U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

2.4.12 GROUNDWATER

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of issues related to hydrology

Secondary - None

I. AREAS OF REVIEW

This section of the Design-Specific Review Standard (DSRS) provides guidance for the staff's review of the effects of groundwater on subsurface safety-related or risk-significant structures, systems, and components (SSCs), and of the reliability of groundwater supply and dewatering systems required for safety-related or risk-significant functions.

This section is part of Chapter 2 of the DSRS, which discusses the site characteristics that could affect the safe design and siting of a plant. The U.S. Nuclear Regulatory Commission (NRC) staff reviews information presented by the applicant for a design certification (DC), early site permit (ESP), or combined license (COL) concerning the hydrological setting of the site as it relates to safety-related or risk-significant SSCs. This DSRS section applies to reviews performed for each of these types of applications. These reviews are based on information and analysis presented in the applicant's final safety analysis report (FSAR). The staff's review and findings are described in the appropriate section of the final safety evaluation report (FSER).

The specific areas of review are as follows:

1. Local and Regional Groundwater Characteristics and Use: The staff reviews identification of aquifers and confining units, types and rates of onsite and offsite groundwater use (both present and likely future), sources of recharge, flow rates, travel time, gradients, other properties that affect movement of accidental contaminants in groundwater, groundwater levels and subsurface hydraulic heads[1] beneath the site, seasonal and climatic fluctuations, monitoring and protection requirements, and man-made changes that have the potential to cause long-term changes in the local groundwater regime.

2. Effects on Subsurface Safety-Related or Risk-Significant Structures, Systems, and Components: The staff reviews the information required to evaluate potential adverse effects of hydraulic heads, groundwater flow, other hydrostatic or hydrodynamic

[1] "Groundwater level," as used in this section, refers to the elevation of the water table. "Subsurface hydraulic head" refers to the hydraulic head at locations below the water table. This may be greater or less than the water table elevation, depending on the vertical component of groundwater flow, the presence of confining beds, and other factors. This distinction may be significant for deep structures, which can experience greater or smaller hydraulic head near their bases than would be indicated by the groundwater level.

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characteristics of groundwater, and groundwater quality on design bases of foundations and other elements of safety-related or risk-significant SSCs. For sites located in the permafrost region the review includes information on freezing, thawing, subsurface thermal gradients and impacts of gas hydrates on groundwater flow, pathways, and safety of SSCs.

3. Reliability of Groundwater Resources and Safety-Related or Risk-Significant Systems: The staff reviews the reliability of groundwater resources and related systems used to supply water required for safety-related or risk-significant SSCs.

4. Reliability of Dewatering Systems: The staff reviews the reliability of dewatering systems to maintain groundwater conditions within the plant's design bases.

5. Consideration of Other Site-Related Evaluation Criteria: The staff reviews potential effects of seismic and non-seismic information on the postulated worst-case groundwater conditions for the proposed plant site. This includes the potential effects of seismically-induced land subsidence, potential seismic effects on subsurface hydraulic heads, and the potential effects of the design basis flood on groundwater levels.

6. Additional Information for Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52 Applications: Additional information will be presented dependent on the type of application. For a COL application, the additional information is dependent on whether the application references an ESP, a DC, both, or neither. Information requirements are prescribed within the Contents of Application sections of the applicable Subparts to 10 CFR Part 52.

Review Interfaces

Other DSRS and standard review plan (SRP) sections interface with this section as follows:

1. The review to ensure that adverse environmental conditions, including those from groundwater, will not preclude the safety function of the ultimate heat sink is performed under DSRS Section 9.2.5, "Ultimate Heat Sink".

2. Regional and local groundwater characteristics and subsurface properties are used to determine the bounding set of pathways that result in critical impact to ground and surface water resources in DSRS Section 2.4.13, "Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters".

3. The design basis flood site characteristic in DSRS Section 2.4 "Hydrology Review" is used to determine the potential for effects of surface flooding on groundwater level.

4 The identification of safety-related or risk-significant structures and equipment that must be protected against the effects of internal flooding, including flooding from groundwater seepage, is performed under DSRS Section 3.4.1, "Internal Flood Protection for Onsite Equipment Failure."

5. Maximum groundwater levels and subsurface heads are used in the review of the subsurface hydrostatic and hydrodynamic forces exerted by groundwater on safety-related or risk-significant SSCs, performed under DSRS Section 3.4.2, "Analysis Procedures".

6. The review of subsurface concrete structures as performed under DSRS Section 3.8.1, "Concrete Containment" and Section 3.8.5, "Foundations" considers the effect of groundwater chemistry and requires information on site groundwater quality and maximum groundwater elevation.

7. Geologic information on subsurface conditions that influence groundwater movement is reviewed under SRP Section 2.5.1, "Basic Geologic and Seismic Information.

8. Information on rock and soil properties that influence groundwater movement is reviewed under SRP Section 2.5.4, "Stability of Subsurface Materials and Foundations."

9. For DC applications and COL applications referencing a DC rule or DC application, review of the site parameters in the Design Control Document (DCD) Tier 1 and Chapter 2 of the DCD Tier 2 submitted by the applicant is performed under SRP Section 2.0, "Site Characteristics and Site Parameters". Review of site characteristics and site-related design parameters in ESP applications or in COL applications referencing an ESP is also performed under SRP Section 2.0.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. 10 CFR 50.55(e)(4)(i) and (ii) as it relates to the requirement that any designated license or permit holder who obtains information reasonably indicating that the facility fails to comply with the Atomic Energy Act, as amended, or any applicable regulation, order, or license of the Commission relating to a substantial safety hazard, or who obtains information reasonably indicating the existence of a defect related to construction must notify the Commission.

2. 10 CFR 50.55(a), as it relates to the requirement that SSCs must be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed.

3. 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirements to consider physical site characteristics in site evaluations are specified in 10 CFR 100.20(c).

4. 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

5. 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 2 as it relates to consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

6. 10 CFR Part 50, Appendix A, GDC 4 as it relates to the requirement that SSCs important to safety be designed to accommodate the effects of (and be compatible with) environmental conditions associated with normal operation, maintenance, testing, and postulated accidents (e.g., loss-of-coolant accidents and dynamic effects, including pipe

whip, missiles, and discharging fluids), that may result from equipment failures and from events and conditions outside the nuclear power unit.

7. 10 CFR Part 50, Appendix A, GDC 5 as it relates to the requirement that nuclear power units do not share SSCs important to safety unless it can be shown that such sharing will not impair their ability to perform required safety functions.

8. 10 CFR 50, Appendix A, GDC 44 as it relates to providing an ultimate heat sink for normal operating and accident conditions.

9. 10 CFR 52.17(a)(1)(vi), for ESP applications, and 10 CFR 52.79(a)(1)(iii), for COL applications, as they relate to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

10. 10 CFR 20.1406, as it relates to minimizing contamination of the subsurface environment.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR 52.17(a)(1)(xii) and 10 CFR 52.79(a)(41), for ESP and COL applications, respectively.

1. Local and Regional Groundwater Characteristics and Use: To meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, GDC 2, GDC 4, GDC 5, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), 10 CFR 100.20(c), and 10 CFR 20.1406, a complete description is needed of regional and local groundwater aquifers and confining units, sources, and sinks, local and regional groundwater use, present and known and likely future withdrawals, regional flow rates, travel time, gradients, and velocities, subsurface properties that affect movement of contaminants in the groundwater, subsurface hydraulic heads including their seasonal and climatic fluctuations, groundwater monitoring and protection requirements, and any man-made changes with a potential to affect regional groundwater characteristics over a long period of time. This description should be sufficient to define local and regional groundwater characteristics and groundwater use at and near the site under both pre-construction and post-construction conditions.

2. Effects on Subsurface Safety-Related or Risk-Significant Structures, Systems, and Components: To meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, GDC 2, GDC 4, GDC 5, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), sufficient information is needed to evaluate the effects of groundwater levels, subsurface hydraulic heads, groundwater velocity, other hydrostatic or hydrodynamic characteristics of groundwater, and groundwater quality on the design

bases of plant foundations and other elements of subsurface safety-related or risk-significant SSCs. Anticipated extreme, post-construction groundwater conditions are compared with the design bases of the plant to identify potential adverse effects. For most sites, these requirements are satisfied by assuring the maximum groundwater level at the site does not exceed the groundwater level parameter for the standard design, as specified in the DCD. For sites located in the permafrost region the review includes information on freezing, thawing, subsurface thermal gradients and impacts of gas hydrates on groundwater flow, pathways, and safety of SSCs.

3. Reliability of Groundwater Resources for Safety-Related or Risk-Significant Systems: To meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, GDC 2, GDC 4, GDC 5, GDC 44, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), a complete description of all safety-related or risk-significant SSCs that depend on groundwater is needed. Sufficient data and analyses regarding the reliability of the groundwater source should be provided. Appropriate sections of Regulatory Guide (RG) 1.27 (NRC, 1976), which describes the ultimate heat sink to which heat is transferred as required by GDC 44, are used by the staff as guidance.

4. Reliability of Dewatering Systems: To meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, GDC 2, GDC 4, GDC 5, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), a complete description is needed of any site dewatering system that is proposed in the plant design to maintain groundwater conditions within the groundwater design bases of safety-related or risk-significant SSCs during plant operation. The description must include dewatering system layout, components, discharge location and permits needed, capacity, reliability, conditions under which it will be operated (if not continuously), effects of normal operation, components and procedures for operational monitoring and reporting, and consequences of failure (including estimates of how rapidly subsurface hydraulic heads would rise in the event of system failure or partial failure). This description is not needed for dewatering systems that are not safety-related, for example a system to prevent groundwater intrusion into an on-site office building, or a system for dewatering during construction..

5. Consideration of Other Site-Related Evaluation Criteria: To meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, GDC 2, GDC 4, GDC 5, 10 CFR 52.17, 10 CFR 52.79, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), an assessment is needed of the potential effects of seismic and non-seismic information on the postulated worst-case scenario related to groundwater effects for the proposed plant site. This assessment should be sufficient to demonstrate that the applicant's design bases appropriately account for these effects, including the potential effects of seismically-induced land subsidence, potential seismic effects on subsurface hydraulic heads, and the potential effects of the design basis flood on groundwater levels.

6. Appropriate sections of RG 4.21 (NRC, 2008), as it relates to minimizing contamination of the subsurface environment, are used by staff for the review of the acceptance criteria.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs:

1. Compliance with 10 CFR 50.55 requires that any holder of a facility construction permit who obtains information indicating the reasonable possibility of a deficiency related to construction or a compliance failure involving substantial safety hazards should notify the Commission.

   This criterion is applicable to Section 2.4.12 inasmuch as the initial design of permanent dewatering systems is necessarily based only on measurements made before construction begins. However, data gathered during construction excavation often indicate the need to modify designs for dewatering systems. Such changes therefore have the potential to affect a safety-related or risk-significant structure or system, and must have the concurrence of NRC

   Meeting these requirements provides a level of assurance that the foundations of safety-related or risk-significant plant structures, systems, or components are not exposed to groundwater hazards more severe than those considered when the design bases were established.

2. Compliance with 10 CFR 50.55a requires that structures, systems, and components shall be designed, fabricated, erected, constructed, tested, and inspected in accordance with the requirements of applicable codes and standards commensurate with the importance of each safety function.

   10 CFR 50.55a specifies appropriate codes and standards for use in the design, construction, and inspection of dewatering systems intended for the protection of safety-related or risk-significant structures that might be affected by higher levels of subsurface hydraulic heads. This is an important consideration in such areas as foundation design and slope stability, particularly when the potential exists for seismic ground motion that could cause soil liquefaction.

   Meeting these requirements provides a level of assurance that the safety-related or risk-significant plant structures, systems, or components are designed to withstand (or are protected against the effects of) high groundwater levels or subsurface hydraulic heads.

3. Compliance with GDC 2 requires that nuclear power plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquake, tornado, hurricane, flood, tsunami, and seiche without loss of capability to perform their safety functions. The criterion further specifies that the design bases for these structures, systems, and components shall reflect the following:

   A. Appropriate consideration of the most severe natural phenomena historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and time period in which the historical data have been accumulated;

   B. Appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and

   C. The importance of the safety functions to be performed.

   This criterion is applicable to DSRS Section 2.4.12 because the groundwater level or subsurface hydraulic head is often an important consideration in establishing seismic design bases for the foundations of safety-related or risk-significant structures. In the

case of deeply-embedded safety-related or risk-significant SSCs, which may penetrate confining layers, both groundwater level and subsurface hydraulic head are important considerations. Such concerns may result in decisions to design and construct site dewatering systems to minimize the dynamic design loads on these structures.

For applications under 10 CFR Part 52, meeting the applicable requirements of 10 CFR 52.17 and 10 CFR 52.79 that correspond to GDC 2 provides a level of assurance that the most severe hydrologic site characteristics have been identified. Whether GDC 2 is met with respect to the adequacy of the associated design bases will be evaluated under other DSRS sections.

4. Compliance with GDC 4 requires that components important to safety be designed to accommodate the effects of (and be compatible with) environmental conditions associated with normal operation, maintenance, testing, and postulated accidents (e.g., loss-of-coolant accidents and dynamic effects, including pipe whip, missiles, and discharging fluids). The design of any dewatering system intended to protect safety-related or risk-significant SSCs should be consistent with this design objective.

   DSRS Section 2.4.12 provides guidance on reviewing the design of dewatering systems for safety-related or risk-significant SSCs and to assure that they can accommodate adverse conditions (e.g., extreme precipitation and waterline breaks) that could degrade or overwhelm the system.

   Meeting the requirements of GDC 4 provides assurance that dewatering systems for safety-related or risk-significant SSCs will not be seriously affected by adverse conditions resulting from normal operations or an accident within or near site structures.

5. Compliance with GDC 5 requires that nuclear power units do not share structures, systems, and components important to safety unless it can be shown that such sharing will not impair their ability to perform required safety-related or risk-significant functions.

   DSRS Section 2.4.12 describes staff positions related to the design of a dewatering system for safety-related or risk-significant SSCs. Such a system is often designed to protect an entire site. This criterion is applicable because it provides the basis for requiring that a dewatering system be designed and sized so that an accident, such as a major waterline break in one unit, will not degrade the system to the extent that hydrostatic loadings will exceed the original design bases of safety-related or risk-significant structures associated with other units.

   Meeting these requirements will provide a level of assurance that a site dewatering system shared by two or more nuclear units will be designed so that no single failure will prevent the system from performing its safety-related or risk-significant function. Similarly, if each unit has its own dewatering system, they must be designed to prevent the failure of one dewatering system from affecting the safety-related or risk-significant function of other units.

6. Compliance with GDC 44 requires a heat transfer system from safety-related and risk-significant SSCs to the ultimate heat sink under normal operating and accident conditions. RG 1.27 (NRC, 1976) describes the applicable ultimate heat sink capabilities. For cases in which groundwater resources are used to supply safety-related or risk-significant system functions, the staff reviews the reliability of these resources.

7. As specified in 10 CFR 100.20 (c), the site's physical characteristics (including seismology, meteorology, geology, and hydrology) should be considered when determining its acceptability for a nuclear power reactor.

   DCDs for standard designs of nuclear power plants may specify a maximum groundwater level parameter. If present, this parameter may represent an important design assumption for certain plant SSCs. Groundwater cannot exceed this level at any time. Meeting this requirement provides assurance that safety-related or risk-significant SSCs will not be affected by high groundwater.

   10 CFR 100.20(c)(3) stipulates that on-site measurements be obtained for factors important to hydrological radionuclide transport such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water.

   To satisfy the hydrologic requirements of 10 CFR Part 100, the NRC staff review of the applicant's FSAR should verify the description of groundwater conditions at the proposed site and of how those conditions will be affected by the construction and operation of a nuclear power plant. Particular emphasis should be given to (1) physical characteristics that control the maximum groundwater level at the site, and (2) the direction and velocity of transport of radionuclides by groundwater in the event that a release to groundwater occurs. This description should also include the details of any site dewatering system.

   Meeting this requirements provides a level of assurance that the maximum groundwater level parameter will not be exceeded, and that radionuclide releases to groundwater will not result in doses to offsite receptors that exceed regulatory limits.

8. 10 CFR 100.23 requires that geologic and seismic factors be considered when determining the suitability of the site and the acceptability of the design for each nuclear power plant.

   10 CFR 100.23 is applicable to DSRS Section 2.4.12 because it addresses requirements for investigating vibratory ground motion, including the hydrologic conditions at and near the site. Static and dynamic engineering properties of the materials underlying the site should be determined, including the properties (e.g., density, water content, porosity, and strength) needed to determine the behavior of those materials in transmitting earthquake-induced motions to the foundations of the plant. These properties may be affected by groundwater conditions. Additionally, it addresses the requirements for considering cooling water supply, soil and rock stability and liquefaction potential. It also addresses the effect of possible seismically-induced increases in groundwater level or subsurface hydraulic head on safety-related or risk-significant SSCs.

   Meeting this requirement provides a level of assurance that the subsurface safety-related or risk-significant SSCs are designed to withstand the effects of a safe shutdown earthquake and possible seismically-induced groundwater dynamics, as well as assurance that the site is suitable for the reactor design type.

9. 10 CFR 20.1406 requires that applications describe how facility design and procedures for operation will, to the extent practicable, minimize contamination of the environment. 10 CFR 20.1406 is applicable to DSRS Section 2.4.12 because this section, together with DSRS Section 2.4.13, addresses the need for a conceptual site model reflecting the site configuration following construction, as described in RG 4.21 (NRC, 2008). A

conceptual site model provides the basis for minimizing contamination by identifying potential pathways of radioactive contaminants through the surface and subsurface, facilitating the development of an onsite monitoring program to provide early detection and quantification of leaks and spills, and providing a framework for planning and implementing mitigative actions.

III. REVIEW PROCEDURES

The staff's review must consider plausible alternative conceptual site models beyond those described in detail in the FSAR. The staff should thoroughly review the basis on which the applicant selected the specific conceptual site model used in the FSAR as the most conservative plausible conceptual site model consistent with the requirements of 10 CFR 52.79 to identify the most severe of the natural phenomena that have been historically reported for the site and surrounding area. In the case of modular reactors, staff should consider the effect of sequenced development of multiple reactors at the same site.

The procedures outlined below are used to review ESP applications and COL applications that do not reference an ESP to determine whether data and analyses for the proposed site meet the acceptance criteria given in Subsection II of this DSRS section. As applicable, reviews of COL applications include a determination on whether the content of technical specifications related to hydrologic site characteristics are acceptable and whether the technical specifications reflect consideration of any identified unique conditions.

These review procedures are based on the acceptance criteria identified in Section II of this DSRS. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. In accordance with 10 CFR 52.47(a)(8),(21), and (22), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues (USIs) and medium- and high-priority generic safety issues (GSIs) that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding FSER section.

2. Local and Regional Groundwater Characteristics and Use: Local and regional groundwater conditions are reviewed by comparing the applicant's description of present and projected local and regional groundwater use, including amounts, water levels and hydraulic heads, location, drawdown, and source aquifers, including characteristics of confining layers, with reports by the U.S. Geological Survey (USGS), other agencies, professional organizations, and academic researchers. Drawdown effects of projected future groundwater use, including the possibility for reversing the groundwater flow direction, should be evaluated and may be checked by independent calculations. Construction effects, including dewatering, on areas such as potential recharge areas, wetlands, and well fields may also be evaluated. Other NRC organizational elements with related review responsibilities should be notified of any applicable groundwater data and analyses.

The staff should verify flow directions, gradients, velocities, water levels, hydraulic heads, and effects of potential future use on these parameters, including any possibility for reversing the direction of groundwater flow using data provided by the applicant and supplemented by data from USGS and other State or Federal agencies. The staff should identify any potential groundwater recharge area within the influence of the plant and should examine potential effects of construction, including dewatering, on such areas using information sources such as hydrogeologic maps and wetlands maps. The influence of existing and potential future wells with respect to groundwater beneath the site should be discussed. Bases and sources of data should be described and referenced. Changes resulting from the alteration of hydraulic properties associated with the subsurface portions of the plant and the fill used during construction should also be discussed. Confirmatory or bounding-case modeling may be necessary to examine potential effects of factors that may affect groundwater conditions. Any assumptions and approximations regarding the hydrogeologic properties, aquifer parameters, or boundary conditions need to be documented and described appropriately with justifications.

The need for and extent of procedures and measures to protect present and projected groundwater users, including monitoring programs, should be reviewed based upon site-specific groundwater features since these items are site-specific.

3. Effects on Subsurface Safety-Related or Risk-Significant Structures, Systems, and Components: Groundwater levels, subsurface hydraulic heads, groundwater quality, and, if relevant, groundwater velocities are reviewed in terms of their effects on subsurface safety-related or risk-significant SSCs. This review is based in part on measurements made onsite, but because these measurements are usually infrequent and are made over a limited period, other factors that may affect future groundwater levels must be evaluated. These include groundwater recharge, levels of surface water bodies, evapotranspiration, surface grading and cover materials, dewatering systems, surface flooding, pipe failures, and other events. The review must emphasize post-construction conditions rather than pre-construction conditions. Mathematical modeling, using an accepted procedure such as that described in standard American National Standard Institute/American Nuclear Society (ANSI/ANS)-2.17-2010 (ANS, 2010), is an appropriate way to evaluate post-construction groundwater conditions when construction is anticipated to produce large changes in groundwater levels and flow pathways. The most extreme groundwater levels and other anticipated conditions must be compared with the design bases of the proposed plant. Where margins between anticipated conditions and the design bases are small, technical specifications or permit conditions about continuing groundwater level monitoring may be needed to assure that actual post-construction groundwater conditions remain as represented in the COL application. The adequacy of proposed post-construction groundwater monitoring should be reviewed based upon anticipated groundwater conditions, design basis margins, and the extent of existing monitoring data. For sites located in the permafrost region the review includes information on freezing, thawing, subsurface thermal gradients and impacts of gas hydrates on groundwater flow, pathways, and safety of SSCs. Freezing in the permafrost has the potential to impact the flow of groundwater and mixed with thawing and varying thermal gradient in the subsurface, it can influence the groundwater level. The presence of hydrate gases can be indicative of a biogeochemical environment that can change groundwater pathways and result in other adverse effects.

4. Reliability of Dewatering Systems: If a permanent dewatering system is employed to lower subsurface hydraulic heads, the design of the system and its performance are reviewed. Information should be reviewed regarding (a) all structures, components, and

features of the system; (b) the reliability of the system as related to available performance data for similar systems used at other locations; (c) the various soil parameters (such as permeability, porosity, and specific yield) used in the design of the system; (d) the bases for determination of groundwater flow rates and areas of influence to be expected; (e) the bases for determination of time available to mitigate the consequences of system failure where system failure could cause design bases to be exceeded; (f) the effects of malfunctions or failures (such as a single failure of a critical active component or failure of circulating water system piping) on system capacity and subsequent subsurface hydraulic heads; and (g) a description of the proposed hydraulic head monitoring program and outlet flow monitoring program. For dewatering systems, calculations should be performed to determine groundwater levels and/or hydraulic head, normal flow rates, flow rates into the system as a result of pipe breaks (circulating and service water system pipes), groundwater level recovery times assuming total failure of the system, and maximum system capacity.

5. Consideration of Other Site-Related Evaluation Criteria: Subpart B of 10 CFR Part 100 describes site-related proximity, seismic and non-seismic evaluation criteria for power reactor applications. The staff's review should include evaluation of pertinent information to determine whether these criteria are appropriately used in estimating worst-case groundwater effects at the proposed plant site, including the potential effects of seismically-induced subsidence and groundwater dynamics on subsurface safety-related or risk-significant SSCs, and the potential effects of surface flooding on groundwater levels and subsurface hydraulic heads.

6. Review Procedures Specific to Applications Under 10 CFR Part 52

   A. ESP Reviews: Subpart A to 10 CFR Part 52 specifies the requirements and procedures applicable to the Commission's review of an ESP application for approval of a proposed site. Information required in an ESP application includes a description of the site characteristics and design parameters of the proposed site. The scope and level of detail in the data review parallel that used for a COL review.

      In the absence of certain circumstances, such as a compliance or adequate protection issue, 10 CFR 52.39 precludes the Commission from imposing new site characteristics, design parameters, or terms and conditions on the ESP at the COL stage. Therefore, the reviewer should ensure that the ESP includes all groundwater-related site characteristics, controlling parameters, and COL application action items that are needed to help ensure that a reactor or reactors having appropriate design characteristics can be constructed and operated safely at the site.

   B. Standard DC Reviews: DC applications do not contain general descriptions of site characteristics because this information is site-specific and will be addressed by the construction permit or COL applicant. However, pursuant to 10 CFR 52.47(a)(1), a DC applicant must provide site parameters postulated for the design. Site parameters are values (such as the maximum groundwater level) that define limits for specific site conditions during operation. The reviewer verifies that:

i. The postulated site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application;

ii. Appropriate site parameters are included as Tier 2 information, and the Tier 2 site parameters particularly important for safety are also included as Tier 1 information.[2] Additional guidance on site parameters is provided in SRP Sections 2.0 and 14.3;

iii. Parameters are stated in a site parameters summary table; and

iv. The applicant has provided a basis for each of the site parameters.

C. COL Reviews: For a COL application referencing a certified standard design, NRC staff reviews that application to ensure that sufficient information is presented to demonstrate that the characteristics of the site fall within the site parameters specified in the DCD for the standard design. Should the actual site characteristics not fall within the certified standard design site parameters, the COL applicant must demonstrate by some other means that the proposed facility is acceptable at the proposed site. This might be done by re-analyzing or redesigning the proposed facility. The applicant may also apply for a departure when submitting the COL application.

For a COL application referencing an ESP, NRC staff reviews the application to ensure the applicant provides sufficient information to demonstrate that the design of the facility falls within the site characteristics and design parameters specified in the ESP as applicable to this DSRS section. In accordance with 10 CFR 52.79(b)(2), should the design of the facility not fall within the site characteristics and design parameters, the application shall include a request for a variance from the ESP that complies with the requirements of 10 CFR 52.39 and 10 CFR 52.93.

In addition, long-term environmental changes and changes to the region resulting from human or natural causes after the ESP was approved may have introduced changes to the site characteristics that could be relevant to the design basis. In the absence of certain circumstances (such as a compliance, public health and safety, or adequate protection issue), 10 CFR 52.39 precludes the staff from imposing new site characteristics, design parameters, or terms and conditions on the ESP at the COL stage. Consequently, a COL application referencing an ESP need not include a re-investigation of the site characteristics that have previously been accepted in the referenced ESP. However, in accordance with 10 CFR 52.6, "Completeness and Accuracy of Information," the applicant or licensee is responsible for identifying changes in site characteristics, of which it is aware, that would make a change in the ESP necessary under the criteria specified in 10 CFR 52.39. Information provided by the applicant in accordance with 10 CFR 52.6(b) will be addressed by the staff during the review of a COL application referencing an ESP or a DC.

[2] Tier 1 means the portion of the design-related information in a DCD that is approved and certified by the Commission by being published as a rule. Tier 2 means the information that is approved by NRC but is not certified. Classification of site parameters as Tier 1 and Tier 2 has become customary, but is not defined by regulation and is not required. Tier 1 and Tier 2 are defined only by way of publication of individual DC rules. For examples, see 10 CFR Part 52, Appendices A through D.

For a COL application referencing either an ESP or DC, or both, the staff should review the corresponding sections of the ESP FSER and DC FSER to ensure that any ESP conditions, restrictions to the DC, or COL action items identified in the FSERs are appropriately handled in the COL application.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis, as augmented by the application of programmatic requirements in accordance with the staff's technical review approach in the DSRS Introduction, support conclusions of the following type to be included in the staff's FSER. The reviewer also states the bases for those conclusions.

The staff's evaluation may include performance of independent calculations, and independent validation of appropriate assumptions. While the reviewer may summarize or quote the information offered by the applicant in support of its application, the reviewer should clearly articulate the bases for the staff's conclusions in his or her own language, and should supplement the information submitted by the applicant with information independently derived from other sources.

1. COL Reviews

The following statements should be preceded by a summary of the site characteristics and parameters used for the plant:

As set forth above, the applicant has presented and substantiated information relative to the groundwater effects important to the design and siting of this plant. The staff has reviewed the available information provided and, for the reasons given above, concludes that the identification and consideration of the potential effects of groundwater in the vicinity of the site are acceptable and meet the requirements of 10 CFR 50.55, 10 CFR 50.55a, 10 CFR Part 50, Appendix A, GDC 2, 4, 5, and 44, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR Part 100 CFR 100.20(c), with respect to determining the acceptability of the site.

The staff finds that the applicant has considered the appropriate site phenomena in establishing the groundwater effects in the vicinity of the site. The staff has generally accepted the methodologies used to determine the potential effects of groundwater, which conform satisfactorily to NRC's technical guidance and standard technical practice. Accordingly, the staff concludes that the use of these methodologies results in design bases containing margin sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated. The staff concludes that the identified design bases meet the requirements of 10 CFR 50.55a, 10 CFR Part 50, Appendix A, GDC 2, 4, 5, and 44, 10 CFR 100.20(c)(3), 10 CFR 100.23(d), and 10 CFR 100.20(c), with respect to establishing the design basis for safety-related or risk-significant SSCs.

2. ESP Reviews

The following statements should be preceded by a summary of the site characteristics and design parameters to be included in any ESP that might be issued for the proposed site:

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the identification and evaluation of effects of groundwater in the vicinity of

the proposed site. Section 2.4.12, "Groundwater," of the Design-Specific Review Standard for mPower™ Integral Pressurized Water Reactor (iPWR) Design, provides that the site FSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating effects of groundwater in the vicinity of the site and site regions. Further, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in these site characteristics, as documented in FSERs for previous licensing actions. Accordingly, the staff concludes that the use of these methodologies results in site characteristics containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristics previously identified are acceptable for use in establishing the design bases for safety-related or risk-significant SSCs, as may be proposed in a COL application.

Therefore, the staff concludes that the identification and consideration of the groundwater site characteristics set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c) and 10 CFR 100.21(d).

In view of the above, the staff finds the applicant's proposed site characteristics related to groundwater for inclusion in an ESP for the applicant's site, should one be issued, acceptable.

3. DC Reviews

The following statement should be preceded by a list of all site parameters specified for the plant design. Site parameters should be identified as Tier 1 (approved and certified by NRC) and Tier 2 (approved by NRC), and a value provided for each parameter.

The NRC staff acknowledges that the applicant has selected the site parameters referenced above for plant design inputs, (a subset of the site parameters is included as Tier 1 information) and agrees that they are representative of a reasonable number of sites that have been or may be considered for a construction permit, ESP, or COL application. Effects of groundwater in the vicinity of the site are site-specific and will be addressed by the construction permit, ESP, or COL applicant. Such applications must provide information sufficient to demonstrate that the design of the proposed plant falls within the site parameters specified in the DCD.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, COL, or ESP applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor (SMR) reviews including

the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™-specific DC, COL, or ESP applications submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the SRP revision in effect six months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9) as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.17 (a)(1)(xii) and 10 CFR 52.79 (a)(41), for ESP and COL applications, respectively.

VI. REFERENCES

1. 10 CFR 20.1406, "Minimization of Contamination."
2. 10 CFR 50.55, "Conditions of Construction Permits."
3. 10 CFR 50.55a, "Codes and Standards."
4. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."
5. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Missile Design Bases."
6. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."
7. 10 CFR Part 50, Appendix A, GDC 44, "Cooling water."
8. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."
9. 10 CFR Part 52, Subpart A, "Early Site Permits."
10. 10 CFR 52.6, "Completeness and Accuracy of Information."
11. 10 CFR 52.6(b)
12. 10 CFR 52.17, "Contents of Applications; Technical Information."
13. 10 CFR 52.17(a)(1)(vi)
14. 10 CFR 52.39, "Finality of Early Site Permit Determinations."
15. 10 CFR 52.47(a)(1)

16. 10 CFR 52.47(a)(9)

17. 10 CFR 52.79, “Contents of Applications; Technical Information in Final Safety Analysis Report.”

18. 10 CFR 52.79(a)(1)(iii)

19. 10 CFR 52.79(b)(2)

20. 10 CFR 52.93, “Exemptions and Variances.”

21. 10 CFR Part 100, “Reactor Site Criteria.”

22. 10 CFR Part 100, Subpart A, “Evaluation Factors for Stationary Power Reactor Site Applications Before January 10, 1997 and for Testing Reactors.”

23. 10 CFR Part 100, Subpart B, “Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997.”

24. 10 CFR 100.10(c)

25. 10 CFR 100.10(c)(3)

26. 10 CFR 100.20(c)

27. 10 CFR 100.20(c)(3)

28. 10 CFR Part 100.23, “Geologic and Seismic Siting Criteria.”

29. 10 CFR 100.23(d), “Geologic and Seismic Siting Factors.”

30. ANS, 2010, “Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Plants,” ANSI/ANS-2.17-2010, American Nuclear Society, La Grange Park, IL.

31. NRC, 1976, “Ultimate Heat Sink for Nuclear Power Plants”, RG 1.27, Revision 2, January 1976, U.S. Nuclear Regulatory Commission, Washington DC.

32. NRC, 1987, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition,” NUREG-0800, June 1987, U.S. Nuclear Regulatory Commission, Washington DC.

33. NRC, 2008, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” RG 4.21, U.S. Nuclear Regulatory Commission, Washington DC.

34. NRC, 2010, “Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews,” Staff Requirements Memorandum (SRM) COMGBJ-10-0004/COMGEA-10-0001, August 31, 2010 (ML102510405).