance of Flood Levels, B. Probabilities of Failure of Protective Structures, and C. Probabilities of Radioactive Release.

A. Probabilities of Exceedance of Flood Levels

All sources of flooding will be considered depending on the site location:

(1) river floods by meteorological causes

(2) surges and waves

(3) seiches

(4) tsunami

(5) site drainage failure

(6) failure of water control structures

Plants will be selected in consultation with the NRC so that river sites, coastal sites, Great Lake sites and elevated sites are included in the study. Attempts to improve probabilistic methodology may be undertaken, but the bulk of this research will be performed on the basis of existing and proven methods. Design basis floods estimated from deterministic considerations should be compared to the probabilistically determined levels. For coastal sites a feasibility study is currently being performed by the Waterways Experiment Station (WES) of the U.S. Army Corps of Engineers. Upon completion of this study, methods will be available to improve coastal flooding statistics utilizing numerical modeling based on observed meteorological data. However, proposals based on other innovative approaches will also be considered. Elevated sites are those that are not likely to be affected by surface water bodies. However, the likelihood of inundation of these sites depend on the amount of "point precipitation" and malfunction of the site drainage system for the plant. These conditions should be studied.

The generic aspects of the methods of flood hazard estimates at selected sites should be extended to other parts of the U. S. territory for facilitating the review of future plant sites. For example, geographic distribution can be established for the statistical parameters of flood series or return periods can be established for various flood levels for coastal and great lake regions.

B. Probabilities of Failure of Protective Structures

Upon establishing water levels affecting the power plant sites and other water generated action on the plants, the protective structures will be studied by the following steps.

(1) A survey of existing protective works will be necessary for nuclear power plants at riverine, coastal and the Great Lake sites. Riverine, coastal and the Great Lakes nuclear power plants will be listed and categorized by technical features. A provision for offshore nuclear power plant developments will be considered.

(2) Protective structures will be typified according to R.G. 1.102.

(3) Mode of failures will be established for each type of protective structure by analysis using established methods in hydraulic and coastal engineering. The mode of failure of hydraulic and coastal structures are generally known from established practice.

(4) Upon establishing the mode of failure of the structures above, the failure conditions will be established; i.e., the water levels necessary to break, overturn, or slide the protective and dam structures at each power plant site.

(5) With the input of probability of occurrence of water levels from the hydrologic and oceanographic study, the probability of failures of protective structures will be studied at each power plant site. The probability analysis of failures is complex. The methods of analysis are not always well defined. Consequently, this portion of research may require considerable efforts.

C. Probabilities of Radioactive Release

Upon establishing the mode and probability of failure of protective works (structures), a scenario of water penetration into the perimeter of the nuclear power plant will be established.

(1) The time lag between occurrence of failure of the protective structures and occurrence of penetration of water into the plant building will be taken into account because gradual penetration (with a time lag) produces much less risk of damage than the impact of sudden penetration of water.

(1) See next page

(2) Upon breaching of the Class I safety buildings by water, scenarios will be established for water affecting the interior of the plants. Following these scenarios, pertinent probabilistic methodology will be used for analyzing probability of failures of the internal systems (mechanical equipment and reactors).

(1) ~~(3)~~ Selection of plant and procurement of design and location information will be made with the consultation with the NRC staff.

(4) Construction of event trees for dominant accident sequences, and significant systems will be performed following the procedures and methods established from studies currently being performed by the NRC.

identify/provide reference

(5) Failure modes will be established and their effects on systems and components will be analyzed.

(6) Construction of system fault trees containing susceptible and/or dominant components with failure description will be made.

(7) Evaluation of probabilities of systems failure and of accident sequence occurrences for selected flood conditions will be made.

It is not clear what portion of "Scope of Work" will give these results.

EXPECTED RESULTS

The results of this study will provide two general categories of information: (1) assessment of uncertainties associated with the application of probabilistic methods for predicting severe flooding events, and (2) the residual risk associated with the present flood protection requirements.

Relationship between above and the 4 following is not clear

Assessment of the long-term representativeness of stream, lake and coastal flood records with particular emphasis on causative mechanisms (including hurricanes, large-scale tropical storms and thundershowers).

Identification of acceptable methodology (or methodologies) for selecting confidence limits that (1) minimize residual risks in extreme event magnitude evaluation at design levels of $10^{-6}$ to $10^{-7}$ per year, and (2) minimize the uncertainty in probability estimates at the same design levels. This will also apply to situations where individual components of flood events are used to assess the flood probability instead of a single event.

Assessment of the likelihood of flood protection system not performing its required function and the resulting potential consequences.

Comprehensive probabilistic analyses to provide the basis for (1) maintaining the present level of flood evaluation and protection requirements, (2) requiring less protection, or (3) requiring more protection and changing present evaluation methodologies.