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MAR 9 1984

Mr. O.L. Olson
Project Manager
Basalt Waste Isolation Project Office
U. S. Department of Energy
P. O. Box 550
Richland, WA 99352

Dear Mr. Olson:

Enclosed are our follow-up comments on the Exploratory Shaft Test Plan, BWI-TP-007 (ESTP) that was discussed during the BWIP/NRC workshop held in Richland on November 29 through December 2, 1983.

Our comments are presented in three sections. Section A includes general comments that address NRC concerns which apply to the overall ESTP and would be of interest to reviewers in all technical areas. Specific comments about the hydrogeologic issues in the ESTP are provided in Section B, while specific comments on geomechanics appear in Section C. There are no follow-up comments on geologic issues; geologic matters were discussed during the workshop, and comments were presented in the Summary Meeting Notes.

For your information, we have included our contractors' comments as appendices to the enclosure. As a matter of routine, these are placed in the public document rooms.

Except for coupled conditions, discussed in the next paragraph, we agree that the proposed test plan includes the tests that will be needed to make license application findings. However, we are not convinced that the amount of proposed testing will be sufficient as presented. The additional testing that could be needed cannot be settled until DOE establishes (1) how much performance will be expected from the various engineered and natural system components and (2) the degree of conservatism built into performance analysis. The need for additional testing could affect the ESTP test schedule. We note, in this connection, that the testing schedule makes no provision for contingencies.

We are concerned that the ESTP does not address the issue of coupled thermomechanical and hydrologic conditions associated with waste emplacement. This is a point that we have raised frequently over the past several years (see references identified in Item 3 of Section A). The ESTP does provide for mining of full scale openings over a limited area, and conventional tests are proposed to measure specific parameters relating to underground construction. However, neither direct testing of coupled behavior, nor demonstration that coupled behavior is unimportant, appears to be planned.

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In our view, the approach to underground testing in the ESTP could be acceptable only if certain other conditions are met. These are the following:

a. In evaluating overall repository performance, no credit is taken for that portion of the rock that cannot be evaluated adequately without direct testing of coupled thermal effects.

b. The components of the natural system, for which performance credit is taken, are characterized adequately for evaluation of overall repository performance.

c. Components of the engineered system, such as the waste package, are designed with adequate conservatism to compensate for, or reduce, uncertainties with respect to the coupled thermal, mechanical, hydrologic and geochemical conditions that will be encountered. For example, DOE could limit the density of waste loading and thus reduce thermal loads, or provide thick-walled container designs.

d. As with all site charcterization tests, the tests that support the design of the engineered system are carried out under conditions that bound repository conditions. This means that the design of the tests takes into account the full range of uncertainty about hydro-thermal conditions that are expected to be encountered.

If you have any questions, please call me at FTS 427-4674.

Sincerely,

"ORIGINAL SIGNED BY"

Robert J. Wright
Senior Technical Advisor
Repository Projects Branch
Division of Waste Management

Enclosures:
1. Follow-up comments on the Exploratory Shaft Test Plan, BWI-TP-007 (ESTP)
2. Contractors' comments

Record Note: In my view item 'b' above (p.2) supercedes item 'a' RJW

Appendices 1-6 Already In PDR

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OFC	:WMRP:ejc	:WMRP	:WMEG	:WMGT	:WMGT	:WMEG	:WMGT
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Follow-up Comments on BWIP Exploratory Shaft Draft Test Plan

The attached are the follow-up comments on the proposed tests outlined in the Draft Basalt Waste Isolation Project (BWIP) Exploratory Shaft Test Plan (ESTP), BWI-TP-007, dated November 9, 1983. These comments are based on the ESTP, the NRC-BWIP workshop held at Richland (November 29, to December 2, 1983) and on the NRC contractor's comments. The comments are organized in the following order:

Section A: General comments - These comments are applicable to the Exploratory Shaft (ES) test program in general.

Section B: Comments on hydrogeology tests.

Section C: Coments on geomechanics tests.

Besides the above, the NRC contractor's comments are attached as Appendices for your information.

Appendix 1: Williams and Associates, Inc. (hydrogeology)

Appendix 2: Golder Associates, Inc. (hydrogeology)

Appendix 3: Golder Associates, Inc. (geomechanics)

Appendix 4: Engineers International Inc.

Appendix 5: The U.S. Bureau of Mines

Appendix 6: Sandia National Laboratory.

SECTION A

NRC General Comments

1. The draft ESTP is inadequate in identifying the application of test data to modeling and performance assessment. We suggest that the report should set out a clear connection between the site performance issues and the remaining information needed to address them. This requires:

   - A discussion of the performance issues, and the way in which they have been identified.
   - A discussion of the proposed investigation approach for obtaining the required information.
   - A discussion of the way in which the results of these investigations, namely geologic, hydrologic, and geomechanics test data, will be integrated and used to address the site performance issues.
   - A discussion of how the testing relates to performance requirements intended for the various natural and engineered system components.

   The report should, therefore, provide more complete material on "justifications of need for additional data and proper selection of tests" and "identification of data applications to modeling and performance assessment" (ESTP volume I, page 2).

2. The ESTP has omitted an important objective of exploratory shaft construction, namely: preliminary characterization of the reference repository location block (RRL). It is necessary for the test plan to provide an adequate discussion of this basic objective of the ES construction. For example, the test block, including the lateral boreholes, occupies an area of roughly 500 feet by 500 feet, i.e., about one-hundredth of a square mile. However, the RRL block covers an area of approximately 20 square miles, and the underground portion of a repository would occupy about 3 square miles. The ESTP should discuss the adequacy of the test volume to establish the representativeness of the rock being tested. Discussions should outline a methodology of integrating the data from the ES tests and those from the surface boreholes, and any other existing data including those which can be demonstrated to be applicable from the Near Surface Test Facility, to characterize the RRL.

   Explicit discussions should be made of the scenarios for which the ES test data may not be representative of the entire RRL block. For example, non-representativeness resulting from structural and stratigraphic inhomogeneities and unpredictable tectonic features in the basalt flows should be considered. (See Chapter 4 of NUREG 0960, Vol. 1 for detailed discussions on uncertainties about stratigraphic and structural discontinuities.) Alternative approaches to bound the uncertainties in the repository system performance should be presented.

3. A critical part of the site characterization effort is the development of an understanding of the coupled thermal-mechanical-hydrologic-geochemical behavior of the repository host rock. The Nuclear Regulatory Commission (NRC) has expressed this view several times in the past twelve months (BWIP design workshop, June 1982; NUREG 0960, March 1983; DOE, Headquarters, 1983; Advisory Committee on Reactor Safety, 1983). It is necessary for the test plan to include a description of how the information collected will address this issue, or what other kind of information will be used to handle this question. The forwarding letter provides a statement of conditions under which the NRC staff could accept not performing direct testing of coupled thermal effects.

4. The ESTP does not include testing of concepts on retrievability, sealing, waste package and other engineered barriers. The DOE should explicitly address and provide supporting rationale for what testing, if any, DOE considers is required in these areas to support making the findings that must be made during construction authorization proceedings against all of the performance objectives, requirements and criteria contained in 10 CFR 60. As indicated previously (most recently in NRC staff comments on the Mission Plan), the license application must be complete with respect to design information and supporting data and analysis to make such findings. (See comment number 3 under Section C, "Comments on Geomechanics".)

5. A requirement attached by 10 CFR 60 to construction of an exploratory shaft is that procedures should be developed to control any adverse radiological, safety-related effects from shaft construction; Reference: 10 CFR 60.11(a)(6)(iii). A section in the test plan is needed to show how DOE plans to satisfy this requirement. This matter was brought to the attention of DOE in a letter to John Anttonen dated November 9, 1983.

6. The ESTP states that the BWIP has established work elements that directly relate to criteria identified in 10 CFR Part 60 (NRC, 1981). These are proposed criteria that were published for comment in 46 FR 35280, July 8, 1981. The final rule, published in 48 FR 28194, June 21, 1983, (and available to DOE in November 1982) contain a number of changes that reflect concerns addressed in the public (and DOE) comments. The ESTP should reference the final rule.

7. All drawings showing plans and cross sections should be dimensioned.

SECTION B

Comments on Hydrogeology

The NRC has identified four principal topics which should be re-evaluated and addressed more fully by the DOE:

1. Factors which may significantly influence hydrogeologic test results.
2. Relation of the ESTP hydrogeologic tests and priorities to the surface testing program.
3. Evaluation of the potential for high rates of groundwater influx to the ES and mined drifts.
4. Rationale for the proposed hydrogeologic testing in the Cohassett flow interior.

1. Factors which may significantly affect the quality of hydrogeologic tests proposed in the ESTP.

The following is a list of effects and conditions which could significantly influence data obtained from hydrogeologic testing in the ES and hydrogeology drift. Corresponding concerns of the NRC are presented.

- Possible interference effects between the cluster and chamber tests. As described in the ESTP, these tests are proposed to run concurrently. This is a consequence of the long duration (up to one year) expected for each test and a natural desire to save time and financial resources. The NRC is concerned about the proximity of the test zones to each other as shown in Figure 3-2 on page 3-5 of the ESTP, Vol. II. We can envision a scenario in which a single fracture could intersect boreholes from both tests. Such a condition would hydraulically couple the tests and complicate or invalidate analytical results. This issue could be resolved by more widely separating the tests in space and/or time. The actual separation distance for the tests will have to be determined in-situ, based on the occurrence and orientations of fractures in the candidate horizon.

- Possible creation of preferred vertical pathways for radionuclide transport around the ES and drifts. Previous NRC comments which address these shaft-related issues are contained in Attachment 1 of our letter to John Anttonen (DOE), dated November 9, 1983. That letter provided NRC comments on DOE's response to our letter of January 13, 1983.

The potential impacts of shaft construction on repository performance should be quantified to the fullest extent practicable. The NRC is particularly concerned about the possibility of the creation of a vertically conductive disturbed zone surrounding the ES. The DOE should further address this scenario, as it relates to the short- and long-term isolation potential of all geologic units penetrated by the shaft. The NRC believes that it is important to determine whether or not a significant increase in vertical hydraulic conductivity occurs in close proximity to the ES as a direct result of shaft drilling operations.

The discussion in Hydrogeology comment #2 recommends consideration of a reprioritization of the proposed ES borehole program so that a higher priority is attached to drill holes in flows overlying the candidate horizon. These holes could be used to evaluate the significance and extent of the shaft disturbed zone at several depths. If the ES borehole program is determined to be impracticable, or infeasible in view of testing for competing information needs, DOE should explicitly address alternative means of obtaining the needed data.

- Significance of fracture flow and matrix diffusion on radionuclide transport in basalt. With reference to planned tracer testing at the cluster borehole sites and observation by BWIP of fracture geometries in cores, it is unclear to NRC whether DOE intends to investigate the implications of fracture flow and matrix diffusion on radionuclide transport in fractured basalt. The NRC considers that fractures in basalt may provide preferred pathways for groundwater flow and radionuclide transport which may not be evident from analyses of conventional hydrologic tests (e.g., slug tests). The hydrologic tests performed thus far at the BWIP site have yielded bulk hydraulic conductivity values which represent an average of fracture and porous matrix properties. This averaged, or "equivalent porous medium" hydraulic conductivity, more closely represents the hydraulic properties of the porous matrix than those of the fractures. The properties of the fractures may, in fact, dominate flow and transport. Radionuclide transport through fractures may be many orders of magnitude faster than would be predicted through an "equivalent porous medium" approach. Although the process of matrix diffusion, whereby radionuclides traveling through the fractures diffuse into the basalt porous matrix by virtue of the concentration gradient, may somewhat offset the effects of increased radionuclide velocity through the fissures, there are insufficient data to support the equivalent porous medium approach in fractured basalt. NRC considers that the concept of "retardation" of radionuclides by matrix diffusion applies only to radionuclide transport through discrete fractures, and is not consistent with an "equivalent porous medium" approach to groundwater flow through fractured media. The

combined use of "equivalent porous medium "values for hydraulic conductivities and porosities, and retardation coefficients which take credit for matrix diffusion, would result in nonconservative estimates of radionuclide transport velocities in fractured basalt.

The role of tracer tests in evaluating fracture flow and matrix diffusion should be clarified by DOE.

Effect on the tracer tests of an induced pressure differential. As inferred from the discussion on page 3-137 of the ESTP, mining in the candidate horizon (Cohassett) would result in the establishment of a formation pressure difference with an upper limit of approximately 1350 lb/in^2 and a lower limit of atmospheric pressure. The generated pressure gradient should be well defined for the rock volume containing the cluster test as it will affect the flow path of injected tracer materials. An important parameter to examine in this analysis would be the time-variant change in the formation pressure differential.

2. Relation of the ESTP hydrogeologic tests and priorities to the surface testing program.

Test locations and priorities for exploratory shaft drill holes are discussed in Section 3.3.2.2.1, Vol. II of the ESTP. Numbers and locations of drill holes with respect to shaft depth are illustrated in Figures 3-5, 3-6, 3-7, and 3-8. Porthole stratigraphic locations and drill/test priorities are listed in Table 3-6. In Table 3-8 on page 3-41 the Cohassett flow is described as the preferred candidate horizon, providing justification for assigning priorities 1 and 2 to the Cohassett drill holes. Drill holes in stratigraphic units overlying the Cohassett are assigned to priorities 3 through 6.

The NRC is concerned that few tests will be conducted in the units above the Cohassett because of their low priority. Characterization of these units may be important for repository performance assessment due to possible transport of radionuclides upward from the repository and into these units, caused by thermal buoyancy effects. The footnote to Table 3-5 indicates that the testing priority is dependent on schedule and data needs. We wish to emphasize that construction of the ES will provide a unique opportunity to directly gather data about units above the Cohassett that cannot otherwise be obtained. These drill holes may be useful to hydraulically evaluate the disturbed zone by means of cross-hole tests. They can also provide data on the nature and distribution of discontinuities.

The NRC recommends that DOE consider a revised priority schedule in which more attention is given to drill hole completions in units above the Cohassett or to explicitly address the alternative means for obtaining the needed data.

In Table 3-20 on page 3-72 it is indicated that results of the underground hydrogeologic tests will be compared with each other and with surface testing data. The NRC recommends that DOE consider more explicit connections between the surface and subsurface programs, especially with regard to concurrent monitoring strategies and guidance for future surface testing needs.

3. Evaluation of the potential for high rates of groundwater influx to the ES and mined drifts.

   The ESTP inadequately describes the methodology for assessing the potential of a high groundwater influx to the underground workings. In Table 8-1 on page 8-3 (Volume I), it is suggested that the three main causes of potential flooding are as follows: (1) grout failure, (2) dewatering pump failure, (3) surface flooding in-flow. The NRC observes that significant flooding could also occur if a feature characterized by high hydraulic conductivity is encountered. The DOE should address this possibility, in addition to the three causes listed above.

4. Rationale for the proposed hydrogeologic testing in the Cohassett flow interior.

   The rationale for testing the Cohassett dense flow interior, as expressed by the DOE during the ESTP Workshop, includes the following objectives:

   - Determine the isolation potential of the candidate horizon (Cohassett dense interior) to retard radionuclide migration.
   - Characterize the Cohassett generically for extrapolation to other potential candidate horizons in dense basalt interiors.
   - Establish the constructibility of a repository in the Cohassett dense interior.

   The NRC concurs with the ideas of establishing constructibility and determining the isolation potential of the candidate horizon in the vicinity of the ES. However, we question the concept of generically characterizing most basalt interiors using only parameters measured within a limited volume of the Cohassett, particularly if this means that the DOE plans to assign to other flow interiors the measured isolation potential of the Cohassett. The NRC disagrees with this approach of broadly extrapolating geology-dependent parameters. This is especially true with regard to dense interiors, which have not been satisfactorily evaluated in the surface testing program. In NUREG-0960, the NRC has pointed out the limitations of the surface-based methods employed by BWIP to evaluate the hydrogeologic properties of dense interiors. It is important that the DOE consider every opportunity to directly collect data in these interiors. Boreholes drilled from the ES represent such an opportunity, as discussed in hydrogeology comment #2.

Generic characterization of dense interiors is precluded by the unpredictable occurrance of lateral and vertical heterogeneities within and among basalt flows. Examples include, but are not limited to:

- Concentration and orientations of cooling joints (including fanning of entablature columns).
- Thickness variations of flows and intraflow structures.
- Vesicular zones and the discing phenomenon.
- Tectonic structures.

A specific example of the uncertainty of intra-flow data extrapolation would be the DOE's discovery of an anomalously thick Umtanum flow top breccia in borehole RRL-2. This led to a re-evaluation of potential candidate horizons. Following this discovery, the Cohassett interior was identified as the preferred candidate horizon.

SECTION C

Comments on Geomechanics

1. The ESTP should contain details of sensitivity analyses to determine (a) the relative importance of the design parameters to repository performance and, from this, (b) the needed levels of accuracy and confidence in the proposed geomechanic tests.

2. The ESTP contains a number of terms with ambiguous usage. It is necessary that a clear definition and explanation of each of the following terms be provided: a) rock mass strength; b) failure; c) failure criteria; d) excessive deformation; e) overstressing; f) stability; g) stability criteria; and h) damaged rock zone. There should be a consistency in the usage of these terms in the ESTP. Where appropriate, discussions should be provided for time effects on these parameters.

3. The ESTP should identify the tests which are considered by DOE to be part of performance confirmation and will extend into the repository construction period. The rationale for these tests should also be provided. We will then be in a position to consult with DOE about any differences of view about which tests will be required to support a license application.

   NRC general comment number 4 of the summary workshop notes addresses this matter. The amount of testing to be done before license application is an open item for discussion in the near future.

4. Development of monitoring instruments that function reliably in repository environment is critical for the success of ES testing. Therefore, the ESTP should present or reference necessary details on the instrumentation program. The program should discuss as a minimum:

   - Capability and limitation of the existing instrumentation under adverse test facility conditions.
   - Plans for further research and development, and
   - Uncertainities resulting from non-availability of required instrumentation on a timely basis.

5. For each test, information should be given on the numerical models or codes to be utilized, developed, or modified and whether the media will be modeled as isotropic or transversely isotropic. Also, it should be clarified whether model development, model calibration, or model validation is expected from any given test.

Conflicting statements are made in the document regarding the number of elastic moduli that would be measured or derived. The differences (ranging from two to five moduli) are not trivial, either from a testing or a modeling point of view.

6. The high horizontal stresses can cause problems during ES activities. The shaft liner should be monitored for strains and displacements throughout the testing period.

7. Regardless of the emplacement scheme that will be eventually chosen, it is suggested that the test plan consider alternate emplacement configurations. The final decision can then be made after reviewing test data from alternate emplacement configurations. Specifically, we recommend that DOE consider drilling vertical and horizontal canister holes in one of the drifts to compare the responses. Likewise, a modest program of room widening and pillar convergence monitoring should be considered in the test plan. Data from such tests would be very useful in justifying critical decisions on emplacement.

8. For some important data the ESTP provides for only a single test (heater, mine-by, large flat jack). But no discussion has been presented on how confidence in the results of a single type of test for a particular parameter will be established. For certain other data, for example, deformation modulus measurements, seven different tests/techniques are proposed. The logic and method to integrate data obtained from various tests with different degrees of confidence should be provided.

9. No test has been proposed to measure the in-situ shear strength property of the jointed basalt. A discussion is needed to show how this important parameter will be obtained.

10. The basis for assumption of principal stress directions in hydrofracturing tests should be clearly established and related to the overcoring test results.

Appendices

Comments from NRC Contractors on DSTP

Appendix 1: Williams and Associates, Inc.
Appendix 2: Golder Associates, Inc. (Hydrogeology)
Appendix 3: Golder Associates, Inc. (Geomechanics)
Appendix 4: Engineers International, Inc.
Appendix 5: The U.S. Bureau of Mines
Appendix 6: Sandia National Laboratory