SITE TECHNICAL POSITION

Hydrology Issues for the
Basalt Waste Isolation Project (BWIP)

BWIP S.T.P.- 1.0

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Site Technical Position - Hydrology Issues For
The Basalt Waste Isolation Project

Background

In review of a license application for a high-level waste geologic repository, the NRC staff is required to determine whether the site and design meet the Technical Criteria (Subpart E) of 10 CFR Part 60. The NRC staff determination will be based on the answers to, and supporting analyses of, technical questions concerning the geologic setting and the engineered barrier system. During the process of Site Characterization, the Department of Energy (DOE) performs the laboratory and field investigations that develop the information needed to address these basic technical questions.

Investigations needed to characterize a geologic repository are complex and involve long lead times. The Nuclear Waste Policy Act of 1982 (The Act) has established a schedule for site characterization and selection. Specifically, the Act requires publication of Site Characterization Plans (SCP's) by DOE at an early stage of the process. Subsequent to the receipt of an SCP, the NRC must prepare a formal Site Characterization Analysis (SCA) for each site. Documented site reviews, technical meetings, and site technical position papers will precede and supplement the SCA's.

Because of the complexity and long lead times for site characterization investigations, it is essential that activities be organized to make possible an NRC determination regarding site acceptability. Proper organization necessitates early identification of technical questions (issues) relevant to the specific site. Therefore, this document establishes the NRC position as to the essential issues relevant to hydrology for the Basalt Waste Isolation Project (BWIP) site. Other Site Technical Positions (STP's) and other NRC documents relevant to hydrology will address NRC staff concerns regarding selected issues and acceptable technical approaches for addressing those issues.

In identifying these essential issues, the staff has used a performance analysis approach. In that approach three terms, "site issue", "performance issue" and "significant conditions and processes" have the special meanings described in the following paragraphs.

A Site Issue is a question about a specific site that must be addressed and resolved to complete the licensing assessment of site and/or design suitability in terms of 10 CFR Part 60. Site issues are not necessarily controversial questions.

A Performance Issue is a broad question concerning the operation and long-term performance of the various components of the repository system. A set of performance issues are derived directly from performance objectives in 10 CFR Part 60.

Significant Conditions and Processes (includes potentially adverse conditions of 10 CFR 60) are those that must be considered in the assessment of a performance issue and either: (1) exist before repository disturbance; (2) could cause future changes; or (3) result from change. They may be natural (e.g., faulting), repository-induced (e.g., thermal fluid buoyancy), or human-induced (e.g., withdrawal of water resources).

In its performance analysis approach, the NRC staff first breaks down the performance objectives of 10 CFR Part 60 into a set of performance issues corresponding to the individual performance of the various components of the repository system. As developed in NUREG-0960, performance issues for a geologic repository are:

1. How do the design criteria and conceptual design address releases of radioactive materials to unrestricted areas within the limits specified in 10 CFR Part 20?

2. How do the design criteria and conceptual design accommodate the retrievability option?

3. When and how does water contact the backfill?

4. When and how does water contact the waste package?

5. When and how does water contact the waste form?

6. When, how, and at what rate are radionuclides released from the waste form?

7. When, how, and at what rate are radionuclides released from the waste package?

8. When, how, and at what rate are radionuclides released from the backfill?

9. When, how, and at what rate are radionuclides released from the disturbed zone?

10. When, how and at what rate are radionuclides released to the accessible environment?

11. What is the pre-waste emplacement groundwater travel time along the fastest path of radionuclide travel from the disturbed zone to the accessible environment?

12. Have the NEPA Environmental/Institutional/Siting requirements for nuclear facilities been met?

The next step in the performance analysis approach is identification of the significant conditions and processes that bear on assessment of each of the performance issues. Judgement is involved in determining which conditions and processes are considered significant. Knowledge gained from the staffs' review of various related technical data and documents, site visits, technical meetings and research efforts contributed heavily to the particular selection of significant conditions and processes used in developing this STP. Questions about the significant conditions and processes as they pertain to hydrology constitute the site issues identified in this position.

Information on the hydrology system collected during site characterization at BWIP will be part of the total repository system information needs of the NRC staff required to assess the performance issues. Issues identified in the following section delineate information needed by the NRC staff to adequately assess the hydrologic aspects of the performance issues for BWIP. The sequential order in which issues are identified should not be interpreted as the order of relative importance.

Technical Position

It is the position of the NRC staff that, based on our current level of knowledge of the BWIP site, assessment of compliance with the relevant Technical Criteria of 10 CFR Part 60 requires that, at a minimum, the following specific issues concerning hydrology be addressed.

1.0 Hydrology

1.1 What is the nature of the present groundwater system?

1.1.1. What is (are) the conceptual model(s) of the present regional (within and adjacent to the Pasco Basin) groundwater system?

1.1.1.1. What are the hydrogeologic limits of the regional groundwater system (boundaries, boundary conditions, as well as recharge and discharge locations, mechanisms and amounts of recharge) that are significant to estimating the hydrogeologic conditions within and near the Hanford Reservation?

1.1.1.2 What are the distributions of measured and interpolated hydrogeologic parameters affecting regional groundwater flow?

1.1.1.3 What are the hydrostratigraphic units and structures within the regional groundwater system and how and to what extent do they affect groundwater flow?

1.1.2 What is (are) the conceptual model(s) of the present local (within and adjacent to the Reference Repository Location [RRL]) groundwater system?

1.1.2.1 What are the hydrogeologic boundaries, recharge and discharge locations, mechanisms and amounts for the local groundwater system?

1.1.2.2 What are the distributions of measured and interpolated hydraulic parameters affecting local ground-water flow?

1.1.2.3 What is the hydrochemistry of the local ground-water system?

1.1.2.4 What are the hydrostratigraphic units and structures within the local groundwater system, and how and to what extent do they affect groundwater flow?

1.1.3 What mathematical models are used to predict groundwater flow?

1.2 What is the nature of the present surface water system?

1.2.1 What are the physical characteristics of the surface water system within and adjacent to the Pasco Basin?

1.2.2 What is the potential for flooding within the controlled area at BWIP?

1.3 What are the types, probabilities, and nature of natural changes that would affect groundwater flow?

1.3.1 What are the types, probabilities, and nature of climatic changes that would affect groundwater flow?

1.4 What are the types, probabilities, and nature of human-induced changes (excepting repository-induced changes) that would affect groundwater flow?

1.4.1 How does the value of water resources in the area compare with values in other surrounding areas of similar size, and what is the potential for future use?

1.4.2 What are the types, probabilities and natures of water resource development and use that would affect groundwater flow?

1.4.3 What are the types, probabilities, and natures of mineral hydrocarbon resource development and use that would affect groundwater flow?

1.5 What are the types, probabilities, and natures of repository-induced changes that would affect groundwater flow?

1.6 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from natural changes?

1.6.1 What are the future effects on groundwater flow paths,

velocities, fluxes, and discharge rates resulting from climatic changes?

1.6.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from geologic changes?

1.7 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from human-induced changes, excepting repository induced changes?

1.7.1 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from water resource development?

1.7.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from mineral and hydrocarbon resource development?

1.8 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from repository-induced changes?

1.8.1 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from mechanically-induced changes?

1.8.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from thermally-induced changes?

Discussion

The rationale for each issue is described in the subsequent discussion. In the discussion, the broadest issues, i.e. those that would appear in the first tier of a hierarchy of issues and sub-issues are related directly to the performance issues that are listed in the background section above. Other issues are related by technical argument to the issue(s) directly above in the hierarchy.

1.0 Groundwater

The groundwater issues identified below will need to be addressed in order to address each of the performance issues listed on page 2.

1.1 What is the nature of the present groundwater system?

Groundwater is the primary transporting agent for radionuclide migration from a geologic, high-level waste repository. Accordingly, knowledge of the components of the groundwater system will be necessary for complete evaluation of all performance issues. For example, the potential for inflow of groundwater into the underground facility during the operational phase will likely be a consideration in evaluating Performance Issues 1 and 2. In the context of longer term performance, Performance Issues 3 through 5 relate directly to inflow of groundwater into the underground facility while Performance Issues 6 through 10 relate directly to release of radionuclides from the underground facility via the groundwater pathway (this does not assume groundwater is the only release pathway). Performance Issue 11 is based on a requirement for site suitability; that the pre-waste emplacement groundwater travel time along the fastest path of radionuclide travel to the accessible environment be greater than 1,000 years. Finally, potential impacts of the repository on the present groundwater system will likely be a consideration in evaluating Performance Issue 12. Evaluation of these performance issues depend on an understanding of the components of the groundwater system which are identified, relative to varying levels of scale and detail, in the following issues.

1.1.1. What is (are) the conceptual model(s) of the present regional (within and adjacent to the Pasco Basin) groundwater system?

The nature of the present regional groundwater system should be characterized in order to address performance issues 9 through 12, as listed on page 2. The nature of the regional groundwater system is defined by the conceptual model(s) of the system, and resultant predictions of system behavior based on the conceptual model(s). The level of quantitative and qualitative detail necessary for the conceptual models and performance predictions is dictated by the objectives and requirements of each model application.

The conceptual model(s) of the regional groundwater system provide(s) the hydrogeologic framework for evaluating the nature and significance of hydrogeologic processes in the region that may affect repository performance.

A conceptual model for a given application consists of a characterization of those features of the natural system needed to define the relevant behavior of the system. For the purposes of resolving Performance Issues 10 through 12, a conceptual hydrogeologic model is expected to include, at a minimum, such components as hydrostratigraphic units, recharge and discharge areas, major structures and discontinuities, distribution of groundwater hydraulic parameters, locations of hydrologic stresses, and degree of transience. The degree of spatial and temporal detail necessary for a model is expected to be less than for a smaller-scale model. A range of defensible conceptual models of the groundwater system should be developed that brackets all reasonable interpretations of data.

1.1.1.1. What are the hydrogeologic limits of the regional groundwater system (boundaries, boundary conditions, as well as recharge and discharge locations, mechanisms and amounts of recharge) that are significant to estimating the hydrogeologic conditions within and near the Hanford Reservation?

This information is necessary to define the groundwater system of the geologic setting in terms of general flow direction and volume. The boundaries will define the scale of the regional groundwater system, which is expected to be roughly of the scale of the Pasco Basin.

1.1.1.2 What are the distributions of measured and interpolated hydrogeologic parameters affecting regional groundwater flow?

Defensible interpretations of the three-dimensional spatial and temporal distribution of hydraulic parameters affecting groundwater flow are necessary to make quantitative determinations regarding Performance Issues 10 through 12 The parameters for which information is necessary to make these determinations include but are not necessarily limited to hydraulic conductivity, storativity, total porosity, effective porosity, and hydraulic head.

1.1.1.3 What are the hydrostratigraphic units and structures within the regional groundwater system and how and to what extent do they affect groundwater flow?

The lithology and stratigraphy of the Pasco Basin basalts, interbeds, and suprabasalt sediments are likely to have a controlling effect on groundwater flow in the region. Identification of the units and structures controlling regional groundwater flow, and of their degree of spatial continuity, is a

necessary component of a regional groundwater flow model. The effect that these structures and hydrostratigraphic units, and associated structural and stratigraphic discontinuities, have on the regional groundwater system should be assessed in order to resolve the performance issues.

1.1.2 What is (are) the conceptual model(s) of the present local (within and adjacent to the Reference Repository Location [RRL]) groundwater system?

The nature of the present local groundwater system should be known in order to address each of the twelve performance issues listed on page 2. The nature of the local groundwater system is defined by the conceptual model(s) of the system, and resultant predictions of system behavior based on the conceptual model. The level of quantitative and qualitative detail necessary for the conceptual models and performance predictions is dictated by the objectives and requirements of each model application.

The conceptual model(s) of the groundwater system provide the hydrogeologic framework for evaluating the nature and significance of the hydrogeologic processes that may affect repository performance. As noted in section 1.1.1, a conceptual model consists of a characterization of those features of the real system needed to define the relevant behavior of the system. For the purposes of resolving the performance issues, a conceptual sub-regional hydrogeologic model would include, at a minimum, such components as hydrostratigraphic units, local inflow and outflow (or recharge and discharge) areas, local structures and discontinuities, distribution of hydraulic parameters, locations of hydrologic stresses, and degree of transience. For evaluations of the degree of transience, the impact of Hanford site activities, such as drilling, pumping, injecting, and waste disposal, on the sub-regional groundwater system should be assessed.

The level of spatial and temporal detail necessary would likely be higher than for a larger-scale model, depending on the precise application of the model. For example, for evaluations of performance issue 9 (releases from disturbed zone), it may be necessary to obtain detailed information about individual fracture systems that may provide hydraulic connectivity in the deep basalts. The appropriate level of detail should be identified for each given application of the conceptual model through parametric sensitivity studies (of the appropriate level of sophistication). A range of defensible conceptual models of the groundwater flow system should be developed that brackets all reasonable interpretations of data.

1.1.2.1 What are the hydrogeologic boundaries, recharge and discharge locations, mechanisms and amounts for the local groundwater system?

This information is necessary to define the conceptual model of groundwater flow in terms of general flow direction and volume. The boundaries will define the scale of the groundwater system, which is expected to be roughly of the scale of the Hanford site.

1.1.2.2 What are the distributions of measured and interpolated hydraulic parameters affecting local ground-water flow?

Defensible interpretations of the three-dimensional spatial and temporal distribution of groundwater hydraulic parameters are necessary to make quantitative determinations regarding compliance with 10 CFR 60.112 and 60.113, and presence of favorable and potentially adverse conditions related to groundwater noted in section 1.1. The parameters for which information in necessary to make these determinations include but are not necessarily limited to hydraulic conductivity, storativity, total porosity, effective porosity, and hydraulic head.

1.1.2.3 What is the hydrochemistry of the local ground-water system?

Hydrochemical data may assist in the development of conceptual flow models by providing, for example, verification of the existence of chemically distinct hydrostratigraphic units, or by providing support for hypothetical flow paths based on hydrochemical transport considerations. Information regarding the hydrochemistry will also be valuable for radionuclide transport analyses.

1.1.2.4 What are the hydrostratigraphic units and structures within the local groundwater system, and how and to what extent do they affect groundwater flow?

The lithology, stratigraphy, interflow and intraflow structure of the Hanford site basalts, interbeds, and suprabasalt sediments are likely to have a controlling effect on groundwater flow. Identification of the units and structures controlling groundwater flow, their hydraulic properties and characteristics, and their degree of spatial continuity, is a necessary component of a groundwater flow model. The effect that these structures and hydrostratigraphic units, and associated structural and stratigraphic discontinuities (including individual fractures and fracture sets) have on the groundwater system, and on the local groundwater flow characteristics which

govern radionuclide transport, should be assessed in order to evaluate the status of the performance issues.

1.1.3 What mathematical models are used to predict groundwater flow?

A mathematical model is the translation of the conceptual understanding of the groundwater flow system into mathematical expressions describing physical processes. In general, mathematical models are either solved analytically or converted to a set of algebraic equations that are solved numerically. Mathematical models might be used to verify the compatibility of conceptual models with field measurements, and they might be used to predict groundwater and radionuclide travel paths and travel times. It is necessary to show that the mathematical models used are representative of the physics of the hydrogeological processes being described. For example, if a mathematical model based on the equations of flow through porous media is utilized for a particular application describing flow or transport through fractured basalt, it must be shown that the idealization of the fractured medium as a porous medium for that particular application is a reasonable approximation of the true physical system.

For example, some processes which likely will need to be considered in mathematical models relative to BWIP hydogeology include saturated flow, fracture flow, multi-phase flow, heat flow, and coupled thermo-hydro-chemico-mechanical interactions. In addition, mathematical models likely will be applied at varying scales t evaluate repository system and subsystem performance in relation to the performance issues.

1.2 What is the nature of the present surface water system?

Performance issues 1 and 2 relate design criteria and conceptual design of the geologic repository to: A. Releases of radioactive materials to unrestricted areas (within limits specified in 10 CRT Part 20); and B. The retrievability option. These primarily are operational considerations. An understanding of the nature of the present surface water system is essential to determine the potential for flooding of surface and underground facilities. Analysis of the potential flooding resulting from the surface water system will be an important consideration in evaluating performance issues 1 and 2.

1.2.1 What are the physical characteristics of the surface water system

within and adjacent to the Pasco Basin?

The potential for flooding within the BWIP controlled area is in part a function of the physical characteristics of the surface water system within and adjacent to the Pasco Basin. For example, specific data on drainage areas and flow patterns for various channels, channel cross-sections, and stage-discharge relationships of the appropriate drainage basins of the Pasco Basin region are the types of information necessary to define the physical characteristics of the surface water drainage system. In addition, either occupancy within or modification of flood plains are considered relevant physical characteristics of the surface water drainage system.

1.2.2 What is the potential for flooding within the controlled area at BWIP?

Flooding within the controlled area (including surface and underground facilities) could affect isolation of the waste and will be a consideration in the evaluation of repository performance as discussed in Issue 1.2. Typically, evaluation of potential flooding includes identification of historical flood events and calculation of peak flows (including peak velocities and flood stages for flood events ranging in magnitude from a 100-year flood to a probable maximum flood). In addition, evaluation of failure of existing or planned man-made surface water impoundments needs to be included in the analysis of flooding potential.

1.3 What are the types, probabilities, and nature of natural changes that would affect groundwater flow?

Natural processes which may change site conditions in the future and that would change the existing groundwater system need to be considered in determining whether long term performance of the repository will comply with radionuclide release standards. Specifically, future effects of such natural processes on groundwater flow need to be considered in evaluating Performance Issues 3 through 10 (see Issue 1.5). Identification of the types of processes is the necessary first step. Determining probabilities of occurrence of the various types of processes identified is the next step; this step may facilitate the elimination of some processes from further consideration. The nature of these changes is the necessary basis for consequence assessment.

Identified below is one particular natural process which is subject to change over time and is applicable to BWIP (Issue 1.3.1; Climate). Other natural processes which could change over time are included in the general category of geologic processes. Issues related to the types, probabilities, and nature of geologic changes are outside the scope of this Site Technical Position and are included in BWIP Site Technical Position 5.0, "Geology Issues for the Basalt Waste Isolation Project". However, effects on the groundwater system of plausible future geologic changes will be a consideration under Issue 1.6.2 of this Site Technical Position.

1.3.1 What are the types, probabilities, and nature of climatic changes that would affect groundwater flow?

Climatic variations are known to be important natural changes that could affect groundwater flow. Significant changes in climate have occurred in the past over the same lengths of time in which repository performance will be assessed. Within the Columbia Plateau, pluvial episodes during the Holocene epoch periodically increased the availability of moisture for recharge. This probably had significant effects on the hydrogeologic system. Therefore, climatic changes which can affect groundwater flow paths, rates and radionuclide releases need to be identified, quantified, and evaluated with respect to probability of occurrence and importance. This serves as a basis for consequence assessment.

1.4 What are the types, probabilities, and nature of human-induced changes (excepting repository-induced changes) that would affect groundwater flow?

Human-induced changes that would affect groundwater flow need to be considered in assessing long term repository performance. Specifically, future effects of plausible human-induced changes on groundwater flow need to be considered in evaluating Performance Issues 3 through 10 (see Issue 1.6). Identification of the types of changes, probability of occurrence, and description of the nature of changes are necessary. If warranted based on probability of occurrence, an assessment of the effects on repository performance also is necessary. Information provided by studies addressing this issue provide the basis for consequence assessment.

1.4.1 How does the value of water resources in the area compare with values in other surrounding areas of similar size, and what is the potential for future use?

Evaluation of the value of water resources within and surrounding BWIP, coupled with the historical development of water use and demand will provide a basis for establishing the probability and potential magnitude of future water resource development which could impact repository performance.

1.4.2 What are the types, probabilities and natures of water resource development and use that would affect groundwater flow?

Groundwater and surface water exploitation or manipulation could affect groundwater flow rates and paths. Identification of the types of water use activities that might occur as well as determination of the probabilities and nature of those water use activities provides a basis for determining necessary consequence assessments (see Issue 1.7.1).

1.4.3 What are the types, probabilities and natures of mineral and hydrocarbon resource development and use that would affect groundwater flow?

Mineral and hydrocarbon exploration or extraction could affect groundwater flow rates and paths. Identification of the types of exploration activities that might occur as well as determination of the probabilities and nature of exploration activities provide a basis for determining necessary consequence assessments (see Issue 1.7.2).

1.5 What are the types, probabilities, and natures of repository-induced changes that would affect groundwater flow?

The construction of the repository and the heat generated by emplaced waste may induce chemical, mechanical and hydrological changes that significantly affect the rates and direction of groundwater movement. These changes must be identified in order to evaluate their impact on repository performance.

1.6 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from natural changes?

The expected effects of plausible natural changes over time on groundwater flow paths, velocities, fluxes and discharge rates relate directly to the evaluation of Performance Issues 3 through 10.

1.6.1 What are the future effects on groundwater flow paths, velocities,

fluxes, and discharge rates resulting from climatic changes?

Within the Columbia Plateau, pluvial episodes during the Holocene epoch periodically increased the availability of moisture for recharge. A similar degree of variation in recharge potential can be expected during the next 10000 years. Accordingly, the effects of such climatic changes on the groundwater system need to be evaluated with respect to Performance Issues 3 through 10.

1.6.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from geologic changes?

In general, geologic processes which may affect the groundwater system include regional tectonic movements and associated local faults, folds and fractures. Evaluation of future effects on the groundwater system resulting from plausible geologic changes will be a consideration in evaluating Performance Issues 3 through 10.

1.7 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from human-induced changes, excepting repository induced changes?

The expected effects of plausible, human-induced changes over time on groundwater flow paths, velocities, fluxes and discharge rates relate directly to the evaluation of Performance Issues 3 through 10.

1.7.1 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from water resource development?

Groundwater and/or surface water exploitation or manipulation, whether for human, industrial or agricultural use, could affect groundwater flow rates and paths. In considering these changes, the value of resources relative to values in surrounding areas of similar size, the probability of resource exploration and/or development, and the potential impacts of these activities on groundwater flow and radionuclide transport should be evaluated.

1.7.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from mineral and hydrocarbon resource development?

Mineral and hydrocarbon exploitation or manipulation could affect groundwater flow rates and paths. In considering these changes, the value of resources

relative to values in surrounding areas of similar size, the probability of resource exploration and/or development, and the potential impacts of these activities on ground-water flow and radionuclide transport should be evaluated.

1.8 What are the future effects on groundwater flow paths, velocities, fluxes, and discharge rates resulting from repository-induced changes?

During the process of developing the repository, physical changes will be made in the repository block. In addition, during and after waste emplacement, thermal effects will begin to affect hydraulic gradients in proximity to the repository. For example, the environment of the repository (fractured basalts in the saturated zone) creates the potential for solute transport along fractures, faults or other pathways of preferential permeability. The thermal effects may create physical environments in which some minerals become unstable. Considerations such as these should be assessed with respect to the effect on repository preformance. Specifically, future effects on groundwater flow into, within, and out of the disturbed zone resulting from repository-induced changes need to be considered in evaluating both operational (Performance Issues 1 and 2) and long-term performance (Performance Issues 3 through 10).

1.8.1 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from mechanically-induced changes?

During construction of shafts and the underground facility physical changes will be made in the host rock. The effect of construction on fractures, faults or other pathways of preferential permeability and resulting effects on groundwater flow into, within, and out of the disturbed zone should be assessed with respect to operational and long-term repository performance.

1.8.2 What are the future effects on groundwater flow paths, velocities, fluxes and discharge rates resulting from thermally-induced changes?

During and after waste emplacement heat generated by the waste will begin to affect the hydrologic regime of the repository environment. In particular, hydraulic gradients may be significantly altered with a corresponding effect on preferred fluid migration pathways. The effect of this thermal load on fluid movement into, within, and out of the disturbed zone should be assessed with respect to operational and long-term repository performance. It should be noted that the thermal loading is anticipated to decay with time and is not

likely to be a factor during the full period of performance of the repository system.