Richton Dome EA Review Comments

Comment Number	Comment
3.1	Section 3.2.5.4 Uplift and Subsidence Page 3-37. Inadequate discussion on uplift rate disparities The uplift rate estimates according to geodetic releveling surveys are 200 to 400 cm per 1000 years compared to 10 cm per 1000 years by other estimates. A reevaluation of the geodetic data for possible errors is planned. How would the differences be resolved if no errors are found in the geodetic data?
3.2	Section 3.2.6.1 Geomechanical Properties Page 3-50 (Table 3-4). No attempt to explain reduction in strength with depth of caprock Both the unconfined compressive and the tensile strengths decrease with increasing depth within the caprock according to the data in Table 3-4. Is this a coincidence or could there be a relationship between strength and proximity to the salt/caprock interface?

3.3

Section 3.2.6.1 Geomechanical Properties
Page 3-51,
Inadequate discussion of strength models and data

The Mises-Schleicher model appears to have been picked at random. This type of failure model is appropriate to describe yielding, i.e., onset of plastic flow. In salt, distinguishing plastic flow from creep can be quite cumbersome. Of course, a separate formulation is included to quantify the creep strain. The creep parameters in Table 3-5 have been obtained by assuming a value for E_{ss} and forcing a fit to obtain the other parameters, based on data from only three tests.

No compressive strength or tensile strength data are given.

Comment Number	Comment
4.1	Section 4.1.1.2 Engineering Design Studies Page 4-25, Inadequate description of EDBH location and data needs

The Engineering Design Borehole (EDBH) location, i.e., its distance from the proposed exploratory shaft location, needs to be specified and justified. What specific data will be collected and how will it be utilized? Will this activity be completed prior to ES excavation?

4.2 <u>Section 4.1.1.2 Engineering Design Studies</u>
<u>Page 4-27</u>.
<u>Incomplete and confusing discussion on cone penetrometer tests</u>

It is not clear whether the Cone Penetrometer Tests (CPT) are to be performed during the drilling of foundation boreholes or if they are unrelated. What is meant by the following statement (from paragraph 1): "Core penetrometer tests, placed between auger borings, provide in-situ measurements of salt properties ...." Since the auger borings will extend from 15 to 60 m in depth, no salt property data could be expected from these holes. If separate boreholes are intended for CPT tests, how many such holes are planned and what are their depths?

4.3 **<u>Section 4.1.2.2 Construction</u>**
<u>Pages 4-40 to 4-45</u>,
<u>Lack of mechanical support for liner; related problems with seals and grout</u>

Since the 10-ft inside diameter casing will only be installed to a depth of 500 meters, the weight of the liner (or casing) plus the seals and grouting around the liner need to be supported at the bottom. No system is described that would perform that function.

4.4 **<u>Section 4.1.2.3 Testing</u>**
<u>Pages 4-56 to 4-58</u>,
<u>Amount and type of at-depth testing inadequate</u>

While the three planned at-depth tests are essential and extremely useful, they are not sufficient for a relatively complete characterization. No tests are included to determine: the in-situ state of stress, rock moduli, variability of thermal, mechanical, and thermomechanical properties, in-situ strength, feasibility of large emplacement holes, and demonstration of retrievability.

4.5 **Section 4.3.1 Alternative Exploratory Shaft Construction Pages 4-131 to 4-134. Inadequate consideration of important issues in comparing shaft sinking methods**

The drill-and-blast and large-hole-drilling (LHD) methods are stated as being roughly equivalent in terms of their environment impact. The decision to select the LHD method appears to have been based primarily on its anticipated shorter construction time. However, the opportunity to gather geologic and geotechnical data during shaft construction is sacrificed when using the LHD method. Considering the purpose and scope of the exploratory shaft facility, the additional data that could be obtained when using the drill-and-blast technique would constitute a major advantage in terms of site characterization.

4.6 **Section 4.3.1 Alternative Exploratory Shaft Construction Page 4-133. Larger finished ES diameter for drill-and-blast alternative more useful**

The finished ES diameter for the drill-and-blast method is 12 feet versus 10 feet for the LHD method. The larger inside diamter will, no doubt, provide more flexibility and larger capacities for a number of activities.

Comment Number	Comment
5.1	Section 5.1 The Repository Pages 5-2 and 5-4. Optimization of service shaft diameter A diameter of 31 feet is shown in Table 5-1 for the service shaft. How was this size selected? The size of disturbance around the shaft perimeter is a function of the shaft diameter. Was this taken into account and appropriate trade-offs considered before selecting such a large sized shaft?
5.2	Section 5.1.1.2 Repository Shafts and Ventilation System Pages 5-12 to 5-14. Inadequate discussion of shaft construction and monitoring of performance Aside from some factual information of dimensions and location, no details are provided on the construction of the repository shafts. No programs are described to

gather geotechnical and stratigraphic data during the excavation and outfitting periods of shaft construction. Seal emplacement and monitoring of seal performance are not addressed. In short, the discussion is extremely cursory.

5.3 <u>Section 5.1.3.1 Repository Construction Activities</u>
<u>Pages 5-27 to 5-29</u>.
<u>Lack of discussion on contingencies</u>

The description of underground development activities is very limited and assumes ideal conditions in space and time. No artificial support activities are mentioned. What steps will be taken when gas pockets are encountered? How will the design be modified if structural discontinuities or brine pockets are discovered during excavation of rooms or corridors?

5.4 <u>Section 5.1.3.2 Repository Operation Activities</u>
<u>Pages 5-34 and 5-35</u>.
<u>Inadequate treatment of retrievability issue</u>

Generic comments are made about the intent to maintain retrievability. It is also stated that, "The ability to retrieve the waste packages will be demonstrated prior to a decision to backfill all waste storage rooms." No information is provided on how this will be accomplished. The in-situ test plans have no such planned demonstration. Will a test area be backfilled (including the room) and then reexcavated to show the ability to retrieve? The high temperature environment is likely to complicate retrievability.

5.5 <u>Section 5.1.3.3 Decommissioning and Decontamination</u>
<u>Page 5-36</u>.
<u>Lack of discussion on shaft backfilling, plugging, and sealing</u>

A single sentence is included to mention the fact that the shafts will be backfilled and sealed. An expanded discussion needs to be developed that describes the placement of seals, their performance requirements, composition of backfill materials, degree of compaction for salt backfill, etc.

Comment Number	Comment
6.1	Section 6.2.1.4 Meteorology, Guideline 960.5-2-3 Pages 6-27 and 6-30, Inconsistent conclusion with respect to the qualifying condition In Table 6-5, the Qualifying condition for Meteorology is shown to be "met." On p. 6-30, the conclusion is that, "the qualifying condition... can reasonably be expected to be met."
6.2	Section 6.2.1.8 Transportation, Guideline 960.5-2-7 Pages 6-65 to 6-69, Internally inconsistent conclusions with respect to Favorable Conditions (1), (2), (5) Table 6-9 on p. 6-65 shows Favorable Condition (1) as "found," whereas p. 6-68 states it as, "...expected to be found." Table 6-9 on p. 6-66 shows Favorable Condition (2) as "not expected," whereas p. 6-69 states it as "not found." Table 6-9 on p. 6-66 shows Favorable Condition (5) as "found," but p. 6-69 states it as "expected."

6.3 <u>Section 6.2.1.8 Transportation, Guideline 960.5-2-7 Pages 6-67, 6-68, 6-72, and 6-73, Internally inconsistent conclusions with respect to Potentially Adverse Conditions (1) and (3)</u>

Table 6-9 on p. 6-67 states Adverse Condition (1) as "not expected." Page 6-72 shows the same condition as "expected to be found." Table 6-9 on p. 6-68 shows Adverse Condition (3) as "not found." But p. 6-73 states the same condition as "found."

6.4 <u>Section 6.3.1.1 Geohydrology, Guideline 960.4-2-1 Pages 6-92 and 6-97, Internally inconsistent conclusion for Favorable Condition (3)</u>

Table 6-13 on p. 6-92 reports Favorable Condition (3) as "found." But p. 6-97 states that the condition is "expected to be found."

6.5 <u>Section 6.3.1.2 Geochemistry, Guideline 960.4-2-2 Pages 6-111 and 6-112, Incorrect statements in Table 6-14</u>

The statement accompanying DOE's finding on Potentially Adverse Condition (1) reads, "In contact with limited and unlimited.... respectively." The terms "limited" and "unlimited" need to be reversed. The statement should read, "In contact with unlimited and limited...., respectively." In the statement accompanying DOE's finding on Potentially Adverse Condition (3), "...indicates a chemically oxidizing environment" should read, "...indicates a chemically reducing environment."

6.6 Section 6.3.1.2 Geochemistry, Guideline 960.4-2-2
Page 6-115,
Inconclusive statement needs further elaboration

In the analysis of Favorable Condition (4), the following statement is made: "The criterion of 0.001 percent of the total curie content at 1000 years is expected to be met for 300 years." Is that good or bad? It is not clear whether the above statement indicates a meeting of the criterion by a large margin or nearly satisfying the criterion (but not quite).

6.7 <u>Section 6.3.1.3 Rock Characteristics, Guideline 960.4-2-3 Page 6-120, Suspect Poisson's Ratio data; incomplete description of conductivity data range</u>

In Table 6-15, a range of 0.21 to 0.55 is given for Poisson's ratio. For an isotropic material, the theoretical maximum is 0.5. If the material is not isotropic, then more than two independent constants are necessary to describe its elastic behavior.

A range of 2.45 to 4.15 is given for the thermal conductivity of Richton Dome salt. Is this range at a given value of temperature or is there a temperature range associated?

6.8 <u>Section 6.3.1.3 Rock Characteristics, Guideline 960.4-2-3, Pages 6-122 and 6-124, False claim regarding thermal expansion coefficient of salt</u>

In Table 6-16 (p. 6-122) and on p. 6-124 it is claimed that the host rock (domal salt) has a low coefficient of thermal expansion. This is completely false. Compared to other rock types, salt has a very high expansion coefficient. For example, Table 6-15 (p. 6-120) gives a range of 37.5-46.2 x 10^{-6}/°C for the expansion coefficient of Richton Dome salt. In comparison, the Hanford basalt has a coefficient of expansion that ranges between 5.7 x 10^{-6}/°C and 8.7 x 10^{-6}/°C. So, the finding of the second favorable condition may be somewhat diluted.

6.9 <u>Section 6.3.1.6 Dissolution, Guideline 960.4-2-6</u>
<u>Page 6-146</u>
<u>Inadequate basis for assuming the degree of collapse and dissolution</u>

The last item in the right hand column in Table 6-19 (p. 6-146) asserts that structural collapse and dissolution are not present to the degree that they would create interconnection between the repository and the geohydrologic system. How was this established? There is, at present, no defensible basis to make that assumption.

6.10 <u>Section 6.3.1.6 Dissolution</u>
<u>Page 6-147</u>,
<u>Undefined salt anomaly</u>

Near the bottom of the page, reference is made to a "saline anomaly." What is this anomaly? What is its exact location?

6.11 <u>Section 6.3.3.2 Rock Characteristics</u>, <u>Guideline 960.5-2-9</u> <u>Page 6-191</u>, <u>Assumption of retrievability overly optimistic</u>

Paragraph 3 under <u>Assumptions and Data Uncertainty</u> claims that reexcavation of storage rooms and relocation of waste canisters is possible with reasonably available technology, and without undue hazard. It is highly unlikely that reasonably available technology will be adequate to reexcavate relatively hot (~100°C) salt and relocate the waste packages. Neither should the hazard be considered undue. There is potential for substantial hazard, both in terms of working environment and the possibility of breaching a waste package.

6.12 <u>Section 6.3.3.2 Rock Characteristics</u>, <u>Guideline 960.5-2-9</u> <u>Pages 6-193 and 6-197</u>, <u>Nonfinding of Potentially Adverse Condition (5) questionable</u>

Table 6-26 on p. 6-193 and the analysis on p. 6-197 both make overly optimistic conclusions based on a very limited data base or, indeed, in the absence of data. The fact that there is no evidence of shear zones simply may mean that appropriate investigations have not yet been undertaken that would produce such evidence. What is the basis of stating that pressurized brine pockets are unlikely in a dome? Again, just because no data are available to suggest vertical anomalous zones at Richton Dome, it does not mean that such zones are not present. At best, a potentially adverse condition may not be expected. There simply are not sufficient data to make a confident finding on this condition.

6.13 Section 6.3.3.2 Rock Characteristics, Guideline 960.5-2-9
Page 6-199,
Factors controlling stability more complex and performance requirements more stringent than for commercial mining

Reference is made in the document to the reduced Pillar loading due to the lower extraction ratio for the repository. This load reduction is largely countered by the thermal loads and thermomechanical stresses.

Enhanced creep rates due to higher temperatures cause much larger convergences. The increased length of time during which many of the openings must be maintained also introduces unique stability problems.

6.14 Section 6.3.3.2 Rock Characteristics, Guideline 960.5-2-9
Page 6-200.
Inconsistent statement with respect to in-situ testing

The conclusion (6.3.3.2.6) paragraph states that, "Difficulty of retrieval would be evaluated from site-specific in-situ testing. This is inconsistent with the description given in Chapter 4 (Section 4.1.2.3) of the in-situ testing; there is no mention of any tests that would assist in an evaluation of retrievability.

6.15 Section 6.3.3.4 Tectonics
Page 6-209.
Finding of the Favorable Condition debatable

Depending on the perspective, one might argue equally successfully that almost half of the nuclear plants have a lower projected maximum earthquake shaking than that projected for the Richton Dome Site.

6.16 <u>Section 6.3.4.2 Evaluation Process (Preclosure System Guideline 960.5-1(a)(3)) Page 6-216, No basis for assuming nongassy subsurface conditions</u>

Past experience with salt mines in domes has shown occurrence of gas in those mines. Even in the Richton Dome EA, it is stated on p. 6-198, "Previous mining experience in the region indicates pockets of various gases may exist in Richton Dome." On p. 6-226, the second paragraph states that brine and/or gas pockets could significantly affect the overall subsurface costs. What then is the basis for the assumption (underlying the engineering work performed thus far) that nongassy subsurface conditions will exist during underground operations?

6.17 **Section 6.3.4.3 Analysis (Preclosure System Guideline 960.5-1(a)(3)) Page 6-224, Lack of justification for proposing different shaft construction methods for ES and repository shafts**

What are the reasons for using one construction method for exploratory shaft(s), but a different method for the repository shafts? The advantages outlined for selecting the blind-drilling method for exploratory shafts would still hold for the repository shafts. The additional holes that have to be drilled around the shaft perimeter in order to freeze the groundwater during shaft construction using the drill-and-blast method might present subsequent problems with plugging and sealing.

6.18 **Section 6.3.4.4 Conclusion (Preclosure System Guideline 960.5-1(a)(3)) Pages 6-223, 6-229, and 6-230, Inaccurate assessment of comparative costs**

The text on pp. 2-229 to 2-230 states that, "...the Richton repository costs are higher than the other dome sites as well as the Permian sites...." This is contrary to the data presented in Table 4-30 (p. 6-223) which shows the Richton repository costs to be the lowest among all the salt sites.

6.19 <u>Section 6.4.2.1 Performance of Engineered Barriers</u>
<u>Page 6-251</u>,
<u>Inconsistent treatment of temperature dependence of thermal properties</u>

According to the text, a transformation technique accounts for the temperature dependence of thermal conductivity but does not do the same for diffusivity. This does not make sense since conductivity and diffusivity are related as follows:

$$\alpha = \frac{k}{\rho c}$$

where: α is the diffusivity,
k is the conductivity
ρ is the density
and c is the specific heat capacity.

6.20 <u>Section 6.4.2.1 Performance of Engineered Barriers</u>
<u>Page 6-251</u>.
<u>Increasing conductivity would make predicted thermal response less conservative</u>

Possible errors in the laboratory measurements of thermal conductivity (due to sample disturbance) are proposed to be corrected by a 40 percent increase. This should not be done without a careful evaluation because higher values of thermal conductivity would reduce the predicted peak temperatures in the very-near-field. Appropriate in-situ tests could be conducted that would provide more reliable thermal conductivity data and thus reduce uncertainty.

6.21 <u>Section 6.4.2.1 Performance of Engineered Barriers</u>
<u>Page 6-259</u>.
<u>Individual canister loadings too high?</u>

The initial heat generation rates of 9.5 kW for CHLW and 5.5 kW for SFPWR packages seem too high. Previous kW/canister data have been of the order of 3kW. Since the peak temperature predictions are comparable to previous studies, the numbers given in the EA seem suspect.

6.22 <u>Section 6.4.2.1 Performance of Engineered Barriers Pages 6-248 and 6-259, Internally inconsistent temperature data</u>

The maximum expected surface temperatures on the waste package are 292°C for CHLW and 175°C for SFPWR as presented in 6.4.2.1.1 on p. 6-248. However, on p. 6-259 the values given are 296°C and 180°C, respectively.

6.23 <u>Section 6.4.2.1 Performance of Engineered Barriers Pages 6-262 and 6-263, Inadequate discussion of hydrogen production and its consequences</u>

The corrosion reaction produces 271 cubic meters of hydrogen gas per cm of overpack thickness. Where does this gas go? Can high pressures be created by its presence? Do other reactions follow?

6.24 <u>Section 6.4.2.1 Performance of Engineered Barriers Page 6-269, Incorrect prediction of stress decay</u>

According to the text, the normal stress on the waste package gradually decays to lithostatic pressure within the first decade. This will generally not be the case. Many design factors as well as the thermal properties control the variation of stress at a given location. As long as the temperature and the temperature gradients are not constant, the stress can be expected to vary.

6.25 <u>Section 6.4.2.1 Performance of Engineered Barriers</u>
<u>Page 6-272</u>,
<u>Lack of justification for expecting uniform corrosion only</u>

In Paragraph 1, it is stated that, "Uniform corrosion, versus pitting, etc., is expected for the material selected for the overpack." There is no basis offered for this assumption. In general, both types of corrosion could occur, and depending on the environment, quality control, etc., one or other mode could dominate.

6.26 <u>Section 6.4.2.2 Performance of Shaft Seals</u>
<u>Page 6-285</u>,
<u>Potential disturbance due to the keying in of bulkheads not addressed</u>

At the location of a bulkhead, more material must be excavated in order to key the bulkhead. What are the effects of this excavation process? How big a zone would be disturbed? Would the composition of the concrete bulkheads be tailored to assure compatibility with the adjacent rock?

6.27 <u>Section 6.4.2.3 Disturbed Zone</u>
<u>Page 6-292</u>.
<u>Inadequate consideration of uplift of stratigraphy</u>

The text acknowledges that rigorous analyses of the effects of thermal-mechanical expansion on the caprock have not been performed. Another aspect, that is perhaps more important, needs to be considered: The differential uplift or expansion along the seal or plug interfaces (e.g., along the shaft length) is likely to cause damage to the seals and create preferential pathways for groundwater flow.

6.28 <u>Section 6.4.2.3 Disturbed Zone</u>
<u>Page 6-295</u>.
<u>Discrepancy in period over which heat influences flow is suspect</u>

The results shown indicate the period over which flow velocities are influenced is different for different hydraulic conductivities. As long as the amount of heat carried by the flow is small (which presumably is the case), the time period over which heat influences flow should be nearly the same. Is it possible that the late-time velocities (and, therefore velocity ratios for the two assumed hydraulic conductivities) are artificially affected by the boundary condition and/or the solution algorithm?

6.29 Section 6.4.2.3 Disturbed Zone Page 6-296, Improper interpretation of the thermal-hydrologic disturbed zone size

The table included in the conclusion section shows a "disturbed zone size" of 10 meters for the thermal-hydrologic disturbance. The 10 meters represent the extra distance traveled in 10,000 years due to the effect of heat, and not the size of the thermal-hydrologic disturbed zone.