NUREG-0800
(Formerly NUREG-75/087)

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

SECTION 2.4.12 GROUNDWATER

REVIEW RESPONSIBILITIES

Primary - Hydrologic and Geotechnical Engineering Branch (HGEB)

Secondary - None

I. AREAS OF REVIEW

Data presented in the applicant's safety analysis report (SAR) on local and regional groundwater reservoirs are reviewed to establish the effects of groundwater on plant foundations. Other areas reviewed under this SRP section include identification of the aquifers and the type of onsite groundwater use, the sources of recharge, present and future withdrawals, monitoring and protection requirements, and design bases for groundwater levels and hydrodynamic effects of groundwater on safety-related structures and components. Flow rates, travel time, gradients, other properties pertaining to the movement of accidental contamination, and groundwater levels beneath the site are reviewed, as are seasonal and climatic fluctuations, or those caused by man, that have the potential for long-term changes in the local groundwater regime.

II. ACCEPTANCE CRITERIA

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

1. 10 CFR Part 50, §50.55 requires that significant deficiencies in construction of or significant damage to a structure, system, or component which will require extensive redesign, or extensive repair to meet the criteria of the construction permit be reported to the Commission.

2. 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.

3. General Design Criterion 2 requires structures, systems, and components important to safety to be designed to withstand the effects of natural phenomena.

Rev. 2 - July 1981

4. General Design Criterion 4 requires structures, systems, and components important to safety to be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation and postulated accidents.

5. General Design Criterion 5 requires that structures, systems, and components important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

6. 10 CFR Part 100 requires that hydrologic characteristics be considered in the evaluation of the site.

7. 10 CFR Part 100, Appendix A sets forth the criteria to determine the suitability of plant design bases with respect to seismic characteristics of the site. It also requires that the adequacy of the cooling water supply for emergency and long-term shutdown decay heat removal be assured, taking into account information concerning the physical, including hydrological, properties of the materials underlying the site.

To meet the requirements of the hydrologic aspects of 10 CFR Part 100 and its Appendix A, the following specific criteria are used.

For SAR Section 2.4.12.1: A full, documented description of regional and local groundwater aquifers, sources, and sinks is required. In addition, the type of groundwater use, wells, pump and storage facilities, and the flow requirements of the plant must be described. If groundwater is to be used as an essential source of water for safety-related equipment, the design basis for protection from natural and accident phenomena must compare with Regulatory Guide 1.27 guidelines. Bases and sources of data must be adequately described.

To meet the requirements of the hydrologic aspect of 10 CFR Part 100, the following specific criteria are used.

For SAR 2.4.12.2: A description of present and projected local and regional groundwater use must be provided. Existing uses, including amounts, water levels, location, drawdown, and source aquifers must be discussed and should be tabulated. Flow directions, gradients, velocities, water levels, and effects of potential future use on these parameters, including any possibility for reversing the direction of groundwater flow, must be indicated. Any potential groundwater recharge area within the influence of the plant and effects of construction, including dewatering, must be identified. The influence of existing and potential future wells with respect to groundwater beneath the site must also be discussed. Bases and sources of data must be described and referenced.

For SAR Section 2.4.12.3: The need for and extent of procedures and measures to protect present and projected groundwater users, including monitoring programs, must be discussed. These items are site-specific and will vary with each application.

To meet the requirements of 10 CFR Part 50, §§50.55 and 50.55a; General Design Criteria 2, 4, and 5; 10 CFR Part 100; and 10 CFR Part 100, Appendix A, the following specific criteria are used:

For SAR Section 2.4.12.4: The design bases (and development thereof) for groundwater-induced loadings on subsurface portions of safety-related structures, systems, and components must be described. If a permanent dewatering system is employed to lower design basis groundwater levels, the bases for the design of the system and determination of the design basis for groundwater levels must be provided. Information must be provided 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 groundwater levels, and (g) a description of the proposed groundwater level monitoring program and outlet flow monitoring program. Specific criteria relating to the design of permanent dewatering systems are presented in the attached Branch Technical Position HGEB-1, "Safety-Related Permanent Dewatering Systems." In addition, if wells are proposed for safety-related purposes, the hydrodynamic design bases (and development thereof) for protection against seismically induced pressure waves must be described and be consistent with site characteristics.

III. REVIEW PROCEDURES

Section 2.4.12 of the applicant's SAR is reviewed to identify any missing data, information, or analyses necessary for the staff's evaluation. Applicant responses to the requested information will be evaluated using the methods outlined below and staff positions will be developed based on the results of the analysis. Resolution, if possible, of potential groundwater problems or of differences between applicant's and staff's design bases, will be coordinated through the LPM, and the SER will be written accordingly. The review sequence is shown in Figure 2.4.12.

Local and regional groundwater conditions are reviewed by comparing the applicant's description with reports by the U.S. Geological Survey (USGS), other agencies, and professional organizations. Other NRC organizational elements with related review responsibilities will be notified of any applicable groundwater data and analyses. If onsite groundwater use and facilities are safety-related, the criteria of Regulatory Guide 1.27 are applied.

The staff will compare the applicant's description of present and projected local and regional groundwater use, existing users, including ambient use, water levels, location, and drawdown with information and data from references. Drawdown effects of projected future groundwater use, including the possibility for reversing the groundwater flow, will be evaluated and may be checked by independent calculations. Construction effects, including dewatering, on potential recharge areas may also be evaluated.

The needs and plans for procedures, measures, and monitoring programs will be reviewed based upon site-specific groundwater features. Design bases for groundwater-induced loadings on subsurface portions of safety-related structures are reviewed. Independent calculations are performed to determine the adequacy of the design criteria and the capability to reflect any potential future changes which can be induced by variations in precipitation, construction of future wells and reservoirs, accidents, pipe failures, or other natural events. For dewatering systems, calculations are performed to determine phreatic surfaces, normal flow rates, flow rates into the system as a result of pipe breaks (circulating and service water system pipes), groundwater rebound times assuming total failure of the system, and system capacity.

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

IV. EVALUATION FINDINGS

For construction permit (CP) reviews, the findings will summarize the applicant's and staff's estimates of groundwater levels associated with safety-related structures and, where applicable, groundwater flow directions, gradients, velocities, effects of potential future use on these parameters, and applicability and reliability of dewatering systems. If the design bases estimates are comparable, staff concurrence in the applicant's estimates will be stated. If the staff predicts substantially more conservative groundwater conditions and the proposed plant may be adversely affected, a statement of the staff bases will be made. If groundwater conditions do not constitute design bases, the findings will so indicate.

For operating license (OL) reviews of plants that have had detailed groundwater reviews at the CP stage, the CP conclusions will be referenced. In addition, a review of groundwater history since the CP review will be indicated and note of any changes in groundwater conditions or usage will be made. For permanent dewatering systems, any additional information regarding soil properties and groundwater conditions gathered during construction will be evaluated to determine the applicability of the assumed CP design basis. If no CP groundwater review was undertaken, of the scope indicated above, this fact will be noted in the OL findings in addition to the results of the current review.

A sample CP statement follows:

> The proposed site lies within a groundwater region which is part of the Piedmont Groundwater Province. Groundwater in the area is derived entirely from local precipitation. The water is contained in the pores of the residual soils and in joints and cracks of the rock. There is a north-south groundwater ridge at the plant area, and groundwater flow is to the north, east, and west. The groundwater gradient in the plant area is about 6 to 7 feet per 100 feet. Permeability is controlled by the extent and distribution of fractures in the bedrock and by the size and distribution of pores in the overlying soil. The applicant has made laboratory and field permeability tests and has determined values ranging from zero to about 5000 feet per year. Measured depths from the existing ground surface to the groundwater table on the ridges range from about 40 to 80 feet. However, the proposed plant grade will be at about existing groundwater level. The groundwater table is generally at or near the surface in valleys and draws near the site.
>
> In order to meet the requirements of General Design Criterion 2, 10 CFR Part 100, and 10 CFR Part 100, Appendix A with respect to groundwater levels and its effects on the plant, especially during postulated seismic events, the applicant proposes to permanently lower the groundwater levels in the vicinity of safety-related structures. This is to be accomplished by using a system of seismic Category I underdrains and exterior wall drains.

The underdrains will consist of a series of interconnected flow channels spaced on 20-foot centers located under the foundation slabs. The exterior wall drains will consist of zoned filter materials around the walls, which will drain to a horizontal perforated pipe located at mat level. Both the underdrains and the perforated pipe will discharge to a sump located inside the auxiliary building from which the water will be pumped to the plant storm drains system for gravity flow to an auxiliary holding pond onsite. The underdrain system of connected flow channels will be located at the top of rock or at the top of first level of fill concrete below each foundation slab. Each channel will run the full length of the building excavation but will be closed at each end so that no sediment can be transported into it from backfill outside the walls. All channels in the grid system will drain by gravity through eight pipes to a 15-foot square sump located inside the auxiliary building. The exterior wall drains will be located around the exterior walls of the auxiliary and reactor building and will drain to the same sump as the underdrain system. No connection between the wall drains and the underdrain system will exist such that each drains to the sump through independent and separate conduits. The exterior wall drain system will consist of a zoned filter system which extends from 5 feet below yard grade to the bottom of the excavation. The continuous perforated pipe will extend around the perimeter of the building exterior walls at the bottom of the zoned wall filter. Two 120-gallon-per-minute seismic Category I pumps will maintain the water level automatically in the sump with each pump capable of handling the total computed flow of up to 35 gallons per minute per unit. We conclude that the system meets the requirements of General Design Criterion 5 in that those portions which are shared between reactor units have sufficient redundancies to enable them to perform their safety functions in the event of postulated single failures.

The applicant will include provisions in the design for monitoring of pump operation, and visual inspection of drain outlets in the sump will provide assurance that the zoned filter, drains, and pumps are functioning properly. Seismic Category I manholes, located along the exterior walls of the reactor and auxiliary buildings, will provide access to the perforated pipe in the zoned wall filter for inspection and cleanout. These manholes can be used for temporary installation of pumps in the unlikely event that groundwater rises in the wall drains. An inspection and monitoring procedure will be developed for both the construction and operation phase of the plant. Several observation wells will be located at strategic locations to monitor groundwater levels in the vicinity of the shield and auxiliary buildings and will be used to verify that the groundwater drawdown is effected as predicted and to establish its extent of influence in the yard area. These wells will be monitored periodically during construction for a sufficient period to verify that a steady-state condition has been achieved. The details of the operational monitoring program will be provided during the operating license stage of our review.

The applicant states that design parameters used to size the dewatering system and to establish the monitoring program will be verified during construction excavation. The applicant has agreed that the currently proposed system would be modified or other groundwater drainage designs would be adopted in the event that the current design parameters are found to be substantially changed, as determined during construction excavation. For example, if the site soils or rocks are found to be more permeable, causing an increase in the design discharge, modifications such as increased pump size, or other designs would be implemented. The applicant has also agreed that the final design will be based on data gathered during the construction excavation, if the current design bases are inadequate.

We have reviewed the applicant's plans for providing monitoring programs during construction and operation and his commitment to notify the staff and to appropriately modify the design if measurements show significantly higher groundwater flows than assumed for the preliminary design. We conclude that this meets the requirements of 10 CFR Part 50, §50.55(e)(1)(iii) with respect to the dewatering system. We find that the monitoring program will provide sufficient data for design input, and conclude that an acceptable design, in compliance with 10 CFR Part 50, §50.55a, can be provided for the measured groundwater flow.

In addition to the capability of the permanent dewatering system to handle normal groundwater flow, we asked the applicant to consider the effects of accidents and natural phenomena on the capability of the permanent dewatering system in compliance with General Design Criterion 4. The applicant had already considered the effects of infiltration of rainfall within the radius of influence assuming blockage of discharge pipes from the wall drains to the sump in the auxiliary building, but had not considered the effects on the sump in the absence of such blockage.

In considering accidents that could release fluids within the radius of influence, the applicant concentrated his assessment on a large source of water, the condenser circulating water system, and on sources that could be accidently released directly into the wall drain.

The applicant states that the failure of a circulating water system pipe inside the turbine building would cause water to be ponded to a depth of 13 feet above the turbine building floor. The wall of the adjacent auxiliary building facing the turbine building will be constructed as a seismic Category I wall up to a level of 13 feet 6 inches above the turbine floor to prevent flow of the ponded water in the turbine building into the auxiliary building. In addition, the applicant proposes to place a grout curtain under this wall to reduce seepage to the underdrain system and to extend seismic Category I retaining walls outward from the auxiliary building to retain a column of low permeability soil as a barrier to flow of water from the turbine building around to wall drains along the sides of the auxiliary building.

The primary grout holes for the grout curtain below the auxiliary building substructure mat and the retaining wall will be spaced at 20-foot intervals. Secondary holes will split-space the primary grout holes. After the grout curtain is completed, with a maximum hole spacing of 10 feet center-to-center, four core holes will be drilled to verify the adequacy of the grout curtain. Along with visual inspection of the rock cores, the holes will be water tested to assure that the permeability of the grout curtain is less than the average permeability of continuous rock. The grout holes are to be split-spaced until the equality in permeability is attained. After completion of the grouting and testing, the four test holes will be cased and maintained for observation and testing throughout the life of the plant.

We conclude that the criteria for the design of retaining wall and placement of the grout curtain meet the requirements of General Design Criterion 4 and are acceptable and should result in an acceptable means of preventing leakage from the turbine building to the permanent dewatering system. In the event of a circulating water system pipe rupture outside of the turbine building, the applicant has stated that the results of an analysis predict that any additional water which will enter the dewatering system will be minimal, and normal groundwater levels will not be affected.

The applicant initially proposed as a design basis for subsurface hydrostatic loads, groundwater levels at the elevation of the underdrain system. During our review the applicant investigated the consequences of failures of some of the fluid-containing tanks and piping within the radius of influence of the permanent dewatering system. Consequences of some of those failures which could release fluids directly into or near the permanent dewatering system were analyzed by the applicant.

The nuclear service water pipes will pass through the wall drain adjacent to the shield building. As described in Section 9.5.8 of this report, a moderate energy pipe crack within the wall drain would cause overflow of the sump and flooding of the auxiliary building floor, and in addition would cause a localized elevation of water in the wall drain by about 2.5 feet. The applicant in Section 2.4.12 of the PSAR has described the consequences of other accidents and additional design changes that were made to mitigate the consequences of the accidents. Although the accidents do not include all conceivable events that could result in excess flow into the sump, the applicant proposes to use the break of the nuclear service water pipe as the design basis event for evaluating sump overflow. It would appear that alternate designs, such as higher sump walls, could be readily implemented as a backup design feature if other sources result in unacceptable sump overflow. We conclude that the applicant's criteria for limiting sump overflow, or utilization of modifications to the preliminary design, if necessary, provide assurance that a design can be developed that will provide adequate flood protection for systems and components located in the shield and auxiliary buildings and thus meets the requirements of 10 CFR Part 50, §50.55a, and General Design Criterion 4.

In response to our concerns about potential blockage of flow paths from the wall drain to the sump, the applicant has committed, as described in Section 3.8.5 of this report, to design external structural walls surrounded by wall drains and foundation floors to withstand as an extreme environmental load the hydrostatic load caused by postulated rebound of water in the wall drains to plant grade even though no specific mechanism for effecting such a rebound has been postulated. We conclude that this commitment is a conservative approach with respect to maximum design water level in the wall drain and meets the requirements of General Design Criteria 2 and 4.

V. IMPLEMENTATION

The following is intented 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 guide.

VI. REFERENCES

In addition to the following, references on methods and techniques of analysis, published data by Federal and State agencies, such as USGS water supply papers, will be used as available.

1. 10 CFR Part 50, §50.55, "Conditions of Construction Permits."

2. 10 CFR Part 50, §50.55a, "Codes and Standards."

3. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

4. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

5. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."

6. 10 CFR Part 100, "Reactor Site Criteria."

7. 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."

8. "Finite Element Solution of Steady State Potential Flow Problems," HEC 723-G2-L2440, Corps of Engineers (1970).

9. T. A. Prickett and C. G. Lonnquist, "Selected Digital Computer Techniques for Groundwater Resource Evaluation," Bulletin 55, Illinois State Water Survey, Urbana, Illinois (1970).

10. D. B. Cearlock and A. E. Reisenauer, "Sitewide Groundwater Flow Studies for Brookhaven National Laboratory, Upton, Long Island, New York," Battelle Pacific Northwest Laboratories, Richland, Washington (1971).

11. K. L. Kipp, D. B. Cearlock, A. E. Reisenauer, and C. A. Bryan, "Variable Thickness Transient Groundwater Flow Model--Theory and Numerical Implementation," BNWL-1703, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

12. D. R. Friedrichs, "Information Storage and Retrieval System for Well Hydrograph Data--User's Manual," BNWL-1705, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

13. K. L. Kipp and D. B. Cearlock, "The Transmissivity Iterative Calculation Routine--Theory and Numerical Implementation," BNWL-1706, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

14. D. L. Schreiber, A. E. Reisenauer, K. L. Kipp, and R. T. Jaske, "Anticipated Effects of an Unlined Brackish-Water Canal on a Confined Multiple-Aquifer System," BNWL-1800, Battelle Pacific Northwest Laboratories, Richland, Washington (1973).

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

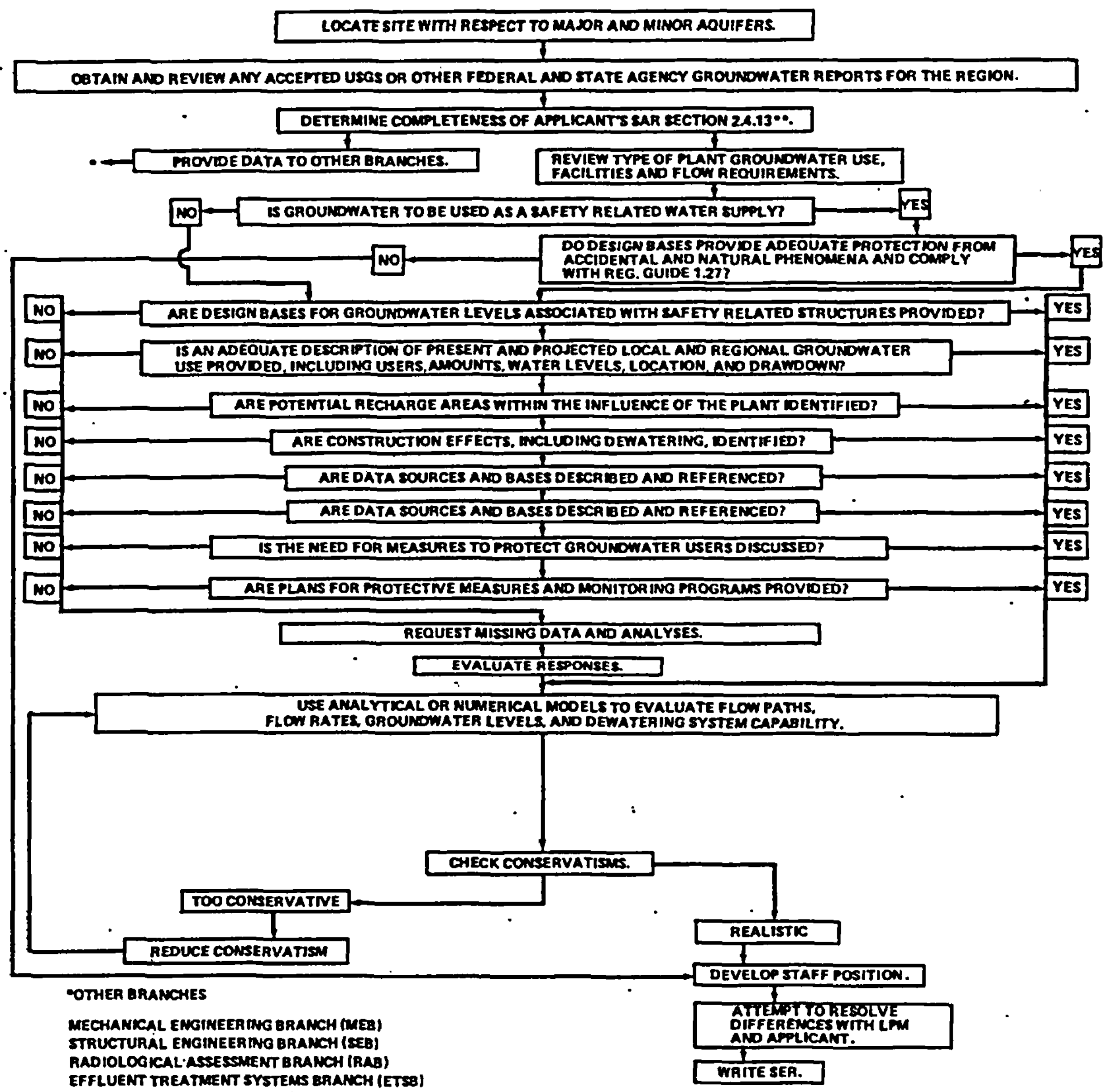
16. D. K. Todd, "Groundwater Hydrology," John Wiley & Sons, Inc., New York (1959).

17. J. Bear, "Dynamics of Fluids in Porous Media," American Elsevier Publishing Company, New York (1972).

18. Branch Technical Position HGEB-1, "Safety-Related Permanent Dewatering System", attached to this SRP section.

FIGURE 2.4.12

STANDARD REVIEW PLAN SECTION 2.4.12
GROUNDWATER



*OTHER BRANCHES

MECHANICAL ENGINEERING BRANCH (MEB)
STRUCTURAL ENGINEERING BRANCH (SEB)
RADIOLOGICAL ASSESSMENT BRANCH (RAB)
EFFLUENT TREATMENT SYSTEMS BRANCH (ETSB)
ACCIDENT ANALYSIS BRANCH (AAB)
AUXILIARY SYSTEMS BRANCH (ASB)
POWER SYSTEMS BRANCH (PSB)

**APPLICANT PROVIDED INFORMATION IN SAR SECTION 2.4.12 IS COMPARED TO GUIDANCE GIVEN IN SF&C DOCUMENT (R.G.1.70) TO DETERMINE COMPLETENESS.

BRANCH TECHNICAL POSITON HGEB-1
(FORMERLY HMB/GSB-1)
SAFETY-RELATED PERMANENT DEWATERING SYSTEMS

I. Summary

This position has been formulated to minimize review problems common to permanent dewatering systems that are depended upon to serve safety-related purposes by describing acceptable geotechnical and hydrologic engineering design bases and criteria. A safety-related designation for permanent dewatering systems is provided since they protect other safety-related structures, systems and components from the effects of natural and man-caused events such as groundwater. In addition, the level of documentation of data and studies which are considered necessary to support safety-related functions is defined. This position applies to both active (e.g., uses pumps) and passive (e.g., uses gravity drains) dewatering systems. This position does not reflect structural, mechanical, and electrical criteria.

II. Background

The staff has reviewed a number of permanent dewatering systems, including McGuire 1 & 2, Cherokee 1 & 2, Perkins 1 & 2, Perry 1 & 2, WPPSS 3 & 5, Douglas Point 1 & 2, and Catawba 1 & 2. Perry, beginning in 1975, was the first plant reviewed with such systems, and was reviewed very late in the CP process. Only WPPSS 3 & 5 and Douglas Point use a passive system (no pumps).

Permanent dewatering systems lower groundwater levels to reduce subsurface water loads on plant structures. In addition, they can increase plant operational dependability and reduce costs. These effects are accomplished by providing added means of keeping seepage water out of lower building levels during the later stages of plant life when normal waterproofing provisions may have deteriorated, and reducing radwaste system operating costs by minimizing the amount of drain water that must be treated. Benefits are, therefore, of two types, tangible (dollars) and intangible ("insurance"). We understand the construction costs of underdrains can vary widely depending on the design. Construction costs of between $125K to $1000K per unit have been suggested. The costs of coping with significant amounts of groundwater inleakage in safety-related building areas, which underdrains are expected to minimize, is estimated to be in the range of $100K to $200K per year per reactor. The construction costs of alternatives to underdrains for structural purposes alone (exclusive of inleakage treatment) is estimated to range upward from $300K per unit and is highly dependent on site conditions. Structural alternatives to permanent underdrains include additional concrete and steel in the lower portions of buildings, and the use of anchor systems to resist floatation.

Dewatering systems are generally composed of three components; the collector system, the drain system, and the discharge system. Water is first collected in collector drains adjacent to buildings or excavations. Interceptor drains or piping are then used to convey this water to a final discharge system. The discharge system can be either gravity flow or a pumping system. Most underdrain structures, systems and components are buried alongside and under structures, although some systems employ pumping systems within larger structures (such as reactor or auxiliary buildings) to discharge collected water. Finally, permanent dewatering systems are not a required feature at any plant, but may be proposed as a cost-effective feature.

Many permanent dewatering systems at nonnuclear facilities, such as dams and large buildings, have functioned over the years. However, the likelihood of a portion of such a system becoming ineffective and, therefore, not performing its intended function may well be considerably greater than the probability of occurrence of a nuclear power plant design basis event such as a probable maximum hurricane, probable maximum flood, or safe shutdown earthquake. Losses of function in the past have generally been attributable to piping of fines, inadequate capacity, or clogging. We have concluded that safety analyses of such systems should consider reliability and failures of features of the system itself, as well as potentially adverse effects of failures of nearby nonsafety-related features. Such systems need not be designed for design earthquakes if they are not intended to perform as underdrains fully during or immediately following a severe earthquake, or if the system can be expected to perform an underdrain function in a degraded condition. Certain portions of such systems, however, may be required to regularly perform other safety functions (e.g., porous concrete base mats) and should be designed for severe earthquakes. Failure of a dewatering system could cause groundwater levels to rise above design levels, resulting in overloading concrete walls and mats not designed to withstand the resulting hydrostatic pressures. In addition to causing potential structural and equipment damage, groundwater could enter safety-related buildings and flood components necessary for plant safety.

The basis for staff concerns over the use of such systems is whether they can be expected to perform their function, and prevent structural failures and interior flooding of safety-related structures. The degree of concern is directly related to the corresponding degree to which the safety of the structures and systems rely on the integrity of the dewatering system, particularly with a dewatering system in a degraded situation. For example, if structures can accommodate hydrostatic loads that would result with a total failure of a dewatering system, our concerns have been primarily limited to the capability of such systems to perform their functions under relatively infrequent earthquake situations. If, however, such systems must remain functional (e.g., keep water levels down), whether in a degraded situation or not to prevent structural failures and internal flooding under potentially frequent conditions, we have been very concerned with system reliability.

Many applicants have indicated that their plants can withstand, or have been designed against, full hydrostatic loadings that would occur in the absence of the underdrain systems, but not if an earthquake were to occur. If the plant can withstand full hydrostatic loading, assuming degradation of the underdrain system, many of the staff's concerns may be eliminated from further consideration because of the time available for remedial action after detection of system degradation.

III. Situations Identified During Previous Reviews

Four general categories of situations have been identified during case reviews as follows:

(a) Estimating and Confirming Permeability Values

It is necessary to estimate the amount of water that will be collected so that system components such as strip drains, blanket drains, collector pipes, and pumps are adequately designed and sized. One of the most important and most difficult parameters to evaluate is the permeability of the soil and rock existing at a site. A permeability value could be affected significantly by conditions of concentrated flow along joints in fractured and weathered rocks, or within other aquifers affected by foundation excavation. In addition, geological and foundation conditions that were not detected in site explorations may affect flow conditions and cause the estimated permeability values and flow regimes to be substantially different from those assumed at the CP preliminary design stage. These conditions are often first detected during construction dewatering. Therefore, we have required a commitment to consider construction excavation and dewatering data in the final design of underdrain systems. (See situation (d) below.)

(b) Operational Monitoring Requirements

To guard against system malfunctions and to assure sufficient time is available for implementation of remedial measures before groundwater could rise to an unacceptable level, provisions must be made for early detection of system failures, and contingency measures for these failures must be well defined prior to plant operation. Since drain systems are usually buried and concealed and there may be no direct way of inspecting them, reliance must be placed on piezometers, observation wells, manholes, and monitoring of collected water to detect problems or malfunctioning of the system. The details of an operational monitoring program are necessary prior to construction of the underdrain to assure that each of the following will be provided: (1) an early detection alarm system during normal operating conditions; (2) regularly scheduled inspection and monitoring; and (3) competent evaluation of observations during both construction and operation. In addition, the bases for acceptable contingency measures suitable for coping with various possible hazards must be established at the CP stage.

(c) Pipe Breaks

A dewatering system might be overloaded by such conditions as leaks or breaks in either the circulating or service water systems. A leak through a pipe break may be a very small percentage of the total flow of the cooling water system, but large enough to exceed the hydraulic capacity of drains, pipes and pumps in the dewatering system. For example, a complete failure of circulating water system piping has been required in the design of the dewatering systems reviewed to date. This requirement was made to assure that such abnormal occurrences do not adversely affect the integrity of safety-related structures, systems, and components.

(d) Sequence of Review

Underdrain systems are usually one of the first items constructed and, after backfilling and construction of subsurface facilities, are then no longer visible for regular inspection. In most cases, these systems are initially designed based on rather limited information from preconstruction field activities, and are tailored specifically for the site and facilities. By necessity then, final review and approval by the staff of the design must rely in some part on information gathered during construction. Therefore, the review and approval can be accomplished in two ways: (1) design details of the permanent underdrain system, the operational monitoring program and plans for construction dewatering can be submitted in the PSAR, with only confirmation of the details required prior to actual construction; or (2) conceptual designs of the permanent underdrain system and the operational monitoring program and details of construction dewatering can be submitted in the PSAR with the more complete review and approval based on construction dewatering requiring review and approval prior to actual construction. Review and approval of unique designs as post-CP matters is based upon 10 CFR Part 50, Subsections 35(b) and 55(e)(1)(iii). To prevent extending the review schedule, the first procedure would be the most desirable, but the staff recognizes that the detail required may not always be available at the time the PSAR is submitted.

IV. Proposed Staff Position

We have reviewed and approved the design of a limited number of permanent dewatering systems. However, because of the importance of these systems to plant safety, we have always required that they be designed and used in a conservative manner. The following is a list of required design provisions which are consistent with requirements in recent CP reviews:

(a) If the dewatering system is relied upon for any safety-related function, the system must meet the appropriate criteria of Appendix A and Appendix B to 10 CFR Part 50. In addition, guidance for structural, mechanical and electrical design criteria is provided in related sections of the Standard Review Plan for Category I structures, systems and components. However, all portions of the system need not be designed to accommodate all design basis events, such as earthquakes and tornados, provided that such events cannot either influence the system, or that the consequences of failure from such events is not important to safety; nevertheless, a clear demonstration of the effectiveness of a backup system and the timeliness of its implementation must be provided;

(b) The potential for localized pressures developing in areas which are not in contact with the drainage system, or in areas where pipes enter or exit the structural walls or mat foundations, must be considered.

(c) Uncertainty in detecting operational problems and providing a suitable monitoring system must be considered;

(d) The potential for piping fines and clogging of filter and drainage layers must be considered;

(e) Assurance must be provided that the system as proposed can be expected to reliably perform its function during the lifetime of the plant; and

(f) Where the system is safety related, is not totally redundant or is not designed for all design basis events, provide the bases for a technical specification to assure that in the event of system failure, necessary remedial action can be implemented before design basis conditions are exceeded.

V. SARs (Standard Format & Content Information, Sections 2.4 & 2.5) for each of the plants with permanent dewatering systems should include the following information:

(a) Provide a description of the proposed dewatering system, including drawings showing the proposed locations of affected structures, components and features of the system. Provide information related to the geotechnical and hydrologic design of all system components such as interceptors, drainage blankets, and pervious fills with descriptions of material source, gradation limits, material properties, special construction features, and placement and quality control measures. (Note structural, mechanical and electrical information needs described elsewhere.) Where the dewatering system is important to safety, provide a discussion of its expected functional reliability. The discussion of the bases for reliability should include comparisons of proposed systems and components with the performance of existing and comparable systems and components for applications under site conditions similar to those proposed. Where such information is unavailable or unfavorable, or the application (design and/or site) is unique, the unusual features of the design should be supported by additional tests and analyses to demonstrate the conservative nature of the design. In such cases the staff will meet with the applicant, on request, to establish the bases for such additional tests and analyses.

(b) Provide estimates, and their bases, for soil and rock permeabilities, total porosity, effective porosity (specific yield), storage coefficient and other related parameters used in the design of the dewatering system. In general, these site parameters should be determined utilizing field and, if necessary, laboratory tests of materials representative of the entire area of influence of the expected drawdown of the system. Unless it can be substantiated that aquifer materials are essentially homogeneous, or that obviously conservative estimates have been used as design bases, provide preconstruction pumping tests and other in-situ tests performed to estimate the pertinent hydrologic parameters of the aquifer. Monitoring of pumping rates and flow patterns during dewatering for the construction excavation is also necessary to verify assumed design bases relating to such factors as permeability and aquifer continuity. In addition, the final design of the system should be based on construction dewatering data and related observations to assure that the values estimated from site exploration data are conservative. Lastly, the final design of the dewatering system and its hydrologic and geotechnical operational monitoring program should be confirmed by construction excavation and dewatering information.

If such information fails to support the conservatism of design information previously reviewed by the staff, the changed information should be reviewed under 10 CFR Part 50, Subsections 35(b) and 55(e)(1)(iii).

(c) Provide analyses and their bases for estimates of groundwater flow rates in the various parts of the permanent dewatering system, the area of influence of drawdown, and the shapes of phreatic surfaces to be expected during operation of the system. The extent of influence of the drawdown may be especially important if a natural or man-made water body affects, or is affected by, the dewatering systems.

(d) Provide analyses, including their bases, to establish conservative estimates of the time available to mitigate the consequences of system degradation* that could cause groundwater levels to exceed design bases. Document the measures that will be taken to either repair the system, or provide an alternate dewatering system that would become operational before the design basis groundwater level is exceeded.

(e) Provide both the design basis and normal operation groundwater levels for safety-related structures, systems and components. The design basis groundwater level is defined as the maximum groundwater level used in the design analysis for dynamic or static loading conditions (whichever is being considered), and may be in excess of the elevation for which the underdrain system is designed for normal operation. This level should consider abnormal and rare events (such as an occurrence of the safe shutdown earthquake (SSE), a failure of a circulating water system pipe, or a single failure within the system), which can cause failure or overloading of the permanent dewatering system.

(f) A single failure of a critical active feature or component must be postulated during any design basis event. Unless it can be documented that the potential consequences of the failure will not result in Regulatory Guides 1.26 and 1.29 dose guidelines being exceeded, either (1) document by pertinent analyses that groundwater level recovery times are sufficient to allow other forms of dewatering to be implemented before the design basis groundwater level is exceeded, discuss the measures to be implemented and equipment needed, and identify the amount of time required to accomplish each measure, or (2) design for all system components for all severe natural phenomena and events. For example, if the design basis groundwater level can be exceeded only as a result of a single nonseismically induced failure of any component or feature of the system, the staff may allow the design basis level of the dewatering system to be exceeded for a short period of time (say 2 or 3 days), provided that (1) effective alternate dewatering means can be implemented within this time period, or that (2) it can be shown that Regulatory Guides 1.26 and 1.29 guidelines will not be exceeded by groundwater induced impairments of safety-related structures, systems, or components.

(g) Where appropriate, document the bases which assure the ability of the system to withstand various natural and accidental phenomena such as earthquakes, tornadoes, surges, floods, and a single failure of a component feature of the system (such as a failure of any cooling water pipes penetrating, or in close proximity to, the outside walls of safety-related buildings where the groundwater level is controlled by the system). An analysis of the consequences of pipe ruptures on the proposed underdrain system must be provided, and should include considerations of postulated breaks in the circulating system pipes at, in, or near the dewatering system building either independently

*See (f) for considerations of differing system types.

of, or as a result of the SSE. Unless it can be documented that the potential consequences will not be serious enough to affect the safety of the plant to the extent that Regulatory Guides 1.26 and 1.29 guidelines could be exceeded, provide analyses to document that (1) water released from the pipe break cannot physically enter the dewatering system, or (2) if water enters the dewatering system, the system will not be overloaded by the increased flow such that the design basis groundwater level is subsequently exceeded.

(h) State the maximum groundwater level the plant structures can tolerate under various significant loading conditions in the absence of the underdrain system.

(i) Provide a description of the proposed groundwater level monitoring programs for dewatering during plant construction and for permanent dewatering during plant operation. Monitoring information requested includes (1) the general arrangement in plan and profile with approximate elevation of piezometers and observation wells to be installed, (2) intended zone(s) of placement, (3) type(s) of piezometer (closed or open system), (4) screens and filter gradation descriptions, (5) drawings showing typical installations showing limits of filter and seals, (6) observation schedules (initial and time intervals for subsequent readings), (7) plans for evaluation of recorded data, and (8) plans for alarm devices to assure sufficient time for initiation of corrective action. Provide a commitment to base the final design of the operational monitoring program on data gathered during the construction monitoring program (if construction experience shows the assumed operational program bases to be nonconservative or impractical). Changes to the operational program are to be documented in the FSAR.

(j) Provide information regarding the outlet flow monitoring program. The information required includes (1) the general location and type of flow measurement device(s), and (2) the observation plan and alarm procedure to identify unanticipated high or low flow in the system and the condition of the effluent.

(k) For OL reviews, but only if not previously reviewed by the staff, provide (1) substantiation of assumed design bases using information gathered during dewatering for construction excavation, and (2) all other details of the dewatering system design that implement design bases established during the CP review.

(l) For OL reviews, provide a Technical Specification for periods when the dewatering system may be exposed to sources of water not considered in the design. An example of such a situation would be the excavation of surface seal material for repair of piping such that the underdrain would be exposed to direct surface runoff. In addition, where the permanent dewatering system is safety related, is not completely redundant, or is not designed for all design basis events, provide the bases for a technical specification with action levels, the remedial work required and the estimated time that it will take to accomplish the work, the sources, types of equipment and manpower required and the availability of the above under potentially adverse conditions. [See Section V(f)].