U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.4.8 COOLING WATER CANALS AND RESERVOIRS

REVIEW RESPONSIBILITY

Primary - Hydrologic & Geotechnical Engineering Branch (HGEB)

Secondary - None

I. AREAS OF REVIEW

This section of the applicant's safety analysis report (SAR) presents the basis for the hydraulic design of canals and reservoirs used to transport and impound plant cooling water. In addition, the hydraulic design basis for protection of structures (e.g., riprap) is reviewed. For canals, the areas of review include the design basis for capacity, protection against wind waves, erosion, sedimentation buildup, and freeboard, and (where applicable) the ability to withstand a Probable Maximum Flood (PMF), surges, etc. For reservoirs, the areas of review include the design basis for capacity, PMF design basis, wind wave and runup protection, discharge facilities (low level outlet, spillway, etc.), outlet protection, freeboard, and erosion and sedimentation processes.

II. ACCEPTANCE CRITERIA

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

1. 10 CFR Part 50, §50.55a requires structures, systems, and components to be designed and constructed to quality standards commensurate with the importance of the safety function to be performed.

2. General Design Criterion 2 (GDC 2) requires structures, systems, and components important to safety to be designed to withstand the effects of floods.

3. General Design Criterion 44 (GDC 44) requires an ultimate heat sink capable of accepting the plant's heat load under normal and accident conditions.

4. 10 CFR Part 100 requires that hydrologic characteristics be considered in the evaluation of the site.

To meet the requirements of 10 CFR Part 50, §50.55a, GDC 2, GDC 44, and 10 CFR Part 100 as they relate to cooling water canals and reservoirs, the following specific criteria are used:

1. The acceptance criteria for the protection of cooling water canals from wind waves, PMF, surges, etc., are the same as those outlined in SRP Sections 2.4.3, 2.4.4, 2.4.5, 2.4.6, and 2.4.7. The criterion for canal capacity is that the canal must be capable of transmitting to the plant sufficient water to meet all safety requirements during postulated extreme hydrologic events (i.e., both floods and droughts). Where canals comprise a part of the ultimate heat sink, Regulatory Guide 1.27 is used as a basis for the adequacy of design criteria and provisions. The design basis for canal capacity is analyzed to assure that safety-related water requirements can be supplied under all postulated extreme hydrologic events, or that alternative conveyance systems are designed to be available during the postulated conditions.

2. The acceptance criteria for the hydraulic design of dams and reservoirs are as follows:

   a. For protection of structures against wind waves, input from SAR Sections 2.4.3, 2.4.4, 2.4.5, and 2.4.6 for PMF, Probable Maximum Hurricane (PMH), other dam failures, surge, seiche, or tsunami levels and coincident waves and runup must be considered to establish the maximum and minimum water level and wave conditions. Also, normal pool level and coincident probable maximum wind-wave activity must be considered. Criteria and methods as reported in Corps of Engineers publications are generally acceptable for design of embankment protection (riprap, grass, soil cement, tetrapods, dolosse, etc.) and freeboard.

   b. For protection of structures from ice effects such as extreme forces on structures and components, ice blockages of spillways, and interruption of cooling water supply, input from SAR Section 2.4.7 is considered.

   c. For emergency storage evacuation, the spillways are acceptable if they can safely pass the PMF, or controlling design basis flood, with antecedent or coincident conditions as discussed in Regulatory Guide 1.59, without endangering safety-related facilities or increasing the hazard to downstream residents. Model tests may be required for unusual spillway designs. Regulatory Guide 1.125 provides guidance in the use and evaluation of physical models. In addition, a low level outlet may be necessary to evacuate the storage in an emergency.

   d. For reservoir routings, the maximum still water level is acceptable if the spillway design flood has been routed through the spillway (and outlet works, if applicable) using standard methods as suggested by the Corps of Engineers, USBR, and others, and a minimum of three feet of freeboard (including waves) is available. However, the antecedent reservoir level to be used with the flood routing must be at least as high as that suggested by Regulatory Guide 1.59.

e. The probable minimum low water level is acceptable if the flow during the design basis drought (from SAR Section 2.4.11) has been routed through the reservoir[1] using standard methods as suggested by the Corps of Engineers, USBR, and others. The antecedent reservoir level for this routing, if reservoir storage is the sole water supply source, must be the lowest reasonably possible, considering regional conditions at the beginning of the drought and water demands, including plant requirements. In no case should the antecedent reservoir level be greater than the established normal operating level.

f. Where not covered above, the hydraulic design for the low level outlets, conduits, spillways (gated and ungated, regulating and emergency), and embankment protection is required where the failure of such items could constitute a threat to essential plant facilities or to safety-related water supplies. The design is acceptable if standard techniques have been used as suggested by the Corps of Engineers, USBR, and others such that the minimum design water level for safety-related pumps would not be violated.

g. If reservoirs comprise a part of the ultimate heat sink, Regulatory Guide 1.27 is used as a basis for judging the adequacy of the design criteria and provisions.

3. Applicable portions of the following documents are to be used to determine the acceptability of the applicant's data and analyses. Regulatory Guide 1.59 discusses the design basis for flooding. 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. Regulatory Guide 1.27 describes design criteria and provisions which the ultimate heat sink must meet. Regulatory Guide 1.125 provides guidance on the use of physical models of hydraulic structures. Publications of the Corps of Engineers and USBR provide guidance for canal and reservoir design criteria. SRP Sections 2.4.3 through 2.4.7 provide basic hydrologic data for analyzing the hydraulic design of canals and reservoirs.

III. REVIEW PROCEDURES

The conservatism of the applicant's design basis is judged against the criteria indicated above. SAR Sections 2.4.3, 2.4.4, 2.4.5, 2.4.6, and 2.4.7 should provide the basic data for analyzing the high flow hydraulic design basis of the facility. The applicant's hydraulic design basis is judged against standard design practices discussed in Corps of Engineers (Waterway Experiment Station) or USBR publications. Low flow input data are taken from SAR Section 2.4.11. The review procedures consist of independently "designing" (hydrologically and hydraulically) the applicant's facilities (e.g., dams, canals, spillways) using the above methods and comparing the resultant "design" with

[1]For those plants proposing multiple reservoirs for water supply, analyses must be provided to assure that storage allocated for safety-related water supply in alternate reservoirs will be available during postulated drought conditions. Additionally, evidence of the right to use the water consumptively must be documented.

the applicant's. Wave and runup protection is evaluated using the methods of References 24 and 25. Subsequently, the staff will develop a position based on the analyses; resolve, if possible, differences between the applicant's and staff's design bases; and prepare the SER input accordingly.

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

IV. EVALUATION FINDINGS

For construction permit (CP) reviews, the findings will consist of a statement of the applicant and staff estimates of the type and adequacy of required structure protection and the hydraulic design basis of canals and reservoirs.

Because of the advanced design required for the CP and where the design has received a detailed review at the CP stage, the operating license (OL) findings will only be an acknowledgement of any changes and a statement of acceptability. If a design or flooding potential was not reviewed in detail at the CP stage, it will be done at the OL stage.

Sample statements from CP reviews follow:

> The staff concludes that the auxiliary and main dams meet the requirements of 10 CFR Part 50, §50.55a and General Design Criterion 2 with respect to hydrologic and hydraulic design and are therefore acceptable. This is based on the following evaluation.
>
> Although postulated flood waters are not expected to reach plant grade, protection of the essential auxiliary and main dams against their respective probable maximum floods is to be provided by riprap protection of exposed embankment surfaces (including areas in the plant site vicinity along the auxiliary reservoir intake channel) and concrete overflow spillways. At our request, the applicant provided design bases for riprap protection and the hydraulic design criteria for the two spillways. The applicant at our request, in Amendment No. 31 to the PSAR, provided criteria for the windwave riprap protection based upon an empirical relationship for the median size stone to be placed in a blanket approximately two feet thick and indicated its specifications for stone gradation. A filter blanket approximately one foot thick is to be placed under the riprap to prevent piping (removal of smaller material) through the larger armor riprap cover layer. Criteria were provided for the filter gradation, angularity, durability of the riprap, and placement which provides assurance that erosive failure of safety-related embankments should not occur. An armor protection layer also is provided. We find these riprap design bases and spillway hydraulic design criteria to be acceptable.
>
> The staff concludes that the hydrologic aspects of the design of the reservoir system meets the requirements of General Design Criterion 44 and 10 CFR Part 100 and is therefore acceptable. This conclusion is based on the following evaluation.

Storage in the three reservoir system, runoff from the contributing drainage area, and diversion of A River flows to the main reservoir during periods of low runoff and high reservoir evaporation will constitute the water supply for the four-unit once-through cooling systems.

The applicant has provided analyses of the capability of the main and auxiliary reservoirs to supply water during emergency conditions requiring emergency shutdown and cooldown of one unit and the simultaneous normal shutdown and cooldown of the remaining three units as suggested in Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants." In addition, the applicant has provided analyses of the operation of the plant and the main reservoir under historical and a synthesized 100-year drought condition. For the shutdown conditions, the applicant has demonstrated that the two reservoir-A River diversion system constituting the ultimate heat sink would have a water supply available in excess of 30 days in the auxiliary reservoir if water were not available from the main reservoir-auxiliary reservoir-A River diversion facilities. The operation of the sink as a whole will require that the auxiliary reservoir be kept at its normal operating level of elevation 250 feet MSL at all times by pumping water from the main reservoir to make up for water lost to normal evaporation.

For the analyses of evaporation under normal plant operation during periods of assumed recurrence of historical droughts, the applicant has used historical flow records for the A River and synthesized flow data for the drainage area contiguous to the reservoir system. For the analysis of evaporation during a more extreme drought than has occurred historically, the applicant has synthesized flows from both the A River and the contiguous drainage areas for what is called a 100-year frequency drought. The staff, in consonance with our consultant (the U.S. Geological Survey), independently developed and analyzed synthesized flows from both drainage areas. We concluded that it is likely that flows from both areas could be substantially less than estimated by the applicant. The applicant is installing a streamflow gage near the plant to determine runoff characteristics from the contiguous drainage which should allow more accurate analysis of the operating capability of the reservoir system prior to plant operation. Inaccuracies in estimation of runoff are considered to be only indirectly safety related since an adequate shutdown and cooldown water supply will be available in the auxiliary reservoir should evaporation and the lack of runoff prevent replenishment of main reservoir storage above the minimum operating level of elevation 244 feet MSL.

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

1. 10 CFR Part 50, §50.55a, "Codes and Standards."

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

3. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water."

4. 10 CFR Part 100, "Reactor Site Criteria."

5. Am. Soc. Civil Engineers, "Hydraulic Models," Manual of Engineering Practice No. 25 (1963).

6. Leo R. Beard, "Flood Control Operation of Reservoirs," Jour. Hydraulic Division, Proc. Am. Soc. Civil Engineers, Vol. 88, No. HYI, pp. 1-25 (1963).

7. Leo R. Beard, "Methods for Determination of Safe Yield and Compensation Water from Storage," Seventh International Water Supply Conference, Barcelona, Spain (1966).

8. E. F. Brater and H. W. King, "Handbook of Hydraulics for the Solution of Hydrostatic and Fluid-Flow Problems," McGraw-Hill Book Company, New York (1963).

9. V. T. Chow (ed), "Handbook of Applied Hydrology," McGraw-Hill Book Company, New York (1964).

10. V. T. Chow (ed), "Open Channel Hydraulics," McGraw-Hill Book Company, New York (1959).

11. C. V. Davis (ed), "Handbook of Applied Hydraulics," McGraw-Hill Book Company, New York (1964).

12. G. W. Fair, J. C. Geyer, and D. A. Okien, "Water Supply and Waste Water Removal," John Wiley & Son, Inc., New York (1966).

13. G. A. Hathaway, "Determination of Spillway Requirements for High Dams," Proc. Fourth International Conference on Large Dams, New Delhi, Vol. 2, pp. 301-347 (1951).

14. H. W. King and E. F. Brater, "Handbood of Hydraulics," McGraw-Hill Book Company, New York (1963).

15. R. K. Linsley and J. B. Franzini, "Water-Resources Engineering," McGraw-Hill Book Company, New York (1964).

16. H. Rouse (ed), "Engineering Hydraulics," John Wiley & Son, Inc., New York (1951).

17. "Hydraulic Design Criteria," prepared by the Corps of Engineers Waterways Experiment Station, loose-leaf by serials.

18. "Hydraulic Design of Flood Control Channels," Engineer Manual 1110-2-1601, Corps of Engineers, July 1970.

19. Hydraulic Design of Spillways," Engineer Manual 1110-2-1603, Corps of Engineers, March 1965

20. "Hydraulic Tables," Corps of Engineers (1944).

21. "Hydrologic Engineering Methods for Water Resources Development," Volumes 1 through 12, Corps of Engineers Hydrologic Engineering Center, Davis, California (1971).

22. "Reservoir Regulation," Engineer Manual 1110-2-3600, Corps of Engineers, May 1959.

23. "Reservoir Storage-Yield Procedures," Corps of Engineers Hydrologic Engineering Center, Davis, CA (1967).

24. "Shore Protection Manual," Technical Report No. 4, Third Edition, Corps of Engineers Coastal Engineering Research Center (1966).

25. "Shore Protection Manual," Corps of Engineers Coastal Engineering Research Center (1977).

26. Hydraulic Model Studies of the Corps of Engineers Waterways Experiment Station.[2]

27. "Design of Small Dams," Second Edition, Bureau of Reclamation, U.S. Department of the Interior (1973).

28. "Design Standards No. 3, Canals and Related Structures," Chapter 2 of "General Design Information for Structures," Bureau of Reclamation, U.S. Department of the Interior, April 1962.

29. "Hydraulic Model Studies"[2] of the Bureau of Reclamation, U.S. Department of the Interior.

30. "Hydraulic Model Studies"[2] of the Dept. of Water Resources, State of California.

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

[2]A series of such studies exists in the literature too numerous to mention here. In addition to the three specifically cited series, studies by others will be utilized on an "as-available" basis.

32. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."

33. Regulatory Guide 1.59, "Flood Design Basis for Nuclear Power Plants."

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

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

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

37. ETL 1110-2-221, "Wave Runup and Wind Setup on Reservoir Embankments," Department of the Army, Corps of Engineers, November 29, 1976.

38. Regulatory Guide 1.125, "Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants."