ADDENDUM A

Final Remedial Action Plan
DOE-EM/GJ1547
July 2008

DOE Responses to NRC Comments

Number	Title	
April 2006	NRC Comments and DOE Responses, April 2006 Meeting	
June 2006	NRC Comments and DOE Responses, June 2006 Meeting	
February 2007	NRC Comments and DOE Responses, February 2007 Request for Additional Information	
September 2007	NRC Comments and DOE Responses, September 2007 Open Issues Meeting	
Final RAP	NRC Comments and DOE Responses, Final RAP	

ADDENDUM A – NRC COMMENTS AND DOE RESPONSES

April 2006 Meeting

Geology

1(a). "Linear feature - explain further why the stratigraphy of the Prairie Canyon Member defines the lineament..." It is asserted that the lineament is stratigraphically controlled, i.e., there is little direct technical support provided in the RAP that an informed reviewer could rely on to concur. The nature of the contact of the two members of Mancos Shale that are adjacent to or directly underlie the footprint take on importance for understanding present and future site conditions and the behavior of surface and ground water that flows across and through the contact zone. If the contact is stratigraphic, explain why is it not linear everywhere it is exposed. If the lineament cannot be explained definitively as stratigraphic, then it may be structural, such as a fault contact. Such a possibility would entail investigating whether or not it is a capable fault.

1(b). "...and that the linear feature is not offset by faults." The applicant's idea of explaining why the linear feature is not offset by faults (and the significance of such an observation) is potentially useful for showing structural integrity of the lineament only where it is exposed to scrutiny.

Response for 1(a) and 1(b):
The stratigraphic horizon referenced in this comment is represented by discontinuous concretionary masses of dolomitic siltstone that mark the top of the Prairie Canyon Member. These resistant concretionary masses are near the north edge of the disposal cell footprint in the south parts of Sections 22 and 23, as shown in the March 12, 2007, geologic map. Exposures of this stratigraphic horizon are not linear everywhere because the exposures are characteristically poor and the concretionary masses are discontinuous both along strike and along dip. Additionally, subtle spatial variations in strike and dip directions within the Mancos Shale, coupled with the topographic elevation of the individual exposures, cause the exposed masses to appear nonlinear in outcrop. Stratigraphic characteristics of the Prairie Canyon Member of the Mancos Shale at the Crescent Junction Site are similar to the descriptions provided in two important references (listed here).

Cole, R.D., R.G. Young, and G.C. Willis, 1997. *The Prairie Canyon Member, a New Unit of the Upper Cretaceous Mancos Shale, West-Central Colorado and East-Central Utah,* Utah Geological Survey Miscellaneous Publication 97-4.

Hampson, G.J., J.A. Howell, and S.S. Flint, 1999. "A Sedimentological and Sequence Stratigraphic Re-Interpretation of the Upper Cretaceous Prairie Canyon Member ("Mancos B") and Associated Strata, Book Cliffs Area, Utah, U.S.A.," *Journal of Sedimentary Research*, 69(2), pp. 414–433.

The revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (Attachment 2, Appendix B) includes additional mapping results, stratigraphic descriptions, and literature citations that describe this important horizon in the Prairie Canyon Member.

2. "Provide photo(s) from the top of the Book Cliffs showing the lineament." [does not affect RAP]. This request was made to enable the NRC staff to inspect the lineament more clearly in a larger form than what is in the draft RAP.

Response:
Four photographs taken on July 19, 2005, from the top of the Book Cliffs just north of the site, showing the subject lineament, were sent to the NRC on May 3, 2006, for their inspection.

3. "Linear feature - evaluate any geophysical reflection data on fracture orientations in boreholes (005 and 023) and corehole (0201) north of the lineament." The objective of such investigations appears to be to obtain data on the characteristics of the contact zone and to seek evidence for the origin of the lineament. Such data may be potentially useful for assessing the geomechanical properties of the rocks, flow and transport properties and conceptual models of the rocks at and near the site.

Response:
Geophysical seismic surveys conducted at the site consisted of the refraction rather than the reflection method. The refraction survey was conducted to obtain shear wave velocities in the weathered Mancos Shale to determine its rippability characteristics. The refraction survey area was south of the lineament, and this survey method would not provide useful data for a lineament investigation.

4. "Low sun-angle photos - send a copy to NRC for inspection." [does not affect RAP]. The request was made because the photos were identified, but not provided in the draft RAP.

Response:
A set of low sun-angle photographs taken on July 27, 2005, was sent to the NRC on May 3, 2006, for their inspection.

5(a). "Document/evaluate rates of changes of surface geologic processes such as scarp retreat of the Book Cliffs…"

5(b). "…rock falls and roll distances (petroglyph dates),..." These geomorphic processes result in (i) erosion of the cliffs that dominate the site by gravity, running water and wind, (ii) the transport of rock particles of all sizes up to large boulders, and (iii) the deposition of the rock particles. The smaller particles, sizes up to small boulders, are shown on photos and reported to have been transported to (and impinge upon) the proposed footprint and beyond (lower elevations), largely by sheet wash. There is a need to quantify or otherwise bound the sediment loading of the surface drainage system for the next 200 to 1,000 years as input to the design of the empoundment to achieve the necessary performance.

Response for 5(a) and 5(b):
Northward scarp retreat of the Book Cliffs was estimated from average scarp retreat rates in the literature (listed here) for the Book Cliffs and for rock types in arid environments at 5 feet (ft) per thousand years.

Schumm, S.A., and R.J. Chorley, 1983. *Geomorphic Controls on the Management of Nuclear Waste*, prepared for the U.S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-3276.

Woodward-Clyde Consultants, 1983. *Overview of the Regional Geology of the Paradox Basin Study Region,* unpublished technical report ONWI-92, prepared for the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio, March.

Rock art (petroglyphs) on several boulders at the base of the Book Cliffs is from the Fremont era of 200 BC to 1350 AD. This gives a minimum age of the rock falls as 650 years, but they could have fallen as long as 2,200 years or more ago. Calculation of the rock fall runout distance for rocks falling from the top of the Book Cliffs was made along two profiles, using an empirical angle that defines the limit of runout. Distances from the empirical rock-fall runout limits from the two profiles to the edge of the disposal cell footprint were 900 and 950 ft. This indicates the disposal cell and any access roads or infrastructure are far enough from the base of the Book Cliffs to not pose a hazard from rock falls.

The scarp retreat rate information was included in the revised calculation set for Site and Regional Geomorphology – Results of Literature Research (RAP Attachment 2, Appendix C). Information on rock-fall runout distances was included in the revised calculation set for Site and Regional Geomorphology   Results of Site Investigations (Attachment 2, Appendix D).

5(c). “...and rate of incision (headcutting) migration of West Kendall and Crescent Washes.” In fact, the potential hazard to the proposed empoundment from any stream, wash or gully that may erode headward and intersect or otherwise affect the empoundment in the next 200 to 1,000 years needs to be fully investigated and evaluated as potential inputs to design for mitigation.

Response for 5(c):
Forecasts of headward erosion are in the revised calculation set for Photogeologic Interpretation and in the revised calculation set for Site and Regional Geomorphology Results of Site Investigations (RAP Attachment 2, Appendices G and D, respectively). The progress of headward incision of three tributaries of the West Branch of Kendall Wash was compared in the registered historical aerial photographs from 1944, 1974, and 2005. Results showed the progress of headcuts was approximately 1.3 to 2.3 ft per year over the 60-year period. At these rates, headward erosion would reach the site access road in about 250 years and just outside the southwest corner of the disposal cell in about another 250 years. Approximately 1,600 years of headcutting would be required to reach northwestward to Crescent Wash, where a capture of that drainage by the West Branch would be possible.

To protect the disposal cell from the headcutting, the outlet of the main diversion channel coming from the north side of the disposal cell has been extended away from the cell and with sufficient riprap at the outlet. In addition, a rock apron was also designed around the toe of the east, west, and south sides of the cell to protect against erosion and dissipate energy from cell runoff.

6(a). "Evaluate the effect (if any) of fractures on weathered Mancos Shale and on hydrology."

Because fractures exist at the site and beyond (from observations of pits, core and outcrops) in weathered (and unweathered) Mancos Shale, characteristics of fractures in both the Prairie Canyon and Blue Gate Members should be investigated only to the level of detail commensurate with their significance to design and to performance evaluations.

6(b). Suggest DOE prepare explicit characteristics of "weathered" and "unweathered" Members of the Mancos Shale, given that these are end members of a gradational series. The goal is to minimize ambiguous data from samples that are partially weathered or partially unweathered. Implicit in the description of the characteristics of the weathered Mancos Shale, such as fractures, is the need to describe the characteristics that distinguish the weathered Mancos Shale from the bedrock Mancos Shale (for both the Prairie Canyon and Blue Gate Members). DOE stated at the meeting that the weathered zone of the Mancos grades gradually into the unweathered (bedrock) Mancos, making it necessary to describe criteria to distinguish each type of shale.

Response for 6(a) and 6(b):
Characteristics of weathered and unweathered Mancos Shale bedrock for both the Prairie Canyon and Blue Gate Members were compiled from corehole lithologic logs and RQD data and are in Figure 8 in the revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (RAP Attachment 2, Appendix B).

7. "Evaluate more fully the reason(s) for the abandonment of the course of the ancestral East Branch of Kendall Wash and assess if future drainage abandonments could occur and their affect on the site." The significance of a stream abandonment on a bajada or pediment for understanding future stability or predictability of drainage networks depends on the cause(s), rates of reestablishment of the drainage change, and future site conditions. The observation of large boulders in a wash in or near the abandoned system unusually far from the Book Cliffs suggests the possibility that a highly energetic, but localized, wash may occur again in a situation similar to that of the proposed footprint.

Response:
Additional characterization of the withdrawal area east of the proposed disposal cell footprint (including the East Branch) was conducted in October 2006. Several additional areas of large boulders were found associated with the East Branch and its ancestral drainages. These areas are at least 1 mile (mi) east of the disposal cell footprint and appear to be expressions of high-energy flows from the East Branch drainage system that heads in two canyons (known as Little Blaze Canyon and an unnamed canyon just to the west of it) that are reentrants into the Book Cliffs. Based on the difference in the depths of incision of the ancestral East Branch and the present East Branch at the point of capture, capture of the ancestral East Branch occurred approximately 6,000 to 9,000 years ago.

This additional information and the implications for the disposal cell area were included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

8. "Erosion surfaces appear to be displaced from aerial photos - determine if they are displaced and their significance if they show Quaternary movement." Because displaced erosion surfaces may have been caused by neotectonic activity, they are potential clues to seismic sources. They may be also caused by a seismic structural deformation. Such potential surfaces were reported in RAP Attachment 2, Appendix G, Plate 1 and captions 'g' and 'h' for Low Sun Angle photograph.

Response:
Area "g" was investigated in May 2006 and determined not to be related to faulting. It had appeared from aerial photographs that Crescent Bench, a mantled pediment surface, was displaced down to the north. Upon inspection, the lower surface was not the same mantled surface as Crescent Bench; it was an unmantled surface on Mancos Shale, and the difference in height of the two surfaces could be explained simply by erosion rather than faulting.

Possible displacement of the Quaternary surface along a linear feature at area "h" was investigated in November 2006. No displacement was seen and the linear feature was determined to be an old dozer cut about 2 mi long made for a seismic survey line probably in the 1960s. Results from investigations of both areas "g" and "h" were included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

9. "Expand the discussion on potential natural resources (oil/gas, salt/potash, uranium/vanadium, and gold) based on current economics." An update is prudent, given that gold is near its all time high and oil is at its all time high, for example.

Response:
Oil and gas are the geologic resources that have the highest potential for occurrence and development at the site area. The entire withdrawal area is currently leased for oil and gas, and several oil and gas test holes have been drilled recently just to the south and west of the withdrawal area. Exploration and production of oil and gas (if it occurs) is permitted in the withdrawal area and production could take place even under the 250-acre disposal cell by directional drilling.

The probability of occurrence of potash and other salt mineral resources is low in the site area because of post-depositional movement of the saline facies of the Paradox Formation toward the axis of the Salt Valley Anticline about 2 mi to the southwest of the site. As a result, these deposits at the site are thin to absent. Uranium and vanadium and copper and silver deposits are in the Morrison Formation in widely scattered locations more than 5 mi south of the site area; the low probability of the occurrence of these metals beneath the site and the greater than 3,000-foot depth of the Morrison Formation make their exploration and development economically unfeasible. Gold content is slightly higher in Mancos Shale in the site area than what normally occurs in shale; however, to warrant economic extraction, the gold content would have to be 10 to 100 times higher.

Additional information on these potential natural resources in the site area is in the revised calculation set for Site and Regional Geology   Results of Literature Research (RAP Attachment 2, Appendix A). The discussion is based primarily on two BLM reports, which give the occurrence and development potential of these resources.

10. "If oil/gas resources are present below the site, and these were exploited, could subsidence (and how much?) occur?"

Response:
Possible oil and gas production from beneath the disposal site at depths of between 4,000 and 11,000 ft would not result in subsidence. Void (pore) space in the rock (typically a sandstone) that would contain the oil and/or gas typically amounts to as much as 20 to 25 percent of the rock volume. Recovery of the oil and/or gas (usually less than 50 percent of the resource) would therefore result in creating a void space consisting of only about 10% of the rock volume. Adequate grain support in the well-lithified sandstone of Paleozoic or Mesozoic age and the great depths of the possible production horizons would make surface subsidence highly improbable. No subsidence has been reported as a result of oil and gas production from numerous fields at similar depths in east-central Utah (personal communication in 2007 with David Tabet, Geologic Manager of Energy and Minerals Program for the Utah Geological Survey). This information was added to the Resource Development section in the revised calculation set for Site and Regional Geology   Results of Literature Research (RAP Attachment 2, Appendix A).

11. "Further document the past occurrence of shallow gas in the Mancos Shale and its potential to occur at the site." Given that DOE reported evidence of natural gas in at least one of its boreholes on or near the site, that gas blowout preventers have been used by local drillers because of a known (little evidence presented) or presumed hazard, it is prudent to investigate the history, likelihood, expected magnitude of such a hazard at the site or at analogous sites in the area.

Response:
More details of the occurrence of gas in one borehole from the 1920s were added to the revised calculation set for Site and Regional Geology   Results of Literature Research (RAP Attachment 2, Appendix A). No other shallow test wells from the area have reported gas, but the occurrence of gas in thick marine shale is not unusual.

12. From Disposal Cell Section: "The sheet flow process described in the geology section is expected to continue after cell construction and must be considered in the design." From a geological review perspective, the description of the sheet flow hazard (in the Geology Section) would need a technical basis to support an estimation of locations, rates and magnitudes of water and mass movements over the next 200 to 1,000 years.

Response:
Because the disposal cell is designed such that maximum flows coming down the main sheet wash path (in the east part of the cell) would be diverted westward and eastward around the perimeter of the disposal cell, sheet wash flow is not considered a hazard and determination of the rate of accumulation of sheet wash deposits is not necessary.

Seismology

13. "Indicate which faults are capable/not capable and basis for assumption." Identify the known and suspected faults in the area such that if any were of such size and distance from the site that, if seismogenic, would affect the site and need to be evaluated for its seismic loading potential.

Response:
Faults are identified as capable/not capable in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, Table 3). Known and suspected faults are identified and discussed in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, pages 5–12).

14. Provide rationale for using 6.2 for the floating earthquake when 5.9 is listed as the maximum earthquake on page 6.

Response:
Rationale to explain the difference between the estimation of the maximum predicted earthquake and the maximum historically recorded event is explained in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 5).

15. Indicate why some faults included in the calculations for the Cheney Site were not included for the Crescent Junction Site.

Response:
An explanation is given in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, page 11) that although the Cheney Site is used as a comparison for a site within the same tectonic province, the sites are not in the same location, so faults located closer to one site will have the potential of having larger impacts on the close site as compared to the farther site. Specific faults will be addressed on an individual basis that is relevant to both sites.

16. Provide velocity data from geophysics for the rippability study for the weathered and unweathered Mancos Shale below the site.

Response:
The geophysical investigation at the Crescent Junction Site was done specifically to access rippability of the Mancos Shale during construction of the disposal cell. As such, the investigation consisted of determining the seismic velocities of the weathered and unweathered shale deposits using compression wave data. Shear wave velocities and shear modulus are typically the parameters used to evaluate the stiffness of the foundational materials to evaluate if amplification of ground motions would be expected. However, on a qualitative basis, the seismic velocity data will be presented to support the claim that site amplifications will be negligible. Velocity data are provided in the revised calculation set

for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

17. Provide more justification to support the salt dissolution origin for the Thompson Anticline and Tenmile Graben structures.

Response:
A preliminary field investigation of several unnamed faults, associated with the Thompson Anticline (Willis 1986; Doelling 2001), showed no evidence of Quaternary movement (no Quaternary deposits were displaced by the faults). It was concluded that no recent movement has occurred along faults associated with the Thompson Anticline, and that they reflect slow, incipient subsidence related to dissolution of deep salt deposits along the northeast edge of the Paradox Basin.

The Tenmile Graben, which is approximately 35 km long, is a narrow zone of faulting displacing Cretaceous and Jurassic bedrock along Salt Wash southeast of the town of Green River. The graben is on the northwestern edge of an area typified by northwest-trending, elongated oval valleys that are collapsed or depressed anticlines. The graben is probably related to salt dissolution. The youngest rocks offset by this fault are the upper members of the Cretaceous Mancos Shale (Doelling 2001). No Tertiary rocks are preserved along the Tenmile Graben. Quaternary alluvium and eolian sediments do not appear offset by any of the faults (Doelling 2001). Because no evidence exists for Quaternary deformation of the Tenmile Graben, it is not considered a capable fault for seismic-hazard assessment purposes.

Further discussion is presented in RAP Attachment 2, Appendix E, pages 6–7 and 10–12.

18. Determine if Granite Creek and Ryan Creek Faults on the Uncompahgre Uplift are connected and what acceleration would result.

Response:
The possibility of Granite Creek and Ryan Creek Fault systems being connected was investigated. The two fault systems appear to be separate based on mapping both by Doelling (2001) and in a cross section by Ely et al. (1986). Because the Granite Creek and Ryan Creek Faults are roughly parallel and overlapping, the total fault trace would not increase if they were considered collectively. Several faults of similar strike parallel the Granite Creek Fault to the northeast. Both Granite Creek and Ryan Creek Faults may merge at depth with the major uplift-bounding (Uncompahgre) reverse fault. For purposes of the Moab Remedial Action Plan, the Granite Creek Fault zone is considered a capable fault.

Discussion on the connectivity of these faults is given in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E).

19. In Appendix B Table, change the Wells and Coppersmith rupture-length reference to Campbell.

Response:
The table in calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F), has been adjusted to make column headings more clear.

20. Provide latitude and longitude for fault systems in tables.

Response:
Latitudes and longitudes have been shown on all figures in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F).

21. Provide copy of Cheney RAP.

Response:
The Cheney RAP was sent to the NRC on May 3, 2006.

22. Provide justification for using 0.42 g for Cheney design while 0.21 g for Crescent Junction.

Response:
According to the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 18), the seismotectonic stability studies done for the Grand Junction mill tailings/Cheney Disposal Site identified a fault (Fault 8) with a length of 11.0 km at a distance of 9.0 km from the site. Although no evidence of Quaternary displacement was proven, it was considered to be capable on the basis of its apparent association with a possibly active regional structure, the Uncompahgre Uplift. This fault was adopted as the design fault for the Cheney Disposal Site, resulting in a recommended design acceleration of 0.42g. The capabilities of this fault and other faults related to the Uncompahgre Uplift have negligible impact on the Crescent Junction Site due to the distance of these faults to the Crescent Junction Site.

23. Address amplification when estimating the seismic design for the site.

Response:
The TAD (DOE 1989) states in Section 5.4.4 that for shallow soil sites with less than 30 ft of overburden above bedrock, the site surface acceleration is considered to be the same as the acceleration derived from the seismic study. In Campbell and Bozorgnia (2003) attenuation relations, the PHA equations account for local site conditions of the upper 30 meters of rock or soil. As defined in their paper, the site is categorized as a firm rock site, based on underlying geologic unit consisting of pre-Tertiary sedimentary rock (Late Cretaceous Mancos Shale). This category assignment is supported by the SPT data, which place the less-weathered Mancos Shale as a BC soil class as defined by the National Earthquake Hazard Reduction Program.

A discussion of amplification at the site is presented in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

24. Provide any available reflection or geophysical data which may shed light on the stratigraphy and seismic velocity at the site.

Response:
Seismic velocity data from the rippability study summarized the three main geologic layers. The upper layer (alluvium and eolian deposits) ranged in depths from 4.5 to 18 ft, with seismic velocities ranging from approximately 1,160 to 1,330 feet per second (fps), typical for unsaturated alluvial overburden soils. The base of the second layer (weathered Mancos Shale) was interpreted to vary between approximately 24 and 60 ft, with seismic velocities ranging from about 4,060 to 5,220 fps. Velocities for the unweathered Mancos Shale ranged from about 9,000 to 10,000 fps. These data are provided in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

25. Make sure the earthquake distributions in Fig. 4 App. (E) are consistent with those in Fig. 1 App. (F).

Response:
Modifications were made for consistency in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, Figure 4) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, Figure 1).

26. Identify the different symbols in App. (E/B) and App. (F/A).

Response:
In RAP Attachment 2, the Appendixes have been modified in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F).

27. Address if liquefaction may occur at the site.

Response:
Tailings liquefaction is not likely because tailings would be placed in the cell at near-optimum moisture conditions (i.e., unsaturated), at compaction densities achieved with placement in lifts and rolling with construction equipment, and the fines content of the tailings. In the event that zones of tailings do become saturated, the calculated stress ratio required to cause liquefaction of the tailings is higher than the seismic stress ratio for all of the cases considered, indicating that liquefaction would not occur. Liquefaction is discussed in the revised calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D).

June 2006 Meeting

Ground Water Hydrology

1. What is the deepest weathered Mancos Shale encountered at other sites? Is it similar to the approximately 20-foot (ft) thickness found at the Crescent Junction Site?

Response:
The weathered zone in the Mancos Shale at the Shiprock, New Mexico, Legacy Management Site is approximately the same thickness as the weathered Mancos Shale at the Crescent Junction Disposal Site. Packer tests conducted at the Shiprock Site suggest that the weathered zone (the zone with relatively higher permeabilities) extends to a depth of approximately 35 ft. Below that depth, the permeabilities are approximately 3 to 4 orders of magnitude lower than in the upper weathered zone.

2. What is the basis for concluding that water encountered in the 300-ft-deep characterization holes is connate?

Response:
The ground water in the Mancos Shale is suspected to be connate based on several factors, including its salinity, variable ground water levels, and isolation from sources of recharge. In August 2006, the ground water was sampled in wells 0203 and 0208 and analyzed for radiocarbon (^{14}C). Results of the analyses show that the age of the ground water exceeds 40,000 years, which is the approximate detection limit for radiocarbon age dating. A calculation set describing the results of ^{14}C dating of ground water from two wells (0203 and 0208) at the disposal site is included in a new calculation set for Radiocarbon Age Determinations for Ground Water Samples Obtained From Wells 0203 and 0208 (RAP Attachment 3, Appendix F).

Water Resources Protection Strategy

3. Provide geochemistry data on water from the 300-foot-deep holes.

Response:
A hard copy of the requested data was provided to NRC at the meeting. A summary of geochemistry data for the Crescent Junction Site is included in RAP Attachment 5, Appendix H, Background Ground Water Quality.

Disposal Cell Design and Engineering Specifications

4. Recommendation was made on rock size and filter requirements that only the Abt-Johnson method and not the Stephenson method be used with the objective of reducing filter layer thicknesses and rock thickness and size on the side slopes. Ted Johnson indicated that perhaps only the south side slope and the drainage channel(s) may require a filter layer (east, west, and north side slopes may not require a filter layer), but a thinner filter layer could be used. Also, the thickness of the rock does not have to be twice the D_{50}, and that 1.5 times the D_{50} would suffice.

Response:
The calculation set for Erosional Protection of Disposal Cell Cover (RAP Attachment 1, Appendix H) was revised using the Abt-Johnson method, which reduces the size of the rock on the side slopes. The filter layer will be eliminated on the east, west, and north side slopes, but is necessary on the south side slope to accommodate runoff from the surface of the disposal cell. A filter layer will also be used under the riprap along the toe of the north side slope. The rock layer thickness will be kept at twice the D50 or near the D100 size requirements.

5. The proposed toe protection on the south side slope for a scour depth of 1 foot is too low, as cited in Figure 4 in the calculation set for Erosion Protection of Disposal Cell Cover. The total thickness of the rock was acceptable, but the thickness of rock for protection of the south slope apron should be re-evaluated according to NUREG-1623, page D-19.

Response:
The apron protection on the south slope was recalculated to be 2.5 ft deep, and this was incorporated in the calculation set for Erosional Protection of Disposal Cell Cover (RAP Attachment 1, Appendix H).

6. The issue was discussed on how to handle sedimentation in the north drainage channel from small precipitation events while maintaining a full channel to accommodate the Probable Maximum Precipitation. Suggestion was made that DOE consider eliminating the north drainage channel and just use toe protection buried below grade as is proposed for the south side slope.

Response:
Diversion of upland runoff around the north side of the disposal cell involves conveying runoff to the west of the cell without eroding materials at the toe of the north slope of the cell. Diversion also involves accommodation of sediment from upland runoff that may settle out due to the decrease in gradient from 2 percent (in upland areas) to 0.5 percent (along the toe of the north slope). These factors are included in the current design along the north slope of the disposal cell. Erosion protection along the north slope of the disposal cell will consist of (1) a rock mulch on the slope above the anticipated level of flow along the toe of slope, (2) riprap on the slope within the anticipated level of flow along the toe of slope, (3) riprap on an apron extending from the toe of slope and (4) buried riprap in a trench beneath the apron, extending below the estimated depth of scour. A channel will be constructed along the toe of the north slope to facilitate placement of erosion protection materials; the channel will drain to the west-southwest at a 0.5 percent slope, and it is anticipated that it will fill with sediment from upland runoff. The above design changes were incorporated in the revised calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

7. The NRC agrees with construction of a cut-off wall at the end of the north drainage channel. Instead of using a gabion basket for this wall, use of a rock-filled trench is proposed. This is because the basket wire will deteriorate during the 1,000 year life of the cell.

Response:
A rock-filled trench will be used without the gabion baskets. This design change was incorporated in the revised calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

8. The proposed radon barrier is highly conservative and DOE can re-evaluate in the interest of reducing layer thicknesses. Major factors influencing radon barrier thickness are the Ra-226 concentration of tailings and, to a lesser degree, the moisture content of the barrier.

Response:
The Ra-226 values have been revised in the calculation set for Average Radium-226 Concentration for the Moab Tailings Pile (RAP Attachment 1, Appendix K) to reflect the average of known concentrations. Previous Ra-226 values (one standard deviation above the mean) were 868 to 954 pCi/g. The updated mean Ra-226 value for the Moab pile is 707 pCi/g.

9. NRC contends that placement of contaminated railroad ties in the disposal cell will not pose a problem because they are creosote treated and will be exposed to very little moisture over the long term.

Response:
None required.

Vicinity Properties

10. DOE will continue to do gamma screening surveys on the 1971 EPA list as time/budget allows. If vicinity property remediation is done where contamination was left in place above 40 CFR 192 standards (Supplemental Standards), NRC will review/approve the completion report and application for Supplemental Standards. If no Supplemental Standards are applied, NRC will not review/approve the completion report.

Response:
None required.

General

11. NRC believes that later in the UMTRA Project, draft and final RAPs were merged into one document. NRC explained that ultimately the RAP needs to contain construction specifications and drawings (e.g. the documents that would be bid upon for the remediation work). DOE explained that because of contractual matters regarding conceptual versus final design, there will likely be a distinction in the draft versus final (degree of completeness).

Response:

The draft RAP will not contain detailed plans or specifications. The draft RAP does include an outline of technical specifications for construction and reclamation of the disposal cell to provide input on how the disposal cell will be constructed and how construction quality assurance testing will be conducted. DOE's current contractor does not have the contractual scope to complete these documents. To facilitate review and approval of the final RAP, DOE is still seeking NRC's review of the draft to ensure that the Crescent Junction Site and proposed design features meet applicable NRC guidance and the standards set forth in title 40 of the *Code of Federal Regulations* (40 CFR 192. U.S. Environmental Protection Agency (EPA), "Promulgated Standards for Remedial Actions at Inactive Uranium Processing Sites"). Based on the draft RAP and NRC comments, DOE's new contractor in 2007 can complete the detailed plans and specifications and submit a final RAP.

2007 Request for Additional Information

Geology and Seismology

G1. Geomorphology: Provide additional evidence that the discontinuous east-striking line of low, north-dipping, cuesta-like mounds just north of the disposal cell footprint near the top of the Prairie Canyon Member of the Mancos Shale are formed by resistant dolomitic siltstone concretions.

RASR, page 2-7, section 2.3.3. The text indicates "geomorphic features include......(4) a discontinuous east-striking line of low, north-dipping, cuesta-like mounds formed by resistant dolomitic siltstone concretions near the top of the Prairie Canyon Member of the Mancos Shale just north of the disposal cell footprint." This linear feature also shows up on most aerial photographs of the site and was visited during the site visit in December 2006. These cuesta-like mounds may have been formed by resistant dolomitic siltstone concretions, but additional evidence should be provided that this is the case and is not a structurally-controlled feature, possibly a fault. Are there analogous mounds in other locations away from the site where the top of the Prairie Canyon Member of the Mancos Shale outcrops producing similar cuesta-like features or is there other evidence to support the mounds have been formed due to resistant dolomitic siltstone concretions?

Response:
See response for 1(a) and 1(b) in the NRC Comments and DOE Responses for the April 2006 Meeting.

G2. Geomorphology: Evaluate headcutting rates for West Branch Kendall Wash and evaluate the possibility of stream capture of Crescent Wash by West Branch Kendall Wash.

RASR, page 2-7, section 2.3.3. The text indicates "geomorphic features include......(6) incised channels of the West and East Branches of Kendall Wash and the slow northward advance of headward incision of the West Branch of Kendall Wash." West Branch Kendall Wash is experiencing headcutting. This head cutting is progressing toward Crescent Wash. Text in section 2.4.1 indicates this headward advance will have to be monitored. Additionally, in the RASR Appendix A, DOE has committed to obtaining aerial photographs from 1944 to try to determine headcutting rates. Stream capture was verified on the abandoned wash shown as number 5 on the high-altitude vertical photographs, and this possibility should be explored for West Branch Kendall Wash.

Response:
See response for 5(c) in the NRC Comments and DOE Responses for the April 2006 Meeting.

G3. Geomorphology: Determine why constant roadway maintenance is required for Route 70 in the vicinity of the site and determine if similar problems could occur with the disposal cell.

RASR, page 2-7, section 2.3.4. The text describes "constant roadway maintenance required for Interstate Highway 70, which traverses Mancos Shale just south of the site." The text indicates that "analyses of the Mancos Shale and Mancos Shale-derived soils did not show the presence of swelling clay or highly plastic materials at the Crescent Junction Disposal Site." It appears DOE has assumed that road failures are due to montmorillonite clays and since montmorillonite clays are not present at the cell site the hazard does not exist. Has DOE considered that road failure is due to something other than montmorillonite swelling clay that may also be present at the Crescent Junction cell site? lnterstate 70 and the cell will be located on the same geologic material and the maintenance problems encountered on 1-70 should be investigated fully to determine if they could occur on or within the cell.

Response:
Expanded discussion of the well-known problem of swelling clay because of the presence of montmorillonite in Mancos Shale is included in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). Rigid concrete pavement and concrete slab structures pose a problem if built on swelling Mancos Shale. If no such structures are constructed at the disposal cell, then the swelling clay should not pose a hazard. The text of the RAS Report was changed to restate the results of analyses of Mancos Shale and Mancos Shale-derived soils.

G4. Geomorphology: Clarify the depth of the disposal cell and on what material the cell will be constructed.

RASR, page 4-3, section 4.1.2. Text in this section indicates "the disposal cell excavation is anticipated to be into the Quaternary materials, as well as into upper portions of the weathered and fractured Mancos Shale." On page 7-1, section 7.0, the text indicates the anticipated depth of excavation is 15 to 20 feet (ft). Figure 7-2 shows the excavation limits as approximately 10 ft below bedrock. Figure 7-3 shows the cell directly on the weathered Mancos Shale contact. It is unclear how far the cell will be placed into the Quaternary alluvial material and/or the weathered and fractured shale. Will the top several feet of weathered shale be removed or will the cell be placed directly on the first contact of the weathered Mancos Shale? The depth of the cell and what material the cell will be placed on should be clearly stated and consistent throughout the Report.

Response:
The base of the disposal cell will grade to the south at approximately a 2 percent slope, roughly following existing grades. Typical sections that cut north-south and east-west through the disposal cell, as well as the section locations, are shown on the revised figures in Section 7 of the RAS. The depth of excavation across the site varies in limited areas from as shallow as approximately 12 ft to as deep as approximately 21 ft. On an average basis, the depth of excavation is approximately 16 ft.

Also shown on the figures is the approximate contact between the Quaternary alluvial soils and weathered Mancos Shale, as estimated from borehole and corehole data. On average, the excavation will be approximately 11 ft in Quaternary alluvial soils, and approximately 5 ft in weathered Mancos Shale. There is a small area in which the Mancos Shale is estimated to be slightly below the excavation depth. In this area, a small remnant of the Quaternary alluvial soils will be left in place. This area is internal to the disposal cell.

Therefore, the remnant of alluvial soils will not act as a pathway for seepage migration out of the disposal cell. In the area of the dikes, a minimum of 5 ft of excavation into the weathered Mancos Shale will be required in order to prevent a lateral pathway for flow out of the disposal cell.

A revised Figure 7–2, a new Figure 7–3, and a revised Figure 7–4 have been inserted into Section 7.0 of the RAS.

G5. Geomorphology: Discuss slump features identified near the site. Indicate why slumping will or will not have an impact on the site during the compliance period.

Attachment 2, Appendix G, High-Altitude Vertical Photographs (6), page 3. There is mention of a slump block or mass-wasting feature on the north side on the Book Cliffs in Horse Haven and at several other locations. The text indicates the slides were likely initiated in wetter times during the Pleistocene. What is the basis for this conclusion that the slides likely occurred in wetter times during the Pleistocene? Wetter Pleistocene could have been the condition at the site only about 12,000 years ago and may be relevant to the next 1,000 years projection. Are there analogous site(s) along Book Cliffs that have known high or higher (and/or low or lower) rates of slumping hazards similar to those at Crescent Junction?

Response:
In most of arid to semi-arid Utah, it has been recognized that most landslides are presently inactive, or they become active only during periods of extremely high amounts of precipitation. Times of glaciation during the Pleistocene were during a climate of much lower temperatures and much larger amounts of precipitation than at present and were favorable for the formation of landslides (Shroder 1971). The landslides north of the site in the Book Cliffs were likely active during the most recent glacial episode in the late Pleistocene, and they may have formed then or during earlier glacial episodes in the Pleistocene. This reference on landslides in Utah by Shroder (1971) and additional discussion are included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

G6. Geomorphology: Explain the origin and age of the pediment-mantling deposits and surfaces located near the site.

Attachment 2, Appendix B, page 7, Section 2.5, discusses the "pediment-mantling deposits" reported by the applicant. Has DOE considered that these deposits might be indicative of former, uplifted pediments? If they are tectonic- geomorphic features, what clues do they provide to rates of erosion, episodes of differential uplift, possibly faulting? If the surfaces are tectonic-geomorphic in nature, is the age of the surfaces known, or is it possible to determine the approximate age, and if tectonic activity produced the surfaces, is this significant to the design of the disposal cell?

Response:
The origin of the pediment-mantling deposits is discussed in the revised calculation set for Site and Regional Geomorphology – Results of Literature Research (RAP Attachment 2, Appendix C). Intact pediments mantled by alluvial material are west of the withdrawal area

and represent alluvial deposits from the ancestral Crescent Wash. No evidence for fault displacement has been seen around the pediments to indicate they have been uplifted. The location and characteristics of the mantled pediment surfaces are consistent with their origin as alluvial deposits from ancestral drainages from the Book Cliffs that were preserved as pediment mantles after stream capture by drainages in Mancos Shale. It is possible that a new mantled pediment surface could start to form after an estimated 1,600 years after capture of Crescent Wash by incisional headcutting of the West Branch of Kendall Wash, as described in the revised calculation set for Site and Regional Geomorphology – Results of Site Investigations (RAP Attachment 2, Appendix D). This erosional process, if it occurred, is far enough away to the west to not affect the disposal cell.

G7. Mining, Oil & Gas: Discuss current or past mining, mineral, and oil and gas claims for the site or within a radius near the site that have similar geologic characteristics.

RASR, page 3-4, section 3.4. The statement is made that "Pockets of natural gas were encountered during the drilling conducted as part of this project. Commercial exploration for oil and gas has been, and continues to be, common in the Crescent Flat area." Also, many boreholes are noted on the USGS quadrangle as well as mining pits. Is there a possibility that this site could cause a conflict with future mining claims?

Response:
An expanded discussion of oil and gas resources and exploration in the site area is in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). In that calculation set, it is stated that the withdrawal area is leased for oil and gas, and that surface exploration would not be prohibited from the area, except for the disposal cell (approximately 250 acres). Directional drilling would allow the area under the disposal cell to be explored. No active mining claims are in the withdrawal area, and the establishment of the withdrawal area precluded new mining claim locations. After the disposal cell is constructed, most of the withdrawal area will be released, and mining claim locations will be allowed. As noted in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G), the pits southeast of the withdrawal area along old U.S. Highway 50, initially thought to have been made for gold exploration, were actually made for exploration for road metal for highway construction.

G8. Mining, Oil & Gas: Discuss past mining, mineral, and oil and gas activities that may have occurred at the site.

Attachment 2, Appendix A, Resource Development, page. 5, para 1. This section refers to a petroleum accumulation 3 mi SSW, without extrapolating the potential significance. However, there is an oil accumulation about 3 mi WNW of the site that is not mentioned. It is not known if this play is in the Mancos or deeper (reference is a booklet on Grand County geology by Utah Geol Survey dated 1987). The statement is made, "Data concerning the targeted gas horizons and the actual results of this exploration are not currently available. When will additional data be obtained on oil and gas targets in the site vicinity and on pressurized gas pockets? This may bear on potential future disruptive activities that may be safety related.

Has DOE checked for past drilling activities at the proposed site? Old drill sites and improperly abandoned drill-holes may provide a pathway for water and transient drainage from the cell to impact groundwater. Geophysical survey logs, borehole logs, geological descriptions and cross sections may be available for the site area. Also, driller's reports of subsurface conditions such as groundwater, brines, pressurized gas, deformable holes and other information may be available.

Response:
Discussion of oil and gas resources for the withdrawal area and nearby surrounding area was expanded in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). Included in the revision is information on oil and gas wells and fields from the Oil and Gas Fields Map of Utah (Chidsey et al. 2004), the Utah Division of Oil, Gas and Mining oil and gas information website, the Mineral Potential Report for the BLM Moab Planning Area (Tabet 2005), and the Mineral Report by the BLM on the DOE Proposed Disposal Site (Bain 2005).

G9. Seismology: Describe the association of the earthquakes that are located close to the Little Grand Fault No. 9 and the proposed site. Examine the possibility that the two earthquakes in the vicinity of the Little Grand Fault may have resulted from movement on this fault.

Attachment 2, Appendix F, Figure 7, page 13. There are earthquakes located very close to Fault No. 9. Does Fault No. 9 have a bearing as to the design earthquake for the site? Earthquake locations are not known accurately due to lack of instrumentations in the vicinity of the site. Provide good evidence that the Little Grand Fault is not capable.

Response:
The two events in question are a July 30, 1953, event with an estimated intensity of 5, and a March 31, 1954, event with an estimated intensity of 4. Both events are cataloged as non-instrumental events in the Catalog of Earthquakes Occurring in the Eastern, Central, and Mountain States of the United States, 1534-1986 [SRA (Stover, C.W., G. Reagor, and S.T. Algermissen, 1984, United States earthquake data file: U.S. Geological Survey Open-File Report 84-225.)].

Epicenter accuracy for both events is estimated to be within 0.5 to 1 degree, or approximately 30 to 60 mi (SRA). The source for the catalog comes from the University of Utah Seismograph Station (Arabasz et. al, 1979). In this earthquake listing, non-instrumental epicenters are assigned coordinates corresponding to the location of the town or city where the felt effects were strongest. In this case, the coordinates were assigned to the location of the town of Green River. Therefore, the earthquake location is fairly uncertain, and in actuality could have occurred at any location within 30 to 60 mi of Green River. Due to the low magnitude of the events (estimated by converting intensity to Richter magnitude) of 4.3 and 3.7, respectively, it is unlikely that either of these events would result in a surface rupture. Therefore, it is unlikely that the true location of these events could be better estimated by field evidence.

The capability of the Little Grand Fault (earlier referred to as the Little Grand Wash Fault) was evaluated during the seismotectonic study performed for the Green River Site, as discussed in the calculation set for Site and Regional Seismicity – Results of Literature

Research (RAP Attachment 2, Appendix E, page 14). Based on the lack of offset in the alluvial, colluvial, and talus materials overlying the fault, it was concluded during that study that the fault is not capable. Later mapping of the fault (Chitwood, J.P., 1994.

Provisional Geologic Map of the Hatch Mesa Quadrangle, Grand County, Utah, Utah Geological Survey, Map 152, scale 1:24,000), (Doelling, H.H., 2001. *Geologic Map of the Moab and Eastern Part of the San Rafael Desert 30' × 60' Quadrangles, Grand and Emery Counties, Utah, and Mesa County, Colorado,* Utah Geological Survey Map 180, scale 1:100,000) also did not observe any offset of Quaternary deposits.

Further capability of the Little Grand Fault was also evaluated in April 2007 to specifically examine the eastern portion of this fault that is closest to the site. South of the Green River, Utah, Site, displacement on the Little Grand Fault is more than 500 ft. Displacement on this easterly-striking normal fault (down to the south) decreases eastward. The fault was checked for evidence of Quaternary movement for approximately 6.5 miles along its eastern part (using mapping mainly by Doelling [2001] and Chitwood [1994]), starting where the fault passes under old U.S. Highway 50 in the SE¼ Section 27, T.21S., R.17E. The fault becomes less distinct eastward through Green River Gap (where displacement is only a few tens of feet) and to the easternmost place where it is recognized by Chitwood (1994) along the left fork (or west branch) of Floy Wash in the SE¼ Section 22, T.21S., R.18E. In places along the fault where it is overlain by Quaternary pediment-mantling material or terrace gravels, no displacement of these units was seen. Based on this traverse of the eastern part of the Little Grand Fault, it is concluded from the lack of Quaternary displacement that the fault is not capable.

The information above has been included in revised calculation sets for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F) and for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E).

G10. Seismology: Explain why some faults that show no evidence of Quaternary faulting are considered capable while others are not.

Attachment 2, Appendix F, Table 3, page 16. Table 3 indicates that Fault No. 7 shows no evidence of Quaternary faulting, but it is considered as a potential design fault. Meanwhile, Faults 4, 5, and 6 also do not show Quaternary faulting but they are not potential design faults. Please provide appropriate rationale to explain this discrepancy.

Response:
Discussion as to the capability of these faults based on literature review is discussed in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, p.14). In this discussion, it is explained that unnamed faults 1, 2, and 3 are all of similar strike and appear to be features related to salt subsidence related to the Thompson Anticline. Faults 1 and 2 were investigated in 2005 and showed no sign of Quaternary movement. By association, fault 3 is assumed to also be related to subsidence of the Thompson Anticline. It was concluded that there is sufficient evidence to suggest faults 1, 2, and 3 are not active, and therefore not potential design faults. Unnamed faults 4, 5, and 6 appear to be splays of the Salt Valley Anticline. As discussed on page 9

of the calculation set, there is sufficient evidence to suggest these faults are related to dissolution and collapse of the Salt Valley Anticline, are not active, and therefore are not potential design faults.

Fault 7 is unique from the other unnamed faults in that it does not appear to be related to salt subsidence. The likely age of disturbance is between Late Cretaceous and early Eocene and there is no known Quaternary displacement on this fault. However, the age of faulting has not been substantially documented in literature, nor has it been field verified.

Therefore, it has been conservatively assumed that this fault, due to lack of thorough investigation, will be considered a potential design fault. This consideration has negligible impact on the seismotectonic characterization of the site, as the peak horizontal acceleration (PHA) estimated for fault 7 of 0.13g is below the recommended design PHA of 0.22g.

G11. Geology: Discuss additional field work that has taken place to confirm or deny the existence of faults.

Attachment 2, Appendix A, Structural Setting, page 5, para. 2. The statement is made, "Surface field work and an additional search for well data in the area will be undertaken to confirm or deny the existence of the fault." Clearly indicate what additional field work has taken place and document the findings.

Response:
No surface evidence of a northeast-striking fault was found in the southwest corner of the withdrawal area during field work in April 2006. The existence of a fault in that area had been inferred from differences in depths to the base of the Mancos Shale found in two nearby oil test wells drilled in the 1920s. The surface location of only one of the old test wells has been found. Results of the search for this fault and any other faults in the withdrawal area are in the revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (RAP Attachment 2, Appendix B).

G12. Geology: Explain the origin of the fault associated with the axis of the Thompson

Anticline and why this fault shows up to 90 ft of displacement in some locations but no apparent displacement of the Mancos.

Attachment 2, Appendix G, low sun-angle photographs (e.), page 4. Potential fault. The graben strikes N20W and is located 2 miles from withdrawal area, at Thompson Anticline. One fault shows displacement of up to 90 ft. No displacement of these faults is discerned at contact with Mancos. There is no additional evidence to support that no displacement has occurred at the contact with the Mancos. Clearly identify this fault on the seismic map and explain why there is no apparent displacement in underlying Mancos. How small a displacement could have been detected given the methods used?

Response:
The origin of the faults along the axis of the Thompson Anticline is discussed in the revised calculation set for Site and Regional Geology – Results of Literature Research

(RAP Attachment 2, Appendix A) and the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E). An investigation of faults in the area was conducted in November 2005. Displacement of the resistant sandstone beds of the Blackhawk Formation and Castlegate Sandstone that cap the Book Cliffs is well exposed along the faults, but displacement (even though it apparently occurs) in the underlying soft and mostly talus-covered Mancos Shale is not exposed. This observation is in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

G13. Geology: Discuss the two pediment remnants near the site identified by DOE that are vertically offset.

Attachment 2, Appendix G, Low sun-angle photographs (g), page 5. A potential fault has been identified by DOE. Two pediment remnants are vertically offset about 45 ± 5 ft, center of Sec 33. It is uncertain whether the surfaces are two different pediment surfaces or is the same surface that is faulted. If it's a fault, it appears to be young and is close to the site and could be a capable fault. This potential fault warrants further assessment.

Response:
See Response for 8, in relation to area "g", in the NRC Comments and DOE Responses for the April 2006 Meeting.

G14. Geology: Investigate the linear feature striking N 70 E that appears on the Plate 1 aerial photograph extending from Horse Heaven to the northeast and through Crescent Wash to the southwest.

This linear feature is not noted by DOE in the RASR. However, it was noted and discussed by NRC staff during the site visit in December 2006. Additional field investigation should be considered to determine if there is any evidence that this feature is a fault, and if so, if it is capable.

Response:
Characteristics of the N70E-trending linear feature were investigated in March 2007 and are discussed in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G). No evidence for faulting was seen along the length of the feature from Crescent Wash to the south part of Horse Heaven. A prominent joint system in the Blackhawk Formation strikes approximately the same direction as the trend of the linear feature, and several parallel rotational slump blocks in the south part of Horse Heaven trend in a similar direction. It was concluded that the linear feature is an expression of the prominent joint system, which is important for landslide erosion on the north side of the Book Cliffs, but will not affect the disposal site area.

G15. Seismology: Provide the basis for choosing the parameter values, in Attachment 1,

Appendix D, Liquefaction Analysis, for water content, type of sand (clean/silty), and relative density, and provide their uncertainties. Provide the necessary justification for using Fig. 11.8 mentioned in the calculations, although the design earthquake for the site is less than that mentioned in the figure.

Justification for the parameter values was not provided. Changes in these parameters may change the condition of the layer from being non-liquefiable to being liquefiable.

Response:
The calculation for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) has been updated to reflect tailings test results. The key tailings parameters used in the liquefaction analyses were compacted unit weight and fines percentage (derived from the tailings testing). The unit weight representing compaction to 90 percent of Standard Proctor density (50 percent relative density) was used, and fines percentages representing the minimum and mean measured values were used.

The calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) was revised, and changes were made to text in RAS Section 4.2.2.

Geotechnical Stability

GT1. Characterization of Site Stratigraphy and Tailings: DOE and Golder Associates have indicated several data quality issues with test data from the laboratory used for geotechnical testing. As examples, there are questions on permeability test inconsistencies (Attachment 5, Appendix K), and there are several open comments on data quality from a Golder letter dated March 23, 2006 (Attachment 5, Appendix J). Provide a list of all unresolved issues with the test data quality and discuss the status of resolution of each of the issues.

Response:
All issues pertaining to test data quality have been resolved in revised calculation sets that were completed for the draft final RAP.

With regard to the calculation set for Supplemental Geotechnical Properties of Native Materials (RAP Attachment 5, Appendix K): Data quality checks of the original laboratory data revealed that retests would be needed for the triaxial compressive strength and hydraulic conductivity analyses of sample number 154 at 20 ft. Laboratory results of this retest are presented in Appendix C of this revised calculation.

In addition, data quality checks also indicated that retests of hydraulic conductivity would be required for sample numbers 152 at 23 ft, 154 at 12 ft, and 156 at 12 ft. Laboratory results of these retests are contained in Appendix D of this revised calculation. With the completion of the triaxial and hydraulic conductivity retests, which are documented in Appendixes C and D of this revised calculation, all data quality deficiencies associated with the original calculation were resolved.

With regard to the calculation set for Geotechnical Laboratory Testing Results for the Moab Processing Site (RAP Attachment 5, Appendix J): On August 16, 2006, the laboratory responded to the comments in Golder Associates' March 23, 2006, letter. In conjunction with their response, the laboratory issued page changes to the May 3, 2006, *Certificate of Analysis*. These page changes were inserted into both the electronic version of the May 3, 2006, data set and the paper copies of that data set.

During QA verification of the final data set, S.M. Stoller discovered one remaining error in the May 3, 2006, *Certificate of Analysis*. In a letter dated February 21, 2007, the laboratory responded and sent one additional page change to the May 3, 2006, data set. With the inserted page changes, the data contained in the May 3, 2006, *Certificate of Analysis* is now deemed to be complete and validated. No additional action is required. Appendix C contains, in chronologic order, each of the letters that were generated during the data review process. Page changes issued by the laboratory are included in the May 3, 2006, *Certificate of Analysis*, which is contained in Appendix B of this calculation.

GT2. Characterization of Site Stratigraphy and Tailings: In Section 4.1.2 of the Remedial Action Selection Report, DOE indicates that all of the materials that will be used in construction of the disposal cell cover will be obtained from the cell excavation. Based on the boreholes and test pits conducted at the disposal site, provide representative cross sections of the Quaternary materials and weathered Mancos Shale. Using these cross sections, provide estimates of the volumes of materials available from the excavation and a demonstration that the volumes will be adequate to construct both Alternative covers being considered without the need for additional borrow areas.

Response:
Section locations and cross sections are provided in Section 7 of the RAS as part of the response to Comment G4. The disposal cell layout has been based on a capacity for 12 million cubic yards (yd^3) of residual radioactive material (RRM). The objective of the excavation and cell construction was to achieve a balanced cut-and-fill, subject to the constraint that the height of the tailings above adjacent ground would be minimized while the base of the disposal cell would be cited beneath the top of the weathered Mancos Shale. All of the excavated material is intended to be used for cell-construction. Excess excavated material (if produced) will be placed on the top of the disposal cell as additional cover material or on the side slopes as additional embankment material.

The cell will be excavated into weathered Mancos Shale, with an anticipated average depth of excavation of 16 ft. This excavation will provide approximately 3.4 million yd^3 of Quaternary alluvial and colluvial soils and approximately 1.7 million yd^3 of weathered Mancos Shale. This excavated material will be used to construct the perimeter embankment and cover for the disposal cell. For this cell layout, the required embankment volume is approximately 1.2 million yd^3. The required volume for the UMTRA Project cover is approximately 2.9 million yd^3, and the required volume for the Alternative cover is approximately 3.6 million yd^3. Assuming an average of 13 to 15 percent shrinkage for the two cover systems, the excavation produces approximately the quantity required for cover and dike construction.

The following three tables summarize the estimated amounts of material to be excavated within the footprint of the disposal cell, along with approximate material requirements for the two proposed cover alternatives.

Table 1. Materials Excavated from Within Disposal Cell Footprint

Material	Volume (million yd^3)

Quaternary alluvium	3.42
Weathered Mancos Shale	1.69
Total cut material	5.11

Table 2. Materials Required for Disposal Cell Construction (UMTRA Project Cover)

Material	Volume (million yd^3)
Berm (Quaternary alluvium and weathered Mancos Shale)	1.24
3.9 ft of Radon Barrier (weathered Mancos Shale)	1.29
3.0 ft of Frost Protection (Quaternary alluvium and weathered Mancos Shale)	0.99
1.0 ft of Interim Cover (Quaternary alluvium and weathered Mancos Shale)	0.33
Net Excess cut (Quaternary alluvium and weathered Mancos Shale)	1.26
Net Excess cut (Quaternary alluvium and weathered Mancos Shale) accounting for 15 percent shrinkage with compaction	0.49

Note: Rock-Mulch Barrier and Infiltration and Barrier account for 0.17 million yd^3 each and are derived from off-site borrow sources.

Table 3. Materials Required for Disposal Cell Construction (Alternative Cover)

Material	Volume (million yd^3)
Berm (Quaternary alluvium and weathered Mancos Shale)	1.24
8.8 ft of Monolithic Cover (Quaternary alluvium and weathered Mancos Shale)	2.91
1.0 ft of Interim Cover (Quaternary alluvium and weathered Mancos Shale)	0.33
Net Excess cut (Quaternary alluvium and weathered Mancos Shale)	0.61
Net Excess cut (Quaternary alluvium and weathered Mancos Shale) accounting for 8 percent shrinkage with compaction	0.25

Note: Rock-Mulch Barrier and Infiltration and Barrier account for 0.17 million yd3 each and are derived from off-site borrow sources.

GT3. Characterization of Site Stratigraphy and Tailings: In Section 2.5 of the Remedial Action Selection Report, DOE indicates that the presence of swelling clays in the Mancos Shale is a potential geologic hazard. Provide discussion of the samples tested and the corresponding test results that demonstrate that swelling clays will not be a problem at the Crescent Junction Disposal Cell.

Response:
Swelling clays are a component of the Mancos Shale in the western U.S., and are a geologic hazard in terms of volume change from variations in water content. This is not a factor at the base of the disposal cell (where variations in water content are not expected). In the disposal cell cover, variations in water content should be accommodated within the frost-protection zone of the cover.

In general, a plasticity index greater than 15 can be an indication of highly swelling clays (International Building Code, 2003. Section 1802.3.2, International Code Council, Country Club Hills, Illinois). The average plasticity index of the weathered Mancos Shale is 11 (Geotechnical Properties of Native Materials, RAP Attachment 5, Appendix E). Therefore, the weathered Mancos Shale is likely to be slightly to moderately expansive in the area of the disposal cell, which can be accommodated in the design of disposal cell.

GT4. Slope Stability: In general, the various analyses make it unclear what exactly the cover and clean-fill dike are composed of. The slope stability analyses were performed using only the Alternative Cover. In the Remedial Action Selection Report (Figure 5.1), DOE indicates that the cover is composed of a mixture of "slopewash, eolian soils, and weathered Mancos Shale." The slope stability analysis considers the cover (radon barrier) to be composed of only "sheet wash and eolian soils" (Attachment 1, Appendix C, Table 1). There is a similar discrepancy for the clean-fill dike. Table 1 of the slope stability analysis shows the clean-fill dike material to be recompacted "weathered Mancos Shale," while Attachment 1, Appendix C, page 7, describes the clean-fill dike as "recompacted weathered Mancos Shale, alluvial, and eolian soils." Provide clarification of these discrepancies and discussion of any resulting impact on the slope stability analyses.

Response:
The perimeter embankment (clean-fill dike) and cover will be constructed from the material excavated from within the footprint of the disposal cell, consisting of Quaternary alluvial, colluvial, and eolian soils and weathered Mancos Shale. The only segregation of these materials will be for construction of the radon barrier, where weathered Mancos Shale will be used. The rest of the structures will be constructed with a mixture of these excavated materials. This composition of materials is represented in the revised calculation for Slope Stability of Crescent Junction Disposal Cell (RAP Attachment 1, Appendix C).

GT5. Settlement: Include additional information as part of the settlement analysis presented in

Attachment 1, Appendix D. Provide a tabulation of the material layers considered in the analysis, references to the tests performed (or other basis) to determine each layer's settlement analysis parameters, and the resulting engineering parameters. Also provide a description or figure indicating the locations chosen for settlement analysis to demonstrate that the worst, average, and best settlement conditions have been selected and the largest differential settlement conditions have been analyzed.

Response:
The calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) has been updated to incorporate tailings-consolidation test results. Settlement analysis calculations were conducted for the largest anticipated tailings thickness (38 ft) and the largest anticipated thickness of cover and interim cover (13 ft). Settlement was analyzed at approximately the 1/3 and 2/3 depths within the tailings profile, and added to provide estimated total settlement of 1 ft or less (for primary settlement).

For differential settlement, the location within the disposal cell anticipated to have the highest potential for differential settlement is along the perimeter of the inside of the disposal cell, where the tailings thickness varies from 38 ft to zero over a distance of 76 ft. Other areas of tailings within the disposal cell would not the have the tailings thickness variation as along the cell perimeter, and would be spread in lifts and compacted.

GT6. Settlement: In Section 4.2.2 of the Remedial Action Selection Report, DOE indicates that settlement will be low due to the methods of mixing, placement, and compaction of the tailings in relocating the contaminated material to the Crescent Junction Disposal Cell. Provide additional description of the procedures for bringing the excavated wet tailings to optimum moisture at placement and compaction.

Response:
Initially upon excavation from the Moab tailings pile, the moisture content of the slime tailings is likely to exceed optimum conditions for compaction. Excavated slime tailings will therefore be mixed at the Moab site with the drier sand tailings. Mechanical mixing will yield an average water content that is appropriate for the transportation technique selected by the remedial action contractor. The transported tailings will be placed in the disposal cell and processed by the following procedure: (1) dumping from trucks along a working face or specific area, (2) spreading in lifts with a dozer, and (3) compacting the spread lift of tailings with a compactor. Water will be added as necessary (by spraying) for dust suppression. From this process, the tailings should be near optimum water-content conditions during compaction in the cell.

GT7. Settlement: Provide a discussion of whether or not there are plans for monitoring settlement during and following construction of the disposal cell. If there are plans, provide details of the monitoring plan; if there are no plans, provide the basis for not monitoring.

Response:
Because the tailings will be placed, spread, and compacted in the disposal cell in lifts, with significant time between tailings placement and cover construction, significant tailings settlement is not anticipated. Monitoring of settlement of the cover surface is planned for confirmation of cell performance, by monitoring of settlement plates or survey monuments.

GT8. Cover Design: In Section 5.0 and Figure 5-1, DOE discusses and portrays two different cover alternatives, but does not indicate which is planned or preferred. Provide a discussion on the factors that will determine which of the two covers will be used.

Response:
Both cover alternatives will meet the appropriate performance standards in 10CFR192 and NRC guidance. Selection of the cover alternative will be based on permitting and construction costs.

GT9. Cover Design: In its settlement analysis (Attachment 1, Appendix D), DOE analyzes settlement and cracking for only the UMTRCA cover. In its slope stability analysis (Attachment 1, Appendix C), DOE only analyzes the stability with the Alternative cover. Provide a discussion of why different covers are used from analysis to analysis and how the analyses presented conservatively band both covers being considered.

Response:
The UMTRCA cover was analyzed for settlement and cracking because of the compacted clay radon barrier in the cover system. Settlement and cracking of the Alternative cover is not as critical for cover system performance due to the increased thickness of the total cover and the lower level of compaction effort during construction. The Alternative cover was used in the slope stability analysis because it represents the thickest cover configuration and, therefore, the highest slope heights. However, the UMTRCA cover has been conservatively analyzed by changing the properties of the cover to represent the compacted clay properties of the weathered Mancos Shale. The actual UMTRCA cover consists of several layers, but the compacted clay represents the weakest of those layers. The calculation set for Slope Stability of the Crescent Junction Disposal Cell (RAP Attachment 1, Appendix C) has been updated to include these analyses. The computed factors of safety are similar to the Alternative cover analysis. Critical failure surfaces pass predominately through the perimeter embankment. Therefore, the stability of the disposal cell is relatively insensitive to cover-material thickness, and to the shear strength of the cover material and compacted tailings.

GT10. Cover Design: In Section 4.1.2 of the Remedial Action Selection Report, regarding the potential for "bathtubbing", DOE indicates that the excavation will be into the weathered Mancos Shale, which has hydraulic conductivities of from 10^{-4} to 10^{-3} cm/sec. Elsewhere, DOE estimates the hydraulic conductivity of the cover to be 7×10^{-5} cm/sec. Discuss the basis for concluding that both of the covers being considered have conductivities as low as $7x10^{-5}$ cm/sec. In addition, discuss the potential for the cell excavation to extend to a depth that removes most of the weathered Mancos Shale, and thus result in a base conductivity much less than the assumed 10^{-4} cm/sec.

Response:
Excavation for the disposal cell is anticipated to average approximately 16 ft, which results in the removal of alluvial/colluvial materials and notching the base of the disposal cell below the surface of the weathered Mancos Shale. The weathered Mancos Shale transitions into unweathered Mancos Shale, with minimal fracturing, at depths of 60 to 80 ft below the original ground surface. Because the base of the disposal cell will be in the uppermost weathered Mancos Shale, the thickness of the weathered Mancos Shale beneath the disposal cell will be approximately 40 to 60 ft.

The key parameter for the evaluation of bathtubbing is not the hydraulic conductivity of the cover, but the net rate of infiltration through the cover. The net infiltration is dictated by the hydraulic conductivity of the cover materials as well as the thickness and water-holding capacity of cover materials to retain moisture for evapotranspiration. After the onset of steady-state drainage conditions, the net infiltration rate for both Alternative and UMTRA covers is conservatively estimated to be on the order of 1×10^{-7} cm/sec (or 0.1 ft/year).

The potential for bathtubbing as well as the potential for tailings leachate to migrate laterally and enter nearby gullies and washes is evaluated below. The key stratigraphic zones are summarized in the following table.

Zone	Approximate Thickness (ft)	Hydraulic Conductivity or Flux Rate	
		(cm/sec)	(ft/yr)
Cover	9-11	$1.0\text{x}10^{-7}$	0.1
RRM	35-45	$3.0\text{x}10^{-5}$	30
Weathered Mancos Shale	40-60	$2.1\text{x}10^{-3}$	2100
Unweathered Mancos Shale	2,400	$3.6\text{x}10^{-8}$	0.036

Because the influx of meteoric water is controlled by the design flux through the cover, meteoric water could migrate downward at an average rate of 0.1 ft/year (RAP Attachment 3, Appendix G). Steady-state infiltration through the cover would occur as unsaturated flow and gradually penetrate down to the top of the unweathered Mancos Shale. Inasmuch as the hydraulic conductivities of the RRM and the unweathered Mancos Shale are larger than the design flux through the cover, conservative assumptions indicate that the resulting downward flow could pass through the entire stratigraphic sequence and build up a zone of saturation at the top of the unweathered Mancos Shale, where the flux (at a unit gradient) would be a factor of 2.8 smaller than 0.1 ft/year.

The downward movement of meteoric water through this stratigraphic column is explained in terms of a simple water balance. For a flux of 0.1 ft/yr, the flow through the 250-acre disposal cell is approximately 1.09 million ft^3/yr [15.5 gallons per minute (gpm)]. The downward flux (at a unit gradient) into the unweathered Mancos Shale is conservatively 0.036 ft/yr or approximately 0.39 million ft^3/yr (5.6 gpm) over the area of the disposal cell. Therefore, approximately 0.70 million ft^3/yr (9.9 gpm) could migrate laterally away from the perimeter of the disposal cell footprint.

The leachate would eventually be consumed by slow vertical leakage into the unweathered Mancos Shale (RAP Attachment 3, Appendix G). If more realistic assumptions are considered, there is no potential for mounding or lateral spreading to occur in the weathered bedrock. Regardless of the assumptions that are considered, there is very little risk of potential discharge of leachate into surface drainages.

Surface Water Hydrology and Erosion Protection

SW1. Design of Erosion Protection for North Diversion Channel: The RAP indicates that riprap will be provided for the north slope of the disposal cell and the left side of the diversion channel and that the rock will be designed to protect against velocities produced by the PMF in the channel. However, it appears that the design of the riprap may also need to be based on velocities and shear stresses that will occur in gullies that discharge into the diversion channel. It appears that a significant number of gullies have formed and will discharge into the diversion channel in an unpredictable manner. The staff concludes that these gullies are likely to produce the design condition for the rock in the channel.

Staff review of the RAP indicates that DOE computed the scour depth, using assumptions associated with flows occurring perpendicular to the diversion channel, and the staff concludes that DOE'S assumptions related to gully size and discharge are appropriately conservative. However, the size of the riprap should also be based on similar assumptions. It is likely that the flow velocities occurring in these gullies will exceed the velocities in the diversion channel, thus requiring larger riprap sizes. In addition, the proposed rock cutoff wall and/or rock toes should be designed for the gully velocities, and the size and volume of rock should be adjusted accordingly.

DOE should either revise the design to account for velocities in the gullies, or provide additional justification for the current design.

Response:
The riprap along the base of the channel will have a median rock size of 20 inches to resist flow velocities from gullies discharging into the diversion channel. The riprap will be placed in adequate volume to act as self-launching riprap that will fill in scour holes to the maximum predicted scour depth. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW2. Design of Riprap for the Diversion Channel Outlet: Staff review of the design of the riprap for the diversion channel outlet indicates that the rock size and volume may not be adequate to prevent head-cutting and gully intrusion into the channel. The assumptions related to flow distribution across the outlet structure do not appear to account for localized flow concentrations. Further, the volume of the rock provided does not appear to be adequate to fill in scoured areas during the occurrence of major floods.

During the December site visit, the staff observed significant gullies downstream of the site, relatively close to the southwest corner of the proposed cell. Because the drainage area to this area will be increased by diverting flows in the diversion channel, there is a significant potential for large gullies to form and migrate upstream toward the disposal cell.

The design condition for computing the rock size and volume should be based on assumed areas of flow concentrations occurring downstream of the outlet structure. The velocities in these areas of flow concentration should then be used to compute the scour depth, rock size, and rock volume, based on collapse of the rock structure on a slope of about 1V on 2H. It is relatively obvious that flows occurring on the steep 1V on 2H collapsed slope will likely result in very large rock sizes. Alternately, DOE could provide a design where the downstream slope of the structure is constructed on a pre-formed specific slope, such as 1V on I0H, thus reducing the rock size requirements.

DOE should revise the design or provide additional justification that the design is adequate to prevent head-cutting into the diversion channel. If DOE chooses to make revisions, the design of the outlet for this diversion channel could be similar to other Title I designs that have been previously approved. Guidance may also be found in NUREG-1623.

Response:
The outlet structure has been modified to include a pre-formed, 1V:10H, buried rock structure excavated to the maximum predicted scour depth. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW3. Design of West Slope and Toe of Disposal Cell: Based on observations of on-site gullies during the site visit, the staff considers that flows discharging from the currently-proposed location of the diversion channel outlet could potentially erode the west side slope and/or toe of the disposal cell. Based on the size, depth, and relative closeness of the existing gullies immediately downstream of the southwest corner of the proposed cell, it appears that gullies of similar size and depth could form immediately adjacent to the toe and could erode to a depth that could undercut the rock toe.

DOE should revise the design of the west slope and toe of the disposal cell by: (1) increasing the rock size and volume of the toe; (2) extending the outlet of the diversion to the west so that the west side slope of the cell is not affected; or (3) changing the footprint and alignment of the west side of the cell.

Response:
The outlet of the diversion channel has been extended westward to minimize impacts on the west side slope of the cell. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW4. Delineation of Competent Mancos Shale: On page 5 of Appendix G, DOE indicates that riprap will extend to the computed scour depth or to where competent Mancos Shale is encountered. In general, the staff considers that many Mancos Shale formations may not be extremely hard or durable if exposed to weathering. If riprap is keyed into such formations, erosion and loss of rock volume could occur. Further, during the site visit where the test pit was observed, the staff did not observe any competent shale layers that would provide suitable protection if exposed by erosion.

DOE should provide a clear description and definition of what will be done to determine the competency of Mancos Shale in those areas where riprap will be extended below grade or where erosion is expected to occur. Alternately, DOE could provide rock of sufficient volume to extend to the expected depth of scour.

Response:
DOE has selected the alternate approach; riprap volumes have been increased such that the rock will extend to the expected depth of scour. The riprap will not be keyed into the Mancos Shale. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW5. QA/QC Procedures for Rock Production: Based on observations made during the December site visit, it appears that the rock in either of the proposed quarries is somewhat variable, depending on the location where rock will be produced within the quarry. DOE should provide additional information to document the quality assurance and quality control (QA/QC) procedures that will be implemented during rock production at the quarries to address this variability and to assure that rock of acceptable quality will consistently be produced. DOE should discuss how acceptable rock will be identified and unacceptable rock avoided as part of the QA/QC procedures for rock production.

DOE should describe the lithologic variability of the rock sources and identify features adverse to rock durability and resistance to weathering. Variability is also the basis for selecting representative samples for durability tests and petrographic analysis. Discuss how representative samples were obtained. Potential features could include mudstone/clay interbeds, conglomerate/calcrete beds, bedding planes, or fractures that could be vulnerabilities to freeze thaw and reduction in rock size. Explain how the mudstones and limestones above and below the sandstone will be able to be avoided in producing the sandstone.

Petrographic analysis, together with published literature, should be used to identify the minerals and percentages. Petrographic analysis should clearly identify the rock source of the sample. Mineralogy of the sandstone cement should be identified and the type of clays, if present.

In addressing the above items, consider the sedimentologic, stratagraphic, and petrologic analysis given in Currie, Brian S. "Upper Jurassic-Lower Cretaceous Morrison, and Cedar Mountain Formations, NE Utah-NW Colorado: Relationships between Nonmarine Deposition and Early Cordilleran Foreland-Basin Development", Journal of Sedimentary Research, Vol. 68, No. 4, July 1998.

Response:
The selected rock for use as erosion-protection material will be assessed in two phases. The first phase will be evaluation of the potential rock quarries from testing of representative rock samples from each quarry for durability. Rock quality designation values will be calculated using the test methods for rock type outlined in NUREG-1623. Testing will include petrographic analyses, with specific emphasis on bedding planes and fracturing, as well as the presence of clay minerals or soluble minerals. The results of the

first phase will be determination of rock quarries that can produce acceptable rock for erosion protection.

The actual rock quarry to be used will be selected from the quarries that can produce acceptable erosion-protection material based on production and transportation cost, production schedule, material variability, and other factors. The second phase of evaluation will be confirmation that rock from the selected quarry will meet required durability requirements and particle-size distribution specifications. This evaluation will consist of testing of rock samples produced from the selected quarry either at the quarry or as delivered to the disposal cell site. The frequency of testing is usually based on a test per ton or cubic yard of rock, and is structured to represent rock production from startup to completion of operations. Rock not meeting the durability or particle-size requirements during this second phase of evaluation will be rejected.

Water Resources Protection

GW1. Discuss how tailings drainage will be confined to the weathered and unweathered Mancos Shale and be precluded from seeping along the contact between the weathered Mancos Shale and the overlying unconsolidated Alluvial/colluvial material and possibly migrating offsite.

RASR (Remedial Action Selection Report), page 2-7, section 2.3.2. There is NRC interest in the contact between the weathered Mancos and the overlying alluvial sediments to determine if this contact could provide a pathway for tailings drainage, especially where paleochannels exist and cut into the Mancos Shale bedrock as noted in this section. Up to 25 ft of weathered alluvial material mantles Mancos Shale at the site. Horizontal hydraulic conductivity and vertical hydraulic conductivity have been determined for the weathered Mancos Shale, but hydraulic conductivity has not been determined for the alluvial material overlying the weathered Mancos. If hydraulic conductivity is greater within the unconsolidated overlying material, which is likely the case, this may allow for preferred pathway or a "path of least resistance" for tailings drainage to seep from the tailing pile along this contact and migrate downgradient and offsite.

Response:
Excavation for construction of the disposal cell will be through Quaternary alluvial/colluvial soils and into the weathered Mancos Shale. In addition, the inside slope of the disposal cell excavation will be tied into the compacted perimeter embankment. Where buried swales exist that are deeper than the average depth of excavation, the unconsolidated materials will be excavated from the buried swales. Therefore, potential pathways for lateral tailings drainage migration will be cut off by the inside slope of the disposal cell excavation and the compacted perimeter embankment. Tailings drainage will thus progress vertically downward into the weathered Mancos Shale. The DOE response to comment GT10 describes what happens to the tailings drainage after it enters the weathered Mancos Shale.

GW2. Calculate the approximate volume of leachate that may drain from the tailings and the volume of water that is expected to seep through the cover. Estimate the distance and depth this volume of leachate may seep from the tailings impoundment.

RASR, page 4-8, section 4.3.4. The statement is made that "the average moisture content of the tailings will probably be biased on the wet side of optimum, leaving enough residual moisture to drain from the tailings under the influence of gravity." The cover will have a lower hydraulic conductivity than the underlying Mancos Shale to prevent "bathtubbing." Has DOE attempted to calculate the approximate amount of leachate that may drain from the volume of tails expected based on an approximation of "the wet side of optimum?" If so, has the volume of Water calculated been modeled to determine its approximate flow path and distance from the site? There is a concern that leachate may not penetrate the weathered Mancos Shale and prefer to migrate along the weathered Mancos Shale and Quaternary alluvial material contact. If this were to occur, would this result in offsite drainage or the possible development of seeps in either Crescent or Kendall Washes, especially if leachate were to migrate along the paleochannel(s) cited in the text?

The text in this section also notes that DOE will monitor the accumulation of transient drainage with a standpipe tapping a sump at the downgradient toe of the disposal cell. How far into the weathered Mancos Shale is the sump to be constructed or will it only be in the alluvial material? Is only one sump anticipated, or will a series of sumps be considered at the downgradient toe of the cell? Please clarify or develop a plan and basis for location of the sumps. Clarify the "action level" and the plan for pumping and disposal of water from the sump(s).

Response:
The water content of the Moab tailings as excavated and hauled to the Crescent Junction Disposal Cell is likely to be near optimum to above optimum relative to the required compaction effort (at Standard Proctor density). The tailings are anticipated to lose moisture, becoming nearly optimum in water content because of evaporation that is anticipated to occur during mixing, dumping and spreading of the tailings prior to compaction.

The excavated Moab tailings will be placed in the disposal cell and processed by the following procedure: (1) dumping from trucks along a working face or specific area, (2) spreading in lifts with a dozer, and (3) compacting each lift of tailings with a compactor. This tailings-handling process, when performed in an arid climate such as that at the Crescent Junction Site, should dehydrate the tailings to nearly optimum water content during compaction in the cell. Evaporation from the compacted tailings surface should continue to dry the tailings further until the subsequent lift of tailings is placed. Water will be added as necessary (by spraying) for dust suppression.

Based on experience at other DOE Title I sites where uranium mill tailings have been relocated, some drainage of tailings porewater has been observed. Sumps will be constructed in weathered Mancos Shale, along the downslope (south) side of the cell, as a best management practice to collect potential drainage from the tailings. The volume of leachate that might drain from the tailings can be estimated from the difference between the water content of the tailings at optimum water content and at residual water content (drained conditions). This estimate is inherently biased to the high side because evaporation of porewater from the surface of the tailings is expected during dumping, spreading, and compaction, and during the intervening time between placement of successive lifts of tailings.

The average water content (by dry weight) of the transitional tailings at optimum conditions for compaction is approximately 18 percent, and the residual water content averages approximately 15 percent. For 12 million yd^3 of compacted RRM (primarily tailings), this water content difference is equivalent to approximately 5 percent of the total RRM volume, or 600,000 yd^3 (121 million gallons) of leachate. This volume draining over the anticipated period of RRM placement (approximately 20 years) results in an average drainage rate of 12 gpm.

Leachate from the disposal cell would migrate downward as unsaturated flow through the weathered Mancos Shale until it reaches the unweathered Mancos Shale, approximately 60 to 80 ft beneath the original ground surface. Because the conservatively estimated seepage flux (approximately 0.15 ft/year averaged over the footprint of the disposal cell) is higher than the hydraulic conductivity of the unweathered Mancos Shale (approximately 0.036 ft/year as the geometric mean from packer testing), the leachate could perch at the top of the unweathered Mancos Shale and would be expected to migrate laterally along the top of the unweathered Mancos Shale. During the performance life of the disposal cell, conservatively estimated accumulation of leachate and its lateral migration would occur entirely within the weathered Mancos Shale. If more reasonable assumptions are considered, there would be no accumulation or lateral spreading of leachate below the disposal cell (RAP Attachment 3, Appendix G).

GW3. Provide additional data, evidence, or research to support the claim that water in the Mancos Shale beneath the cell location is connate water.

Attachment 3, Appendix D, page 4. The statement is made that "Coreholes 0201, 0203, 0204, and 0208 have continued to yield water at relatively constant rates, signifying that the connate water intercepted by these coreholes is stored in larger compartments, which will require more pumping to deplete. The continued pumping from these larger compartments is deemed unnecessary because the concept that the connate water is trapped in porous zones with limited volume was already demonstrated at corehole 0202."Provide a basis that water in four coreholes is stored in larger compartments. Has DOE considered that fractures may have provided a connection for groundwater flow, thus indicating that behavior of water in the four coreholes is more indicative of groundwater flow than that of corehole 0202?

Response:
The ground water in the Mancos Shale is suspected to be connate based on several factors, including its salinity, variable ground water levels, and isolation from sources of recharge. In August 2006, the ground water was sampled in wells 0203 and 0208 and analyzed for radiocarbon (^{14}C). Results of the analyses show that the age of the ground water exceeds 40,000 years, which is the approximate detection limit for radiocarbon age dating; this would make the ground water at least late Pleistocene in age. A complete summary of the sampling and analysis of the ground water is presented in a new calculation set for Radiocarbon Age Determinations for Ground Water Samples Obtained from Wells 0203 and 0208 (RAP Attachment 3, Appendix F).

GW4. Attachment 4, Appendix B, page 35, section 8.7.2. Discuss proposed modifications to the model based on the likelihood that much of the groundwater transport through the Mancos Shale is through fractures or other large-scale features.

On the very last line of section 8.7.2, the comment is made that, "Thus, if ground water moves dominantly by fracture flow, some modifications will likely be required." In section 8.8, paragraph two, the statement is made, "Because of the low-bulk hydraulic conductivity, much of the ground water transport through the Mancos Shale is likely to be through fractures or other large-scale features. Based on the two statements, modifications of the model may be required." Discuss what modifications have been made to the model to resolve this discrepancy.

Response:
The following text section from Section 8.8 of the calculation describes how the model would be adapted to fracture flow:

> "Adaptation of the model to fracture flow would be accomplished by decreasing the concentrations of sites and minerals (normalizing to a liter of ground water)."

However, no modifications to the model are deemed necessary because the Mancos Shale is preeminently a confining unit that contains isolated pockets of connate, briny ground water, which exists in fractures and apertures and is essentially immobile. The Mancos Shale provides effective hydrogeologic isolation to the Crescent Junction Disposal Site. If through-flow were to exist, it would be under the conditions of very long travel times, as indicated by the ^{14}C age date, exceeding 40,000 BP, which was obtained for the uppermost ground water.

GW5. Attachment 4, Appendix B, page 35, section 9.0, paragraph 2. Discuss what hydrologic investigations are to be used to yield more useful units of travel time and distance for the model, or alternatively, provide a sensitivity analysis to assess the impact of chemical attenuation at the site.

One of the conclusions of Appendix B is that project personnel will need to couple the results from the model with the results from hydrologic investigations to yield more useful units of travel time and distance. Furthermore, in lieu of further investigations, a sensitivity analysis is proposed to assess the impact of chemical attenuation at the site. Provide the additional analysis as based on the conclusion in this Appendix.

Response:
The hydrologic investigations required for improving the travel time and distance estimates were conducted as part of the Hydrologic Characterization. The data interpretation presented in the calculation set for Vertical Travel Time to Uppermost (Dakota) Aquifer (RAP Attachment 3, Appendix E) develops the travel time and distance topics requested in this comment. The resulting travel time ranges from 4,860 to 48,600 years based on effective porosities of 0.05 and 0.005, respectively. These porosities are a factor of 50 and 5, respectively, lower than the porosity of 0.25 that was used in the geochemical calculation. If a porosity of 0.25 is used in the calculation, the resulting travel time to the uppermost (Dakota) aquifer becomes 243,000 years.

Radon Attenuation and Site Cleanup

R1. Please provide more detail on the process for inclusion or exclusion of identified vicinity properties.

Response:
DOE has committed to perform gamma surveys on all of the properties on the EPA list. The surveys will also include soil samples from the areas of highest gamma readings to demonstrate compliance with Radium-226 soil standard. From these measurements an inclusion/exclusion report will be prepared, documenting whether a property exceeds the EPA standards (an inclusion) or does not exceed, resulting in an exclusion.

DOE will follow the enclosed flowchart in making the inclusion/exclusion decision. The flowchart was revised to reflect NRC comments. Instead of relying on visual evidence to confirm the presence of tailings, DOE will rely on visual evidence to confirm that a point source is caused by uranium ore, fossil wood, or fossil dinosaur bones. Point sources usually stand out as gamma anomalies with readings from 100 to 1,000 microroentgens per hour.

Consequently, vicinity properties will be excluded if gamma and soils samples do not exceed EPA standards or if the only elevated readings are point sources caused by uranium ore, fossil wood, or fossil dinosaur bones. An included property will undergo further assessment on both the exterior and interior of the structure to ensure all deposits exceeding EPA standards are identified and remediated.

R2. Please provide more detail on which areas will require supplemental standards and the justification for use of supplemental standards on these areas.

Response:
DOE is currently considering the use of supplemental standards on several areas on the millsite, Policaro vicinity property, and BLM properties surrounding the millsite. Examples of where DOE does not plan to remediate include: contamination under the highway asphalt; contamination around high-pressure natural gas lines and buried electric and fiber optic lines; and contamination on steep slopes where access is not feasible and cleanup would cause excessive environmental damage.

DOE understands that additional information is required to substantiate the application. Depending on which provision of 40 CFR 192.22 is cited, the following minimum information is provided:

Proposed use and justification of applying supplemental standards.

Engineering alternatives studied, including costs to implement.

Radiological levels.

Health risks of leaving RRM behind.

Potential for tailings movement or disturbance.

Property owners’ notification and input.

DOE has a lot of experience in applying supplemental standards for similar scenarios at other UMTRA sites and can share examples if NRC desires.

BOX ORGANIZATIONAL CHART FROM ORIGINAL PDF = AVAILABLE IN NEW PDF

Interior Inclusion/Exclusion Survey

Indoors

Does gamma radiation (exposure rate readings) in any 9.3 m^2 area average

20 μR/hr above background and are elevated readings due to residual radioactive materials (RRM)

Yes

Include

Yes

Complete Radiological Assessment

No

Does gamma radiation in any 9.3 m^2 area average 30% above Background

Yes

Evidence of RRM present from exterior survey

Yes

Take Baseline RDC Measurement

Working Level (WL) 0.02

Yes

Include

No

No

No

Exclude

Exclude

BOX ORGANIZATIONAL CHART FROM ORIGINAL PDF = AVAILABLE IN NEW PDF

Exterior Inclusion/Exclusion Survey

History

Conduct Interview with the homeowner(s), check EPA gamma survey database and any other additional information pertinent to the property prior to the inclusion/ exclusion survey (knowledge of tailings hauled to property)

Outdoors

Perform exterior gamma survey

Does gamma radiation in any 100m^2 area average 30% above background

No

Collect one background soil sample in the area of highest gamma exposure rates

Soil sample less than 5 pCi/g

Yes

No

Yes

Does strong (visual) evidence suggest that uranium ore or naturally occurring radioactive materials (NORM) (petrified wood, dinosaur bone, etc.) is causing elevated readings

No

Collect and analyze soil samples using either the OCS or HPGe counting systems to determine radium (Ra-226) and/ or uranium concentrations as required

Do Ra-226 concentrations in any 100m2 area average 5 pCi/g for surface or 15 pCi/g for any subsurface 15 cm (6-inch) layer above background

No

Yes

Are the elevated gamma readings and radium concentrations due to the presence of residual radioactive materials (RRM) (optional isotopic analyses)

No

Yes

Yes/Can't tell if RRM related

Recommendation Include Property

DOE Concurrence

Finish Radiological Assessment of entire property

Perform Interior Gamma Survey

September 2007 Open Issues Meeting

Further response for February 2007 GT (Geotechnical) Issues

1. **GT 2 -** As part of its volume balance analysis, DOE indicates that a 13 to 15 percent shrinkage factor should be applied from excavated material to compacted material. DOE uses the 15 percent shrinkage factor for the UMTRA cover option, but only assumes an 8 percent shrinkage for the Alternative cover. DOE needs to explain the basis for using an 8 percent shrinkage factor for the Alternative cover, or otherwise describe the source of material to make up the shortage if the 15% shrinkage factor also applies to the Alternative cover.

Response
The final design uses the UMTRA cover option. The alternative cover has been dropped.

2. **GT 3 -** In response to the previous request for additional information on swelling clays, DOE has indicated that "the weathered Mancos Shale is likely to be slightly to moderately expansive in the area of the disposal cell, which can be accommodated in the design of the disposal cell." In the final RAP, DOE needs to include information on how it has factored or plans to factor the Mancos Shale expansive characteristics into the cell design.

Response
The Mancos Shale formation can exhibit characteristics of moderate swelling, due to the possible presence within the shale of expansive clays and thin gypsum lenses, which expand when hydrated. Though possible, expansion of the shale is not considered to be problematic for the following reasons:

a) The shale formation has extremely low hydraulic conductivity, and though the top surface of the shale will be wetted during the time when tailings are being placed and later as excess capillary water migrates to and along the cell floor the water will not migrate very far into the shale formation. The thickness of the shale being wetted is not likely more than 1 to 2 feet and the volume of expansive clay or gypsum in that thin layer of shale cannot expand enough to be of consequence. For example, if two feet of shale is hydrated, and 25% of the two feet thickness is expansive material, and the expansive material expands 50% (typical for some types of gypsum) the total expansion would be 3 inches.

b) Minor expansion, if it occurs, will take place when the Mancos shale is initially wetted. At that point, the cell is being excavated and the first layers of tailings are being placed. There will not be anything in place at that point that could be damaged by minor soil movement. Damage from soil expansion and contraction tends to occur when a sensitive structure such as a building or highway undergoes differential movement. The disposal cell is not a sensitive structure, especially in the early stages of cell excavation and tailings placement.

c) Expansion and/or contraction of expansive soils takes place when significant changes in moisture content occur. When moisture content is relatively constant, expansion and/or contraction does not occur. A relatively thin layer of Mancos shale may expand when initially hydrated, but once several feet of tailings have been placed over the shale, the moisture content at the cell floor should remain relatively constant. Whether the cell eventually dries out or has some residual moisture at the cell floor long-term, it should not be subject to moisture fluctuations that would result in significant cycles of expansion and contraction.

Geotechnical Stability

3. At this time, DOE has indicated that construction details will provided with the final RAP. This will include the proposed sequence of construction and the detailed construction specifications, including contaminated material and cover layer placement procedures, Therefore, until this information is submitted and reviewed, the approval of construction details and specifications remains an open issue.

Response
In the final RAP, Section 7.2 contains the Construction Details and Addendum B contains the Final Design Specifications.

4. DOE will implement an inspection and testing program to ensure quality control of the construction of the various components of the cell. This program will be described in the Remedial Action Inspection Plan to be submitted with the Final RAP. Therefore, until this information is submitted and reviewed, the approval of the testing and inspection details of the quality control program remains an open issue.

Response
Addendum E contains the Remedial Action Inspection Plan (RAIP) for NRC’s review.

5. The factor-of-safety from the DOE slope stability analysis of the long-term pseudo-static condition is just equal to the required minimum value of 1.0 DOE should provide a discussion of these results in terms of the conservative factors in the seismic input assumptions and the analysis as a whole as justification for the factor of safety not exceeding the minimum allowed.

Response
New Slope Stability calculations were performed with computer program, SLIDE, V 5.0 by Rocscience. The SLIDE program analyzes the slope with multiple methods to determine factor of safety, including Bishop Simplified, Janbu Simplified, Janbu Corrected, Spencer, Morgenstern-Price, and Corps of Engineers Methods. Bishop and Janbu methods employ limit equilibrium analysis method, Spencer and Morgenstern-Price methods use both force equilibrium and moment equilibrium to determine safety factors. In this analysis, Spencer results yielded the lowest factor of safety.

The analysis was performed for the End of Construction (short-term) and Long-term cases. Stability of the disposal cell perimeter embankment and cover system was also assessed for the design seismic event for both the short term and long term cases. Seismic conditions were analyzed using guidance provided in the Technical Approach Document (TAD) 1989. The TAD requires the use of pseudo-static approach where Peak Horizontal Acceleration (PHA) value of 0.22 g (previously determined) is taken as half of PHA or 0.11 g for End of Construction case, and 2/3rd of PHA or 0.15 for Long-term case.

The analysis results, summarized in the following table, indicate that the Safety Factor of the critical slope exceeds the Safety Factor required by the TAD for all of the cases. The stability results indicate that the proposed disposal cell site, perimeter embankments, and cover system will be stable when constructed of on site materials and with the planned embankment geometry.

Summary of Slope Stability Analysis

Loading Condition	Calculated Factor of Safety	Factor of Safety Required by TAD
End-of-construction: Static Pseudostatic (k_h = 0.11g)	2.15 1.31	1.3 1.0
Long-term: Static Pseudostatic (k_h = 0.15g)	2.78 1.51	1.5 1.0

K_h = pseudostatic coefficient

6. Both cover options include a 6-inch "infiltration and biontrusion" layer. DOE should provide a detailed description of the function and composition of this layer, and how the composition will serve to meet the functional requirements.

Response

The infiltration and Biointrusion layer has 3 primary functions: It provides positive drainage of any surface water that seeps through the upper layers of the cover and transmits the infiltration to the side slopes of the cover, it provides a barrier against burrowing animals, and it provides a break in the soil regime to discourage root growth into the radon barrier.

The infiltration and biointrusion layer is overlain by a 3-ft layer of soil and a final surfacing of 0.5 ft rock armoring. All three layers act together to resist intrusion into the cell, limit infiltration into the RRM and provide frost protection for the underlying radon barrier.

A description of these cover layers has been included in Section 7.1 of the RAS.

7. In its alternate monolithic cover design, DOE merely indicates a thick mixture of alluvial, Aeolian, and Mancos shale materials. Unless this cover option is eliminated in the final design, DOE should provide a discussion of how it would be constructed to provide a cover of less than or equal to 10-7 cm/sec infiltration rate.

Response
The alternative cover option has been eliminated.

Surface Water Hydrology and Erosion Protection

8. Design of Riprap for the Diversion Channel Outlet: Staff review of the design of the riprap for the diversion channel outlet indicates that the rock size and volume may not be adequate to prevent headcutting and gully intrusion into the channel. Based on observations during site visits in the area, it appears that existing gullies along the west and southwest sides of the disposal cell are deeper than the proposed scour depth of 5 feet. The staff has observed several gullies that are significantly deeper than 5 feet, and the increased drainage area from the north diversion channel may result in gullies that will be similar in depth.

Although the scour model used may be acceptable, the assumptions related to flow distribution across the outlet structure do not appear to adequately account for localized flow concentrations.

The design condition for computing the scour depth, rock size, and volume should be based on assumed areas of very large flow concentrations occurring downstream of the outlet structure. The current assumption of a flow concentration of 3 is probably not adequate. In addition, DOE should carefully analyze the gullies that currently exist and determine an appropriate scour depth for the design of the diversion channel outlet, based on potential headcutting of existing gullies. This information was originally requested in geomorphic comments that were submitted earlier (Comment 3c from 04/06 meeting).

Response
The revised cell design has replaced the north diversion channel with a wedge of compacted surplus material from the excavation. Flow from the north will be diverted around the disposal cell to the east and west. An analysis of sediment transport potential and sediment supply to the area immediately north of the wedge indicates that the wedge will not erode but rather trap sediment from the north and increase in volume over time. After the flow turns southerly at the ends of the wedge it will erode channels that will carry the flow to the east and west branches of Kendall Wash after bypassing the disposal cell. Although the natural ground slope will not direct the flow toward the disposal cell, large diversion berms are to be constructed to ensure that the flow will bypass the cell.

9. Selection of Rock Source: The staff notes that DOE has considered several rock sources, but has not selected any specific source. The staff also recognizes that DOE does not plan to produce and place rocks until several years in the future. However, the staff considers it important for DOE to preliminarily select a specific source and use data from that source to develop a complete design and construction package. Even though DOE has committed to using design criteria such as NUREG-1623 and other NRC suggested guidance, this should be done in the interest of resolving as many issues as possible, prior to construction.

It is important to note that the sizing and the design of the erosion protection is dependent on the specific gravity of the rock, the angularity of the rock, and the quality of the rock placement. For example, the specific gravity is currently assumed to be 2.65, but this may be optimistic for a sandstone source. The rock is also assumed to be angular, but if rounded boulders are used, the rock size may need to be increased by as much as 40 percent.

The staff considers that DOE should develop a preliminary design that is based on the use of a specific rock source. DOE should then provide data from this source regarding rock durability tests, rock production procedures (at the proposed quarry), rock placement procedures, and other QA/QC information.

Response

A source for the riprap will be selected and included as a part of the final RAP along with rock durability tests, rock production (at the proposed quarry), and rock placement.

The Aggregate and Riprap specification contains the following quality requirements:

NRC TABLE OF SCORING CRITERIA FOR ROCK QUALITY

Laboratory Test	**Weighing Factor**			**Score**										
	Limestone	**Sandstone**	**Igneous**	10	9	8	7	6	5	4	3	2	1	0
Specific Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	2.25
Absorption, %	13	5	2	0.10	0.30	0.50	0.67	0.83	1.0	1.5	2.0	2.5	3.0	3.5
Sodium Sulfate, %	4	3	11	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
LA Abrasion, % (100 revolutions)	1	8	1	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
Schmitt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	0

Notes:

1. Scores were derived from Tables 6.2, 6.5, and 6.7 of NUREG/CR-2642, *Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, 1982.*
2. Weighing Factors are derived from Table 7 of "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," by G.W. Dupuy, *Engineering Geology*, July 1965. Weighing factors are based on inverse of ranking of test methods for each rock type. Other tests may be used; weighing factors for these tests may be derived using Table 7, by counting upward from the bottom of the table.
3. Test methods should be standardized, if a standard test is available and should be those used in NUREG/CR2642, so that proper correlations can be made.

ACCEPTABLE ROCK SCORES

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the pile, the rock must score at least 50% or the rock is rejected. If the rock scores between 50% and 80% the rock may be used, but a larger D_{50} must be provided (oversizing). If the rock score is 80% or greater, no oversizing is required.

- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65% or the rock is rejected. If the rock scores between 65% and 80%, the rock may be used, but must be oversized. If the rock score is 80% or greater, no oversizing is required.

ROCK OVERSIZING

Oversize rock as follows;

- Subtract the rock score from 80% to determine the amount of oversizing required. For example, a rock with a rating of 70% will require oversizing of 10 percent (80% - 70% = 10%).
- The D_{50} of the stone shall be increased by the oversizing percent. For example, a stone with a 10% oversizing factor and a D_{50} of 12 inches will increase to a D_{50} of 13.2 inches.
- The final thickness of any layer of oversized stone shall increase proportionately to the increased D_{50} rock size. For example, a layer thickness equals twice the D_{50}, such as when the plans call for 24 inches of stone with a D_{50} of 12 inches, if the stone D_{50} increases to 13.2, the thickness of the layer of stone with a D_{50} of 13.2 should be increased to 26.4 inches.

Water resources Protection

10. Points of Compliance: No points of compliance have been established and I don't believe they need to be for chemical concentrations, however, I believe DOE needs to better explain how they will demonstrate cell performance and monitoring for performance. DOE has modeled the expected lateral spreading of contaminants in the weathered Mancos Shale and estimated a 10 year ring, 200 year ring, and 1000 year ring. I would think that if contamination is expected t spread to the 10 year ring, why not monitor for cell performance? If no contamination or fluids occurs at year 10, cell is performing better than anticipated. If it occurs before, DOE should have a plan to install wells at further out to monitor for performance. No chemically, only the presence or absence of cell fluid is needed to monitor performance because the geochemical nature of the Mancos (saline and briny) and its been written off as a source of water. AI also believe that DOE should be specific as to how many standpipes are going to be installed to monitor cell performance, at the edge of the cell. In RAP, Attachment 3, Appendix G, page 12, last bullet, states, "Up to three piezometers (standpipes) are recommended to monitor the accumulation of leachate within the footprint of the disposal cell, during the transient drainage period, to verify that bathtubbing dissipates as steady-state conditions are achieved. In addition, the piezometer may be used to monitor subsurface hydrologic condition after steady-state drainage is achieved." However, the RAP, page 4-7 states, "DOE will monitor the accumulation of transient drainage with a standpipe tapping a sump at the down gradient toe of the disposal cell…." And on top of page 9-2, "A temporary standpipe to monitor transient drainage is discussed in Section 4.0 of this document." I take this statement to mean DOE has discarded the recommendation made in the RAP, Attachment 3, Appendix G, page 12.

Basically, I have two concerns.

1. DOE should monitor the toe of the cell for leachate and cell performance to make sure they do not have fluids migrating at the unweathered Mancos Shale - Alluvial material interface. I think one locations is not enough for a cell of this size and is contrary tot eh recommendation in the RAP. These multiple locations should be defined.
2. The overall performance of the cell and the disposal strategy of allowing the cell to leak over time needs to be confirmed. DOE has determined that all the fluids will be contained within a defined perimeter around the cell and within the weathered Mancos Shale. They should be require to monitor for this performance for the presence/absence of cell fluids.

Response
The disposal cell has been designed with four locations for standpipes to monitor the presence/absence of cell fluids. The 4 standpipes are along the down gradient interior boundary of the cell (Addendum C Final Design Drawings) The details of the standpipe are shown on drawing E-02-C-104 in that Addendum. If any water accumulates in the standpipe following closure of the cell it can be removed and stored in a cell water retention pond.

During construction of the cell, the slope of the bottom will promote drainage to a temporary sump in the dirty construction area. This water will either evaporate or will be pumped and used as dust control on contaminated areas within the cell. As the construction continues, the amount of water accumulation at the fresh face of construction can be monitored along with any water in the already installed standpipes. This would also provide information for documentation and for future planning.

A decision on future action to monitor water outside the cell would be developed under an observational approach. If there were indications that a larger volume of water than anticipated was accumulating within the cell, there would be studies/modeling performed to ascertain what or if there was an impact and if further action was warranted.

Radon Attenuation and Site Clean Up

11. Editorial: 9.1.3 DOE states that for Th-230 a supplemental standard under criterion “f” will be imposed. 192.21 f refers to the restoration of groundwater. Did they mean “h”?

Response
The correction will be included.

12. Analytical: 9.1.3 DOE stated they will use statistical correlations for radium in lieu of soil sampling. They also state that thorium may be an issue on site. If an area contains RRM other than Ra-226 wouldn’t that cause correlations to be severely inaccurate?

Response
The correlation is based on gamma or exposure rate readings detected in the field. If an area contains RRM other than Ra-226, such as Th-230, it would not affect the radium in

soil versus gamma correlation due to the fact that Th-230 does not contribute significant amounts of gamma radiation. For the areas identified on the site that may contain RRM other than Ra-226, the soil sampling frequency will be increased in order to adequately demonstrate that the appropriate soil clean-up standards have been met.

NRC Comments to Final RAP

NRC Comment	Comment	DOE Response
(1) D. Gillen	Will DOE perform cell cover settlement monitoring post closure If so, add language reflecting DOE's commitment.	Cell cover monitoring language added to RAS Section 4.6 and RAIP Section 6.11. Draft Language provided to D. Gillen 3/13/08
(2) D. Gillen 3/21/08	RAIP – Pg. 7 of 25 – 2nd bold heading "In-Place Density Testing of Waste Cell Spoil Material Embankment" - this Section doesn't belong here.	Section will be removed.
(3) D. Gillen 3/21/08	RAS Pg. 7-1, last paragraph – Sum of quantity of individual cell components do not equal total quantity indicated.	Error in quantity of wedge quantity. Clarifying language provided 5/8/08.
(4) D. Gillen 3/20/08	Cover thickness inconsistencies in RAS and Calculations C-10 and C-11. (8',9',10')	The correct final cover thickness is 9'. The RAS text will be corrected to reflect this. Revised calculations provided to NRC 5/8/08.
(5) D. Gillen 3/20/08	Cover cracking typo, RAS, pg.4-9, allowable strain given as .065 and .056 in same paragraph.	.065 is correct value. RAS text will be revised.
(6) T. Johnson / M. Fliegel	Rock quality results in Section 6.6 – The overall score for the tan, friable SS appears to be too high based on the individual scores	Rock lab made error in overall score of tan, friable SS
(7) M. Fliegel / T. Johnson / R. Johnson conf. call 4/17/08	Discuss concerns regarding Silliman rock – test crush Silliman rock to see if poor quality rock breaks up, perform petrographic analysis on Silliman rock types, perform analog study	DOE is no longer proposing Silliman rock as a source. For RAP approval, DOE will propose Fremont Jct. as sole source. Revised Section 6.6 will be submitted to NRC ASAP.

Comments from 5/19/08 meeting at NRC offices		
RAS Document		
(8) D. Gillen	Table 4-1, pg 4-4 – check CJ dike fill moisture content of 17.4%	Table 4-1 dike fill moisture content revised to 11.7% - sent to NRC 6/24/08
(9) D.Gillen	Section 4.24, pg. 4-9, .065 & .056 % both used as maximum strain, Also correct delta / l information in the text per Calc C-15.	Revised text provided to NRC 6/24/08
(10) D.Gillen	Section 5.2.1, pg.. 5-3 explain how 12% long term moisture for radon barrier was determined.	Response provide to NRC 6/24/08
(11) D.Gillen	Section 7.0 – add description of purpose for each cover layer component	Text provided to NRC 6/24/08
(12) D.Gillen	9/07 Open Issues Meeting – Comment response No. 6 calls for a 4' frost protection layer while design has 3'.	Revised Response Text Provided to NRC 6/24/08
RAIP		
(13) D. Gillen	Globally in document – replace tailings with RRM	Tailings replaced with RRM throughout – Revised RAIP sent to NRC 6/24/08
(14) D. Gillen	Pgs 7 & 8, incorrect indenting	Corrected – revised RAIP to NRC 6/24/08
(15) D. Gillen	Section 6.3.5 – Remove 'In-Place Density Testing" from heading	Corrected
(15) D. Gillen	Section 6.4.3 – Make clear testing requirements when CAES not used	Corrected
(16) D. Gillen	Cover drawing pg. 15 – remove "Random Fill" from drawing	"Random Fill" replaced with proper material description
(17) D. Gillen	Section 6.7.1, 2nd paragraph, remove "Table 2"	Completed
(18) D Gillen	Section 6.8.1 remove "Erosion and Rip-Rap Type A & B"	Completed

Specifications		
(19) D Gillen	Earthwork – 1.2.6 – Need definition of Select Granular Material	Spec Revised – Revised Specs sent to NRC 6/24/08
(20) D Gillen	Earthwork – 3.11.1 correct typo –"brake" should be "break"	Corrected
(21) D Gillen	Earthwork – 3.11 – Need subsections for embankment, wedge etc.	Spec Revised
(22) D Gillen	Earthwork – 3.14 – Need range for moisture control spec	Spec Revised – within 3 % of optimum for RRM, Radon Barrier, within 5% of optimum for embankments, wedge
(23) D Gillen	RRM Placement – Make requirements consistent with RAIP, add moisture range	Specs, RAIP consistent – moisture % for RRM placement within 3% of optimum
(24) D Gillen	Final CAP Layers, Section 2.2 – make reference to Aggregate spec for gradation requirements for cover rock	Reference added
(25) D Gillen	Final Cap Layers – Section 3.2.5 – need compaction procedure reference i.e. per ASTM ….	Reference Added
(26) D Gillen	Final CAP Layers, Section 3.2.1 – 200 sieve is only testing requirement – need to add others	DOE would like to discuss with NRC
(27) D Gillen	Aggregate & Rip-Rap – Section 1.4.2.2 do we need liquid limit and plastic limit testing?	Liquid Limit and Plastic Limit requirements eliminated
Calculations		
(28) D Gillen	Calculation C-15, pg.6 – is there an error in delta / length calc?	Calc Revised – Provided to NRC 6/24/08
Health Physics		
(29) T Youngblood	Written comment provided – Section 9.1.3 page 9-2 – does DOE have technical basis document for use of GPS / Gamma Scan ?	Basis Documents for use of Gamma Scan provided to NRC 5/28/08
Conf Call 6/23/08		
Health Physics		
(30) T Youngblood	Section 9.1.3, Pg 9-3, mention in text that Supp Stds requires NRC approval	Language added to Section 9.1.3
(31) T Youngblood	Section 9.1.3, Pg 9-3, use language in VP Completion Reports to address Th 232 remediation standards.	

Groundwater		
(32) R Linton	Comment from Draft RAP not addressed, Attachment 3, Appendix E, pg.7 – Uses both 6.7E-8 cm/s and 4.5E-8 cm/s, which one is correct?	The 6.7E-8 cm/s value is correct. The calculation set has been revised to reflect the correct value.
(33) R Linton	Comment from Draft RAP not addressed, Attachment 4, Appendix B, Section 9 Conclusions – states that geochemical results should be coupled with the field testing (i.e. hydraulic parameters) to yield more useful assessment of chemical attenuation at the Crescent Jct Site. Does DOE plan to do this?	Section 3.4 was clarified to indicate that the results of the geochemical attenuation modeling was coupled with the hydraulic parameters obtained by the field testing to yield a more useful assessment of the chemical attenuation at the Crescent Jct. Site.
(34) R Linton	Calculations in the RAP estimate a lateral travel distance in the weathered Mancos from transient drainage of tailings fluids. DOE should consider monitoring the weathered Mancos for cell leakage outside of the cell foot print.	RAS Section 7.2.4, Transient Drainage, has been modified to state that 4 existing wells, one on each side of the repository will be recompleted as weathered Mancos Shale monitoring locations.
Moab Mtng 6/26/08		
(35) T Johnson	Erosion of ends of energy dissipaters feeding sed ponds – the ends of the dissipaters will head cut – need to address this issue.	Design has been modified to incorporate a buried 10:1 slope at the end of the dissipaters with approximately 10” rock
(36) T Johnson	CJ cell N diversion ditch – If unlined ditch at the toe of the wedge fills with sed, will the rock lined cell channel handle the flow from the wedge and also the cell cover? Confirm calculation.	Calculation C-04, Area between Cell and Wedge has been revised and Drawings E-02-C-500 and E-02-C-501 have also been revised. A more detailed response is provided in Attachment 1 to this Table.
(37) T Johnson	Drawings need to provide more detail on wedge - cell tie-in. Reference drawings E-02-C-501, E-02-C-502.	Additional provided on Drawings E-02-C-501, E-02-C-502

(38) T Johnson	Rock Gradations – In some cases the D50 rock specified is too small. For example the south top slope rock requires a D50 of 1.8". The calculations state that the D50 should be 1.8 inches. However, the specifications state that a D50 of 1.5 – 2.0 inches is required, possibly resulting in undersized rock.	A revised rock gradation spec was approved by T. Johnson via conference call on 6/30/08. Revised specs will be incorporated. The RAIP has been revised to include verification that fines are dispersed evenly throughout the rock during placement.
(39) T Johnson	Rip Rap Placement – RAIP document should include manual testing of the rock thickness against the CAES data to ensure specified thickness is being obtained.	RAIP has been revised to add requirement for manual rock testing check every 10,000 cubic yards of rock placed.
(40) R Johnson	Suggested conducting durability testing of the other than grey basalt rock present at the Fremont Junction quarry.	Samples were collected on 6/26/08 and durability testing is currently being conducted. Test results will be provided to NRC when they are available.
(41) R Johnson	RAS Section 6.6.3.3, page 5, 3rd paragraph, 2nd sentence – specify a depth range instead of several "several feet"	Text was revised to indicate 3 ft.
(42) R Johnson	RAS Section 6.6.3.3, page 6, 2nd paragraph, 3rd sentence – delete this sentence – not substantiated by rock testing.	Confirmed with R. Johnson on 7/9/08 that sentence is ok to leave as is.
(43) R Johnson	RAS Tables Section 6-15 and 6-16, page 9 –check the sample description for Samples 2B and 5B "Weathered Basalt" vs "Basalt cobble"	The description of the degree of weathering from the petrographic analysis was included where available. This information is not available for samples TP-3A and TP-3B.
(44) R Johnson	RAS Section 6.7.2 – 2nd paragraph, 2nd to last sentence – Rock which "passes"…should be "retained".	This sentence was clarified.
(45) R Johnson	Section 6.6. Discuss discrepancies between 1988 and 2007/2008 field observations.	Sections 6.6.1, 6.6.2, and 6.6.3 were clarified to explain the discrepancies.

(46) R Johnson	6.6.3.3. Explain how natural analogs are being used.	This section was clarified to explain that natural analogs provide insight for long-term performance of engineered covers.
(47) R. Johnson	Reference Section: Would like copy of Smith et al. 1997.	A copy of this report was forwarded to R. Johnson.
(48) R. Johnson	6.6.4.1. Expand this section to include x-ray diffraction results.	This section was expanded to include results from the 1988 x-ray diffraction analysis.
(49) R. Johnson	Section 6.7. Change title to "Rock Selection During Production"	The title was changed as requested.
(50) R. Johnson	Section 6.7.2. Clarify size of material removed by crushing.	Section 6.7.2, 3rd paragraph, 1st sentence states that the crushing will "provide appropriate sizes to meet the gradations specified in Addendum B (see Table 3)". This paragraph was clarified to state that sizes smaller and larger than specified in Addendum B will not be retained.
(51) R. Johnson	Section 6.7.3. Discuss potential heterogeneities field personnel needs to look for.	This section was expanded as requested.
(52) R. Johnson	Section 6.7.4. 2nd paragraph. Clarify that removed rock is crushed away.	This sentence was clarified as requested.
(53) R. Johnson	Include that durability testing will be conducted every 10,000 yards even though it is specified in the RAIP.	Section 6.7.2 was expanded to indicate testing will be conducted every 10,000 yards.
(54) R. Johnson	State NRC has approved the Fremont Junction rock source for the Green River cell.	This is stated in Section 6.6., 3rd paragraph, 2nd sentence.
Call w Dan Gillen 6/30/08		
(55) D Gillen	RAIP – Section 6.7.1, pg 17 of 27 – Reference to ASTM 1140 should be revised to ASTM 422 as in the specs	Corrected
(56) D Gillen	RAIP – Section 6.7.4 – Inspection and Testing, pg. 18 of 27, 1st	Language added

	paragraph – add moisture content of (3% of optimum)	
(57) D Gillen	RAIP – Section, 6.8.2, last paragraph, add a bullet that addresses manually checking the thickness of the rock placed to ensure	Bullet added to manually check rock thickness every 10,000 cubic yards of rock placed.
(58) D Gillen	RAIP – Section 6.9.4, pg 22 of 27, 1st paragraph, add moisture content requirements (5% of optimum)	Language added
(59) D Gillen	RAS – new Section 7.0 – description of Radon Barrier purpose – add that radon barrier also limits infiltration (not just contains radon).	Language Added
(60) D Gillen	RAS – Section 7.0 – The heading for "Erosion Control" is mislabeled as "Frost Protection"	Corrected
(61) D Gillen	RAS Section 5.2.1 – comment to revised Section – See Comment Response No. 10 need to expand 1st paragraph – where does "typical" moisture content from tailings come from? Do we have data?	Typical tailings moisture content explanation provided in text and in Attachment 2 to this Table.