Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

November 3, 1982

U.S. Nuclear Regulatory Commission
High Level Waste Technical Development Branch
Division of Waste Management
Washington, D.C. 20555

Attention: Mr. Lud Hartung, Project Manager

Subject: Contract No. NRC-02-81-037, Technical Assistance for Repository Design
Letter #77

Note: This review preceded the identification of the unsaturated zone as the preferred horizon for a repository and the choice of conventional methods of sinking the exploratory shaft.

Gentlemen:

Pursuant to your request (ref. NRC letter #24), this letter report is submitted in accordance with the subject contract, Task 6, Project #17-1, Golder Associates' review of the DOE document entitled, "Conceptual Design Report, Exploratory Shaft - Phase I, Nevada Nuclear Waste Storage Investigations."

We were directed to make a "Best Level of Effort" critical review of the document with regard to:

- Proposed ES construction techniques
- Cost estimates
- Testing plan

This review of the NNWSI Exploratory Shaft Conceptual Design renews our recently-limited involvement on NTS. By way of review, we provide the following reference list:

1. Our letter #15, September 16, 1981, reporting on our visit to the Peer Review at NTS, August 1981 (plus our associated inhouse document 5-70-17 with Appendix A).

2. Our Task 1 report "Identification of Characteristics which Influence Repository Design - Tuff"; Task 2 report "In Situ Test Programs Related to Design and Construction of High Level Nuclear Waste (HLW) Deep Geologic Repositories"; Task 3 report "Evaluation of Alternative Shaft Sinking Techniques for High Level Nuclear Waste (HLW) Deep Geologic Repositories"; and Task 4 report "Relationship of an In Situ Test Facility to a Deep Geologic Repository for High Level Nuclear Waste." (Note that Task 1 report refers to appropriate NRC/DOE agreements reached in topical meetings.)

3. NRC Technical Position on Borehole and Shaft Sealing and our letter #71, October 13, 1982 reviewing the same.

4. The core (lithologic) logs (USW-H1) reported in our Task 1 report on tuff.

5. NRC's BWIP Design Issues (draft of 10/7/82) as related to shaft sealing to include:

   - o What is the maximum expected radionuclide release rate from the engineered system and is this rate in compliance with NRC technical criteria?
   - o Is borehole backfill required?
   - o Can repository shafts, tunnels and exploratory boreholes be constructed and sealed adequately?
   - o How is repository performance expected to be affected by construction of the Exploratory Shaft?

6. NRC 10CFR60, "Disposal of High Level Radioactive Wastes in Geologic Repositories" through proposed regulations of July 7, 1982. In particular, what we understand as "NRC licensing requirements" which are stated in 10CFR60-11(6)(iii), "provisions to control any adverse safety-related effects from site characterization" and performance objectives in 60.111-60.113.

7. Comments by D. Pentz and J. Daemen on Shaft Sealing in our letter #76 of October 25, 1982, following the BWIP Repository Design - Exploratory Shaft Workshop, Oct. 5-6, 1982.

The two major issues for NRC related to our review of the subject report are:

- o The ability of the ES to meet the standards of 10CFR60, as outlined in 6 above. Using DOE's words from the Conceptual Design Report (ref. Part II-A4 - page 6):

  "The ES will not be an NRC-licensed facility; however, extreme care shall be taken during design and construction to assure that nothing is done that will preclude its use as part of a licensed repository at some future date."

- o The adequacy and suitability of the proposed underground tests of Phases I and II to meet the requirements for License Application. It is assumed for this review, based on our overall understanding of the DOE program, that Phases I and II will be accomplished prior to License Application and that At-Depth Testing (ADT) will be accomplished after License Application. Thus, NRC's Safety Evaluation Report and hearings will take place without the benefit of the results of the ADT.

Our review relates primarily to these two issues, with general comments followed by detailed comments attached as Enclosure 1. Our overall view is that the Conceptual Design Report is thorough and professional. The valuable pertinent experience that DOE has at NTS is evident-throughout the report. The ability to meet the short-term requirements of 10CFR-60.111 are well documented for a design at this stage of development. Flexibility is built in where appropriate. Both of the questions above, however, are primarily related to long-term performance to which many of the following comments relate.

General Comments

The construction procedures for the exploratory shaft proposed by DOE are consistent with good construction practice as established from shaft drilling programs at NTS and elsewhere. The 98-inch internal diameter steel liner will be grouted into position over its full length, by displacing the drilling mud with grout slurry in stages. The grouting program will be designed to ensure that the design loads of the steel liner are not exceeded during construction.

As noted in our letter #71 (Golder Associates review of NRC Technical Position on Borehole and Shaft Sealing), our review of the NTS Conceptual Design report indicates that DOE is not currently in compliance with the Technical Position as follows:

- Proven sealing techniques have not been developed for the excavation methods selected.
- No detailed provisions have been made for characterizing and sealing the disturbed zone along the entire shaft.
- Validation of seals is not included in the shaft test program.
- Effect of construction on sealability has not been determined before selection of excavation techniques.
- Information required for characterizing strata through which the shaft will be sunk will probably not be available with the assumed blind drilled shaft sinking methods.

- NTS Design Objectives include "Licensability", but since "the ES will not be an NRC-licensed facility," specific provisions to meet licensing requirements are not included in conceptual designs.

As the report states, NRC Technical Positions and regulations do not apply directly to exploratory shafts. However, where DOE anticipates that shafts will become part of a licensed site, they will ultimately need to comply. It is therefore in DOE's interest to comply now with the Technical Position unless they can demonstrate that compliance can be established at a later time.

In summary, it appears that the short-term sealing performance of the shaft will be satisfactory but that there has been no consideration of how to demonstrate the long-term performance of the shaft seal.

There is virtually no discussion of the DOE rationale for the selection of the underground testing program. Golder Associates Task 2 report outlines our rationale for test selection. The purpose of testing is to reduce the level of uncertainty associated with the sites' ability to meet the performance objectives of 10CFR60 and EPA standards, to an acceptable level. Our understanding of the site to date is contained in our Task 1 tuff report (NUREG/CR-2614). In that report we pointed out the lack of critical data available to us and the apparent great variability of material properties, both of which adversely impact our ability to predict performance at this time. Therefore, if this is in reality the case, in order to significantly reduce uncertainty, the following are required:

- sufficient exploratory investigation (from surface or underground) to adequately characterize the repository, and in particular to identify the variability anticipated. It is not clear from the conceptual design report how the limited surface investigations and the 2000-ft. long horizontal holes from the test openings in the vicinity of the ES will adequately define the lateral continuity, homogeneity, etc., of the proposed repository horizon. Furthermore, of course, lack of adequate site characterization implies that the representativeness of properties determined from a test facility will be unknown.

- in situ testing to define pertinent material properties. In Golder Associates Task 4 report (NUREG/CR-2959), an example of an in situ test facility configuration for basalt was presented. Based on our current understanding of conditions at Yucca Mountain, Golder Associates recommends the test program outlined for tuff in the Task 2 report. Such a program should be carried out in an underground test facility at least as large as the example for basalt in the Task 4 report. Test details for the ES facility are discussed in the DOE report in only the most general of terms. It is therefore not possible to compare the proposed program with the scope of testing outlined in the Task 2 report. However, the proposed test facility has no full-scale tunnels and only about one-fourth of the underground development recommended in the Task 4 report. We therefore consider that based on available data the proposed test program is probably inadequate for License Application.

We trust that you will find these documents useful. Please call if you have any questions or require further discussion.

Sincerely,

GOLDER ASSOCIATES

Richard H. Gates, Ph.D., P.E.
Project Manager

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ENCLOSURE 1
DETAILED COMMENTS

Page	Comment
1 (para. 2)	What will be the basis for selection of the ES location and depth in early FY 83?
1 (para. 2)	We concur with the flexibility of continuing to consider conventional methods of shaft sinking although the assumption is made on page 7 that drilling techniques will be used for the conceptual design. Blind sinking of the ES constitutes the only possibility since bottom access is not available. Conventional drill-and-blast is a most versatile procedure but can experience difficulties in coping effectively with water-producing zones of great thickness. There are concerns about formation damage and the subsequent difficulty of sealing the damaged zone against vertical migration of water. A further concern of conventional sinking is the construction safety aspect. Blind shaft drilling would appear to offer a number of technical and safety aspects, and be capable of dealing with a wide range of rock and groundwater conditions. A prime purpose of the ES will be to demonstrate the technology. The limited damage to the shaft walls has an appeal in relation to shaft sealing, but the method of grouting behind the liner is less direct than that employed in conventional shaft sinking. The influence of the drilling mud on sealability and the effectiveness of mud displacement by the grout are of some concern.
1 (para. 2)	How is limited exploration to be carried out in the shaft during construction for the preferred drilling technique? An advantage of the conventional drill-and-blast procedure is that full wall inspection is permitted during sinking.
4 (para. 4)	We note that the repository may be above the water table. Although 10CFR60 addresses this possibility, new issues will become of considerable interest if DOE selects this option.

Page	Comment
7 (para. 4)	What is the nature of the surface explorations that are currently being carried out at Yucca Mountain? What criteria are being used to select the ES location and the test horizon? If the techanical data required to determine the suitability of the site for a repository or TEF have not been fully defined, are the required data for selecting the ES location and the test horizon (from surface exploration) known? If so, what are the data? If not, on what basis was the surface exploration program formulated?
7 (para. 5)	What is the purpose of the confirmatory borehole in the proximity of the ES? Is it part of the initial exploration program? What other borings will be made as part of the exploratory program? What testing will be carried out in the confirmatory borehole? Will the hole be used in an attempt to understand the hydrologic picture (which might be of more interest for long-term performance) of the site? Will specific tests be carried out on the core to investigate drillability, stability, etc?
8 (para. 1)	Will the drilling operations be interrupted at all by exploratory-type experiments, i.e., prior to sinking and grouting the lining? If so, what types of exploration are envisaged?
8 (para. 1)	For the drilled shaft, the shaft itself should be watertight. All water flow into the underground openings will therefore come from the test horizon. If this is located within the welded tuffs below the water table, fracturing should constitute the prime flowpaths. Effective hydraulic conductivities should be sufficiently low that a 100 gpm inflow represents a suitably conservative assumption. For a conventionally sunk shaft, a one-foot thick concrete liner (App. A, pg. 49) for a 12-ft. ID shaft under 1500-ft. hydrostatic head does not represent a hydrostatic liner design. It is not clear from Appendix A whether it is the intention to construct a hydrostatic lining. If so, the liner thickness would probably need to be increased somewhat towards the bottom of the shaft. If not, all ground water control in the shaft would have to be accomplished by grouting the formations themselves.
8 (para. 1)	How will the three (Phase I) holes be located in relation to the potential location of the TEF? What is the significance of the 2000-ft. length holes? Will they pass through the TEF location or not?

Page	Comment
8 (para. 5)	What current technology is available and reasonably proven that would enable the use of other than a steel liner for the drilled shaft; or does the "other lining" reference relate to the concrete liner of a conventionally sunk shaft?
8 (para. 5)	What methods will be applied to prevent cave-in during drilling and to maintain an acceptably straight shaft?
9 (para. 3)	It is not clear how 2000-ft. long horizontal holes drilled from the vicinity of the shaft will provide an adequate basis for an assessment of the lateral continuity of stratigraphic intervals on the scale that is of interest to the final repository. A relatively insignificant area will be opened up by the initial test facility and observation of the performance of this facility will be useful only if there is some understanding of how representative the test region is of the repository horizon as a whole. The 2000-ft. horizontal holes will expand the area of inspection beyond the facility itself, but once again there must be a procedure for relating the properties of the region explored by the horizontal holes to those of the repository zone as a whole. How can we assess the representativeness of the studies associated with the ES program to the entire repository? How will the surface investigations be used to extend the applicability of the test data obtained for the ES facility?
9 (para. 4)	It is not possible to comment on test details within the ES facility as these have not been described, i.e., apparently the test details have not yet been decided upon. Obviously the facility and the core will be geologically/geotechnically/hydrologically mapped and logged respectively, and these data will provide useful information. The mechanical performance of the facility will also provide useful data, but as discussed above, there should be a methodology for evaluating the representativeness of the information. Rock mass strength in relation to field stress may be inferred from the facility performance, and there is an indication that some suitable monitoring (in particular, displacement monitoring) of the facility is to be undertaken.
10 (para. 1)	What test programs are envisaged (if any) to evaluate the efficacy of the shaft seal and the effect of the construction disturbed zone on the adequacy of the seal? From the point of view of long-term containment, it is presumably not sufficient to evaluate the shaft seal by direct observation of water ingress, etc.

Page	Comment
11 (para. 2)	There is no discussion of sealing procedures for the 2000-ft. long exploratory boreholes.
12-19	Scanned only.
21 (para. 1)	Another advantage of drilling versus conventional sinking is the minimization of formation damage and the subsequent improved shaft seal potential.
22 (para. 7)	Difficult to comment on adequacy of 3 days of logging prior to casing without knowing extent and nature of the logging program.
25-28	Scanned only.
30 (para. 2)	The exploratory drifts are smaller in cross-section than the planned repository rooms. Additional useful data would be obtained by constructing the drifts to full cross section.
30 (para. 4)	It is not clear just what loadings are to be measured by strain meters. (Rock bolts? Steel sets?)
30 (paras.5-7)	This discussion is highly theoretical, and more practical and applicable comments should be offered. Other factors need to be considered, e.g., loosening type failures may be enhanced by attempting the type of proportioning and profiling suggested. It is not necessary to shape and orient to achieve maximum stability, but simply adequate stability. Cost factors are also important, e.g., if we need 15-ft. headroom, do we excavate a 30-ft. wide span when only 20 feet is required, just because the horizontal stress is twice the vertical stress? The discussion appears somewhat pointless in this context anyway, as the in situ stress will probably not be known prior to facility development unless hydrofracturing is to be carried out in the shaft confirmatory borehole. No mention is made of this.
30 (para. 8)	Extraction ratio really has no sensible meaning for this configuration because of the limited amount of excavation.
31 (para. 2)	Don't understand the reason for the rather specific recommendations regarding the placement of wire mesh on the sidewalls.
33 (para. 3)	During construction of the adits, trial blasts to evaluate rock damage minimization procedures and profile control should be undertaken.
33-35	Scanned only.

Page	Comment
35 (para. 5)	Strain meters to monitor what loadings?
36-46	Scanned only.
48 (para. 3)	Be more precise than "several months" in discussing conventionally sunk and drilled shaft schedules.
51 (para. 2)	If the shaft is designed to be watertight (backsheeting, etc.) the 1-ft. thickness liner is not sufficiently thick for a hydrostatic liner.
65-74	Scanned only.
76 (para. 2)	How are unacceptable hole deviations to be corrected?
95-96	This section outlines in general terms the shaft grouting program. The report should specifically address shaft seal testing as discussed in the general comments.
124-192	Scanned only.
194 (para. 1)	It should be noted that grouting in the test horizon prior to cutting the casing may substantially alter the rock mass properties in this area and hence the representativeness of the exploratory openings in the vicinity of the shaft.
195 (para. 4)	Provision should be made for full grouting of the rockbolts, following tensioning.
205-224	Scanned only.

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