EI Document Review

File No: 1085-010

Document: Letter, T. O. Hunter, SNL, to D. T. Oakley, LANL, "Performance Analysis Studies to be Used in Determining Quality Assurance Levels for the Exploratory Shaft Design and Construction Activities", July 2, 1985

Reviewer: Engineers International, Inc.

Date Approved:

Date Review Completed: August 15, 1985

Significance To NRC Waste Management Program

Since the Exploratory Shaft (ES) facilities are likely to be incorporated into final repository design, an early assessment is required on the ability of the ES to meet the performance objectives of 10CFR60.111 and 113. In addition, the ES construction should meet the licencing requirements as specified by 10CFR60 Subpart D, and the quality assurance standards as specified by 10CFR60 Subpart G. This document seeks to define the standards to be applied in the design and construction of the ES and it is therefore important to evaluate the bases for the findings and conclusions presented therein.

Summary of Document

This document presents the results of a series of analyses performed by DOE with regard to the design and construction of the ES. Specifically, performance analyses have been performed in the following areas:

- to assess the potential for radionuclides to reach the accessible environment via the damaged rock zone (DRZ) around the ES
- to establish the performance required of the ES liner during the operational and post-closure phases of the repository
- to establish the role of the shaft internals in the ES during repository operations.

The results of the first two analyses are presented in detail, while the latter is briefly mentioned.

Three basic mechanisms of possible radionuclide release are investigated, namely:

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- surface water drainage down the ES
- subsurface water inflow in the repository from a discrete fault
- airborne release of radionuclides through the ES

The first scenario assumes that all the water from a 500-year flood (equivalent to 86,000 m^3 of water) reaches the waste canisters through the ES. A 40-acre emplacement area of the repository is estimated to be flooded based on the perconceptual design of the repository. The quantity of radionuclides entering into the water by matrix dissolution is estimated and the value is inflated 20 times to project the radionuclide release quantity over 10,000 years. These release quantities are compared to the NRC and EPA criteria for radionuclide release rates and limits.

The second scenario considers a situation where ground water enters the repository from a fault zone, contacts the waste and then flows downgrade in the drifts toward the ES. The ES then acts as preferred pathway for radionuclide migration towards the ground water table. Estimates of possible flow quantities entering through the fault zones are made, as well as quantities that eventually reach the ES. Finally, an assessment of whether the ES will significantly affect radionuclide migration to the water table is presented.

The airborne release scenario only considers the mechanism for convective air flow through shafts, ramps, drifts and the host rock. The model used does not couple heat transfer and air flow. The resulting flow calculations have been used to estimate the possible impact of this mechanism on radionuclide release to the accessible environment.

Each scenario mentioned above have been evaluated under the assumptions that a damaged zone will exist arcund the ES and that the ES and the repository drifts will be backfilled with a material whose properties are not currently known (hydraulic conductivity of the backfill has been varied in the analyses between 10^{-6} to 10 cm/s). The damaged zone model used is a simplified one which assumes a uniform zone of rock, having a permeability that is 2 orders of magnitude higher than undisturbed rock, extending one radius from the shaft wall.

In addition, the effect of ES penetration into the Calico Hill unit is explored although detailed analysis of this is to be performed later. Since the Calico Hill unit is at least 125 ft thicker near the ES than elsewhere in the repository area, the 70 ft or so penetration into the unit, DOE does not expect that pre-waste emplacement travel times will fall below 1,000 years as specified in the siting guidelines.

The conclusions drawn from these analyses seem to indicate that the radionuclide releases that may occur as a result of water inflow through the ES or discrete faults, or due to airborne transport should be well below the NRC and EPA limits, if each mechanism is considered in isolation. In addition, the presence of the damaged zone around the ES is not likely to affect the post-closure isolation capability of the repository system.

The overall recommendation made on the basis of the above findings is that the ES construction techniques and quality assurance (QA) standards adopted need not consider the sealing aspects of the repository. The construction controls and level of QA need only be adequate from a short term stability viewpoint. Furthermore, the shaft and drift backfills do not need to conform to quality standards demanded from a sealing viewpoint. Further studies are recommended to assess the drainage capacity of the Topopah Spring Member, confirm the extent and hydraulic conductivity of the damage zone, and the quality of water inflow from discrete sources.

Problems Limitations and Defeciencies

The document presents analyses based on a set of assumptions, the validity of which will eventually determine the significance and reliability of its findings. Overall, many of the assumptions appear to be fairly realistic and sometimes overly conservative, however, a few assumptions may need to be reevaluated for their validity and degree of conservatism. These are discussed below.

1. A flux of 0.5 mm/yr is assumed for the calculation of travel time through the Topopah Springs and Calico Hills members (page 2 of letter). This value was previously reported in the DOE Draft Environmental Assessments (EA) and was strongly questioned by NRC (see NRC Comments on the EA - Major Comment 3, page 3, and Detailed Comments 6.31, page 53, and 6.45, page 62).

2. The performance assessments have assumed the thickness of the zeolitized Calico Hills formation to be 150 m (page 2 of letter). This is probably an overestimate in light of the thicknesses of the Calico Hill unit above the water table shown in Table 1 (see also Figure 1 for borehole locations). Furthermore, the Draft EA assumed a value of 100 m in the travel time calculations (page 6-137, DOE, 1984)

   The distance between repository horizon and the water table (assumed to be 200 m on page 3 of Appendix A) may be similarly overstated.

3. The hydraulic conductivity of undisturbed host rock is assumed to be 10^{-5} cm/s (page 20, Appendix A). This data was apparently derived from assumed fracture spacings and aperture widths (Fernandez and Freshley, 1984). The range suggested on the

Table 1 Variation of the Calico Hills Unit in the Vicinity of the Repository Block (based on generalized core logs provided in Fernardez and Freshley, 1984)

Hole No.	Thickness of Calico Hills to water table m (ft)	Vertical Distance between base of Calico Hills and the Static Water Table m (ft)	Calico Hills Zeolitized ?
UE-25a#1/ UE-25b#1	54 (176	-	No
USW H-1	107 (351)	-	partially
USW H-3	29 (95)	298 (977)	N.A.*
USW H-4	104 (342)	14 (47)	N.A.
USW H-5	72 (235)	114 (375)	N.A.
USW H-6	39 (128)	68 (222)	N.A.
USW G-1	115 (376)	23 (75)	Yes
USW GU-3	45 (147)	N.A.	No
USW G-4	107 (352)	5 (15)	Yes

* Data Not Available

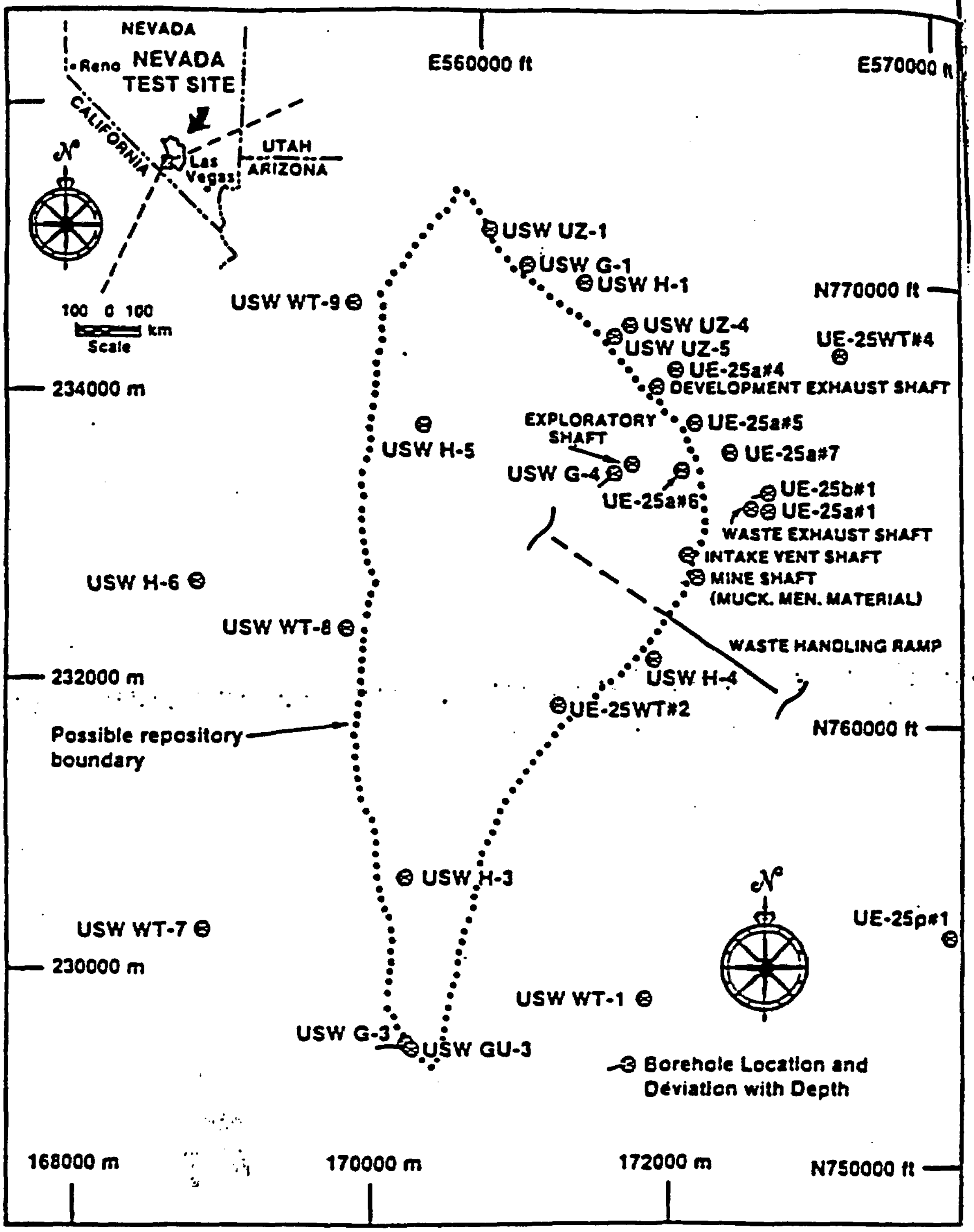

Figure 1. Location of Boreholes and Proposed Shafts Within and In the Vicinity of a Possible Repository Boundary (From Fernandez and Freshley, 1984)

basis of the few measurements in that study was 1.8×10^{-6} to 3.7×10^{-4} cm/s. These values did not take into account the interconnecting and cross joints, lithophyseal cavities, or other heterogeneities that may further affect hydraulic conductivity. Thus, the assumed value of 10^{-5} cm/s may not be conservative enough.

4. The estimated portion of the repository waste emplacement area likely to be affected by flooding has been shown to be 40 acres based on proposed drift gradients in the preconceptual design. This estimate does not take into account the following uncertainties:

- the final repository design may be different from the preconceptual design
- there may be other sources of water supplementing the water inflow from the ES (e.g. fault zones, perched water zones, other shafts and ramps)
- any blockage of flow downdip of the ES may result in flood water flowing updip to adjacent panels.

In view of these uncertainties, the estimate of the area affected and, consequently, the number of canisters in contact with water may not be realistic. This is an extremely important variable, one that could invalidate most of the major conclusions cited in this study.

5. The model of the damaged zone (page 20, Appendix A, page 5, Appendix B) assumed in the analysis appears to be rather simplistic, and since it is based on a basalt model its applicability to tuff is uncertain. Other questionable assumptions in this regard include:

- the increased permeability zone is assumed to extend one radius away from the shaft. This needs to be verified. Further, the excavated diameter of the shaft should be used instead of the finished diameter (14 ft as approach to 12 ft)
- the assumed permeability of the damaged zone may not be conservative enough
- as shown by the Kelsall et al (1982) study the permeability increase close to the shaft wall is about 3 orders of magnitude higher. The assumption of uniform permeability increase within the one-radius distance neglects the

possibility that water would tend to flow preferentially through the highest permeability zone and reach the repository much faster than that predicted by average flow. Also, this high permeability zone may increase in extent due to the passage of time through erosion and alteration

- other factors that may affect the extent and nature of the damaged zone, such as stress field, geologic structure, tectonic processes, and the like are not taken into consideration.

6. The water inflow calculations from fault zones and flow to the ES, and the assumed hydraulic conductivity values for the fault zones may not be conservative enough for the following reasons:

- the analysis of water inflow from faults considers the Ghost Dance Fault in <u>isolation</u> and does not consider secondary fault systems that may contribute to the total inflow (page 24, Appendix B)

- the analysis assumes that the effective rock mass hydraulic conductivity for welded tuff to be representative of the hydraulic conductivity of the fault zone (page 26, Appendix B). Due to the highly sheared and fractured nature of typical fault zones, a much higher value of hydraulic conductivity is more realistic

- although water bearing fault zones are said to have been intercepted in tunnels at the Nevada Test Site, (page 23, Appendix B) these data were not included in inflow estimates

- the drainage characteristics of the repository floor would influence to a large extent on how much water reaches the ES. However, this was not considered in the calculations. The comparison of the total floor area of the repository to the area of the ES should be of little significance.

7. The amount of radionuclide released into the ground water is computed by assuming that water comes in contact only with the horizontal cross-section of the waste canister (page 13, Appendix A). In reality, though, the entire surface area of the

canister will be contacted by water. Consequently, the computed values of release quantities may be different under this assumption.

8. The airborne release amounts are estimated on the basis of a single transport mechanism and does not couple heat transfer and airflow (page 31, Appendix B). Although this shortcoming is acknowledged, no effort has been made to attach a factor of safety to the results for the sake of conservatism.

Recommended Action:

The document concentrates on areas that are extremely critical to the success of the site characterization program as it evaluates the likelihood of the ES facilities in altering the post-closure isolation capability of the repository. In so doing, the document makes several sweeping conclusions and recommendations, namely:

- control of damaged rock zone around the ES is not important
- QA standards during ES construction need not be stringent
- shaft and drift backfills are of little significance.

These findings, if endorsed by the NRC, could lead to significant reduction in the levels of detail of information to be provided by DOE in its site characterization plans (SCP). In addition, it may result in little emphasis being given to construction procedures, design of shaft liners, control of adverse effects, shaft sealing plans, and QA requirements during ES conditions and testing. It is therefore imperative that each assumption, analysis procedure, and result be thoroughly reviewed, preferably by a team of multi-disciplinary staff composed of geohydrologists, waste package analysts, geochemists, and rock mechanics engineers.

The principal areas that need to be reevaluated include:

- water volume calculations for the various flooding scenarios
- water inflow volumes through faults
- hydraulic conductivity for the rock mass, damaged zone, and fault zone for the different tuff units
- drainage capacity of various tuff units

- relationship between various site specific factors and the extent of the damaged zone

- the rate of dissolution of radionuclides into contact water

- radionuclide release associated with a combination of different release mechanisms, such as flooding of ES accompanied by other water inflows from fault zones or other openings.