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

SECTION 2.4.11 LOW WATER CONSIDERATIONS

REVIEW RESPONSIBILITIES

Primary - Site Analysis Branch (SAB)

Secondary - None

I. AREAS OF REVIEW

The purpose of this section of the applicant's safety analysis report (SAR) is to identify natural events that may reduce or limit the available cooling water supply, and to assure that an adequate water supply will exist to operate or shut down the plant, as required.

Depending on the site, the areas of review include:

1. The worst drought considered reasonably possible in the region.
2. Low water (setdown) resulting from surges, seiches, or tsunamis.
3. The effect of existing and proposed water control structures (dams, diversions, siltation, dam failures, etc.).
4. The intake structure and pump design basis in relation to the events described in SAR Sections 2.4.11.1, 2.4.11.2 and 2.4.11.4, and historical low water conditions.
5. The use limitations imposed or under discussion by federal, state, or local agencies authorizing the use of the water.
6. The range of water supply required by the plant, including minimum operating and shutdown flows, compared to availability.

II. ACCEPTANCE CRITERIA

Acceptance is based principally on the adequacy of the intake design basis for safe shutdown, cooldown (first 30 days), and long-term cooldown (periods in excess of 30 days) in the event of adverse natural phenomena or plant accidents. Where the specific design bases preclude plant operation during severe hydrologically-related events, sufficient warning time must be demonstrated so that the plant may be shut down during or in advance of adverse events without causing potential damage to safety-related facilities. In cases where sufficient warning time to permit advance shutdown is considered necessary to protect safety-related components, an item in the plant Technical Specifications will be required.

SAR Section 2.4.11.1 (Low Flow in Rivers and Streams): for essential water supplies the low flow/low level design for the primary water supply source must be based on the probable minimum low flow and level resulting from the most severe drought that can reasonably be considered possible for the region. The low flow and level design bases for operation (if different than the design bases for essential water requirements) should be such that shutdowns caused by inadequate water supply will not cause frequent use of emergency systems. In cases where a common source of cooling water for operation and safety is provided, and where operation can affect minimum levels required for safety, the system will be acceptable if technical specifications are provided for shutdown before the ultimate heat sink can be adversely affected.

SAR Section 2.4.11.2 (Low Water Resulting from Surges, Seiches or Tsunamis): if the site is susceptible to such phenomena, minimum water levels resulting from setdown (sometimes called runout or rundown) from hurricane surges, seiches, and tsunamis must be higher than the intake design basis for essential water supplies. For coastal sites, the appropriate probable maximum hurricane (PMH) wind fields must be postulated to give maximum winds blowing offshore, thus creating a probable minimum surge level. Low water levels on inland ponds, lakes, and rivers due to surges must be estimated from probable maximum winds oriented away from the plant site. The same general analysis methods discussed in Standard Review Plans 2.4.3, 2.4.5 and 2.4.6 are applicable to low water estimates due to the various phenomena discussed.

SAR Section 2.4.11.3 (Historical Low Water): if historical flows and levels are used to estimate design values by inference from frequency distribution plots, the data used must be presented so that an independent determination can be made. The data and methods of the National Oceanic and Atmospheric Administration, United States Geologic Survey, Soil Conservation Service, Bureau of Reclamation and the Corps of Engineers are acceptable.

SAR Section 2.4.11.4 (Future Controls): this section is acceptable if water use and discharge limitations (both physical and legal), already in effect or under discussion by responsible federal, regional, state, or local authorities, that may affect water supply at the plant have been considered and are substantiated by reference to reports of the appropriate agencies. The most adverse possible effects of these controls must be shown and taken into account in the design basis to assure that essential water supplies are not likely to be affected adversely in the future.

SAR Section 2.4.11.5 (Plant Requirements): acceptance is based on the following required information:

1. Minimum essential cooling water flow rates and levels must be presented (or cross-referenced) and shown to be less than the probable minimum low flows and levels from the applicable sources of supply.
2. Maximum water requirements for normal operation must be presented and (if applicable) shown to be less than the water available under all likely conditions from the sources of supply.

SAR Section 2.4.11.6 (Heat Sink Dependability Requirements): the required data and information are those necessary to determine that the facility meets the criteria of Regulatory Guide 1.27. The analyses will be considered complete and acceptable if the following are adequately addressed:

1. The initial water inventory must be sufficient for shutdown and cooldown of the plant.
2. Water losses (such as seepage, drift, and evaporation) must be conservatively estimated, as suggested in Revision 1 to Regulatory Guide 1.27.
3. The design basis hydrometeorology (temperature, dewpoint, etc.) must be as conservative as the criteria of the guide (see Standard Review Plans 2.3).
4. The limit on the heat sink return water temperature must be less than the maximum allowable cooling water inlet design temperature.

III. REVIEW PROCEDURES

Minimum plant requirements (water level and flow) that are identified in SAR Sections 2.4.11.5 or 9.2.5 are compared to the estimated minimum water levels and flows given in Section 2.4.11.1. If normal operation is not assured at the minimum water supply conditions, and loss of normal operation capability can adversely affect safety-related components, estimates of warning time are reviewed to assure that shutdown or conversion to alternate water sources can be accomplished prior to the trip. For such cases, emergency operating procedures are required, and are reviewed to assure that they are consistent with the postulated conditions. The analysis of the dependability of the ultimate heat sink is reviewed and the conclusions are provided to the Auxiliary and Power Conversion Systems Branch (APCSB). Determination of the dependability of the ultimate heat sink is accomplished by using Revision 1 of Regulatory Guide 1.27 as a standard of comparison.

Each source of water for normal or emergency shutdown and cooldown, and the natural phenomena and site-related accident design criteria for each should be identified. A systems analysis is first undertaken of all water supply sources to determine the likelihood that at least one source would survive (1) the most severe of each of the natural phenomena; (2) site-related accident phenomena; and (3) reasonable combinations of less severe natural and accident phenomena. Second, arbitrarily assumed mechanistic failures of water supply structures and conveyance systems are postulated and the systems analysis repeated, to assure that the failure of one component will not cause failure of the entire system. These analyses are coordinated with the APCSB review of the ultimate heat sink and related cooling systems, to avoid duplication. Operating rules for each portion of the system are ascertained to determine the amount of water that can be assumed available in the event of normal or accidental shutdown. Consultations with the Meteorology and the Seismology, Geology, and Foundation Engineering Sections of SAB, and with Accident Analysis Branch, Structural Engineering Branch, and APCSB are undertaken where design criteria are not firmly established.

Estimates of water loss due to drift, evaporation, and blowdown are evaluated based on observed severe hydrometeorological measurements at similar locations (coordinated with the Meteorology Section of SAB). If independent analyses are deemed necessary, computer programs such as HEC-2 (Water Surface Profiles), HEC-3 (Reservoir System Analysis) HEC-4 (Monthly Streamflow Simulation), etc. are utilized.

The potential for surges in intake sumps that could cause adverse effects are reviewed to assure that the effects have been properly incorporated for the intake design. The potential for adverse hydrodynamic effects of a trip of the intake pumps is evaluated based on potential surges in intake sumps.

For multiple purpose (normal operation, normal shutdown, and emergency shutdown) water supply systems, the primary portion of the system is first reviewed to determine that the water supply will be maintained at minimum volume requirements at all times. The secondary portion of the system is then reviewed to determine whether an adequate emergency water supply can be expected to be available during operating conditions such as the regional drought of record (flows must be adjusted for historical and potential future effects). If not, the applicant is requested to provide a technical specification requiring plant shutdown at the point where an adequate shutdown water supply is still assured.

Institutional restraints on water use, such as limitations in water use and discharge permits, are reviewed to assure the plant will have an adequate supply and not exceed limitations imposed upon operation. If a conflict is foreseen, the applicant is requested to either obtain a variance or make a design change to accommodate the limitation.

For plants using rivers, minimum design service water levels are compared with asymtotic extrapolations of low flow frequency curves which have been corrected for historical and potential future effects. For ocean or estuary plants, design low water levels are compared with probable maximum hurricane and tsunami-induced low water levels. For Great Lakes plants, design low water levels are compared with minimum historical levels coincident with probable maximum surge or seiche-induced low water levels.

If the ultimate heat sink system is not capable of continued long-term water supply under the criteria in Revision 1 to Regulatory Guide 1.27, or the above considerations, the system will be reviewed in two parts; short-term capability and long-term capability. For short-term capability, the APCSB and the Licensing Project Manager (LPM) will be informed if the independently-estimated supply appears to be less than 30 days. The applicant will be asked to determine whether sufficient personnel and equipment can safely be made available to switch water supply sources in the event of an accident. If emergency procedures are required to obtain the use of alternate water supplies, the applicant's water supply sources and procedures will be reviewed with APCSB and the LPM to determine that there is continuity of water supply. The time period for which a highly dependable water supply would be available is compared with the time required to obtain water from an alternative supply, and the natural or accident environmental conditions which could prevail.

For long-term water supply capability, different sources and means of obtaining water may be required because of the limited capability of a "short-term" supply. In those cases where different sources are necessary to assure the long-term plant heat removal capability, the alternative sources and the means of supplying water from the sources to the plant should be identified. Any plant design provisions necessary for such situations should also be described or a reference provided to other SAR sections for the descriptions.

Emergency means for obtaining long-term water supplies will be judged on the basis of the time required to obtain such supplies, natural or accident phenomena likely to prevail or to have caused the need for such supplies, and the dependability of the supply itself.

IV. EVALUATION FINDINGS

For construction permit (CP) reviews the findings will consist of a statement of the applicant and staff estimates of the design basis minimum water flows and levels. If the estimates are similar, staff concurrence in the applicant's estimate will be stated. If the staff estimates substantially lower water levels or flows, and if the proposed plant may be adversely affected, a statement of the staff position (bases) will be made. A similar finding on the design bases for the ultimate heat sink will be made. If technical specification requirements are needed to assure an adequate supply, they will be indicated in the CP statement and required for operation.

For operating license (OL) reviews of plants for which detailed low water reviews were done at the CP stage, the CP conclusions will be referenced. In addition, the results of a review to reaffirm the low water design bases will be noted. If no changes have been made to the ultimate heat sink design since the CP review, the conclusions of the CP will be referenced. However, for both the low water considerations and the ultimate heat sink, an evaluation will be made during the OL review to assure that the design bases have been properly implemented. The availability of long-term water supply will be noted. If no low water and ultimate heat sink review was undertaken at the CP stage (of the scope described), this fact will be noted also.

A sample CP-stage statement follows:

> "The applicant proposes two sources of water supply; groundwater and the adjacent A River.
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> "Groundwater would be used for make-up to the essential service water cooling towers, for potable water supply, and for demineralizer water. The applicant estimates the demineralizer would require about 825 gallons per minute (gpm) for the first several months and an average rate of 425 gpm thereafter. Potable water requirements are estimated at about 10 gpm.
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> "The A River is to provide the principal source of cooling water. The applicant estimates the maximum water requirement for the plant will be 107 cfs. Of this, 61 cfs would be consumptively used and 46 cfs would be returned to the Rock River. The historical recorded low flow in the A River in the site region was about 500 cfs at the B gage on September 14, 1958 and about 440 cfs at the C gage on August 20, 1934. The applicant estimates the comparable low flow at the site to be 400 cfs. Assuming breaching of D Dam five miles downstream, the low flow would result in an estimated water surface elevation of 664 ft MSL.
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> "Emergency cooling sources and associated principal facilities comprise the A River, groundwater, the river screenhouse, the essential service cooling towers, groundwater well(s) and attendant distribution systems. The river screenhouse is to

be a seismic Category I facility and was initially proposed to be protected from flooding up to the Standard Project Flood (SMF). Groundwater wells, located at the plant site, are above estimated PMF water levels. The applicant proposes to use groundwater for make-up to the essential service towers whenever the A River, screenhouse, or piping is unavailable. Estimated groundwater use would be 1600 gpm. At the staff's request the applicant reconsidered the flood design basis for the river screenhouse for relatively long periods of time when the A River could be higher than a SPF and an earthquake could prevent water from being available from wells. The applicant subsequently upgraded the flood design basis for the screenhouse to a Probable Maximum Flood, and concludes the proposed facilities meet the suggested criteria of Regulatory Guide 1.27 - Ultimate Heat Sink. We concur.

V. REFERENCES

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22. "Reservoir System Analysis", HEC-3, Corps of Engineers Hydrologic Engineering Center (updated).

23. "Monthly Streamflow Simulation", HEC-4, Corps of Engineers Hydrologic Engineering Center (updated).

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