see memo to file Sm. Weber 7/31/87

101

TECHNICAL EVALUATION REPORT

HYDROGEOLOGY OF THE HANFORD SITE
BASALT WASTE ISOLATION PROJECT
BENTON COUNTY, WASHINGTON

APRIL 1986

HYDROLOGY SECTION

GEOTECHNICAL BRANCH

DIVISION OF WASTE MANAGEMENT

U. S. NUCLEAR REGULATORY COMMISSION

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Introduction

Consistent with the Nuclear Waste Policy Act of 1982, the Nuclear Regulatory Commission (NRC) will license the construction and operation of deep mined geologic repositories for the disposal of high-level radioactive waste (HLW) by the Department of Energy (DOE). In preparation for licensing in the 1990's, NRC is evaluating hydrogeologic assessments prepared by the DOE and its contractors against the Commission's regulations in 10 CFR Part 60. This Technical Evaluation Report (TER) presents the current NRC staff position on DOE's hydrogeologic assessments of the Hanford site, thus providing a status report on the validity, adequacy, and timeliness of DOE's assessments as of April 1986.

The TER is organized to address specific portions of 10 CFR Part 60 for which hydrogeologic assessments will be used to demonstrate compliance, including siting criteria (§60.122), the geologic setting performance objective (§60.113(a)(2)), the overall system performance objective (EPA standards - §60.112), and operational requirements (§60.131(b)(1)). After a brief overview of site characteristics for perspective, the TEM summarizes tentative NRC staff conclusions regarding either DOE's demonstration of compliance with the requirements of 10 CFR Part 60, or the lack of this demonstration, highlighting existing uncertainties and DOE's plans for testing and assessment to support future demonstrations of compliance. The positions presented in this TER are not intended to serve as pre-licensing findings, but rather as informal appraisals of DOE's hydrogeologic investigations. As pre-licensing activities proceed, the NRC staff plan to update the TER periodically based on information derived from future evaluations of DOE's hydrogeologic assessments relevant to the Hanford site.

Site Description

As shown in Figure 1, the Reference Repository Location (RRL) is located in the center of the Pasco Basin in the Columbia and Snake River Plateau physiographic province. The RRL is located entirely within the Hanford Reservation, a government-owned facility of approximately 1500 square kilometers that was established during World War II. At a surface elevation of about 200 m AMSL, the Hanford Reservation is a relatively flat to gently sloping desert that is bounded to the West by Rattlesnake Mountain (1100 m AMSL) and the Yakima and Columbia Rivers (73 m AMSL) to the South and East, respectively. Annual precipitation at the site averages less than 18 cm. Surface runoff from the northeastern one-third of the RRL drains northeasterly to the Columbia River, whereas most of the RRL drains to Cold Creek, an ephemeral stream that traverses the southwestern corner of the site. Five kilometers downstream from the site, Cold Creek merges with the ephemeral Dry Creek and flows southeast to the horn of the Yakima River (DOE, 1984).

The RRL is underlain by Quaternary unconsolidated fluvial and lacustrine sediments (Hanford and Ringold Formations) and a thick sequence of intercalated continental flood basalt flows and sedimentary interbeds of the Columbia River Basalt Group. Basement rocks beneath the RRL have not been identified because of their great depth (G. T. 2000 m) and lack of deep exploration. The basalt

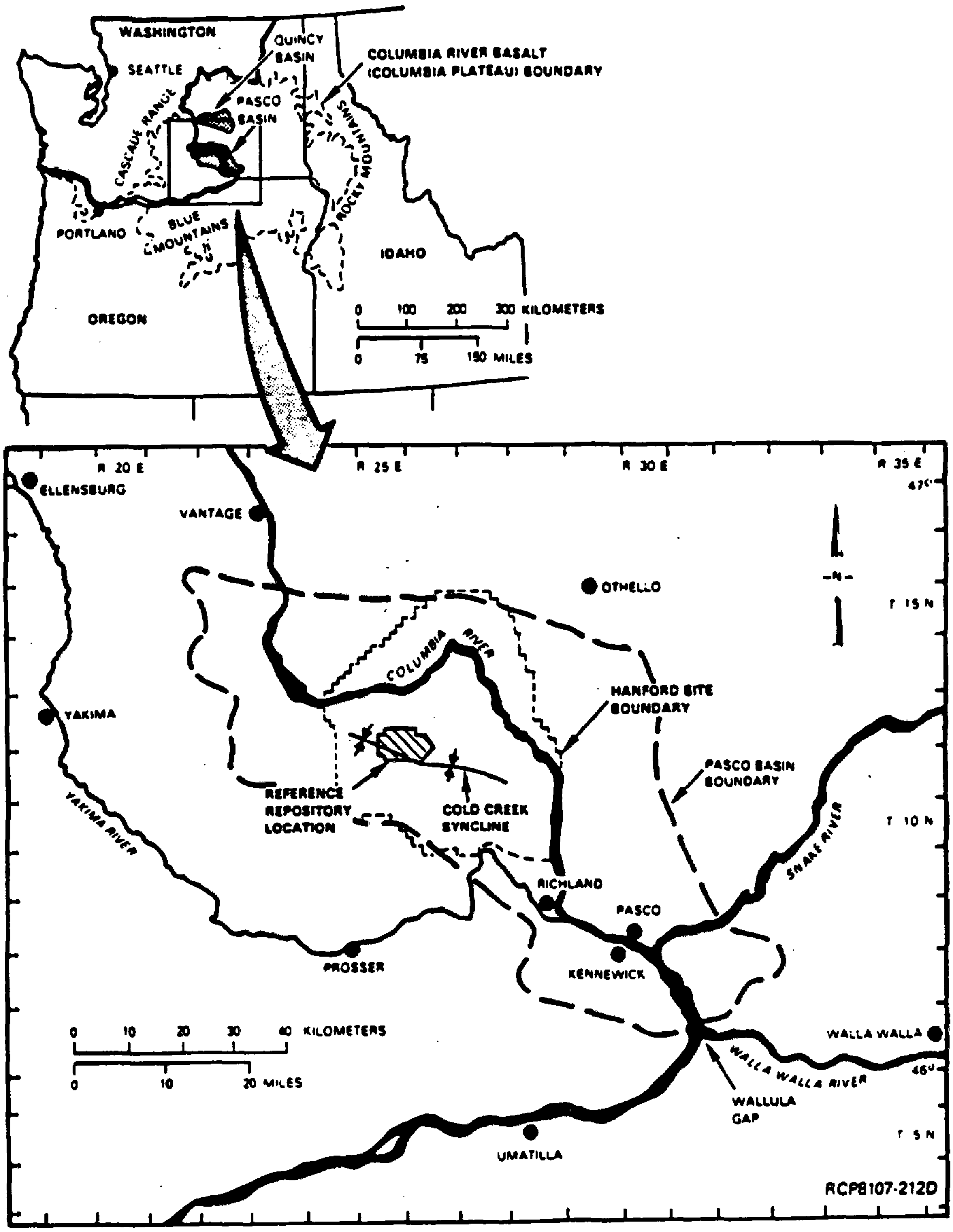

Figure 1. Location of the Columbia Plateau, Hanford Site, Cold Creek Syncline, and Reference Repository Location (DOE, 1982).

flows belong to three formations, which are the Saddle Mountains (6 to 13.5 mybp), Wanapum (13.5 to 14 mybp), and Grande Ronde (15.6 to 17 mybp) from youngest to oldest (DOE, 1984). The preferred repository horizon is located at a depth of 950 m in the Cohassett flow of the Grande Ronde Formation (see Figure 2). Individual flows may generally be divided into sections characterized by discrete morphologies including vesicular and brecciated flow tops; relatively dense, jointed flow interiors; and vesicular, fractured, and brecciated flow bottoms. The Cohassett flow contains a relatively thick vesicular zone in the upper portion of its flow interior. In addition to intraflow structures, the basalts have been folded into broad synclines, anticlines, and monoclines. The basalts have been faulted, especially near the fold axes. More intense deformation exists locally with tight and overturned folds along thrust and tear faults in the basalts.

Groundwater exists predominantly under unconfined conditions within the unconsolidated sediments and basalts near the land surface. Recharge occurs at higher elevations in the west, although recharge by the rivers occurs along their banks and where human activities (e.g., waste disposal, impoundments) locally discharge to the unconfined groundwater system. Groundwater quality in the unconfined system is generally potable, except where evaporation or percolation through saline sediments has increased ion concentrations, or where human activities have contaminated the groundwater.

Groundwater flows in the basalts under confined conditions, except locally where the water table exists in basalt. Based on available information, it appears that most of the groundwater flows through the more-permeable interflow zones (flow tops and bottoms, and interbeds). The Priest Rapids Member of the upper Wanapum Formation appears to be contain the most transmissive basalt interflows at Hanford. Groundwater flow through the dense flow interiors is believed to occur through joints and fractures, as well as larger, subvertical tectonic structures that may interconnect flows along the crests of anticlinal folds at Gable Mountain and Gable Butte north of the RRL and the extension of the Yakima Anticline south of the RRL. Water quality in the Wanapum and Saddle Mountains basalt flows is generally potable. Groundwater in the deeper Grande Ronde Formation may not be potable without treatement because of high concentrations of ions such as fluoride, chloride, and trace metals (DOE,1984).

Siting Criteria

The NRC regulations in 10 CFR Part 60.122 require that the geologic setting of a candidate site for HLW disposal exhibit an appropriate combination of favorable conditions so that, together with the engineered barrier system, they are sufficient to provide reasonable assurance that the performance objectives in §60.111-113 will be met. Relevant hydrogeologic favorable conditions include: (1) the nature and rates of hydrogeologic processes operating in the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate waste; (2) favorable hydrogeologic characteristics including a host rock with low horizontal and vertical permeability, downward or dominantly horizontal hydraulic gradients in the host rock and adjacent units, and low vertical permeability and low hydraulic gradient between the host rock and surrounding units; and (3) a pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years. In addition, Part 60.122 requires that potentially adverse conditions shall not significantly affect the ability of the geologic repository to satisfy the performance objectives, are compensated by a combination of favorable characteristics, or can be remedied so they do not significantly jeopardize performance of the geologic repository.

REFERENCE REPOSITORY LOCATION STRATIGRAPHY

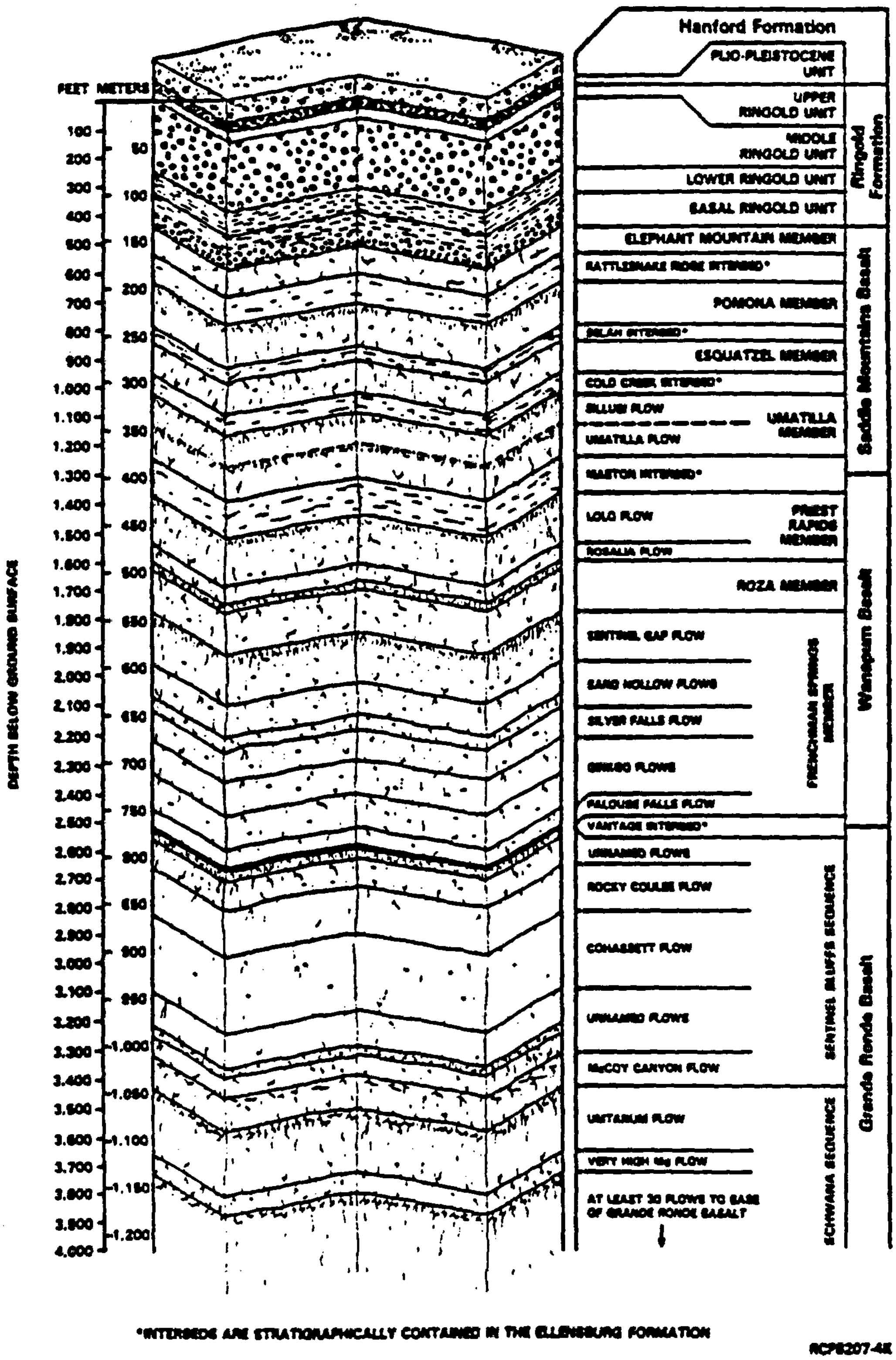

Figure 2. General stratigraphy at the RRL (DOE/NRC, 1986).

Potentially adverse hydrogeologic conditions that may affect isolation within the controlled area include: (1) potential for flooding of the underground facility caused by modification of floodplains or failure of existing or planned surface impoundments; (2) foreseeable human activities that adversely affect the groundwater flow system; (3) potential for natural phenomena of such magnitude that large-scale surface impoundments could be created that would change the regional groundwater flow system; (4) structural deformation that may adversely affect the regional groundwater flow system; (5) potential for changes in hydrologic conditions that would affect the migration of radionuclides to the accessible environment; (6) potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes; (7) the presence of groundwater or surface water, whether identified or undiscovered, in such form that either economic extraction is currently feasible or potentially feasible during the foreseeable future, or the water resource has a greater gross value or net value than the average for other areas of similar size that are representative of and located within the geologic setting; (8) evidence of drilling for any purpose within the site; and (9) groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts. The favorable and potentially adverse conditions listed above intentionally omit siting criteria that apply to disposal in the unsaturated zone because DOE presently proposes to dispose of HLW in the saturated zone well below the regional water table. The following section describes the status of DOE's demonstration of compliance with respect to the siting criteria in 10 CFR Part 60.

Favorable Conditions

Nature and Rates of Hydrogeologic Processes

In the draft Environmental Assessment (DOE, 1984), DOE has tentatively asserted that recent hydrogeologic processes have had mostly local, transient, and shallow effects on the hydrogeologic system. DOE asserted that these processes would not adversely affect the ability of the repository to isolate waste. For the comparison of site characteristics with the comparable DOE siting criterion in 10 CFR Part 960, DOE added the qualifier "during the next 100,000 years" to NRC's favorable condition in 10 CFR Part 60.122(b)(1). DOE has not, however, prepared assessments that systematically identify and evaluate the significance of hydrologic processes with respect to repository performance. DOE has not asserted that the nature and rates of recent hydrogeologic processes would favorably affect the ability of the repository to isolate waste. Thus, DOE has not demonstrated that the nature and rates of hydrogeologic processes operating within the Quaternary Period at BWIP, when projected, will not adversely affect or will favorably affect the ability of the repository to isolate HLW waste. In the absence of pertinent assessments, the NRC staff has not determined whether this favorable condition is present at the Hanford site (cf. DEA major comment number 2; NRC, 1985).

Hydrogeologic Characteristics

For disposal in the saturated zone, 10 CFR Part 60.122(b)(2) denotes the following hydrogeologic characteristics as favorable: (1) a host rock with low horizontal and vertical permeability, (2) downward or dominantly horizontal hydraulic gradient in the host rock and immediately surrounding units, and (3) low vertical permeability and low hydraulic gradient between the host rock and the surrounding hydrogeologic units. All three of these characteristics must be present for DOE to demonstrate that the favorable condition is present at a site. Based on available information for the Hanford site, DOE tentatively concluded that the first two characteristics are present at Hanford. DOE has asserted in the draft EA that both the vertical and horizontal permeability of the Cohassett flow interior (host rock) are very low.

Addressing the second characteristic, DOE asserted that hydraulic gradients in the Grande Ronde are low in magnitude and either horizontal or slightly upward. This assertion is based on analyses of water level and pressure data recently collected in nested piezometer installations around the RRL. NRC analyses indicate that the magnitudes of vertical gradients are generally greater than lateral hydraulic gradients within the host ~~host~~ and surrounding units (Winter, 1986). Hydraulic gradients are directed upward through the interiors of the Cohassett (host rock), Rocky Coulee, and composite Grande Ronde flows. Therefore, the second characteristic does not appear to be present at the Hanford Site because the gradients are not directed downward and are not dominantly horizontal.

Although hydraulic gradients in the host rock and adjacent units appear to be low, it is presently unclear whether the third characteristic is present at Hanford because of uncertainties about the definition of "low" vertical permeability. Low gradients between the host rock and surrounding units satisfies the second part of the third characteristic. Reliable estimates of the vertical permeability between the host rock and surrounding units do not presently exist. Even if such data did exist, it would be difficult to determine whether the permeabilities were low. Although they may be low compared with a transmissive alluvial aquifer, they may be relatively high compared with expected permeabilities of structureless evaporite deposits.

Based on available information, the staff presently concludes that this favorable condition does not appear to be present at the Hanford site because hydraulic gradients in the host rock and surrounding units are not directed downward or dominantly horizontal. The staff recognizes, however, that considerable uncertainties currently exist in hydraulic parameter and head data. These uncertainties preclude conclusive comparisons of Hanford site characteristics with the favorable hydrogeologic conditions listed in 10 CFR Part 60.122(b)(2) at this time (cf. DEA comments 6-15, 3-19, 3-20, 3-22, 6-16, and 6-105; NRC, 1985).

Groundwater Travel Times

The seventh favorable condition in 10 CFR Part 60.122(b) is present at sites where the pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment substantially exceeds 1,000 years. As an example, travel times on the order of tens of thousands of years would be considered by the staff to substantially exceed the 1000-year criterion. DOE has tentatively concluded that this condition is present at the Hanford site because median pre-emplacement groundwater travel times are expected to exceed 10,000 years. The NRC staff considers that such expectations are premature and indefensible at this time because of considerable limitations and uncertainties associated with the information used to predict the groundwater travel times (cf. DEA major comment number 1 and comments E-3, 3-23, 6-11, 6-12, 6-15, 6-101, 6-102, 6-103, 6-104, 6-105, and 7-1; NRC, 1985). Thus, the NRC staff has not determined whether pre-waste emplacement groundwater travel times from the disturbed zone to the accessible environment substantially exceed 1,000 years. The groundwater travel time criterion is discussed in greater detail in the subsequent section on performance objectives.

Potentially Adverse Conditions

Underground Facility Flooding

Potential for flooding the underground facility prior to closure, whether resulting from the occupancy and modification of floodplains or from the failure of existing or planned man-made surface impoundments, is the first potentially adverse condition of 10 CFR Part 60.122(c). In the draft EA, DOE asserted that this potentially adverse condition is not present at the Hanford Site because (1) the site is not located in a floodplain, (2) the site is elevated above conceivable flood elevations of the Columbia and Yakima Rivers, considering both natural flooding and impoundment failure scenarios, and (3) flash flooding of the site along the Cold Creek drainage channel would not result in unmanageable water levels in areas of repository support facilities. NRC staff reviewed this assessment and concluded that the estimated water levels were highly uncertain and not conservative. Based on assessments prepared by DOE to date, the staff have identified a potential for flooding, which may be remedied through appropriate design and operation measures. The NRC staff considers it likely that the underground facility and supporting surface facilities could be designed, constructed, and operated to prevent surface water flooding of the underground facility.

Human Effects on Groundwater Flow System

A potentially adverse condition may be present at sites where potential, foreseeable human activities will adversely affect the groundwater flow system. Examples of such activities include groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activity, and construction of large-scale surface water impoundments. In the draft EA, DOE stated that there is potential for foreseeable human activities, such as groundwater withdrawal and irrigation. DOE also stated, however, that available information is insufficient to determine if these activities could adversely affect the groundwater flow system.

NRC staff have qualitatively reviewed available information relevant to this adverse condition and have concluded that all of the activities listed as examples of foreseeable human activities in 10 CFR Part 60.122(c)(2) have occurred near the Hanford site. Groundwater is pumped from shallow and deep aquifers off-site for domestic and agricultural water supplies. Nearby portions of the Pasco Basin are extensively irrigated as part of the Columbia River Irrigation Project. The Hanford Atomic Energy Commission Works disposed of wastes by injecting them into shallow hydrogeologic units beneath the Hanford Site. The city of Richland uses underground pumped storage of Columbia River water to augment city water supplies. Stretches of the Columbia River have been impounded for flood control and development projects (e.g., Priest Rapids Dam). In support of military activities, large surface impoundments have been used on the Hanford site for waste disposal, process water storage, and cooling purposes. With increased population and development of the Pasco Basin near the Hanford site, the demand for surface water and groundwater use is expected to increase, which may further stimulate existing and potential human activities that may adversely affect the groundwater flow system.

These past, present, and potential activities may have significant adverse effects on the groundwater flow system by modifying hydraulic gradients and potentially decreasing groundwater travel times from the underground facility to the accessible environment. For example, waste water disposal at the Hanford Site has created large groundwater mounds in the shallow unconfined aquifers, which may have reversed the ambient vertical gradient from upward to downward through the Saddle Mountains and Upper Wanapum basalts. This observation suggests that foreseeable human activities may have significant effects on the groundwater flow system at the Hanford Site, especially because of the low ambient hydraulic gradients. Because of existing uncertainties in the magnitude of discharge and recharge to the groundwater flow system associated with human activities, however, DOE has not been able to determine conclusively whether foreseeable human activities would adversely affect the groundwater flow system (cf. DEA major comment number 2 and comments 6-18, 6-57, and 6-19; NRC, 1985). Lacking defensible conceptual models of the groundwater flow system and accurate descriptions of the human activities, the NRC staff have not evaluated the anticipated effects of human activities on the groundwater flow system.

Impoundments caused by Natural Phenomena

The potential for the creation of large-scale surface water impoundments by natural phenomena that may change the regional groundwater flow system is considered a potentially adverse condition in 10 CFR Part 60.122(c)(3). Examples of such phenomena include landslides, subsidence, or volcanic activity. The condition implies that changes to the regional groundwater flow system would adversely affect performance of the geologic repository. DOE has tentatively asserted that this condition is not present at the Hanford site because it does not appear that natural phenomena near the site could create large-scale, long-term surface impoundments. DOE has not assessed the potential effects of such impoundments on the regional groundwater flow system on the presumption that the impoundments will not be created by natural phenomena or that these impoundment, if created, would not last long enough to significantly influence the regional groundwater flow system. NRC staff have not determined the probability of the occurrence of such phenomena, their ability to create large-scale surface impoundments, or the potential effects of such impoundments on the regional flow system.

Flow System Changes caused by Deformation

The presence of structural deformation, such as uplift, subsidence, folding, and faulting, is considered a potentially adverse condition if the deformation may adversely affect the regional groundwater flow system [60.122(c)(4)]. DOE has concluded that the low rate of structural deformation is not expected to affect the regional groundwater flow system, and thus this adverse condition is not present at the Hanford Site. DOE has not, however, assessed whether plausible structural deformation at Hanford would affect the groundwater flow system. The NRC staff has not determined whether DOE's projections for future deformation are valid or whether structural deformation would have an adverse effect on the regional groundwater flow system (cf. DEA major comment number 4 and comments 6-41, 6-42, and 6-49; NRC, 1985).

Changes in Hydrologic Conditions

A potentially adverse condition may exist at sites where potential changes in hydrologic conditions would affect the migration of radionuclides to the accessible environment [10 CFR 60.122(c)(5)]. Examples of relevant conditions include hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, recharge, discharge, and potentiometric levels. In the draft EA, DOE stated that a final conclusion on the presence of this potentially adverse condition cannot be acheived at Hanford because of limitations of the present data base. DOE also stated, however, that this condition appears to be absent because estimated groundwater travel times appear to be sufficiently long to inhibit radionuclide migration to the accessible environment during the first 10,000 years after closure. Thus, changes in hydrologic conditions would not significantly affect radionuclide migration to the accessible environment. This assertion was primarily based on assessments of climatic and thermal effects on the groundwater flow system, both of which are anticipated by DOE to be insigificant following repository closure.

Preliminary NRC assessments, however, indicate that these effects may significantly affect radionuclide migration to the accessible environment. In addition to thermal affects on hydraulic gradients, other activities and processes, such as groundwater pumping or repository construction, may also significantly affect hydrologic conditions. Based on present analyses, the NRC staff concludes that this potentially adverse condition may be present at the Hanford Site because changes in hydrologic conditions may occur that would affect radionuclide migration to the accessible environment (cf. DEA major comment number 2 and comments 6-18 and 6-27; NRC, 1985).

Climatic Changes

Potential changes in hydrologic conditions resulting from reasonably foreseeable changes in climate are considered as a potentially adverse condition in 10 CFR Part 60.122(c)(6). DOE has not determined whether this condition is present at the Hanford Site. Although DOE asserts that the climate of the Hanford Site is not expected to change significantly during the next 10,000 years, DOE has not provided analysis to support the assertion. Specifically, DOE has not assessed climatological effects of increases in CO_2 concentrations in the atmosphere nor the probability of the onset of another period of continental glaciation. Furthermore, the effects of past climate changes during the Quaternary Period have not been determined (cf. DEA major comment number 2 and comments 6-38 and 6-39; NRC, 1985). In the absence of these assessments, DOE has assumed that glacial and glacial-related events affected the hydrologic system of the Columbia Plateau. DOE plans to assess these effects based on data collected through site characterization. Based on the limited amount of information about the effects of climate changes on hydrologic conditions, NRC staff have not determined whether reasonably foreseeable changes in climate would signficantly change hydrologic conditions at Hanford.

Presence of Water Resources

The presence of water resources, whether identified or undiscovered, within the site is a potentially adverse condition, provided that (1) economic extraction of the water resources is currently feasible or potentially feasible during the foreseeable future or (2) the resources have a greater gross or net value than the average for other areas of similar size that are representative of and located within the geologic setting [60.122(c)(17)]. Other examples of naturally-occurring materials include fossil fuels, metalliferous and non-metalliferous ores, and industrial minerals. DOE has concluded that this potentially adverse condition is not present at Hanford because the extraction of any naturally-occurring materials on site is not considered to be economically feasible in the foreseeable future and the materials are not considered of greater value than surrounding resources in the Columbia Plateau. Based on qualitative evaluations of available information, the NRC staff concludes that the extraction of groundwater may be economically feasible from aquifers beneath the site (cf. DEA comment number 6-20; NRC, 1985). Therefore, the staff concludes that this potentially adverse condition may be present at Hanford.

Evidence of Drilling

Evidence of drilling for any purpose within the site is a potentially adverse condition [60.122(c)(19)]. In the draft EA, DOE amended the condition to exclude consideration of drilling for site evaluation and include a qualifier that drilling must be to a depth sufficient to affect waste containment and isolation. Using this amended condition, DOE concluded that the potentially adverse condition was absent at Hanford because drilling for other purposes than site evaluation had not occurred at the RRL and drilling nearby had not occurred to a depth sufficient to affect waste isolation. The potentially adverse condition stated in 10 CFR Part 60, however, includes any drilling regardless of its significance to repository performance. Consistent with NRC's regulations, the staff concludes that this potentially adverse condition may be present at the Hanford Site because drilling for natural gas exploration and water resource development has occurred on and near the site.

Groundwater Conditions Requiring Complex Engineering

The presence of groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts is a potentially adverse condition [60.122(c)(20)]. Similar to the potentially adverse condition immediately above, DOE modified the condition in its evaluation of the site against the DOE siting criteria and found that the condition was not present at Hanford.
This conclusion was based on consideration of "in situ characteristics and conditions." DOE assessments have, however, identified several potential problems associated with the development of the underground facility and shafts. The primary hydrogeological problem is potentially high rates of groundwater inflow into the mined repository caused by the intersection of high permeability vertical structures or flow tops. Based on preliminary calculations prepared by DOE, it appears that expected inflow rates will not

require "complex" engineering measures for construction. The word "complex" is here interpreted as "beyond reasonably available measures." However, the staff has not determined whether (1) the estimated rates of groundwater inflow are valid and reasonable, and (2) the engineering measures required to handle groundwater inflow for facility construction would be complex (cf. DEA comment number 6-72; NRC, 1985).

Groundwater Travel Time Performance Objective

The groundwater travel time performance objective in 10 CFR Part 60.113(b) requires that the pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel shall be at least 1,000 years or other such time as approved by the Commission. The travel time is determined along paths from the disturbed zone to the accessible environment. Paraphrased from the definition in 60.2, the disturbed zone encompasses the underground facility and its immediate vicinity where physical and chemical properties have significantly changed as a result of repository construction or emplacement of the radioactive waste.

Based on a series of deterministic and stochastic simulations of the groundwater flow system at the Hanford site, DOE has tentatively concluded that the pre-waste emplacement groundwater travel time exceeds 1,000 years from the disturbed zone to the accessible environment. DOE acknowledges, however, that the estimated groundwater travel times are highly uncertain because of uncertainties in hydrologic parameters, such as transmissivity, effective porosity, and hydraulic gradient, and because available site information supports a variety of alternative conceptual models of the flow system. Through site characterization, DOE hopes to reduce uncertainties in the understanding of the groundwater flow system in preparation for licensing.

In a joint effort in 1978, Los Alamos Technical Associates, Inc., and Intera Environmental Consultants, Inc., developed a model of the Pasco Basin to estimate groundwater travel times from an underground facility in the Umtanum. This model predicted a 12-km groundwater flow path to the north with a travel time of 33,000 years (LATA, 1981). Two years later, Pacific Northwest Laboratory developed a Pasco Basin model from a larger-scale model of the Columbia Plateau as a demonstration of PNL's groundwater modeling capabilities. PNL's model indicated groundwater flow paths to the north that ranged from 12 to 16 km with travel times from 13,000 to 17,000 years (Dove, et al., 1981). In 1981, Rockwell Hanford Operations simulated the groundwater flow system of the Pasco Basin. The flow path in this simulation was directed southeast beneath the Columbia River to Wallulla Gap. Travel time along the 32 km path from the underground facility to beneath the Columbia River north of Richland was about 30,000 years (Arnett, et al., 1981).

Departing from the deterministic approach taken prior to 1983, DOE has recently simulated groundwater flow stochastically in a two-dimensional composite flow top. The stochastic approach uses the computer code MAGNUM-MC to estimate groundwater travel times for a large number of simulations. The output of the code is summarized in a single travel time probability curve (either a density function or a complementary cumulative distribution function) which incorporates uncertainties in input parameters. These simulations related uncertainties in flow top transmissivity to uncertainties in groundwater travel times. By keeping the effective thickness (effective porosity x real thickness) and hydraulic gradient constant and using a probability distribution for transmissivity, DOE estimated a median groundwater travel time along a 10-km flow path of 17,000 years, with a 95% probability that the travel time would exceed 1,000 years (Clifton, et al., 1983). RHO upgraded these simulations in 1984 by also considering effective thickness and hydraulic gradient as stochastic variables with unimodal distributions ranging from 0.001 to 0.1 meters and 0.0001 to 0.001, respectively. These simulations estimated a median groundwater travel time along a 10-km flow path of 81,000 years with a 95% probability that the travel time will exceed 1,000 years (Clifton, et al., 1984). DOE presently prefers the results of the upgraded simulations because (1) the simulations explicitly account for uncertainties in all input parameters, (2) ranges in parameter values reflect present limitations of DOE's understanding of the groundwater flow system, and (3) the travel time probability distribution has a larger range than the distributions of other stochastic simulations.

The NRC staff has reviewed DOE's estimates of pre-waste-emplacement groundwater travel time and identified several questionable aspects of these estimates, including: (1) the reliability and representativeness of transmissivity, hydraulic gradient, and effective porosity values, (2) the treatment of these data in both deterministic and stochastic models, (3) development of the numerical models, and (4) identification of flow paths from the disturbed zone to the accessible environment used in estimating groundwater travel times (NRC, 1985). DOE's limited understanding of the groundwater flow system and hydrologic parameters of the Hanford Site presently precludes defensible conclusions about pre-waste emplacement groundwater travel times from the disturbed zone to the accessible environment along the fastest path of radionuclide travel. In addition, DOE has not identified the extent of the disturbed zone surrounding the underground facility, from which groundwater travel times are to be calculated.

Consistent with the conceptual model assumed in DOE's stochastic simulations, NRC calculations indicate that substantially lower estimates of groundwater travel time can result from reasonable interpretations of existing data (NRC, 1985). These calculations yield some travel times less than 1,000 years in comparison with the results of DOE's simulations that estimate a 95% probability that travel times exceed 1,000 years. The NRC estimates, however, should not be construed as accurate or reliable predictions of groundwater travel time because of the simplified nature of the calculations and questions about the representativeness of present values of hydrologic parameters. Neverhtheless, the NRC parametric calculations cast significant doubt on the defensibility of DOE's tentative conclusion that groundwater travel times are well in excess of 10,000 years or that the travel times have high probabilities of exceeding 1,000 years as DOE indicated in the draft EA for the Hanford Site.

At this time, the staff considers the limited reliability and representativeness of hydrologic parameter values contribute the greatest uncertainty to DOE's estimates of groundwater travel times. The limitations arise from irregularities in testing procedures, improper test analyses, temperature effects, effects of dissolved gases and solids in water, the effects of large- and small-scale heterogeneities, and the ability of small-scale values to represent the hydrologic system on the larger-scale relative to repository performance assessment. DOE has not characterized vertical hydraulic conductivity, a parameter critical to determining flow paths and rates in the layered basalt sequence at Hanford. Based on available potentiometric information, DOE has not been able to characterize consistent directions and magnitudes of hydraulic gradients in the Grande Ronde and Wanapum basalts. DOE estimates of effective porosity are based on the results of one test that was conducted under perturbed conditions significantly different than ambient in the McCoy Canyon flow top. The ability to develop realistic probability distributions for effective porosity in the Columbia River Basalts is inherently limited by the small size (one value) of the existing data base. In addition, DOE has not defensibly characterized the true thickness of conductive zones in which effective thickness and transmissivity have been measured, both of which depend on thickness for their conversion to effective porosity and hydraulic conductivity for use in repository performance assessment. Since uncertainties in hydrologic parameter values carry through assessments of groundwater travel time, travel time estimates are highly uncertain and presently indefensible.

In addition to uncertainties in parameter values, NRC staff have identified other significant uncertainties in DOE's estimates of groundwater travel times from the disturbed zone to the accessible environment. These uncertainties include (1) estimation of the extent of the disturbed zone and distance to the accessible environment, (2) lack of defensible conceptual models of the groundwater flow system, (3) the lumping of hydrogeologic units together into "representative" units, (4) treatment of numerical model geometry, and (5) techniques to incorporate available hydrologic parameters into quantitative models of site performance. These uncertainties are described in greater detail in the NRC staff comments on the draft Hanford Environmental Assessment (NWPA) (Comments 1, E-3, 3-19, 3-22, 6-11, 6-12, 6-15, 6-101, 6-102, 6-103, 6-105, and 6-106; NRC, 1985).

Overall Containment Requirements

The NRC regulations in 10 CFR Part 60.112(a) (proposed) implement the EPA standard for overall containment of radionuclides as provided in 40 CFR Part 191.13(a). The regulation requires that the design of disposal systems for HLW provide reasonable assurance, based on performance assessments, that cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal have greater than 90% probability of being less than the limits in 10 CFR Part 60.115 (proposed) and greater than 99.9% probability of being less than 10 times these limits. Releases are calculated by considering all anticipated and unanticipated processes and events. Performance assessments conducted to demonstrate compliance with 60.112 need not provide complete assurance of compliance with the standard, but rather demonstrate with reasonable assurance that compliance will be acheived based on the record presented during licensing.

Although DOE has not demonstrated that the Hanford site complies with the overall containment performance objective, it has initiated a series of assessments to support the compliance demonstration. These assessments include estimation of pre-emplacement groundwater travel time, prediction of radionuclide releases from waste packages and engineered barrier subsystem, assessment of the repository seal subsystem, identification of anticipated and unanticipated release scenarios (processes and events) through delphi surveys, approximate quantification of scenario probabilities, and calculation of cumulative radionuclide releases over 10,000 and 100,000 years using the one-dimensional computer code EPASTAT. DOE has not demonstrated the validity of the approach used in EPASTAT, which does not account for diffusion/dispersion and daughter product generation of radionuclides in far-field transport. In addition, the EPASTAT models assume diffusion-controlled release of radionuclides from the engineered barrier subsystem (DOE, 1984). Based on these ongoing assessments, DOE has tentatively concluded that the BWIP site has a high probability of complying with the cumulative radionuclide release limits for 10,000 and 100,000 years (DOE, 1984). DOE recognizes that further development and defense of this conclusion requires information that will be collected during the site characterization phase of repository development.

Based on reviews of these preliminary calculations, the NRC staff has concluded that the calculations are too premature to warrant thorough review at this time. The staff notes, however, that DOE's approach at BWIP appears to deviate somewhat from the approach the staff interprets will be necessary to demonstrate compliance with the EPA release limits. For example, the DOE tentative conclusion cited above assumes that pre-waste emplacement groundwater travel times are representative of travel times under post-emplacement conditions. Non-isothermal modeling of the groundwater flow system at Hanford by the NRC staff has indicated that pre- and post-emplacement groundwater travel paths and times may be significantly different (Gordon and Weber, 1983). The differences would mandate that DOE consider post-emplacement groundwater travel paths to estimate cumulative releases to the accessible environment. As another example, the DOE assessments have not developed probability ranges for disruption scenarios or evaluated these scenarios against the EPA release limits. Recognizing these and other uncertainties that presently exist, the staff concludes that DOE's tentative conclusions regarding overall performance of the Hanford repository are not currently defensible (cf. DEA comments 6-29, 6-88, 6-89, 6-90, 6-91, and 6-109). NRC Hydrology staff plans to focus on developing guidance on acceptable approaches for demonstrating compliance with hydrogeologic aspects of the EPA release limits during the next fiscal year.

Individual Protection Requirements

The NRC regulations in 10 CFR Part 60.112(b) (proposed) implement the individual protection requirements of the EPA standards in 40 CFR Part 191.15. These requirements prohibit annual dose equivalents for 1,000 years after closure to any member of the public in the accessible environment from exceeding 25 millirems to the whole body or 75 millirems to any critical organ. In demonstrating compliance with this provision, DOE only needs to consider undisturbed performance of the repository. Individual exposure should be calculated by summing exposures along potential pathways including direct consumption of groundwater from any significant source of groundwater outside of the controlled area. EPA defines a "signficant source of groundwater" either as an aquifer that provides the primary source of water for a community water system as of November 18, 1985, or an aquifer that satisfies the following four criteria: (1) contains groundwater with less than 10,000 mg/l total dissolved solids (TDS); (2) is within 2,500 feet of the land surface; (3) has a transmissivity greater than 200 gallons/day/foot, provided that any portion of the aquifer has a hydraulic conductivity greater than 2 gallons/day/square foot; and (4) is capable of continuously yielding 10,000 gallons per day of water to a pumped or flowing well for a period of at least one year.

The most direct approaches for demonstrating compliance with the individual protection requirements are to demonstrate substantial containment by the waste packages for 1,000 years after closure or to demonstrate that post-emplacement groundwater travel times from the underground facility to the accessible environment equal or exceed 1,000 years. An appropriate combination of both of the waste package and travel time approaches could also constitute an acceptable approach. For example, DOE may be able to demonstrate compliance with the individual protection requirements by defensibly estimating a post-emplacement groundwater travel time of 500 years from waste packages that will subtantially contain the radionuclides for at least 500 years. Alternatively, DOE could predict radionuclide concentrations in significant sources of groundwater at the boundary of controlled area for a period of 1,000 years after closure. Individual doses would then be calculated along each pathway based on these predicted radionuclide concentrations.

Because the individual protection requirements were only promulgated on September 19, 1985 (50 FR 38084), DOE has not yet identified significant sources of groundwater in the accessible environment surrounding the Hanford Site, nor demonstrated compliance with the individual protection requirements imposed by the EPA standards. The NRC staff also has not assessed whether the Hanford Site complies with the Individual Protection Requirements.

Groundwater Protection Requirements

Section 112(c) (proposed) of 10 CFR Part 60 imposes groundwater protection requirements of the EPA standards in 40 CFR Part 191.16. These standards require that radionuclide releases from a HLW repository during the first 1,000 years following waste emplacement not cause radionuclide concentrations averaged over any one year in water withdrawn from special sources of groundwater to exceed:

(1) 5 picocuries per liter of combined Radium-226 and -228;

(2) 15 picocuries per liter of alpha-emitting radionuclides (excluding radon); or

(3) The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 liters per day of drinking water from such a source of groundwater.

Similar to the assessment of individual protection requirements, demonstrations of compliance with the groundwater protection requirements need only consider undisturbed performance of the repository. If background concentrations of radionuclides already exceed the limits listed above, the demonstration should prove that releases from the undisturbed repository will not increase radionuclide concentrations in special sources of groundwater by more than the limits listed above. As defined in 40 CFR Part 191.12(o), special sources of groundwater are Class I aquifers as defined in EPA Ground-Water Protection Strategy (August, 1984) that fulfill the following conditions: (1) they are either within the controlled area encompassing a disposal system or less than 5 kilometers beyond the controlled area, (2) they supply drinking water for thousands of persons as of the date that DOE nominates the site for detailed characterization, and (3) they are irreplaceable sources of drinking water because no reasonable alternative source of drinking water is available.

Demonstrations of compliance with the groundwater protection requirements should be based on determinations of radionuclide concentrations in water samples representative of background groundwater quality. Such determinations should be prepared for all special sources of groundwater within the hydrologic basin of the site along potential groundwater flow paths from the underground facility to beyond the controlled area with post-emplacement groundwater travel times less than or equal to 1,000 years. "Background quality" is interpreted to mean the chemical and physico-chemical characteristics (i.e., chemical concentrations and parameters) of groundwater in special sources of groundwater that presently exist at the site prior to perturbations caused by site construction and testing. The background concentrations of radionuclides will be used to set numerical criteria, as described above, against which compliance with the groundwater protection requirements will be evaluated.

Predictive estimates of the temporal and spatial variation of radionuclide concentrations caused by undisturbed releases from the engineered barrier system will be used to compare with these numerical criteria. Alternatively, compliance with the criteria may be accomplished simply by demonstrating that the waste packages will substantially contain the radionuclides for 1,000 years or by demonstrating that post-emplacement groundwater travel times to special sources of groundwater exceed 1,000 years. Selection of an appropriate approach will depend on site characteristics and performance allocation.

EPA promulgated the groundwater protection requirements for HLW disposal on September 19, 1985 (50 FR 38084). Because of this recent promulgation, DOE has not yet identified special sources of groundwater at the Hanford Site nor demonstrated that the repository will comply with the groundwater protection requirements. Similarly, the NRC staff has not evaluated compliance of the Hanford Site with EPA's groundwater protection requirements.

Operational Aspects

In addition to the siting criteria and performance objectives discussed previously, NRC regulations in 10 CFR Part 60 require DOE to demonstrate compliance with design criteria and operational aspects of the repository. Design criteria and operational aspects relevant to hydrology include the following: (1) structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the repository operations area will not interfere with necessary safety functions [60.131(b)(1)]; (2) structures, systems, and components important to safety shall be designed to withstand dynamic effects that could result in loss of their safety function [60.131(b)(2)]; (3) structures, systems, and components shall be designed to maintain control of radioactive waste and effluents, and permit prompt termination of operations and evacuation of personnel during an emergency [60.131(b)(4)]; (4) surface facilities shall be designed to control the release of radioactive materials in effluents during normal operations to comply with 10 CFR Part 20 and 40 CFR Part 190 (including releases from other components of the nuclear fuel cycle) [60.132(c)(1)]; (5) effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides with sufficient precision to determine whether releases conform to the design requirment for effluent control [60.132(c)(2)]; (6) radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable for safe disposal or transportation [60.132(d)]; (7) the underground facility shall be designed so that the effects of credible disruptive events during the period of operations, such as flooding, fires, and explosions, will not spread through the facility [60.133(a)(2)]; (8) the design of the underground facility shall provide for control of water or gas intrusion [60.133(d)]; (9) shaft and borehole seals shall be designed so that they do not become pathways that compromise repository performance after permanment closure [60.134(a)]; and (10) seal materials and placement methods shall be selected to reduce, to the extent practicable, preferential pathways for groundwater contact of waste packages and for radionuclide migration through existing pathways [60.134(b)].

With respect to hydrologic assessments, these design and operation criteria highlight four primary issues for repository development: (1) that surface and subsurface facilities control water containing radioactive materials, (2) that the underground facility and supporting surface facilities accommodate expected ranges of groundwater inflow into the underground facility, (3) that the repository system be sealed in a manner that does not compromise repository performance by providing preferential pathways for radionuclide migration, and (4) that the repository operations area be designed and operated to protect against credible surface water flooding.

Because of the early stage of site characterization, DOE has not selected conceptual and detailed designs for managing water containing radionuclides, defensible estimates and plans to control minewater inflow, and designs and procedures for sealing shafts, boreholes, and tunnels in the underground facility. Consequently, the NRC staff has not yet determined whether the site complies with the design and operational requirements in 10 CFR Part 60. NRC staff hydrologists (WMGT) will review the bases for DOE's designs and will provide input to NRC staff engineers (WMEG) who have the lead responsibility for evaluating DOE's compliance with the design and operational requirements in 10 CFR Part 60.

Performance Confirmation Program

NRC's regulations for HLW disposal also provide for programs to confirm the performance of repository systems and subsystems. The Performance Confirmation Program (PCP) begins with site characterization and ends at the time of permament closure, which may occur up to 50 years after initiation of waste emplacement operations. Hydrologic issues relevant to evaluating the PCP include:

1. Does the program provide data that indicate, where praticable, whether actual hydrogeologic conditions are within the limits assumed in the licensing process [§60.140(a)(1)]?

2. Does the program provide data that indicate, where practicable, whether the hydrogeologic system is functioning as anticipated in the licensing review [§60.140(a)(2)]?

3. Does the program adversely affect the ability of the geologic repository to meet the performance objectives [§60.140(d)(1)]?

4. Does the program provide baseline information and analyses of hydrogeologic parameters and processes that may be changed by site characterization, construction, or operational activities [§60.140(d)(2)?

5. Does the program monitor and analyze changes in baseline conditions of hydrogeologic parameters that could affect repository performance [§60.140(d)(3)]?

DOE has not yet described a Performance Confirmation Program for the Basalt Waste Isolation Project. Consequently, the NRC staff cannot determine whether DOE's program satisfies the requirements in 10 CFR Part 60 for such confirmatory programs.

Proposed Site Characterization Activities

Recognizing limitations in the current understanding of the groundwater flow system at Hanford, DOE is proposing an integrated program for hydrologic site characterization to support repository site licensing under 10 CFR Part 60. The overall objective of DOE's site characterization program is to reduce uncertainty in the understanding of the groundwater flow system and geologic setting (DOE, 1984). DOE is accomplishing this objective by developing a hydrogeologic data base for the Hanford Site and by forumlating conceptual and numerical models of the geologic setting, groundwater flow system, and radionuclide transport. Current planned activities include (1) lithologic characterization, (2) tectonic characterization, (3) hydrologic parameter testing, (4) groundwater monitoring, (5) hydrochemical characterization, and (6) exploratory shaft construction and testing (DOE, 1984).

Lithologic characterization activities include study of the stratigraphic setting, intraflow structures, fractures, and the mineralogy/petrology of the basalt flows and interbeds. These activities support the formulation of conceptual and numerical models of groundwater flow [§60.113(a)(2)], assessment of potential radionuclide migration [60.112(a-c)], comparison with the siting criteria [§60.122], and design of the repository [§60.131 and 134].

The objective of tectonic characterization activities at Hanford is to define the past, present, and future structural and tectonic setting of the reference repository location (DOE, 1984). DOE proposes to characterize the structural and tectonic setting primarily through geologic mapping, paleomagnetic studies, kinematic modeling, borehole studies, trenching studies, and geophysical surveys in the Pasco Basin and vicinity. With respect to hydrologic requirements in 10 CFR Part 60, tectonic characterization activities support assessments of potential radionuclide releases [§60.112(a)] and the effects of geologic processes on the groundwater flow system [§60.122(c)(3 and 4)].

Hydrologic parameter testing activities include (1) large- and small-scale hydraulic stress tests, (2) tracer tests, and (3) studies of mud effects on borehole testing. The objective of these activities is to evaluate groundwater flow characteristics that are critical to understanding radionuclide migration to the accessible environment. These characteristics will then be combined into one or several alternative conceptual models of the groundwater flow system. Most of the hydrologic activities to date have focused on the reference repository location, although DOE has also conducted limited testing outside of the RRL on the Hanford Reservation. In addition, DOE has begun to evaluate hydraulic head data measured off the Reservation but within the Pasco Basin. DOE had proposed initiating of the first of a series of repository-scale hydraulic tests in the Grande Ronde Basalt, but postponed it indefinitely in response to comments from NRC and the Yakima Indian Nation. These activities support assessments of groundwater travel time [§60.113(a)(2)], potential radionuclide migration [§60.112(a-c)], repository design [60.131-134], and site characteristics for comparison with siting criteria [§60.122(b)(1, 2, and 7) and (c)(1, 2, 3, 4, 5, 6, 17, and 20)].

Closely associated with hydrologic parameter testing, DOE's groundwater monitoring program includes (1) installation and monitoring of new piezometers, (2) monitoring of existing piezometers, (3) measurement of hydraulic heads during drilling, and (4) installation of bridgeplugs to eliminate borehole flow between transmissive hydrogeologic units. As portrayed in Figure 3, DOE monitors approximately 20 boreholes in the Grande Ronde Basalt as well as additional boreholes in the Wanapum and Saddle Mountains Basalts. DOE is presently completing additional facilities with the capability to monitor multiple horizons within single boreholes (e.g., DC-23W and -23GR). DOE is using hydraulic head data collected from available boreholes to establish baseline potentiometric levels and to characterize effects of on- and off-site human activities (e.g., irrigation and waste water disposal). Monitoring activities support assessments of groundwater travel time [§60.113(a)(2)], potential radionuclide transport [§60.112(a - c)], repository design [§60.133(d) and 134(a and b)], and site characteristics [60.122(b)(1, 3, and 7) and (c)(2, 3, 4, 5, 6, 17, and 20)].

DOE is attempting to use hydrochemical data to corroborate conceptual models of groundwater flow, which are based on hydraulic heads and conductivities. Hydrochemical characterization activities include (1) groundwater sampling,

HANFORD SITE MAP

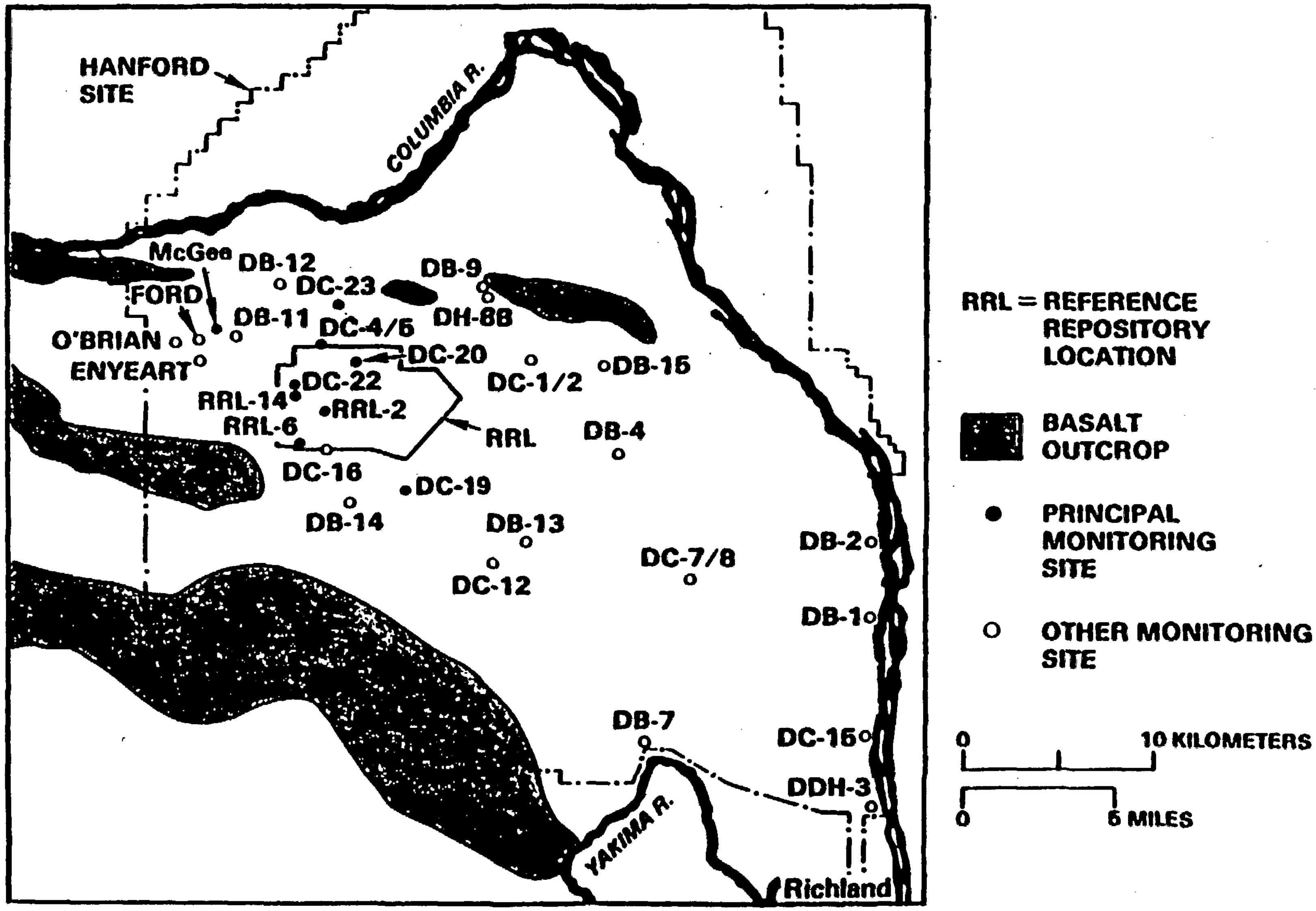

Figure 3. Groundwater monitoring facilities at the Hanford Site (DOE/NRC, 1986).

(2) development of sampling techniques, (3) study of radionuclide transport characteristics, and (4) quantitative geochemical modeling. Relevant to hydrologic requirements in 10 CFR Part 60, these activities support assessments of potential radionuclide transport [§60.112(a - c)], groundwater travel time [60.113(a)(2)], and site characteristics [§60.122(b)(7) and (c)(5 and 17)].

The Exploratory Shaft program is DOE's primary effort to collect in-situ information necessary for repository licensing and construction. The program consists of drilling two large-diameter shafts and constructing underground tunnels in the Cohassett flow. These excavations provide direct access for testing hydrologic characteristics of the host rock and basalt flows above. The Exploratory Shaft testing program also provides for geological testing within the shafts and tunnels to evaluate fracture characteristics (DOE, 1984). Proposed hydrologic characterization activities include (1) chamber testing to estimate large-scale hydraulic conductivity of the Cohassett flow; (2) cluster testing to characterize hydraulic conductivity, effective porosity, dispersivity, and diffusion in the Cohassett flow; and (3) constant head injection tests in rocks around the shafts to determine hydraulic conductivities and grout integrity. These activities support assessments of repository design [§60.131-134], groundwater travel time [§60.113(a)(2)], potential radionuclide transport [§60.112(a - c)], and hydrogeologic site characteristics [§60.122(b)(1, 2, and 7) and (c)(2, 3, 4, 5, and 20)].

NRC staff reviews have identified several limitations and deficiencies of DOE's proposed hydrogeologic site characterization activities. Based on a review of BWIP's Draft Site Characterization Report (SCR) (DOE, 1982), the NRC staff identified significant uncertainties associated with (1) hydraulic parameters (e.g., hydraulic conductivity and effective porosity), (2) hydraulic head measurements, (3) conceptual models of the groundwater flow system,

(4) hydrochemical data, and (5) the presence and significance of groundwater flow along geologic discontinuities (NRC, 1983b). The staff identified the need for DOE to conduct large-scale, multiple-well pump tests to characterize the groundwater flow system and evaluate the significance of discontinuities. In addition, the staff identified the need for continuous monitoring of hydraulic heads to establish a reliable representation of hydraulic gradients in the Pasco Basin.

As an outgrowth of the review, the NRC staff developed the Draft BWIP Site Technical Position 1.1 (NRC, 1983a). This Technical Position identified several important weaknesses of DOE's hydrologic testing strategy at the Hanford Site, including (1) large uncertainties in existing head measurements collected using packer technology in drill-and-test programs; (2) inability of small-scale, single-hole tests to yield hydraulic conductivity measurements that are representative of significant portions of the basalts; (3) inability of single-hole tests to assess the hydraulic continuity of tested units; (4) lack of testing for vertical hydraulic conductivity, effective porosity, and storage characteristics of basalts and interbeds; (5) failure to define defensible external and internal hydrogeologic boundaries; and (6) inconsistent use of hydrochemical data to corroborate groundwater flow system interpretations based on hydraulic data.

In response to NRC's Draft Site Technical Position 1.1, DOE revised its plans for hydrogeologic characterization to develop the kinds of information deemed necessary for repository licensing. These revised plans include a series of multiple-well hydraulic stress tests (i.e., pump tests) to characterize hydraulic parameters and hydrogeologic boundaries (Stone, et al., 1985). The theory used in the performance and analysis of such large-scale testing at Hanford may have to be developed beyond current state-of-the-art techniques.

Technical improvements may be necessary to account for special features of the groundwater system at Hanford, including large well depths, effects of large temperature differences between deep and shallow units, effects of dissolved solids and gases, and the fractured nature of basalts. NRC analyses indicate that these features may be significant in performing and interpreting hydraulic tests at Hanford (DEA comment number 6-13; NRC, 1985).

DOE is currently collecting hydraulic head data to establish a potentiometric baseline consistent with the earliest phase of the strategy described in STP 1.1. At the December 1985 meeting between DOE, NRC, and other interested parties, NRC observed that DOE appeared to be pursuing an alternative strategy to that described in STP 1.1. The NRC staff noted that DOE wanted to start hydraulic stress testing without having first established baseline water levels. In addition, DOE's testing strategy consisted of a series of smaller-scale hydraulic stress tests rather than starting with a larger-scale test (DOE and NRC, 1986). In response to these and other observations, DOE postponed testing and began formulating a revised, comprehensive strategy for hydrogeologic site characterization.

Conclusions

Firm conclusions cannot be acheived at this time regarding the ability of the hydrogeologic system at the Hanford Site to isolate HLW because of large uncertainties and limited information. Based on DOE and NRC evaluations of the Hanford Site to date, the NRC staff has not identified any hydrologic reason why the proposed Hanford repository would fail to meet the performance objectives in 10 CFR Part 60. Substantial uncertainties in anticipated site performance still exist, however, because of present limitations of information about to the groundwater flow system in the Columbia River Basalt Group at Hanford. NRC staff evaluations of available data indicate that large uncertainties are currently associated with DOE's estimates of groundwater travel time and potential radionuclide releases to the accessible environment. The NRC staff will evaluate DOE's proposed site characterization programs if the Hanford Site is nominated for site characterization. Future evaluations include reviews of the BWIP Site Characterization Plan and other hydrogeologic assessments, development of regulatory guidance, and on-going consultation with DOE about the hydrology of the Hanford Site.

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