Mr. Dane L. Finerfrock, Executive Secretary
Utah Radiation Control Board
Utah Department of Environmental Quality
PO Box 144810
Salt Lake City, UT 84114-4810

Re: Shootaring Canyon Uranium Mill Amendment Request for Radioactive Material License No. UT 0900480, 2nd Round Interrogatory Responses

Dear Mr. Finerfrock:

Uranium One Utah, Inc. (Uranium One) has prepared select Interrogatory Responses to the 2nd Round of Interrogatories for the Tailings Management Plan for the Shootaring Canyon Uranium Processing Facility received from the Utah Department of Environmental Quality (UDEQ), Division of Radiation Control (DRC) on August 29, 2007. Please find enclosed two hard copies of this submittal and a computer disc with the submittal in Adobe Acrobat (pdf) format.

Based on the UDEQ\DRC's interrogatories, Uranium One is revising fundamental aspects of the original design proposed by Plateau Resources Limited prior to Uranium One's acquisition of this license. Therefore, not all Interrogatories have been addressed in this submittal, only the Interrogatories for which Uranium One could provide a complete response have been addressed. Where possible, Uranium One has presented modified language for specific portions of the material documents. Uranium One proposes to respond to the August 29, 2007 interrogatories in a series of submittals as design issues and discrete interrogatory elements can be substantively addressed. Once revisions to the design are complete, Uranium One will submit complete copies of the revised documents with the revisions clearly identified. Interrogatories which request final design elements for equipment and processes will be addressed in a future submittal.

I certify under penalty of law that this document and all attachments were prepared under my direct supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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Should you have any questions, please contact me at (970) 231-1160.

Sincerely,
Uranium One

Toby Wright, PG
Environmental Manager

Enclosure

cc: Mill site
John Hultquist (UDEQ\DRC; w/out enclosure)
Rod Grebb, Tetra Tech
Melanie Davis, Tetra Tech
file

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INTERROGATORY R313-24-1(3)-02/02: SUMMARY OF REGULATORY REQUIREMENTS

INTERROGATORY STATEMENT:

Please provide the following revisions and clarifications in Section 2.0 of the Tailings Management Plan:

1. *Reference should be made to the sections in the plan (or other documents) that address the specific requirements presented in this section.*

   Response 1
   Section 2 of the Tailings Management Plan will be revised to provide the requested references in the next submittal as ongoing revisions to this document will slightly change the section references.

2. *Section 2.1.1 has a reference to 10 CFR 40 Appendix A, Criteria 1, which also needs to address sighting as it relates to isolation and minimizing disturbance and dispersion. This includes remoteness from populated areas, hydrologic and other natural conditions that contribute to immobilization and isolation of contamination from groundwater sources, potential for minimizing erosion, disturbance, and dispersion by natural forces. Uranium One stated in their response to this request in Round 1 that since the site exists and the impoundment structure is in place, that this information is not necessary. It is recognized that this is the case; however, a summary of how the site meets this criteria is still needed in the document. Reference can be made to supporting documents as appropriate.*

   Response 2
   Revised text for Section 2.1.1 of the Tailings Management Plan is proposed below. Requested references to specific sections in the TMP and TRDP will be inserted once current revisions to these documents have been completed:

   2.1.1 Utah DRC and NRC Regulations - Guiding Principles

   Permanent isolation of tailings (10 CFR 40 Appendix A, Criterion 1)

   The general goal or broad objective referenced in R313-24 and Criterion 1 of 10 CFR 40 Appendix A for siting and design decisions is the permanent isolation of 11e.(2) byproduct material by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance over a finite time frame (1,000 years to the extent reasonably achievable, and, in any case, for at least 200 years as per Criterion 6). The site features to be considered in achieving this objective include the site's remoteness from populated areas, hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources, and the potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term. The primary emphasis of this Criterion is on the long-term isolation of 11e.(2) byproduct material, which is a function of both site conditions and engineering design, and shall be accomplished in a manner that no active maintenance is required.

   The Shootaring Mill siting was approved by the NRC in the early 1980's in Garfield County, a remote portion of Southeastern Utah to which the region power grid had not yet and still has not reached. Siting criteria were evaluated prior to construction of the existing mill and tailings facility (Woodward-Clyde 1978a, 1978b, and 1978c). The 2006 Census indicates that Garfield County has an area of approximately 5,174 square miles and a population of 4,534, a decrease of approximately 200 people since the year 2000 (population 5,735). This represents and average population density of less than 0.9 persons per square mile or roughly 3 percent of the average population density for this largely rural Sate of 27.2 persons per square mile.

The small town of Ticaboo, located approximately 3 miles to the south of the mill, was originally developed as the company mine and mill town. Its population is currently less than 55 full time residents, though as workers for the mines and mill move to the town this population is anticipated to increase to approximately 500 to 600 persons, mostly supporting the mill and mine workers. The town includes a 70 room hotel which services tourism primarily associated with Lake Powell approximately 14 miles to the south. The nearest residence is located approximately 1.5 miles to the east of the site. The tourism to the area is highly seasonal with extended periods of reduced visitation in the late fall, winter and early spring. This area has remained relatively unpopulated and the increase in local population that is anticipated to occur is due primarily to workers and service providers servicing the local uranium mill and mining activities.

The mill tailings are sited in a local ephemeral drainage depression between sandstone mesas with a very small drainage catchment (<0.35 sq. mile) in one of the most arid areas of the State (an annual average of approximately 11 inches). The combination of these characteristics (a natural depression with low potential erosive energies, a small catchment area from which surface water erosive forces can accumulate, and an arid climate where probable maximum precipitation events are relatively small compared to other regions in the US and the State of Utah, provide an excellent environment for the immobilization and isolation of contaminants and for minimizing erosion, disturbance, and dispersion by natural forces over the long term.

Hydrogeologically, the mill and tailings site is located on Entrada Sandstone, principally a uniform fine grained sandstone of the San Rafael group that contains some thin layers of shale and siltstone units. The Entrada Sandstone, which hosts the uppermost unconfined aquifer in the region, overlies the Carmel Formation, which is a regional aquitard between the overlying Entrada Sandstone and the underlying Navajo Sandstone that consisting mainly of clay, shales and interbedded fine sandstones and is approximately 160 feet thick in the Mill area (Hydro-Engineering, 1998). Both the Entrada Sandstone aquifer and the Navajo Sandstone aquifer are Class IA aquifers of high water quality. The Navajo Sandstone aquifer is the regional aquifer used for drinking water. Though of high quality, the Entrada is not currently used for drinking water in or near the mill area.

Lower permeability (hydraulic conductivity) units within the Entrada Sandstone have been observed at the mill site that create locally perched ground water conditions above the regional water table in the Entrada Sandstone. Ground water monitoring and aquifer testing indicates that the horizontal permeabilities of the Entrada Sandstone range from approximately 0.08 feet per day (ft/day) to 0.21 ft/day while the lower permeability zones above the regional water table range from 0.02 ft/day to 0.18 ft/day. Hydraulic gradients in the Entrada Sandstone average approximately 0.011 ft/ft and average ground water flow is estimated to range from 0.02 ft/day (8 ft/yr) to 0.009 ft/day (3 ft/year) based on an effective porosity of 0.1 (Hydro-Engineering, 1998.) Therefore, any potential for future impacts to local ground water would be promptly detected first by the leak detection system in the engineered liner system that is above the secondary liner and, should both synthetic liners and the low permeability clay sub-liner not prove effective in containing leakage, constituents in the ground water would move so slowly that ground water impacts could be promptly detected and appropriate corrective action could be implemented such that drinking water standards and class of use would be maintained and contamination would not pass the points of compliance or property boundary. By virtue of it's previous license approval, NRC has determined that the combination of remoteness of the location, the physical environment and hydrogeologic environment affords the requisite reasonable assurance of protection of public health, safety and the environment through the immobilization and isolation of contamination from groundwater sources, minimizing potential erosion, disturbance, and dispersion by natural forces to support siting the mill in its current location. The application of best available technologies in this license application only increases this assurance of protection.

No ongoing maintenance (10 CFR 40 Appendix A, Criterion 1)

The erosion protection, cover and liner reclamation designs presented in the Tailings Reclamation and Decommissioning Plan (TRDP; Hydro-Engineering, 2005 and subsequent revisions) will meet all applicable standards and guidance (including US NRC, 2002 and UMTRA-DOE, 1989), and for long-term stabilization and isolation of the tailings and 11e.(2) byproduct material without relying on long-term maintenance in a manner consistent with the numerous Title I and Title II uranium mill tailings facilities already reclaimed, approved and transferred to the Federal Government for long-term stewardship. The tailings will be dewatered to mitigate seepage and tailings settlement. Cover surfaces have slopes designed to be stable under Probable Maximum Precipitation (PMP) flows and the reclaimed tailings surface will be covered with rock mulch or rock riprap to afford erosion protection. A low permeability clay cap and an overlying HDPE geomembrane will control infiltration. These are described in the Reclamation Plan dated December 2005 and subsequent revisions.

BASIS FOR INTERROGATORY:

Section 2 of the Tailings Management Plan appears to be a summary of the regulatory requirements and how the proposed tailings management will meet these regulations. This is a useful summary. However, to make section 2 complete, there needs to be additional clarifications. Uranium One did provide some of these clarifications in the response to Round 1 Interrogatory. However, additional information would be helpful as described the Interrogatory Statement above.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007.

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Processing Facility"

UMTRA-DOE, "Technical Approach Document, Revision II",UMTRA-DOE/AL 050425.0002, December 1989.

US NRC "Design of Erosion Protection for Long-Term Stabilization" NUREG-1623, September 2002.

Woodward-Clyde, 1978a. June 16, 1980 revision. Environmental Report, Shootaring Canyon

Uranium Project, Garfield County. Prepared for Plateau Resources Limited by Woodward-Clyde Consultants.

Woodward-Clyde, 1978b. June 1978. Supplement S1 Environmental Report, Shootaring Canyon

Uranium Project, Garfield County, Utah. Prepared for Plateau Resources Limited.

Woodward-Clyde, 1978c. September 1978. Supplement S2 Environmental Report, Shootaring

Canyon Uranium Project, Garfield County, Utah. Prepared for Plateau Resources Limited.

INTERROGATORY R313-24-1(3)-03/02: SHIPMENT PREPARATION

INTERROGATORY STATEMENT:
In addition to the Transportation Plan provided as Appendix A of the revised License Amendment Request, please provide a description of the substantive content of each procedure listed in Appendix A, Section 2.2. Moreover, please provide a general outline for these procedures.

Uranium One will develop SOPs for the following activities, prior to start-up of the facility:

- Packaging Yellow Cake for Transport
- Loading and Securing Methods for the Transport of Yellow Cake
- Guidelines for Motor Carriers
- Placarding Requirements for the Transportation of Yellow Cake
- Labeling and Marking Requirements for the Transportation of Yellow Cake
- Shipping Paper Requirements
- Transportation Oversight of Plateau Resources Subcontractors

The following summarizes the general content and outline of transportation SOPs to be implemented.

General Content and Outlines of transportation SOPs

a. <u>Packaging Yellow Cake for Transport</u>

Description

The SOP for packaging yellow cake for transport will consist of descriptions of the roles and responsibilities of personnel performing the packaging, employee training, appropriate container and internal liner selection, pre-packaging inspection, packaging precautions, methods for packaging the yellow cake, securing and leak proofing the drums, post-packaging inspection, temporary storage of unused and full containers, appropriate personal protective equipment, and health physics support.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for loading and securing packages, placarding, surface contamination and exposure rate monitoring, labeling and marking requirements, shipping paper requirements, and transportation oversight.

The outline of the SOP for packaging yellow cake will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to Packaging Yellowcake
3.0 Procedure
    3.1 Package Selection
    3.2 PPE
    3.3 Inspections
    3.3 Precautions
    3.4 Packaging Methods
    3.5 Placarding, marking, and labeling
    3.6 Temporary Storage

4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References
7.0 Distribution
8.0 Approval

b. Loading and Securing Methods for the Transport of Yellow Cake

Description

The SOP for loading and securing yellow cake for transport will consist of descriptions of the roles and responsibilities of personnel performing the loading and securing and employee training. Appropriate methods for transferring and securing containers to the transport vehicle will be addressed, including attendance, personnel clearance during movement, avoiding spillages and scattering, hand signals, speed of movement, pre-loading inspection, equipment, strapping, and cabling inspection, precautions, container placement, bracing requirements, and post-securing inspection; appropriate personal protective equipment, and health physics support.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging yellowcake, placarding, surface contamination and exposure rate monitoring, labeling and marking requirements, shipping paper requirements, and transportation oversight.

The outline of the SOP for loading and securing packages of yellow cake will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to Loading and Securing Yellowcake
3.0 Procedure
    3.1 PPE
    3.2 Inspections
    3.3 Precautions
    3.4 Loading and Securing Methods
4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References
7.0 Distribution
8.0 Approval

c. Guidelines for Motor Carriers

Description

The SOP comprising guidelines for motor carriers will consist of a brief summary of Federal Motor Carrier Safety Administration regulations published in 49 CFR Parts 300-399 to which transportation contractors for Uranium One shall adhere. The SOP will address regulations regarding noise emissions, adherence to State laws, routing, driver's licenses, controlled substances and alcohol use, operation of vehicle, inspections, hours of service, inspection, repair, maintenance, emergency response, and transportation of hazardous materials. Site-specific requirements, such as local and site speed limits, security, loading and unloading areas and protocols, substance abuse policy, smoking, and plant entry and egress will also be addressed.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging yellowcake, placarding, surface contamination monitoring, release surveys, labeling and marking requirements, shipping paper requirements, and oversight of transportation contractors.

The outline of the SOP for guidelines for motor carriers will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to Guidelines for Motor Carriers
3.0 Procedure
    3.1 Description of applicable requirements
    3.2 Transportation of hazardous materials
    3.3 Transportation routing
    3.4 Security
    3.5 Site-specific requirements
4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References
7.0 Distribution
8.0 Approval

d. <u>Placarding Requirements for the Transportation of Yellow Cake</u>

Description

The SOP for placarding requirements for the transportation of yellow cake will consist of descriptions of the roles and responsibilities of the personnel placarding vehicles, employee training, affixing placards, visibility and display, general placarding requirements, special placarding provisions for highway transport, and radioactive placards.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging, loading and securing packages, surface contamination monitoring, labeling and marking requirements, shipping paper requirements, guidelines for motor carriers, and transportation oversight.

The outline of the SOP for placarding shipments of packaged yellow cake will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to Packaging Yellowcake
3.0 Procedure
    3.1 Placard selection and numbering
    3.2 Placard affixing and display
    3.3 General requirements
4.0 Roles and Responsibilities
5.0 Employee Training

6.0 References
7.0 Distribution
8.0 Approval

e. <u>Labeling and Marking Requirements for the Transportation of Yellow Cake</u>

Description

The SOP for labeling and marking requirements will consist of descriptions of the roles and responsibilities of personnel performing the marking and labeling, employee training, PPE requirements, positions of markings in relation to other markings, legibility, indelibility, affixing marks, contrasting colors, and avoidance of obscuring markings.

Personnel will be instructed that low specific activity, exclusive use shipments are exempt from most labeling and marking requirements. Uranium One will label each 55-gallon drum as "Radioactive-LSA".

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging, loading and securing packages; placarding, surface contamination monitoring, guidelines for motor carriers, shipping paper requirements, and transportation oversight.

The outline of the SOP for labeling and marking requirements will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to marking and labeling
3.0 Procedure
  3.1 Exemptions for exclusive use shipments of LSA material
  3.2 PPE
  3.3 Marking and labeling procedure
  3.4 Precautions
4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References
7.0 Distribution
8.0 Approval

f. <u>Shipping Paper Requirements</u>

Description

The SOP for shipping paper requirements will consist of descriptions of the roles and responsibilities of personnel completing the shipping papers, employee training, quality control, where to find the most current 24-hour emergency response telephone number, classification of the load, shipper's certification statement, inclusion of the words "exclusive use-shipment", special instructions for exclusive use shipment controls for LSA material, placement of shipping papers in vehicle, and rejected shipments.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging, loading, and securing packages; placarding, labeling and marking requirements, guidelines for motor carriers, and transportation oversight.

The outline of the SOP for shipping paper requirements will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction
3.0 Procedure
    3.1 Selection of shipping papers
    3.2 Completing the shipping papers
    3.3 Quality control
    3.4 Carrying
    3.5 Rejected shipments
4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References
7.0 Distribution
8.0 Approval

g. <u>Transportation Oversight of Uranium One Subcontractors</u>

Description

The SOP comprising oversight of transportation contractors will consist of a brief summary of subcontractors' contractual obligations regarding safe and legal transport and emergency response, instructions on obtaining emergency response contacts and measures, recordkeeping requirements, results of alcohol and controlled substance tests, copies of driver's licenses and logs, accident records, background checks, and performing random or routine vehicle inspections.

References in the SOP will include relevant CFR citations and cross references to Uranium One SOPs for packaging yellowcake, placarding, surface contamination monitoring, release surveys (if applicable), labeling and marking requirements, shipping paper requirements, and guidelines for motor carriers.

The outline of the SOP for guidelines for oversight of transportation subcontractors will provisionally consist of:

1.0 Regulatory Basis
2.0 Introduction to Guidelines for Motor Carriers
3.0 Procedure
    3.1 Required certifications, licenses
    3.2 Accident records
    3.3 Controlled substances
    3.4 Background checks
    3.5 Inspections
4.0 Roles and Responsibilities
5.0 Employee Training
6.0 References

7.0 Distribution
8.0 Approval

Please address the following questions in connection with information presented in Appendix A or the License Amendment Request:

1. *Appendix A, Section 4: Please state the criteria Uranium One will use in specifying transportation routes to transportation contractors.*

Response 1
Revised Appendix A, Section 4 language is provided below.

4.0 Transportation Route

A transportation route is not provided in this plan. Uranium One will retain the flexibility of transporting the yellowcake to a temporary storage facility or one or more uranium refinement and/or enrichment facilities. Uranium One will instruct its transportation subcontractors of the intended route prior to each shipment.

Uranium One will specify, in writing, the following criteria regarding transportation routes to each of its contractors involved in the transportation of non-radioactive hazardous and radioactive materials.

In accordance with 49 CFR § 397.67, the contractor transporting non-radioactive hazardous materials (NRHM) will comply with NRHM routing designations of a State(s) or Indian tribe(s), pursuant to 49 CFR § 397 Subpart C.

Transportation contractors will operate over State, Tribal, and/or local preferred routes. The transportation contractor will operate the vehicle over routes which do not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys, except where the contractor determines that:

- There is no practicable alternative;
- A reasonable deviation is necessary to reach terminals, points of loading and unloading, facilities for food, fuel, repairs, rest, or a safe haven;

or

- A reasonable deviation is required by emergency conditions, such as a detour that has been established by a highway authority, or a situation exists where a law enforcement official requires the driver to take an alternative route.

Operating convenience is not a basis for determining whether it is practicable to operate a motor vehicle in accordance with 49 CFR § 397.67 (b).

In accordance with 49 CFR § 397.101, motor carriers operating a placarded motor vehicle that contains a Class 7 (radioactive) material will

- Ensure that the motor vehicle is operated on routes that minimize radiological risk.
- Consider available information on accident rates, transit time, population density and activities, and the time of day and the day of week during which transportation will occur to determine the level of radiological risk; and
- The transportation contractor will tell the driver which route to take and that the motor vehicle contains Class 7 (radioactive) materials.

The truck transporting yellow cake may be operated over a route other than a preferred route only when the deviation from the preferred route is for necessary rests, fuel or motor vehicle repair stops, or because emergency conditions make continued use of the preferred route unsafe or impossible;

For pickup and delivery not over preferred routes, the route selected must be the shortest-distance route from the pickup location to the nearest preferred route entry location, and the shortest-distance route to the delivery location from the nearest preferred route exit location.

The transportation contractor may authorize a deviation from the shortest-distance pickup or delivery route if it is based upon the criteria described above that pertain to the minimization of radiological risk; and does not exceed the shortest-distance pickup or delivery route by more than 25 miles and does not exceed 5 times the length of the shortest-distance pickup or delivery route.

Deviations from preferred routes, or pickup or delivery routes other than preferred routes, which are necessary for rest, fuel, or motor vehicle repair stops or because of emergency conditions, will also be made in accordance with the criteria described above that pertain to the minimization of radiological risk, unless emergency conditions preclude the application of those criteria.

2. Appendix A, Section 5.1, Uranium One Responsibilities: Explain how Uranium One will determine whether emergency response plans provided by the Transportation Contractors will be adequate.

Response 2
Revised Appendix A, Section 5.1 language is proposed below.

5.1 Division of Responsibilities between URANIUM ONE and Transportation Contractors

There is a division in responsibilities of URANIUM ONE and its transportation contractors:

Uranium One will:

- Package and label drums of yellowcake in accordance with relevant regulations.
- Load drums onto tractor trailers.

- Perform radiological surveys of each drums and departing tractor-trailer for DOT-compliance.
- Provide emergency response information, such as Material Safety Data Sheets (MSDS), to the transportation contractor.
- Prepare shipping manifests.

The transportation contractor will:

- Placard each of its tractor-trailers in accordance with relevant regulations
- Ensure an emergency response plan appropriate for the shipment is in the possession of the driver
- Provide qualified drivers
- Secure drums on each tractor-trailer
- Be responsible for the security of the shipment during transport
- Be responsible for emergency response.

Uranium One will require its transportation contractors to submit their emergency response plans prior to any shipments of yellow cake. Transportation Contractors will also be contractually obligated to provide emergency plans that meet or exceed Uranium One's plan. The elements of an adequate emergency response plan will be, at a minimum:

- A 24-hour emergency response telephone number
- Emergency roles and responsibilities
- Basic description of yellowcake as required by 49 CFR 172.202
- Immediate health hazards
- Risk of fire or explosion
- Precautions to be taken in the event of an accident
- Methods for handling fires
- Methods for handling spills or leaks
- First aid measures
- Notification requirements
- 49 CFR citations
- Annual review, plan updates, and approvals

Transportation contractors will also be required to carry a copy of the DOT's Emergency Response Guidebook during yellowcake transport. Uranium One will evaluate the transportation contractor's plans and their ability to comply with these plans through assessment of the company's internal capabilities and experience.

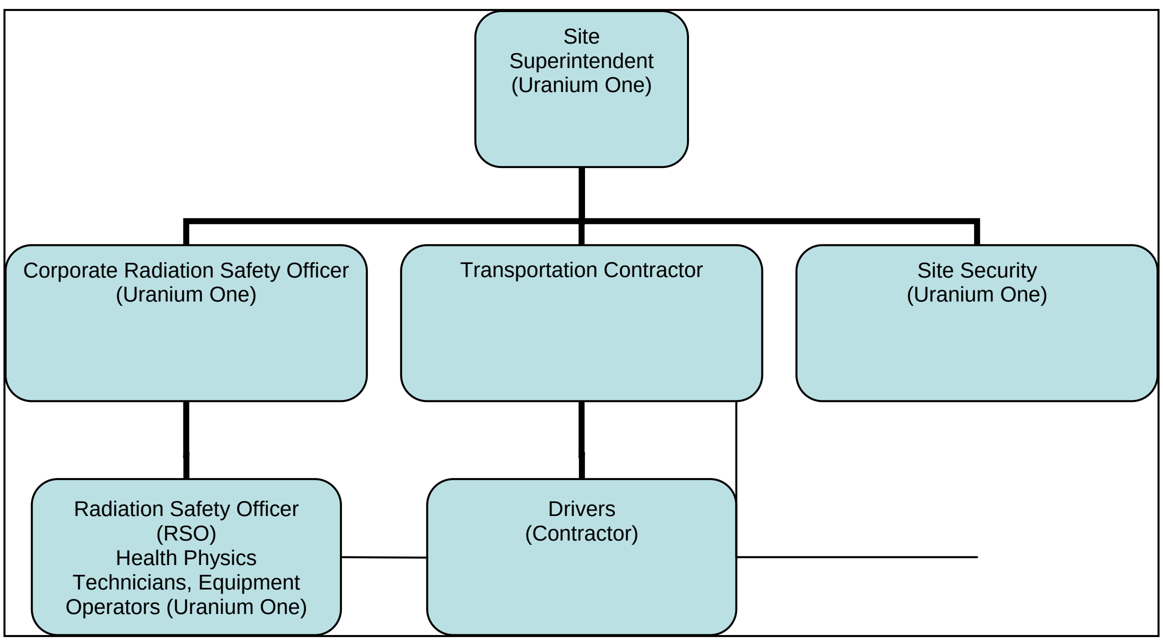
3. *Appendix A, Section 5.2: Provide an organization chart that shows relationships among the positions identified in the Transportation Plan.*

Response 3
Revised Appendix A, Section 5.2 language is proposed below.

5.2 Roles within Uranium One

The Site Superintendent is responsible for implementing this plan. Major tasks related to demonstrating compliance with the regulations will be managed by the Corporate Radiation Safety Officer (RSO). The site RSO, Health Physics Technicians and equipment operators will execute Uranium One's roles in the Transportation Plan in accordance with applicable SOPs, State and Federal regulations. These site personnel will report directly to the Site Superintendent and the Corporate RSO.

The following is the Transportation Plan organization chart. Roles not identified in Section 5.2 of the Transportation Plan, but identified in the chart are: Transportation Contractor, Drivers, Site Security, Health Physics Technicians, and Equipment Operators.



4. *Appendix A, Section 6: State the 49 CFR regulatory requirements that will apply to material packaging and that Uranium One will ensure are satisfied by implementation of future procedures.*

Response 4
Revised Appendix A, Section 6 language is proposed below.

6.0 Transportation Requirements

This section addresses applicable DOT materials classes and shipping, packaging, marking and labeling, placarding, employee training, accident reporting, and transporting requirements.

Offsite transport of Low Specific Activity (LSA) materials is addressed under 10 CFR § 71.5(a), which directs compliance to the DOT regulations, published in 49 CFR Parts 170 through 189. 49 CFR § 173.427 describes requirements to transport LSA-I, Class 7, materials. The yellow cake will be transported in 55-gallon steel drums as DOT Radioactive Material Hazard Class 7, Normal Form, exclusive use, LSA-I materials.

Yellowcake will be transported from the mill using a tractor-trailer or equivalent. The transportation vehicle will be operated in compliance with the FMCSR. The FMCSR also provides the standards for safe means of transportation in commerce. Complying with the FMCSR will ensure safe transportation conditions.

Uranium One's transportation contractor(s) will secure the drums to the tractor-trailer in accordance with the FMCSR Subpart I, *Protection against Shifting and Falling Cargo.*

There are no conveyance activity limits for LSA material, according to Table 9 in 49 CFR § 173.427 (f). Uranium One will implement the following requirements for strong tight, exclusive use containers on a flat-bed tractor-trailer:

- Render the levels of radioactive contamination on external surfaces ALARA;
- Achieve external dose rates less than 200 millirem per hour (mrem/hr) at any point on the outer lateral surfaces of the package (49 CFR § 173.441);
- Achieve unshielded external dose rates less than 1000 millirem per hour (mrem/hr) at any point 3 meters from packages (49 CFR § 173.427);
- Achieve external dose rates less than 200 mrem/hr on vertical planes projected from outer edges of the tractor-trailer and the top of the load (49 CFR § 173.441);
- Achieve an external dose rate less than 10 mrem/hr at points 2 meters from vertical planes extending from the tractor-trailer (49 CFR § 173.441);
- Achieve external dose rates less than 2 mrem/hr in any normally occupied space (the cab) (49 CFR § 173.441);
- Achieve an external dose rate less than 200 mrem/hr on the underside of

the tractor-trailer (49 CFR § 173.441);

- Brace packages to prevent shifts of lading under normal transport conditions;
- Achieve activities of beta, gamma, and low-toxicity alpha emitters in representative 300-cm^2 swipe samples collected from the external surface of the package less than $1*10^{-4}$ microcuries per square centimeter ($\mu Ci/cm^2$) (equivalent to 220 dpm/cm^2) before transport and 10 times this value during transport (49 CFR §173.443); and
- Achieve activities of all other alpha emitters in representative 300-cm^2 swipe samples collected from the external surface of the package less than $1*10^{-5}$ $\mu Ci/cm^2$ (equivalent to 22 dpm/cm^2) before transport and 10 times this value during transport (49 CFR § 173.443).

Uranium One will meet the following packaging requirements for outgoing drums:

- Container integrity will not be reduced by the range of temperatures to which it will be subjected;
- Container integrity will not be reduced by mixing internal gases or vapors;
- The container will be compatible with its contents in terms of corrosivity, permeability, softening, premature aging, and embrittlement;
- The container and its contents will not react chemically or galvanically;
- The plastic liner in the container will be compatible with the yellowcake and will not be permeable to an extent that a hazardous condition is likely to occur during transportation and handling;
- The closed container will be secure and leak proof; that is, identifiable releases to the environment will not occur;
- The container will be easy to handle and secure on tractor-trailers and railroad cars during transport;
- Each lifting attachment that is a structural part of the container will be designed with a minimum safety factor of three against yielding when used to lift the container in the intended manner;
- There will be no other structural parts of the container that could be used to lift the container;
- The external surface will be free of protruding features, pockets, or crevices;
- No features will be added to the containers;
- The container will withstand normal transport ranges of acceleration, vibration, or vibration resonance;
- There will be no valves through which container contents could escape; and
- The exterior surfaces of the containers will be clean.

The first six bullet points address the applicable requirements of 49 CFR § 173.24 (General Requirements for Packaging and Packages); the others address the requirements of 49 CFR § 173.410 (General Design Requirements).

Uranium One will ensure that the following 49 CFR regulatory requirements that apply to material packaging will be satisfied by implementation of future procedures:

- 49 CFR § 173.3 Packaging and exceptions
- 49 CFR § 173.24, General Requirements for Packaging and Packages
- 49 CFR § 173.24a, Additional general Requirements for non-bulk packaging and Packages
- 49 CFR § 173.25, Authorized packagings and overpacks
- 49 CFR § 173.26, Quantity limitations
- 49 CFR § 173.28, Reuse, reconditioning and remanufacture of packagings
- 49 CFR § 173.29, Empty packaging
- 49 CFR § 173.30, Loading and unloading of transport vehicles
- 49 CFR § 173.410, General Design Requirements
- 49 CFR §173.421, Excepted packages for limited quantities of Class 7 (radioactive) materials.
- 49 CFR §173.422, Additional requirements for excepted packages containing Class 7 (radioactive) materials.
- 49 CFR §173.425, Table of activity limits--excepted quantities and articles.
- 49 CFR §173.426, Excepted packages for articles containing natural uranium or thorium
- 49 CFR § 173.427, Transport requirements for low specific activity (LSA) Class 7 (radioactive) materials and surface contaminated objects (SCO).
- 49 CFR § 173.428, Empty Class 7 (radioactive) materials packaging.
- 49 CFR § 173.431, Activity limits for Type A and Type B packages.
- 49 CFR § 173.433, Requirements for determining basic radionuclide values, and for the listing of radionuclides on shipping papers and labels.
- 49 CFR § 173.434, Activity-mass relationships for uranium and natural thorium.
- 49 CFR § 173.435, Table of A1 and A2 values for radionuclides.
- 49 CFR § 173.436, Exempt material activity concentrations and exempt consignment activity limits for radionuclides.
- 49 CFR § 173.441, Radiation level limitations and exclusive use provisions.
- 49 CFR § 173.443, Contamination control.

- 49 CFR § 173.447, Storage incident to transportation--general requirements.
- 49 CFR § 173.448, General transportation requirements.
- 49 CFR § 173.474, Quality control for construction of packaging.
- 49 CFR § 173.475, Quality control requirements prior to each shipment of Class 7 (radioactive) materials.

5. *Appendix A, Section 6.2: State the 49 CFR regulatory requirements that will apply to Making and labeling and that Uranium One will ensure are satisfied by implementation of future procedures.*

Response 5
Revised Appendix A, Section 6.2 language is proposed below.

6.2 Marking and Labeling

LSA, exclusive use shipments are exempt from most labeling and marking requirements. URANIUM ONE will label each 55-gallon drum as “Radioactive-LSA” and its contents.

The markings will be durable, legible, in English, and printed on or firmly affixed to the package. The markings will be displayed on a background of a sharply contrasting color. Markings will be located away from other markings, such as advertising, that could substantially reduce the noticeability of the marking. Markings will not be covered or obscured by labels or attachments.

Uranium One will ensure that the following 49 CFR regulatory requirements that apply to marking and labeling will be satisfied by implementation of future procedures:

- 49 CFR §172.300, Applicability.
- 49 CFR §172.301, General marking requirements for non-bulk packagings.
- 49 CFR §172.302, General marking requirements for bulk packagings.
- 49 CFR §172.303, Prohibited marking.
- 49 CFR §172.304, Marking requirements.
- 49 CFR §172.308, Authorized abbreviations.
- 49 CFR §172.310, Class 7 (radioactive) materials.
- 49 CFR§172.324, Hazardous substances in non-bulk packagings.
- 49 CFR §172.332, Identification number markings.
- 49 CFR §172.334, Identification numbers; prohibited display.
- 49 CFR §172.336, Identification numbers; special provisions.
- 49 CFR §172.338, Replacement of identification numbers.

- 49 CFR §172.400, General labeling requirements.
- 49 CFR §172.400a, Exceptions from labeling.
- 49 CFR §172.401, Prohibited labeling.
- 49 CFR §172.402, Additional labeling requirements.
- 49 CFR §172.403, Class 7 (radioactive) material.
- 49 CFR §172.406, Placement of labels.
- 49 CFR §172.407, Label specifications.

6. *Appendix A, Section 6.3: State the 49 CFR regulatory requirements that will apply to shipping papers and that Uranium One will ensure are satisfied by implementation of future procedures.*

Response 6
Revised Appendix A, Section 6.3 language is proposed below.

6.3 Shipping Papers

Uranium One will complete the shipping papers for each shipment, including the following entries:

- The basic description, in sequence: proper shipping name, Hazard Class (7), U.N. Identification No (UN2912)
- Proper page numbering (e.g., Page 1 of 4)
- 24-hour emergency response telephone number (not an answering machine)
- The total quantity of the material described in appropriate units
- The number and type of packages
- The name of each radionuclide and activity in SI units
- A description of the chemical and physical form
- Shipper’s certification statement, worded exactly as described in 49 CFR § 172.204(a), and signature
- The words “Exclusive Use-Shipment”

Special instructions for exclusive use shipment controls for LSA material will also be included with the shipping papers.

The yellowcake will be shipped on public highways. Thus, a shipping paper will be within the driver's immediate reach while he/she is restrained by the lap belt and either readily visible to a person entering the driver's compartment (that is, NOT in the glove compartment)or in a holder mounted to the inside of the door on the driver's side of the vehicle.

Rejection of a shipment may imply that it is not compliant with transport regulations; that is, it could potentially endanger public health and safety. Thus, the receiving facility will identify non-compliant shipments prior to their return to the Shootaring mill.

Uranium One will ensure that the following 49 CFR regulatory requirements that apply to shipping papers will be satisfied by implementation of future procedures:

- 49CFR §172.200, Applicability.
- 49CFR §172.201, Preparation and retention of shipping papers.
- 49CFR §172.202, Description of hazardous material on shipping papers.
- 49CFR §172.203, Additional description requirements.
- 49CFR §172.204, Shipper's certification.
- 49CFR §172.205, Hazardous waste manifest.

7. *Appendix A, New Section: State the 49 CFR regulatory requirements that will apply to accident reporting and that Uranium One will ensure are satisfied by implementation of future procedures. Commit to developing procedures that address accident reporting.*

Response 7
New text for a new section of Appendix A (Section 7.4-Accident Reporting) is proposed below.

7.4 Accident Reporting

Uranium One commits to future development of procedures for accident reporting. Uranium One will ensure that the following 49 CFR regulatory requirements that apply to accident reporting will be satisfied by implementation of future procedures:

- 49 CFR § 390.5, Definitions.
- 49 CFR § 390.15, Assistance in investigations and special studies.
- 49 CFR §171.15, Immediate notice of certain hazardous materials incidents.
- 49 CFR §171.16, Detailed hazardous materials incident reports.

The following regulations may also apply to accident reporting:

- 40 CFR § 171.21, Assistance in investigations and special studies.
- 40 CFR § 263.30, Immediate action.
- 40 CFR § 263.31, Discharge clean up.
- 40 CFR § 302.5, Determination of reportable quantities.
- 40 CFR § 302.6, Notification requirements.

8. *Appendix A, Section 7.2: State the 49 CFR regulatory requirements that will apply to Employee training and that Uranium One will ensure are satisfied by implementation of future procedures.*

Response 8
Revised Appendix A, Section 7.2 language is proposed below.

7.2 Employee Training

Uranium One will train its employees at least once every two years, to ensure that they can recognize and identify hazardous materials, know how to respond in an emergency situation; and know self-protection measures and accident prevention methods.

Uranium One will ensure that transportation contractors comply with employee training requirements listed in 49 CFR as noted in future procedures. Specific requirements include those noted in:

- 49 CFR § 177.816, Driver training.
- 49 CFR §172.700, Purpose and scope.
- 49 CFR §172.701, Federal-State relationship.
- 49 CFR §172.702, Applicability and responsibility for training and testing.
- 49 CFR §172.704, Training requirements.
- 49 CFR §180, Special Training requirements.

The following regulation also will apply to employee training:

- 29 CFR § 1910.120, Hazardous waste operations and emergency response

BASIS FOR INTERROGATORY:
Although the Division is agreeable to the proposal to provide actual implementing procedures in the future, prior to commencing yellowcake production, we must have a better idea of the substance of these procedures. Appendix A of the License Amendment Request is a good overview of topics to be addressed in the Transportation Plan but is incomplete when compared to the regulatory requirements of URCR R313-24-1(3) and R313-19-100(3).

In addition to the information requested above, the Division will include a license condition requiring that implementing procedures be developed and submitted for Division's review and approval prior to yellowcake production.

REFERENCES
Plateau Resources, Ltd., "Transportation Plan for Plateau Resources," Appendix A of PRL License Amendment Request (New License Application Final.pdf), file dated 12/20/06.

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

INTERROGATORY R313-24-4-05/02: DAILY INSPECTIONS OF WASTE TAILINGS

INTERROGATORY STATEMENT:

Please provide the SOP or include a section in the TMP that details documentation of daily inspections of the tailings and waste retention system. Ensure that this information includes a commitment to notify the Executive Secretary of any failure of any system that could result in a release of tailings or waste unto unrestricted areas or of any unusual conditions that, if not corrected, might lead to a failure of the system.

Ensure that the SOP addresses inspections to be performed to include, but not be limited to:

- *Decant systems*
- *Effluent from under drain pipes*
- *Pond water elevation*
- *Slurry transport system inspection*
- *Retention dam inspection*
- *Diversion and storm water channel inspection*
- *Embankment Settlement*
- *Embankment Slope Conditions*
- *Seepage*
- *Slope Protection*
- *Emergency Discharge Facility*
- *Safety and Performance Instrumentation*
- *Operation and Maintenance Features*
- *Postconstruction Changes*
- *Inspections following significant earthquakes, tornadoes, floods, intense rainfalls, or other unusual events.*
- *Groundwater Monitoring systems*
- *Tailings piles*

Ensure that the SOP specifies that the following information will be included in the annual BAT Report for the facility:

- *Completed inspection reports*
- *Engineering data compilation*
- *General project data*
- *As-built drawings and photographs*
- *Hydrologic and hydraulic data*
- *Test results*
- *Applicable correspondence*
- *Names of the inspector and responsible supervisor*

Revise the inspection plan to explicitly describe conditions under which the Executive Secretary will be notified.

Please provide Form AP-3C that is cited but not provided in SOP AP-3 Section 7.

Response 1

A revised SOP AP-3, incorporating the interrogatory comments, has been developed and is submitted with these responses as Attachment A. In addition, reporting requirements are summarized in AP-3 and reference to SOP AP-4 in which the explicit and specific conditions under which the Secretary will be notified are made. The reference to form AP-3C has been replaced with reference to form AP-3A.

BASIS FOR INTERROGATORY:

Section 5.4 of the Tailings Management Plan (TMP) states that a revised SOP for the Tailings Dam and Facilities Inspection Program will be developed to address the tailings dam inspection program. The Division requires that an applicant for a groundwater discharge permit must include methods and procedures for inspections of the facility operations and for detecting failure of the system. The procedures must address written documentation of daily inspections and immediate notification of potential breaches to waste retention systems.

SOP AP-3 Section 7.4 references Form AP-3C to document unusual conditions, but this form is not provided.

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended April 2007.

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

NRC. Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Washington DC. NRC December 1977.

NRC. Regulatory Guide 3.11.1, "Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mills." Washington DC. NRC October 1980.

INTERROGATORY R313-24-4-06/02: MAINTAINING RECORDS

INTERROGATORY STATEMENT:

Please address the following questions regarding the new Standard Operating Procedure HP-25:

1. *Please provide the Uranium One form that will be used in connection with Section 7.3, "Document and Verify the Amount of Tailings Placed in Tailings Facility." Ensure that the tasks identified in this section describe how a technician will determine the quantity of tailings that any sample represents and the quantity of tailings actually added to the Tailings Facility.*

   Response 1

   The form U1 25-4 has been provided as requested in Appendix A to HP-25, which is included as Attachment B. Additional detail have been added to the SOP regarding the specific tasks that describe how a technician will determine the quantity of tailings that any sample represents and the quantity of tailings actually added to the Tailings Facility.

2. *Include Uranium One Form 25-4 in the list presented in Section 9.*

   Response 2

   The form 25-4 has been provided as requested.

3. *Describe the transfer of records that Uranium One will ensure occurs should the license be transferred to a new licensee.*

   Response 3

   SOP HP-25, Section 9 has been revised to include description of how records will be transferred.

BASIS FOR INTERROGATORY:

Although the SOP HP-25 provides an excellent description of the activities that will be taken to ensure that records accurately reflect the tracking and balance of radioactive materials, it lacks the details identified in the interrogatory statement.

REFERENCES:

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December 2005.

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December 2005.

INTERROGATORY R313-24-4-07/02: NOTIFICATION REQUIREMENTS

INTERROGATORY STATEMENT:

Please specify in SOP AP-4 that immediate notification means notification within four hours.
Please revise the procedure to clearly address constructed and engineered systems, in addition to mechanical equipment.

Response 1

The SOP has been revised as requested and is included for review with this submittal as Attachment C.

BASIS FOR INTERROGATORY:

The term "immediately" is defined in the regulations as occurring within four (4) hours.
While the above regulation speaks of "equipment," its scope, in connection with other regulations, includes mechanical equipment and other constructed and/or engineered systems.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended April, 2007.

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

NRC. Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Washington DC. NRC December 1977.

NRC. Regulatory Guide 3.11.1, "Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mills." Washington DC. NRC October 1980.

INTERROGATORY R313-24-4-12/02: SOIL FINAL STATUS SURVEY FOR SITE DECOMMISSIONING

INTERROGATORY STATEMENT:

Please revise the Tailings Reclamation and Decommissioning Plan (TRDP) to include currently projected MARSSIM classifications for surface soils outside of the tailings area at the Shootaring Canyon facility. Please identify possible MARSSIM classifications for surface areas across the property under control of Plateau Resources, Ltd.

Please revise Section 3 of the TRDP to state which areas have been, or may be, classified as MARSSIM Class 1, 2, and 3 areas and include maps in Section 3 to identify and delineate these areas. Please provide clear definition of "known" Class 1 and 2 areas that presently exist.

Response 1

Proposed text changes to Sections 3 and 8 of the TRDP are presented below to address the items of this interrogatory.

Figure 8-1 has been developed in response to the interrogatory. Proposed text and figure changes are presented below.

3.14 Post-Operation Survey and Cleanup

After processing of uranium is discontinued in the mill, a gamma survey and Ra-226 and Th-230 sampling program will be undertaken to identify additional areas where cleanup is necessary. This program will be similar in scope, scale and implementation to the program that was instituted in 2002. The area of sampling and survey will be expanded as necessary to include areas potentially contacted by ore, tailings, solutions or other contaminated materials. The existing soil contamination outside of the tailings disposal and ore storage areas is limited to small areas adjacent to mill building, CCD Area, and maintenance shop as discussed in previous sections. These currently would be classified as MARSSIM Class 1 areas. At the time of decommissioning, the Class 1 area is anticipated to be much larger, encompassing most of the mill yard, ore storage area, and other areas affected by operations. These areas, along with Class 2 and Class 3 areas are projected to cover most of the site outside the disposal cell as shown in Figure 8-1.

8.0 MILL DECOMMISSIONING AND SITE CLEANUP

8.4 Contaminated Soil Cleanup

Section 3 presents the results of a recent radiological characterization survey that shows areas of the site where soil contamination exists. The survey shows that soil contamination is limited to areas of known spills and the ore storage area. The exact boundaries of the areas cannot be defined at this time since most of the areas were influence by gamma shine from nearby building components, ore piles, or tailings. The affected areas will be remediated using more sensitive survey equipment to assure compliance with the cleanup criteria. In order to assure that the extent of the area has been defined, a 10-meter buffer area (considered Class II and Class III in MARSSIM terminology) contiguous to each contaminated area will be evaluated for potential contamination. The buffer zone for the ore storage area will be 20-meters wide. The site cleanup criteria and procedures are presented in the following subsections.

In general, a “MARSSIM type” approach will be used for verification surveys (final status surveys) using the Data Quality Objectives (DQOs) established in the Quality Assurance Project Plan (QAPP) included in Appendix L. Class I survey units will be defined as the footprint of the affected areas established from process knowledge coupled with characterization surveys. The grid size and sample number for the MARSSIM area will be dependent on mill related contaminant variability estimates obtained from characterization surveys and remedial action support surveys. Compliance with cleanup criteria will be evaluated by comparing the mean mill related radionuclide soil concentration within the Class I survey unit to the appropriate cleanup criteria in Section 8.4.1. These data will be supplemented by field surveys employing gamma and/or gross alpha measurements in soils to demonstrate that the mill related radionuclide spatial distribution within the Class I survey unit area is homogenous. Any hot spots (areas above cleanup criteria for a 100 m2 area) requiring further remediation will have been identified prior to performing the final status survey.

Figure 8-1 shows probable MARSSIM Class areas for the site at the end of the operating period. It is reasonable to assume that soils within the mill yard, the ore storage area, and the ore pad sediment pond will have residual contamination approaching or exceeding the cleanup criteria and therefore these areas are shown as Class 1. Class 2 areas include roadways and areas adjacent to the Class 1 areas that are expected to contain residual material but may not exceed the cleanup criteria. The Class 3 areas shown in Figure 8-1 will require some investigation but are not expected to be contaminated. These areas will require further investigation.

BASIS FOR INTERROGATORY:

The Round 1 Interrogatory response from Uranium One stated the following: “Soil area classification has been done for the known impacted areas (Class 1) and a buffer zone surrounding these areas (Class 2). The remainder of the site is assumed to be a Class 3. This is based on existing site conditions and process knowledge. Future mill use may require reclassification of certain areas. Contamination maps for Class 3 areas are provided in Section 3 of the Decommissioning Plan.”

Section 3 of the TRDP does not state which areas have been, or may be, classified as Class 1, 2, and 3 areas and the maps in Section 3 do not show these areas. It would be helpful to provide clear definition of “known” Class 1 and 2 areas to describe current conditions and modify Section 3 where appropriate to refer to Section 8.4 for additional description of protocol for cleanup and survey classification determinations.

REFERENCES:

Abelquist, E. W. 2002. “Decommissioning Health Physics: A Handbook for MARSSIM Users,” ISBN 0750307617.

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, Rev. 1, Appendix D.

Pacific Northwest National Laboratory 2006b. Visual Sample Plan Version 4.4. Available at http://dqo.pnl.gov/

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

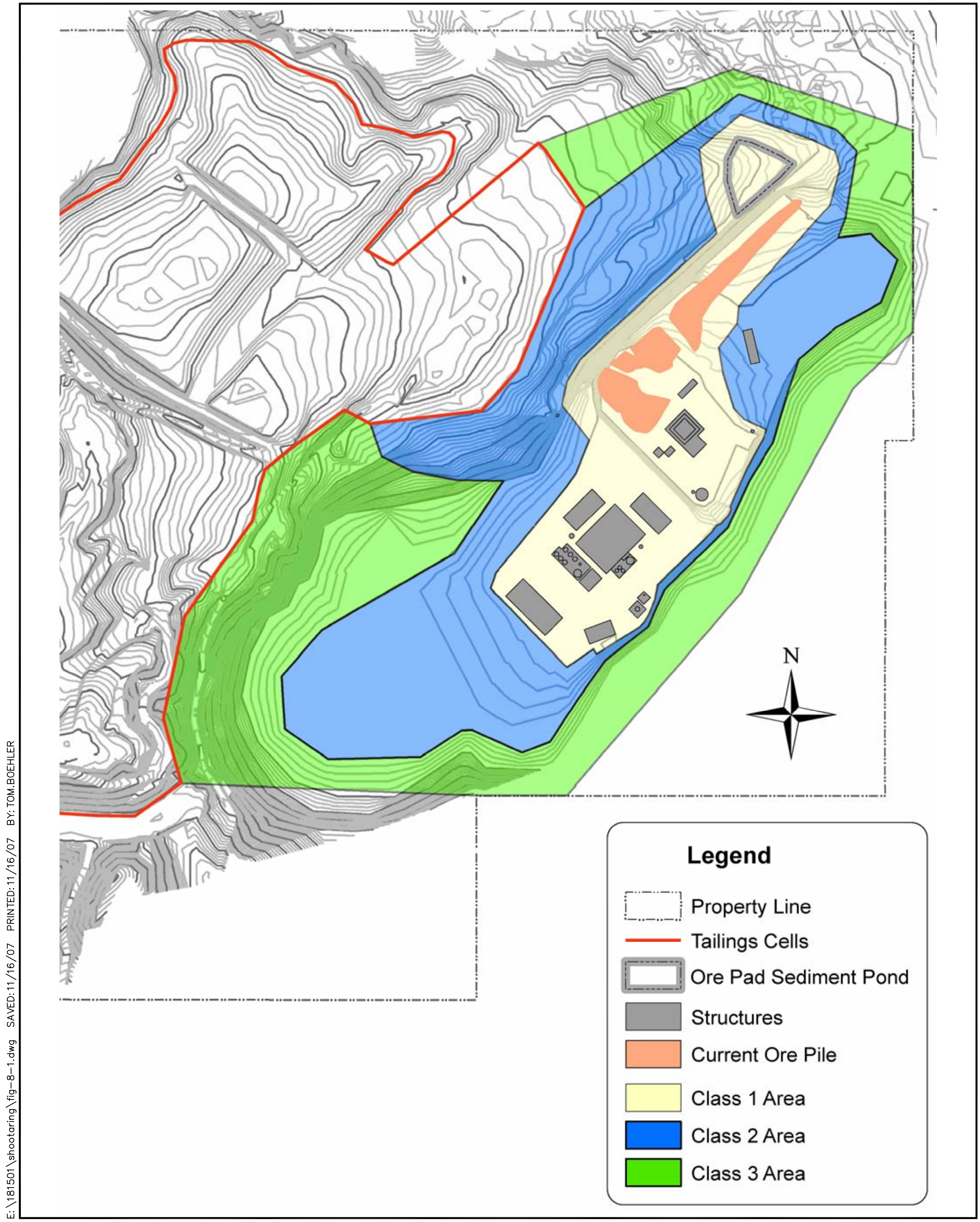


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Figure 8-1
Post-Operations MARSSIM Class Areas

INTERROGATORY R313-24-1-14/02: MILLING OPERATIONS

INTERROGATORY STATEMENT:

In order to understand the handling and processing of the waste tailings and slurry, please provide the following information:

1. *A complete material/production flow diagram that including estimated production and material feed rates and the properties of the solids and liquids generated, starting at the ore pile and ending up in the tailings pile, and evaporation pond. The diagram should include the proposed locations and layout of the liquid extraction equipment, tailing placement equipment, secondary containment components, and transfer piping. Include descriptions of each piece of equipment, component, and process.*

   Response 1a

   The response will be provided in our next submittal.

2. *The SOP for tailings dewatering (or liquid extraction) and placement based on the planned alternative dewatering (or liquid extraction) and placement methods. If Uranium One expects to operate the liquid extraction system without further regulatory review, the SOP should address tailings placement and contingency plans when the liquid extraction system is out of service.*

   Response 2a

   In revision to Plateau Resources Limited's (PRL) previous submittals, Uranium One now proposes to discharge the tailings into the impoundment solely as a conventional slurry with approximately 50 percent solids. The Tailings Management Plan will be updated to reflect this approach. As with conventional slurry deposition, tailings will be spigoted from various points within the impoundment forming a tailings liquid pool in some area of the impoundment. Tailings dewatering during operations and reclamation will occur through liquid collection from the blanket drain as a result of maintaining no more than maximum prescribed head on the primary HDPE liner (one foot) and evaporation from the tailings pool surface and in the evaporation pond (EPPC). A detailed SOP will be provided in the next submittal.

3. *Explanation and justification that no adverse effects on tailings stability are expected with respect to the tailings already in the cell and the use of best available technology for groundwater protection. Please discuss effects if the tailings segregate and identify impacts on operations. Demonstrate through analyses that the environment (with emphasis on groundwater) will be appropriately protected.*

   Response 3a

   The existing tailings will be excavated and placed within the new impoundment prior to discharge of new tailings from the mill. The combined tailings will have similar properties to the new tailings. The existing tailings will therefore have no more significant impact on stability or groundwater protection than the new tailings.

4. *Demonstrate the compatibility of flexible membrane liner material with the "highly acidic process solutions" that will be held in the tailings impoundment.*

Response 4a
Section 5.1.3.2 of the Tailings Management Plan (2007) includes discussion of the chemical resistance of the HDPE to acidic process solutions. The proposed revised text for Section 5.1.3.2 is as follows:

5.1.3.2 HDPE Liner, Geonet, and Piping Material

The liners, geonet, and piping will be comprised of HDPE. The general specifications for the HDPE materials are included in Appendix C. In addition to the structural and strength related specifications, specifications related to UV and environmental stability, as well as chemical resistance of the HDPE are included. Many sources of chemical resistance data were consulted for the purposes of anticipating possible degradation of the liner system. Based on the review of available data, no measurable chemical degradation of the HDPE materials is expected. The identified process stream constituents that were evaluated as potentially detrimental to the liner include: sulfuric acid, sodium chlorate, and kerosene. Other constituents such as flocculants, sodium hydroxide, ammonia, tridecanol, tertiary amine, or sodium bicarbonate may be added or otherwise introduced to the process stream and eventually discharged to the tailings, but not at concentrations, that are considered significant. The UV stability is related to carbon black content specifications in Appendix C.

The acidification of the process stream is considered the primary chemical alteration that has the potential to affect the liner. The estimated free acid (sulfuric) concentration in the discharge to the tailings is 5 g/liter or approximately 5%. All available chemical resistance information indicates that this concentration is not damaging to HDPE and that acid concentrations can be dramatically greater than 5% without damaging the liner. Poly-flex Chemical Resistance Tables (Poly-Flex, 2005) lists non-oxidizing acids as having little or no effect on an HDPE liner. Table 5.8 in Koerner (2005) lists HDPE as having “generally good resistance” to inorganic acids at temperatures ranging from 38 to 70 degrees Celsius. ISCO Industries (2007) lists HDPE as having “satisfactory” chemical resistance to sulfuric acid for concentrations less than 50 percent at temperatures ranging from 21 to 60 degrees Celsius. Zeus Industrial Products, Inc. (2007) lists HDPE as chemically resistant to sulfuric acid for concentrations less than 50 percent at temperatures ranging from 20 to 60 degrees Celsius. Advanced Drainage Systems, Inc. (2007) lists HDPE as chemically resistant to sulfuric acid for concentrations less than 50 percent at temperatures ranging from 20 to 60 degrees Celsius.

There are many sources that document studies supporting the position that the proposed flexible HDPE geomembrane liner material is compatible with acidic process solutions. Numerous studies that have been conducted on the effect of various solutions on geomembranes primarily associated with municipal and industrial landfills. There are limited studies that have been conducted to evaluate the effect of mine waste leachates on geomembranes. Two of these studies are discussed below.

Mitchell (1985) performed geomembrane chemical compatibility tests with simulated uranium mill process solution for three types of geomembranes, HDPE, CSPE, and PVC. The simulated solution consisted primarily of water and sulfuric acid at pH values ranging from 1.5 to 2.5. The HDPE geomembrane samples used for the testing consisted of a section of 40 mil HDPE geomembrane which included a fillet-welded field seam. Temperatures used during the testing ranged from 18 to 76 degrees Celsius. The results of the testing indicated that the acid process solution was "not very aggressive with any of the materials or seams [tested]." The HDPE geomembrane performed better and was more stable than the other geomembranes.

Gulec, et al. (2005) performed chemical compatibility tests on three geosynthetic materials including a geomembrane, geotextile, and drainage geocomposite. Acidic water consisting of sulfuric acid and water was one of the solutions used in the study. The geomembrane evaluated was a 60 mil HDPE geomembrane. The results of the study indicate that a 60 mil HDPE geomembrane is resistant to acidic solutions such as that which will be used at the site.

Current information indicates that HDPE is chemically resistant to acidic uranium mill process solution. The testing conducted by Mitchell (1985) and Gulec et al. (2005) provides lab data to support the use of an HDPE liner as part of the tailings impoundment liner system. Mitchell's testing was conducted on a 40 mil HDPE and Gulec's testing was conducted on a 60 mil HDPE In both cases, the results indicated the HDPE geomembranes were chemical resistant to acidic solutions. A 60 mil HDPE liner has been recommended for the liner at the site.

The same sources listed above for chemical resistance of HDPE to sulfuric acid indicate that sodium chlorate will not damage HDPE. The expected addition of sodium chlorate to the ore stream is at a rate of approximately 1.7 lb/ton of ore feed, so concentration of the salt in the discharge stream will be very small. Available chemical resistance information indicates that pure kerosene will damage HDPE lining, particularly at very high temperatures (60 deg. C or 140 deg F). The anticipated kerosene loss rate from the Solvent Exchange process is 0.5 gal kerosene per 1000 gallons of process feed, which equates to a concentration of approximately 500 ppm. Kerosene is volatile and the concentration in any free solution in the tailings cell(s) will likely be smaller than that in the discharge stream leaving the mill. Ultimately, the limited amount of kerosene that remains within the tailings will become relatively immobile because of adsorption to the tailings solids. It is also possible that the kerosene will undergo a biodegradation process. Because the maximum plausible kerosene concentration in the discharge to the tailings is very small and the degree of contact with the double liner system is very limited, there is negligible potential for damage to the liner, geonet, or piping by the presence of small concentrations of kerosene.

Additional References (will be added to existing reference list for Tailings Management Plan)

Advanced Drainage Systems, Inc.. 2007. *Technical Note 4.01, Chemical Resistance of Polyethylene and Elastomers.* www.ads-pipe.com

Gulec, S.B., Benson, C.H., and Edil, T.B. 2005. "Effect of Acidic Mine Drainage on the Mechanical and Hydraulic Properties of Three Geosynthetics." Journal of Geotechnical and Geoenvironmental Engineering, Vol. 131, No. 8, ASCE, pp. 937-950.

ISCO Industries. 2007. *Chemical Resistance of High Density Polyethylene Pipe*. www.isco-pipe.com.

Mitchell, D. H. 1985. "Geomembrane Compatibility Tests Using Uranium Acid Leachate", Journal of Geotextiles and Geomembranes, Vol. 2, No. 2, Elsevier Publ. Co., pp.111-128

Poly-Flex, Inc. 2005. *Reference Manual*. March. pp. 39-40.

Zeus Industrial Products, Inc. 2007. *Chemical Resistance of HDPE*. www.zeusinc.com.

*Should Uranium One desire the license modification to allow the fluid extraction process without further regulatory review, a complete description of the systems components and tailings (paste) management operations must be provided to the Division. Include **at least** the following information:*

1. *Describe how the tailings paste will be transported to and distributed within the tailings impoundment. Describe how localized accumulations of tailings paste and their attendant stresses on flexible membrane liners and the drainage system layer will be limited to acceptable values. Justify that stresses will be acceptable as tailings paste is deposited and distributed according to the descriptions provided.*

   Response 1b
   Please refer to Response 2a.

2. *Provide specifications, quality control measures, and quality assurance measures applied during operations to ensure that the integrity and functions of the drainage collection and leakage detections system will not be compromised.*

   Response 2b
   Please refer to Response 2a.

3. *All information requested in the Round One Interrogatory (replicated below for ease of reference).*

   Response 3b
   Please refer to Response 2a.

BASIS FOR INTERROGATORY:
A material flow diagram should be provided that includes the production rates and the properties of the product generated, liquids generated, tailings generated, reagents used, losses, etc., starting at the ore pile and ending up in the tailings pile, and evaporation pond. This information is required to demonstrate that the objectives set forth in 10 CFR 40.31(h), Appendix A, have been addressed.

The Tailings Management Plan states that the fluid extraction system may be bypassed if it cannot accept the slurry. With respect to the placement of slurry that does not undergo fluid extraction, the previous interrogatory response stated: "There is no expected adverse affect on the tailings stability. There is a disadvantage in the placement of the tailings as a slurry in that the potential for above-grade placement is limited and the tailings are more likely to segregate."

Should Uranium One desire the license modification to allow the fluid extraction process without further regulatory review, a complete description of the systems components and tailings (paste) management operations must be provided to the Division. Otherwise, a supplemental regulatory review of the details of the fluid extraction system will be required.

The following Round 1 Interrogatory R313-24-1-14/01: Milling Operations is included for ease of reference in connection with details requested for the fluid extraction system:

Please provide the details of the tailings dewatering and tailing placement process. This includes:

1. *Design criteria for the dewatering [fluid extraction] process and tailings placement into the cell.*
2. *Proposed location and layout of the dewatering [fluid extraction] equipment and transfer piping.*
3. *Detailed equipment and operational specifications and drawings of the dewatering [fluid extraction] and related tailings process equipment. This includes (but is not limited to) transfer piping to and from the equipment, the dewatering [fluid extraction] equipment, dewatered tailing placement equipment and methods, and secondary containment measures for tailings transfer and processing operations.*
4. *Quality control and assurance measures to be used to ensure tailings dewatering [fluid extraction] and placement meet design criteria and specifications.*
5. *Rate and make up of the slurry transferred to the dewatering [fluid extraction] area.*
6. *Rate and feed method into the press for dewatering [fluid extraction].*
7. *Feed staging and contingency plans when the dewatering [fluid extraction] system is out of service. It is stated that if the dewatering [fluid extraction] press cannot accept the slurry it will be placed into the cell. How will this impact the material in the cell (water content, stability, etc.)? Will it be removed again and dewatered [fluid extraction]?*

REFERENCES:

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended April 2007.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

INTERROGATORY R313-24-4-16/02: SEISMIC HAZARD CHARACTERIZATION

INTERROGATORY STATEMENT:

Please update the listing of earthquakes and other seismic data, at least through 2006, presented in Section 4 of the Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project (Revised December 2006).

Response 1

The seismic hazard analysis for the Shootaring Canyon site has been updated and is included as Attachment D. An updated figure showing locations of historical earthquakes is provided in Figure 1 of the attached report. A summary of the earthquakes in table form are given in Appendix B of the attached report. Since 1996, 10 additional earthquakes with a moment magnitude of 4.0 or greater have occurred within a 200-mile radius of the site. The largest of these recent events had a moment magnitude of 4.6.

Provide a copy of the State Engineer's written confirmation that the stability analyses it reviewed are acceptable.

Response 2

In lieu of providing written confirmation from the State Engineer for the original analyses, slope stability of the Shootaring Canyon uranium processing facility will be reevaluated using updated geometries, material properties, and seismic coefficients. These updates will be reflected in updates to the Shootaring Canyon Uranium Processing Facility Tailings Management Plan, and Tailings Reclamation and Decommissioning Plan, to be submitted in a subsequent submittal.

Provide a legible copy of the report from Lawrence Livermore National Laboratory; Seismic Hazard Analysis of Title II Reclamation Plans.

Response 3

A legible copy of pertinent sections from the Lawrence Livermore National Laboratory report is included as Attachment E.

BASIS FOR INTERROGATORY:

*The applicant has revised Section 3 of the TMP with statements concerning the history of existing **facility stability analyses** at the site. However the information requested in Round 1 Interrogatory Statement (replicated below for convenience) is necessary to evaluate **current seismicity and adequacy of the basis for the MGHA**. The two documents requested present essential independent evaluations*

The response provided to Round 1 Interrogatory R317-24-4-16/01 and contained in the "Tailings Management Plan does not satisfy the June 2006 interrogatory request (repeated below for convenience).

> *Please provide additional information to support the determination of an appropriate and consistent maximum predicted horizontal ground acceleration (MHGA) for the site. Please include sufficient information regarding historical seismicity and deterministic or probabilistic methodologies used to derive the estimated MHGA value, and to demonstrate that the proposed MHGA value reflects the most current information available regarding predicted seismic hazard levels in eastern/southeastern Utah and the area including the site. Seismic stability analyses should be based on this MHGA value.*

The following was the Basis for Interrogatory included with the Round 1 Interrogatory Statement (repeated below for convenience):

Additional information needs to be provided to justify that selection of the specified MHGA value of 0.19 g is appropriate for the site and that the stated value reflects the best information currently available for southeastern Utah/the project site. The only information provided in "Exhibit C – Seismic Hazard Analysis" to support determination of the 0.19 g value is page 91 from a referenced report ("June 26, 1994 Seismic Hazard Analysis of Title II Reclamation Plans", Lawrence Livermore National Laboratory). Some of the information on that page is illegible (e.g., the exponent in the cited Hazard Level values); also, information items referenced on that page, including hazard curves, a methodology section, and Fault 2, Fault 3 locations are not provided for review. The 0.19 g value was used for a seismic stability analysis for the Shootaring Canyon Dam performed in 1997 (January 9, 1997 letter report by Inberg-Miller Engineers).

Newmark Analyses conducted in 1999 for the Shootaring Canyon Dam and Cross Valley Berm used a peak ground acceleration of 0.33 g based on a magnitude 6.5 earthquake (January 29 and June 14, 1999 letter reports by Inberg-Miller Engineers).

Response 4

The seismic hazard analysis has been updated using probabilistic methods. The complete seismic hazard report is included as an attachment. In summary, the peak ground acceleration (PGA) for the site is 0.22 g, corresponding to an annual probability of exceedance (PE) of 1 x 10^{-4}. The hazard is largely attributed to the hazard of a random, or background, earthquake event. For long-term, pseudostatic analyses, as seismic coefficient of 0.15 g (or two-thirds of the PGA) is recommended.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended April, 2007.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

INTERROGATORY R313-24-4-19/02: DOUBLE LINER SYSTEM CQAP PLAN AND SPECIFICATIONS

INTERROGATORY STATEMENT:

Please revise the CQAP:

- *To include an organization chart that has sufficient detail to show the lines of communication and authority.*

  Response 1

  A detailed organizational chart for the QA/QC Plan is attached and will be included and referenced in Section 4 of Appendix C of the Tailings Management Plan.

- *To include testing to demonstrate that the clay used for the bottom liner meets the $1x10^{-7}$ cm/s* ***field*** *hydraulic conductivity requirement. This can be done by using one of the following test methods (or an approved variation):*
  - *ASTM D5093-02 Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring*

  If a variation of one of these methods or an alternate method is proposed (such as a single-ring infiltrometer), it needs to be submitted to the DRC for review and concurrence.

  Response 2

  This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

As stated in Round 1 Interrogatories, the applicant proposes to use a double liner with leak detection in order to prevent migration of wastes out of the impoundment (sections 4 & 5, TMP). The applicant indicates that the double liner with the leak detection system design is the Best Available Technology (BAT) and comparable to similar facilities in the industry. However, there is insufficient information provided in the Construction Control Quality Assurance Plan (CCQAP) and only limited detailed plans and specifications are provided for the construction of Cell 1 and 2. The deficiencies in the CCQAP are addressed in this interrogatory, while the deficiencies in the plans and specifications are addressed in a separate interrogatory.

*The review of the CCQAP and the responses to this interrogatory revealed a few items that were not clear. The CCQAP does include a description of the roles and responsibilities for the respective construction QA personnel. However, to ensure clarity on the lines of communication, and the level of independence provided by the QA organization proposed, an organization chart is needed that shows who reports to whom, and at what level. In addition, the CCQAP makes reference to the "**Plans**" and "**Specifications**" that have not been provided (addressed in Interrogatory 24/02). A review of CCQAP completeness cannot be performed without a completed set of these* **Plans and Specifications**. *The CCQAP, Plans, and Specifications are all complementary and integral in the implementation of the design.*

The requirement for the hydraulic conductivity of the clay liner is an in place ***field*** *hydraulic conductivity of $1x10^{-7}$ cm/s or less. This is considered BAT for liner systems (see reference Uranium One needs to provide a demonstration that the clay used for the bottom liner meets this requirement. In the response to this interrogatory in round 1, Uranium One stated that field permeability testing would prove too difficult, and preliminary laboratory testing indicated permeability's in the 10^{-8} cm/sec range. Further justification is needed as to why field permeability testing has not been successfully completed, and as to the difficulty is performance of the testing.*

According to "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" (see reference for Bonaparte, Daniel, and Koerner, 2002 below), the most effective means of testing permeability of a soil layer such as a clay liner is in-place with a sealed double-ring infiltrometer. Another method used is a single-ring infiltrometer (see reference for Amoozegar and Warrick, 1989 below). However, since the single-ring infiltrometer is not as widely used or accepted as the double-ring method, the specific methods and procedure for the single-ring infiltrometer will need to be provided for DRC review and concurrence prior to its use. Of particular concern is the ability to test a large enough surface area of the clay liner that will provide reasonable results that represent the actual permeability of the clay layer. Field testing is used because is has been found that laboratory test methods are applied to a small and limited sample size(or area) that is not typically representative of the soil layer being evaluated. Extensive reviews of laboratory tests results (typically involving 75-mm-diameter samples of compacted clay materials) have shown a strong tendency to report smaller saturated conductivities for clay liners than are actually achieved in the field (Benson, Hardianto, and Motan 1994; Bonaparte, Daniel, and Koerner, 2002). For this reason the Division prefers the use of the field methods stated in the interrogatory.

The DRC believes that successful field permeability testing of the clay liner can be performed using "ASTM D5093-02 Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring. Another method can be used (such as a single-walled infiltrometer) provided the specific methods and procedures are provided for DRC review and concurrence.

REFERENCES:

Amoozegar, A, and A.W. Warrick. 1986. Hydraulic conductivity of saturated soils: field methods. American Society of Agronomy.

Bonaparte, Rudolph, David E. Daniel, and Robert M. Koerner, December 2002. Assessment and Recommendations for Improving the Performance of Waste Containment Systems. EPA/600/R-02/099.

Benson CH; Hardianto FS; and Motan ES, "Representative Specimen Size for Hydraulic Conductivity Assessment of Compacted Soil Liners," ASTM Specialty Technical Publication 23883S, January 1994.

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

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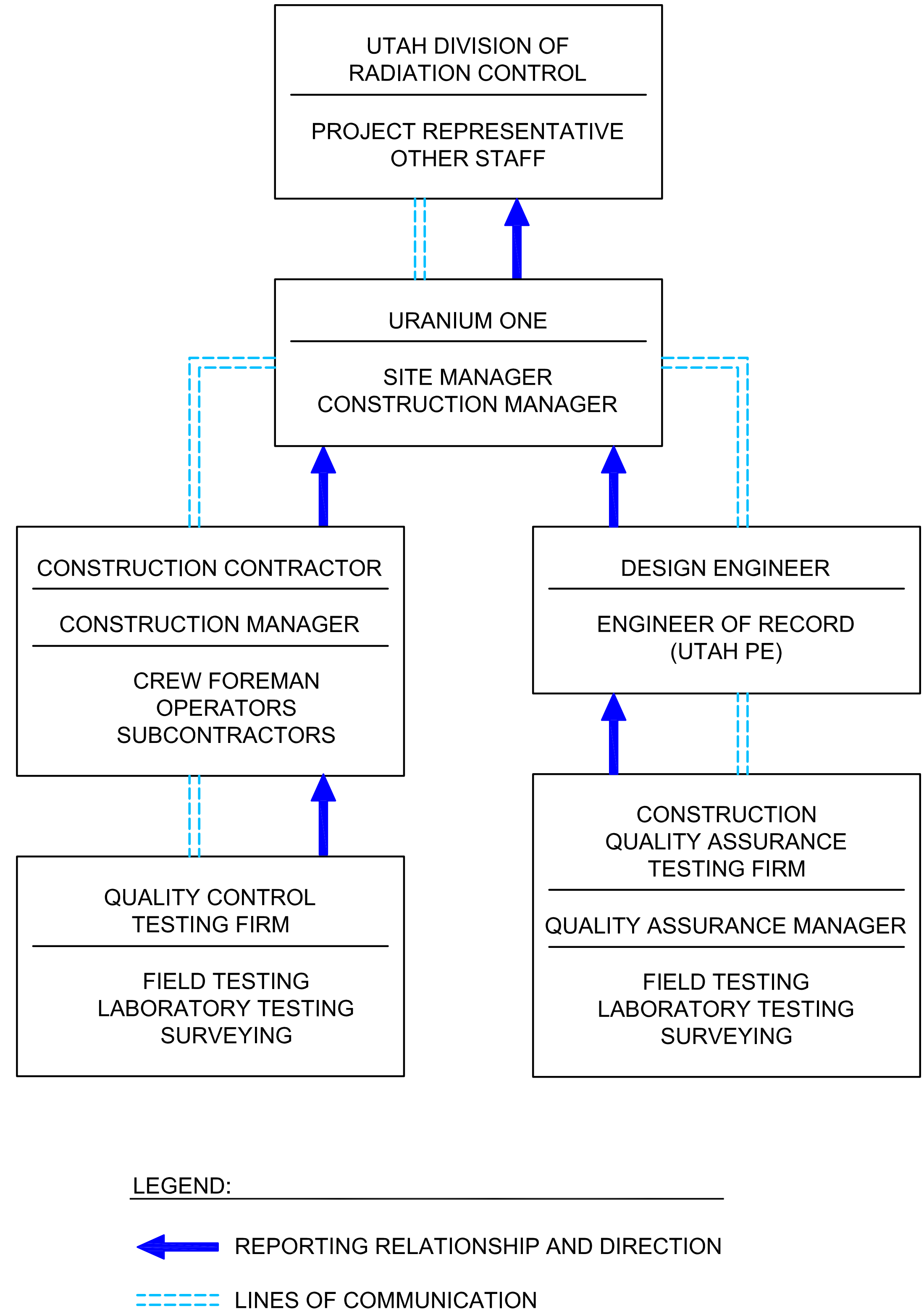


Project No. 181501

November 2007

uraniumone

FIGURE 2
QA / QC ORGANIZATIONAL CHART

INTERROGATORY R313-24-4-20/02: LINER STRENGTH & COMPATIBILITY

INTERROGATORY STATEMENT:

Please provide the following:

1. *An evaluation of the impact of stress imposed by equipment, tailings, and liquid during placement, as well as wind uplift on the liner system that could result in movement and degradation of the liner system, was not provided in response to this interrogatory. Descriptive and qualitative information was provided. Please include an evaluation of the steepest slope that will be subject to the highest stresses during construction as well as placement. Explain what is meant (specifically) when stating that the slopes will be" relatively mild". In addition, please note that since the "Reduced Moisture Tailings Placement (RMTP)" will be developed after the start of milling operations, and it is anticipated that the tailings will be placed in the cell via slurry, the statement that there will be no significant ponding of liquids against the exposed liner is not correct. Consider slurry and free liquids in the cell in the design and evaluating the stability of the liner system.*

   Response 1
   This response will be provided in our next submittal.

2. *An evaluation of the impacts of wind uplift forces and ballasting for wind uplift on the liner system while exposed to these forces.*

   Response 2
   This response will be provided in our next submittal.

3. *Please clarify that the anchor trench calculations utilize the most critical slope and loading conditions. Also, please justify the use of 32-degrees for the friction angle between the membrane and the sand when values from references are 18-degrees.*

   Response 3
   The liner system anchorage calculations provided in Appendix K of the Tailings Management Plan present the most critical slope and loading conditions for runout and anchor trench design. The steepest slope of 3H:1V and the minimum cover thickness were used for both the runout and anchor trench design calculations. Increasing the cover thickness would result in less conservative values for both calculations.

   Liner runout calculations are provided in Appendix K of the Tailings Management Plan for the top of the cross valley berm and the berm separating the EPPC from Cell 1. The interface friction angle between the geomembrane and sand has been revised from 11 degrees to 18 degrees. As indicated above in Interrogatory Comment 3 and the Basis for Interrogatories, an interface friction angle between a geomembrane and sand layer of 18 degrees is reasonable. Koerner (2005) lists 18 degrees as reasonable value for interface friction between a smooth HDPE geomembrane and sand. Using this revised value, liner runout is calculated as 19.7 feet. The actual liner runout is specified as 20 feet.

   Anchor trench design calculations were presented in Appendix K the Tailings Management Plan for perimeter areas where the geomembrane will not be extended to connect with an adjacent cell. For the anchor trench calculations, the steepest slope of 3H:1V and minimum cover of 1.5 feet was used. The interface friction angle between the geomembrane and sand has been revised from 11 degrees to 18 degrees. URS states that the interface friction angle used for the calculations was 32 degrees. This is incorrect. The 32 degree friction angle was used for the internal friction angle of the sand. This is a reasonable value and has not been changed. The minimum runout length has been revised to be 3 feet. The revised calculations result in a calculated anchor trench depth of 10.4 inches for a minimum runout length of 3 feet. The minimum anchor trench depth is specified as 18 inches.

The liner anchorage calculations are applicable to the placement of the tailings as a slurry. The equations that are presented are applicable for dry stack materials and slurry. These equations are same as presented in Koerner (2005) for both liquid and solid waste containment.

The revised Appendix K text and calculations is as follows:

APPENDIX K

Liner System Anchorage

K.0 Introduction

The required anchorage for the Cell 1 and Cell 2 liner system varies dramatically with the slope conditions on the perimeter of the cell and the coverage by the granular drainage layers. The granular drainage layers will be placed on the base of the cells on slopes up to 4H: 1V. The majority of the Cell 1 will be covered by the granular drainage layers and a typical slope on the anchored periphery for these drainage layer covered areas is 5.5H:1V. The upstream and downstream slopes of the cross valley berm and the upstream slope of the Shootaring Dam will be at a 3H:1V slope and there will not be any cover soils placed on these slopes. In addition, the side slopes of Cell 2 will be at a slope of 3H:IV and no granular drainage layers will be placed on these slopes.

The proposed liner anchor mechanisms include: a conventional trench or L anchor, a runout (also horizontal or linear) anchor, and a default linear anchor to connect and provide a continuous liner across the cross valley berm.

The two general anchor failure modes include an anchor pullout or an HDPE liner failure. Within the tailings facility, the anchor pullout will be considered the controlling condition. An anchor pullout will generally be an observable occurrence, while there may be no evidence of a tension failure of one or both of the liners. The tensile strength of one liner will be considered the critical (maximum) anchorage tension. The following methods of evaluating and designing liner anchorage are presented in Koemer (2005).

K.1 Runout Anchor

A runout anchor relies on the normal force created by a cover soil load on a horizontal liner section to produce a frictional resistance to liner pullout. The two adjustable variables in a runout design are the thickness of the cover soil and the length of the runout.

K.1.1 Summation of Forces

Koerner (2005) presents a summation of horizontal forces for a runout liner pullout as:

$$\Sigma Fx = 0$$

$$T_{allow} \cos \beta = F_{u\sigma} + F_{L\sigma} + F_{LT}$$

$$T_{allow} = \cos\beta = \sigma_n \tan\delta_U (L_{RO}) + \sigma n \tan\delta_L (L_{RO}) + 0.5\left(\frac{2T_{allow}\sin\beta}{(L_{RO})}\right)(L_{RO})\tan\delta_L$$

where:

T_{allow} = allowable force in geomembrane = σ_{allow} t, where

σ_{allow} = allowable stress in geomembrane, and

t = thickness of geomembrane;

β = side slope angle;

$F_{U\sigma}$ = shear force above geomembrane due to cover soil;

$F_{L\sigma}$ = shear force below geomembrane due to cover soil;

F_{LT} = shear force below geomembrane due to vertical component of T_{allow};

σ_n = applied normal stress from cover soil;

δ = angle of shearing resistance between geomembrane and adjacent material; and

L_{RO} = Length of geomembrane runout.

K.1.2 Length of Runout

As presented in Koerner (2005) a rearrangement of the previous summation of forces equations presents a summation of horizontal forces for a runout liner pullout as:

$$L_{RO} = \left(\frac{T_{allow}(\cos\beta - \sin\beta \tan\delta_L)}{\sigma_n(\tan\delta_U + \tan\delta_L)} \right)$$

K.2 Trench Anchor

A trench anchor typically includes a runout section with a terminating trench with the liner(s) folded over the edge of the trench prior to backfill. The depth of the anchor trench then introduces another variable into the design process. The formulation of the governing equation is very to similar to that of a runout anchor with the addition of the earth pressures in the trench.

K.2.1 Summation of Forces

Koerner (2005) presents a summation of horizontal forces for an anchor trench liner pullout as:

$$\Sigma Fx = 0$$

$$T_{allow} \cos\beta = F_{U\sigma} + F_{L\sigma} + F_{LT} - P_A + P_P$$

where the variables are as previously defined with the addition of:

P_A = active earth pressure against the backfill side of the anchor trench; and

P_P= passive earth pressure against the inside of the anchor trench.

K.2.2 Earth Pressure

The additional forces resisting liner pullout are the imposed by the passive and active earth pressure within the anchor trench. Koemer (2005) presents the calculation of these forces as:

$$P_A = (0.5\gamma_{AT} d_{AT} + \sigma_n) K_A d_{AT}$$

$$P_P = (0.5\gamma_{AT} d_{AT} + \sigma_n) K_P d_{AT}$$

where:

- γ_{AT} = unit weight of soil in anchor trench,
- d_{AT} = depth of the anchor trench,
- σ_n = applied normal stress from cover soil,
- K_A = coefficient of active earth pressure = $\tan^2(45 - \varphi/2)$
- K_P = coefficient of passive earth pressure = $\tan^2(45 + \varphi/2)$, and
- φ = angle of shearing resistance of respective soil.

The resulting equation for determining liner pullout resistance has the design variables of cover thickness, length of runout and trench depth. Since the equation can only be solved for one variable, the cover thickness and length of runout are generally established as constants and the equation is solved for the depth of the trench

K.3 Top of Berm Runout Anchor Design

A runout anchor will be employed across the top of cross valley berm and the berm separating the EPPC from Cell 1, as well as other selected locations. The horizontal runout section across the top of the berms will be approximately 20 feet to extend completely across the berm and the cover layer will consist of a protective sand layer with a roadbed sand and gravel overlay. The total cover thickness is estimated at two feet. The interior slopes on the berm will be 3H: 1V. The desired condition for a failure of one of the liners is to have the anchor pull out before liner rupture. Since the length of runout is basically fixed for the top of berm runout, the required length of runout to result in a tensile failure will be calculated. This length of runout will then be compared with the fixed berm width runout to determine likely controlling failure mode and the utilization of the allowable tensile force in one of the two liners.

K.3.1 Length of Runout Calculation

The inputs for the calculation are as follows:

σ_{allow} = 2100 psi

t = 0.060 inch

$T_{allow} = \sigma_{allow}\, t$ = 126 lb/in

β = 18.4 degrees

σ_n= cover thickness x unit weight of soil = 2 ft. x 100 lb/ft^3 = 200 lb/ft^2 = 1.39 psi

δ_L = 18 degrees

δ_u = 0 degrees

The maximum length of runout that will result in reaching allowable liner tension at liner pullout is estimated as:

$$L_{RO} = \left(\frac{T_{allow}(\cos\beta - \sin\beta\tan\delta_L)}{\sigma_n(\tan\delta_U + \tan\delta_L)} \right)$$

$$L_{RO} = \left(\frac{126(\cos(18.4) - \sin(18.4)\tan(18))}{1.39(\tan(0) + \tan(18))} \right) = 236\text{ inches} = 19.7\text{ feet}$$

The calculated liner runout of 19.7 feet is less than the berm width of approximately 20 feet. Figure K-1 presents a diagram of the runout anchor.

K.4 Trench Anchor Design

A trench anchor will be used as the runout anchor will be employed as the typical anchor on perimeter areas where the liner is not extended to connect with an adjacent cell. In many areas on the perimeter of Cell 1, the liner terminates with a very mild slope and coverage by the drainage layers. In these areas, the anchor runout and trench is unnecessary, but these areas will be used as the bounding condition for establishing the minimum runout length of four feet. This allows a minimum anchorage width on the perimeter for those areas where the side slopes are very mild and the covering drainage layers are present. For areas where the liners terminate at the crest of 3H: 1V side slope, the minimum runout length will be four feet, but this may be increased for ease of construction. The general thickness of cover is assumed to be 18 inches with a unit weight of 100 lb/ft^3. In order to limit the potential for a tensile failure in the liner, the pullout force will be limited to one-half of the allowable tension.

K.4.1 Trench Anchor Calculation

The inputs for the calculation are as follows:

σ_{allow} = 2100 psi

t = 0.060 inch

$T_{allow} = \sigma_{allow}$ t/2 = 126/2 = 63 lb/in

β = 18.4 degrees

σ_n = cover thickness x unit weight of soil = 1.5 ft. x 100 lb/ft^3 = 150 lb/ft^2= 1.04 psi

δ_L= 18 degrees

δ_U= 0 degrees

L_{RO} = 3 feet = 36 inches

γAT = 100 lb/ft^3 = 0.0579 lb/in^3

φ = conservatively assumed to be 32 degrees for fine uniform sand.

$K_A = \tan^2(45 – 2) = \tan^2(45 - 32/2) = 0.307$

$K_P = \tan^2(45 + φ/2) = \tan^2(45 + 32/2) = 3.255$

The required depth of anchor trench is calculated according to:

$$T_{allow} = \cos β + F_{U\sigma} + F_{L\sigma} + F_{LT} - P_A + P_P$$

$$F_{U\sigma} = \sigma_n \tan\delta_u (L_{RO}) = (1.04)\tan(0)(L_{RO}) = 0$$
$$F_{L\sigma} = \sigma_n \tan\delta_L (L_{RO}) = (1.04)\tan(18) (36) = 12.16 \; lb/in$$
$$F_{U\sigma} = T_{allow} \sin β \tan \delta_L = (63)\sin(18.4)\tan(18) = 6.46 \; lb/in$$

$$P_A = (0.5\gamma_{AT} d_{AT} + \sigma_n)K_A d_{AT} = (0.5(0.0579)d_{AT} +1.04)(0.307)d_{AT}$$
$$P_A = 0.00889 \, d_{AT}^2 +0.319 \, d_{AT}$$

$$P_P = (0.5\gamma_{AT} d_{AT} + \sigma_n)K_P d_{AT} = (0.5(0.0579)d_{AT} +1.04)(3.255) \, d_{AT}$$
$$P_P = 0.09423 \, d_{AT}^2 +3.385 \, d_{AT}$$

$$T_{allow} = \cos β = 63 \cos(18.4) = 59.8 \; lb/in$$

$$59.8 \; 0 + 12.16 + 6.46 - (0.00889 \, d_{AT}^2 + 0.319 d_{AT}) + 0.09423 \, d_{AT}^2 +3.385 d_{AT}$$
$$0 \; 0.0853 \, d_{AT}^2 + 3.066 \, d_{AT} – 39.38$$

Using the quadratic equation solution, the depth of the trench is determined to be:

d_{AT} = 10.4 inches

A specified trench depth of 18 inches with a minimum runout of 3 feet is sufficient to utilize one-half or more of the available tensile strength for a single HDPE liner. Figure K-2 presents a diagram of the trench anchor.

K.5 Summary and Conclusions

The runout anchor specified for the crest of the cross valley berm and the berm between the EPPC and Cell 1 is sufficient to resist pullout for forces that approach, but do not exceed, the allowable tensile stress in one of the two HDPE liners in the liner system. The runout anchor would generally be sufficient for mildly sloping areas on the perimeter of Cell 1, but a trench anchor is specified in the interest of uniformity of anchor construction. The liner trench anchor will be used as the on the remaining perimeter of the liner(s). The specified minimum runout for the trench anchor is 3 feet with a minimum trench depth of 18 inches. This is sufficient for the critical areas of anchorage on the perimeter of the cells.

K.6 References

Koerner, R.M. 2005, Designing With Geosynthetics — Fifth Edition. Prentice Hall, Upper Saddle River, NJ.

BASIS FOR INTERROGATORY:

As stated in Round 1 Interrogatories, the Applicant's submission does not include sufficient information to allow a complete review of adequacy of the lining system design for meeting the requirements of 10 CFR 40, Appendix A, Criterion 5 A(2) which addresses cell liner requirements, or for meeting the criteria identified in R317-6-1, 1.3 for BAT, for double liner systems. Still lacking is a complete evaluation of the stresses on the liner system under maximum loading conditions. These maximum loading conditions need to be defined as the design basis, then calculations need to be developed and provided that demonstrate the liner system is capable of maintaining the design integrity, configuration, and performance. Reference is made to the RMTP as being an important basis of the design. However, the revised plan and responses to Round 1 Interrogatories state the tailings will also be placed as slurry, and it is inferred that the RMTP will be used when and if developed. A concise and well-defined design basis needs to be included that is then demonstrated to meet the respective criteria through technical evaluation, data, and calculations.

Response 4

This response will be provided in our next submittal.

Clarification is needed on the anchor trench design calculations. Is the slope evaluated the most critical condition subject to the greatest loading (on imposing the greatest stress on the liner system)? The calculations state a conservative friction angle between the sand and membrane of 32-degrees, whereas Kroener sites a conservative value of 18-degrees. Using 18-degrees yields a longer pullout length than 32-degrees. Also, what is the soil that the trench is comprised of? It is not defined on Figure K-2. In addition, now that the tailings will be placed in the cells via a slurry, will this placement technique induce added loads to the liner? Should additional material be used in the discharge areas to handle this impact and loading (i.e., splash guards)?

Response 5

Clarification of the anchorage calculations was addressed in Response 3. In regards to the use of additional material for discharge areas, it is recommended that splash guards or rub sheets be used in discharge areas if deemed necessary to protect the sand drainage layer from displacement due to spigot discharge. This recommendation will be included in the revised Tailings Management Plan text in our next submittal as part of Response 1 and 4 for this Interrogatory.

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Valero, S.N., and Austin, D.N., 1999. "Simplified Design Charts for Geomembrane Cushions", in Geosynthetics '99, Boston, Mass. Available at: http://www.sedimentremediation.com/TechRef/Dredge/GPD-SM-116.pdf

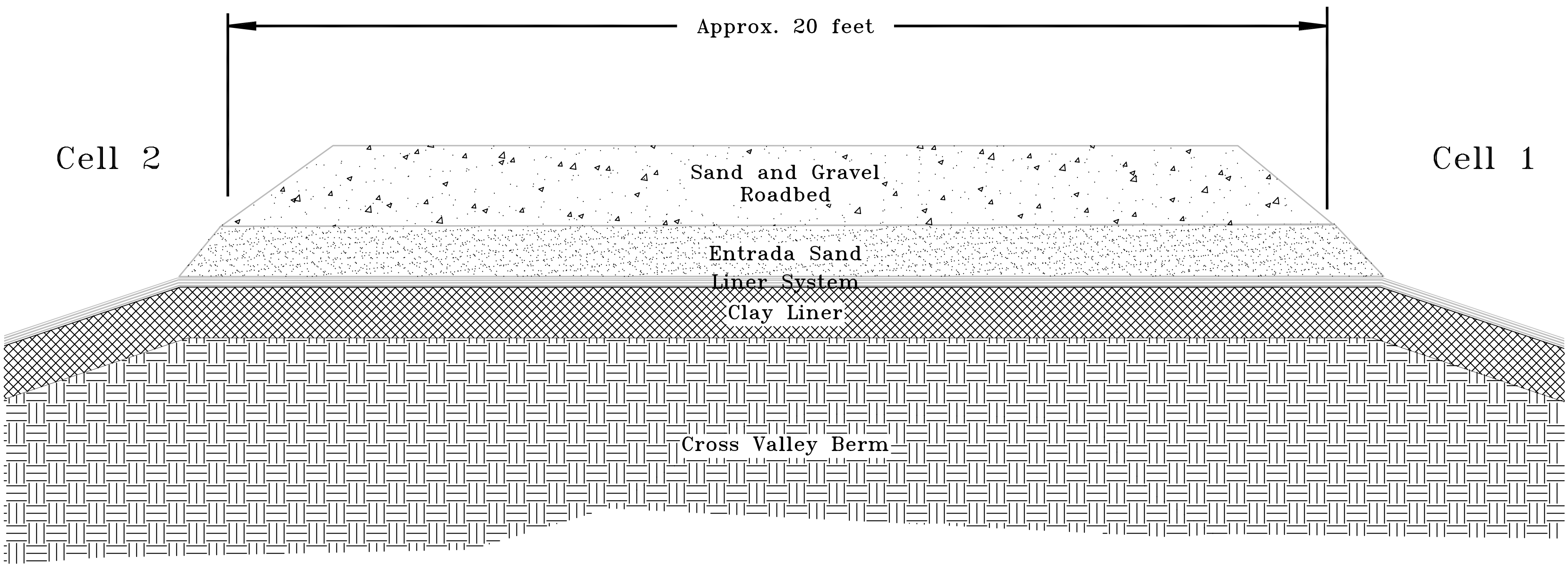
Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999. Design of Geomembrane Anchorage Against Wind Action", in Geosynthetics International, Vol. 6, No. 6, 1999, pp. 481-507.

Hsuan, Y.G., Lord, A.E., and Koerner, R.M., 1991. "Effects of Outdoor Exposure on a High Density Polyethylene Geomembrane", in Geosynthetics ' 91, Atlanta, GA, pp. 287-302.

Koerner, R.M. , Hsuan, Y.G., and Koerner, G.R., 2005. "Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions", Geosynthetic Institute White Paper #6, June 7, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007



NOT TO SCALE

Project No. 181501

Source: Plateau Resources Ltd., 4-2007.

November 2007

uraniumone

Figure K-1
Runout Liner Anchor Schematic

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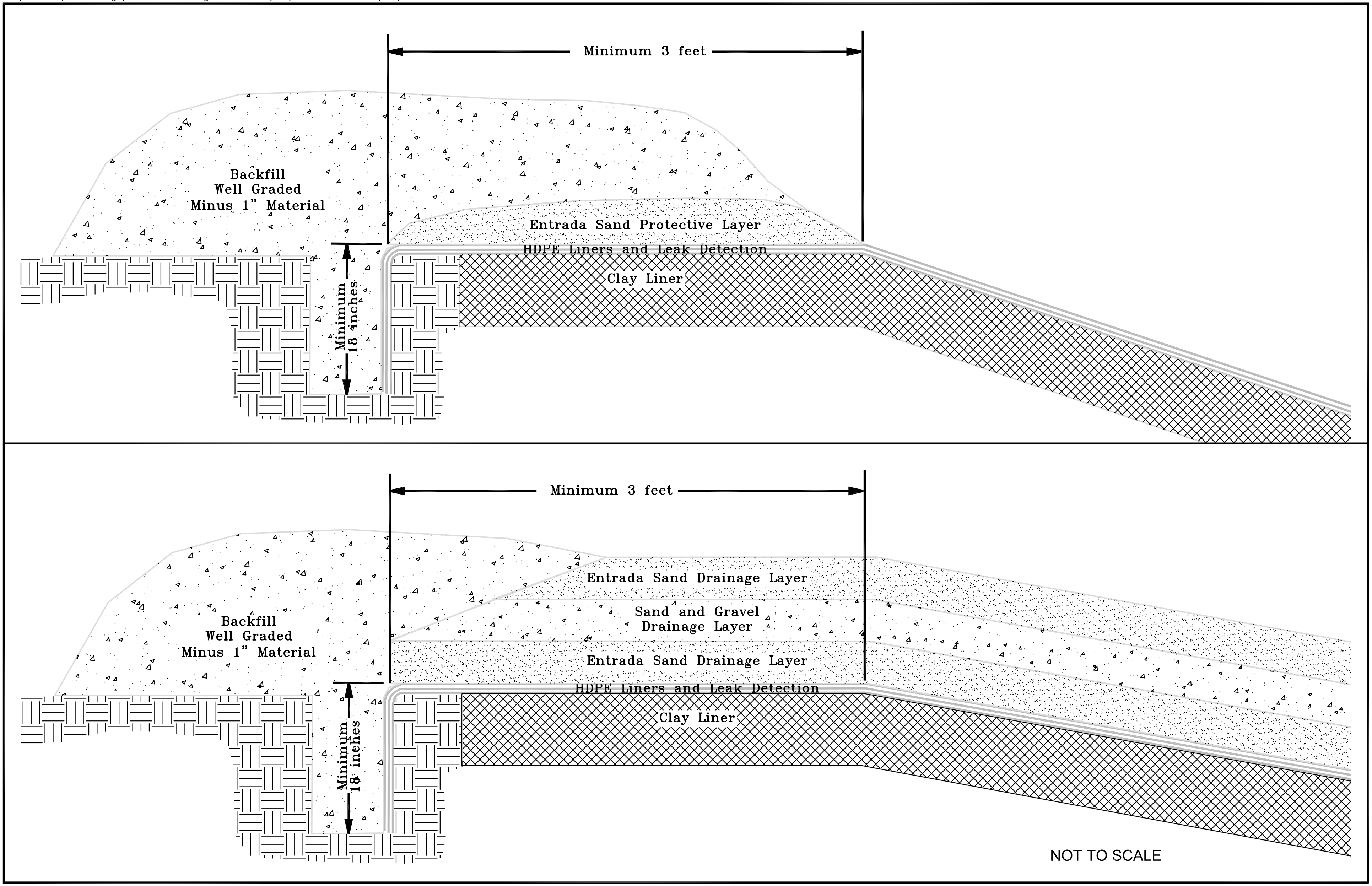

Project No. 181501

Source: Plateau Resources Ltd., 4-2007.

November 2007

uraniumone

Figure K-2
Trench Liner Anchor Schematic

INTERROGATORY R313-24-4-21/02: LINER SETTLEMENT

INTERROGATORY STATEMENT:

Please indicate the extent of settlement, differential settlement, and distortion in the cover that are allowed at the time of final closure. Demonstrate that allowable settlement, differential settlement, and distortion resulting tailings consolidation with time will not damage the final liner system. Justify the respective design criteria and tailings material properties used.

BASIS FOR INTERROGATORY:

In response to Round 1 Interrogatory Uranium One explained that the liner subgrade will be the Entrata Sandstone, and therefore settlement of the soil (rock) under the cells is not of concern. In addition, the clay and sand layers placed at part of the liner system will be compacted and also will not pose a concern with settlement. However, not provided is an evaluation and demonstration of the potential settlement of the tailings themselves after cover placement. This is now of particular concern considering that the tailings will be placed in a slurry with high liquid content. Will any anticipated settlement from dewatering of the tailings via the leachate collection system (including differential settlement) impact the integrity of the cover system? How long before dewatering is complete and consolidation of the tailings is no longer of concern? What are the settlement tolerances of the cover system? The moisture content, and other physical properties of the tailings after cover placement, and their potential for consolidation, thereby impacting the cover needs to be considered in this evaluation.

Response 1

This response will be provided in our next submittal.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R313-24-4-22/02: LEACHATE COLLECTION AND DETECTION SYSTEM DESIGN

INTERROGATORY STATEMENT:

Please provide additional information to demonstrate that:

1. *The description of the drainage sock application represented in Figure 5-9 so that it adequately address the issues raised in Round 1 Interrogatory. The outstanding issues are as follows:*
    - *Provide discussion on the function of the fabric in Figure 5-8 (if it is different from the assumed purpose).*
    - *Explain why the fabric is not necessary in Figure 5-9.*
    - *Revise Figure 5-9 to indicate that the application illustrated is only to be used on steep slopes where the drainage layer is not present.*
    - *Correct contradiction between Figure 5-9 (that illustrates a drainage layer similar to that of Figure 5-8) and its supporting the text (that indicates that a drainage layer is not present in the application).*

Response 1

Section 5.1.4.2 of the Tailings Management Plan (2007) includes discussion of Figures 5-8 and 5-9, as well as discussion of the load capacity of the HDPE collection pipe. The alternative pipe installation as shown in Figure 5-9 has been removed from the text. Figure 5-9 will not be included in the revised Tailings Management Plan. The load capacity of the HDPE collection pipe is addressed in Response 4 to Interrogatory R313-24-4-24/02 and the corresponding revised text for Section 5.1.4.2 is included in this response for completeness.

The proposed revised text for Section 5.1.4.2 is as follow:

5.1.4.2 Piping Structural Design

The perforated standard wall collection system piping will be 4 inch diameter SDR 11 HDPE. The pipes will be bedded at the base of a clean gravel envelope that is wrapped within a nonwoven geotextile (see Figure 5-8) meeting the specifications in Appendix C. The nonwoven geotextile serves as a filter layer between the clean gravel and the Entrada sand drainage layer. A geotextile layer will be placed directly on top of the primary liner to cushion the geotextile-wrapped gravel envelope. The wrapping geotextile will be placed between the gravel envelope and the cushioning geotextile over a base width of approximately 6 feet. After placement of the pipe and gravel envelope, the remaining width of the geotextile roll will be folded over the gravel envelope with sufficient overlap to completely enclose the gravel envelope. The anticipated roll width for the geotextile is 15 feet, which should be sufficient to enclose a gravel envelope with 3 to 5 square feet of cross sectional area. This gravel envelope will extend to a minimum of 6 inches above the top of the pipe (see Figure 5-8). Entrada sand or the rocky soil sand/gravel will be placed directly over the top of the geotextile surrounding the gravel envelope as shown in Figure 5-8 and then compacted with small vibratory compactor on both sides of the pipe to compact materials around and over the pipe. This will produce a very dense envelope around the drainage pipes which corresponds to the desirable material Class I with compaction condition for the pipe bedding Soil Modulus (E’) value. Where the pipe is extended up slopes steeper than 4H:1V beyond the drainage layers, a filter sock will be placed around the pipe and the pipe may not be bedded within imported material unless it is necessary to accommodate equipment access.

The drawings in the Tailings Management Plan show the top of tailings elevation as 4455 feet. The lowest elevation of the bottom surface is 4360 feet. Therefore, the maximum anticipated overburden thickness for the leachate collection piping is approximately 100 feet. This estimate includes the thickness of the cover. The small diameter and favorable bedding conditions for the standard wall perforated HDPE pipe will provide a substantial load bearing capacity. A minimum of 27 inches of compacted material must be in place over the pipe (30 inches of material over the primary liner) before general equipment traffic will be allowed. Only specialized low ground pressure or other approved equipment will be allowed on areas where the cover over the pipe or primary liner is less than 27 inches or 30 inches respectively. With these restrictions on equipment traffic and live loading during the construction, the critical loading condition will be the static overburden load at maximum thickness and full cell utilization.

An analysis of the load bearing capacity of the 4 inch diameter SDR 11 perforated collection pipe is included in Appendix J. The method for determining the acceptability of the pipe installation was based on the Modified Iowa Formula as presented in the "Plastic Pipe Design Manual" available on-line from Lamson Vylon Pipe. The Modified Iowa Formula is considered a conservative approach. The results of the calculations indicate that the 4 inch diameter SDR 11 perforated pipe would withstand the maximum static overburden load of 100 feet of tailings at a moist density of 100 pcf.

2. *Entrada Sands appear to have $D_{15filter}$ values that are close, but smaller than the limit allowed by the National Engineering Handbook, "Gradation Design of Sand and Gravel Filters". Please provide additional justification for the selection of the Entrada sand material or provide an additional reference that allows grain sizes that are smaller than those specified in the Handbook.*

Response 2

Appendix B, Section B.2 of the Tailings Management Plan (2007) provides discussion of the drainage filter analysis for the Entrada sand and tailings slimes. The proposed revised text this for section is as follow:

B.2 Entrada Sand and Possible Tailings Properties

Sieve analysis was conducted on two Entrada sand samples during evaluation of the existing tailings facility. The results of this analysis are presented in Figure B-1 along with gradations for three tailings samples. Entrada sand is a very uniform fine sand with only a very small silt and clay fraction. In contrast, the gradation of uranium tailings can range from a slime with more than 85% passing the #200 screen, to a medium to coarse sand with a relatively small fines fraction. The coarsest of the tailings samples in Figure B-1 was taken from the existing tailings at the Shootaring site. The other two samples were taken from a uranium tailings facility in central Wyoming. The three tailings samples generally span the expected range of tailings gradations.

The Entrada sand will be used as the lower and upper layers of the drainage filter system. Because the Entrada sand is free of stones and other debris, this lower layer would protect the upper HDPE liner. The upper drainage layer of Entrada sand would prevent the intrusion of tailings into the drainage layer.

From the standpoint of penetration of fines into the drainage layer and piping collection system, the critical tailings material is fine-grained fraction of tailings (slimes). Because the Entrada sand has a uniform gradation with no concern for a gap-graded material, the applicable filter criterion is related to the maximum D15 of the Entrada sand. According to the criteria described in Chapter 26 of the USDA-NRCS National Engineering Handbook for a fine silt and clay base soil, the maximum D15 of the filter is less than or equal to 9 x d85 of the slime tailings base soil. Based on the gradations presented in Figure B-1, the D15 of the Entrada sand is suitable for tailings with a d85 as small as 0.01 mm. The minimum D15 per the National Engineering Handbook is a function of the desired permeability of the filter material and is less than or equal to 4 x d15 of the base soil, but no less than 0.1 mm. The value of 4 x d15 of the slimes is 0.02 mm. The D15 of the Entrada sand is approximately 0.08mm. Harr (1962) lists typical permeabilities of fine sand ranging from 0.001 to 0.05 cm/sec. Because the gradation of Entrada sand is very uniform, the permeability is likely 0.01 cm/sec or greater and is assumed to be approximately 0.05 cm/sec. Therefore, the properties of Entrada sand represent a reasonable compromise between filtration of fine tailings and the conveyance of drainage to the collection system.

Sherard et al. (1984) presents a method for determining filters for silts and clays. The paper recommends a D15 of less than 0.5mm as “reasonable and conservative”. The paper also provides ranges of values recommended for sand and gravelly sand filters. The ranges show the coarsest D15 values recommended and notes that using a larger content of fine sand than shown is more conservative. Using a D15 value of less than 0.1 mm would be conservative.

Additional References (will be added to existing reference list for Tailings Management Plan)

Sherard, J.L., Dunningan, L.P., and Talbot, J.R. 1984. “Filters for Silts and Clays” Journal of Geotechnical Engineering, Vol. 110, No. 6, ASCE, pp. 701-718.

BASIS FOR INTERROGATORY:

BAT requires that leachate collection and detection systems be designed to resist clogging during the active life and post-closure period. The proper design of the Sand/Tailings interface is a critical point where, under the current design, clogging potential is viewed as the highest.

With regard to the use of the geotextile filter illustrated in Figure 5-8, we recognize that this application likely represents the Best Available Technology for use of a geotextile for filtration.

The drainage sock application represented in Figure 5-9, however, does not fully satisfy the issues raised in Interrogatory 1. The outstanding issues are as follows:

- *There is no separation/filtration fabric shown between either the Entrada sand or the sand and gravel drainage layer and the washed gravel envelope. This fabric is included in Figure 5-8, however, and is assumed to function both as a separation between the poorly-graded washed gravel and the well-graded filter soils. A discussion on the function of the fabric in Figure 5-8 is needed.*
- *Figure 5-9 does not indicate the limited use of the application illustrated. Please revise the figure to indicate that the application illustrated is only to be used on steep slopes where the drainage layer is not present. Also, the figure illustrates a drainage layer similar to the Figure 5-8 application, but the text indicates that a drainage layer is not present in the Figure 5-9*

application. Include a discussion on why the separation/filtration fabric is not necessary in the Figure 5-9 application.

- *Referring to Chapter 26 of the National Engineering Handbook, "Gradation Design of Sand and Gravel Filters", we recognize that the use of part 633.2603, "Determining filter gradation limits" is appropriate. Table 26-2 provides maximum $D_{15filter}$ values (category 1) as less than or equal to 9 x d_{85soil}, and provides a minimum $D_{15filter}$ value of 0.2mm (not consistent with Entrada Sand). However, Table 26-3 allows for a small $D_{15filter}$ value when considering permeability criteria ($D_{15filter}$ greater than or equal to 0.1mm). That being said, Entrada Sands appear to have $D_{15filter}$ values that are close, but smaller than the limit allowed by the Handbook. Please provide additional justification for the selection of this material or provide an additional reference that allows grain sizes that are smaller than those specified in the Handbook.*

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Koerner, G.R, Koerner, R.M., and Martin, J.P. 1993. "Field Performance of Leachate Collection Systems and Design Implications". Solid Waste Association of North America: 31st Annual International Solid Waste Exposition, pp. 365-380.

Reinhart, D.R. et al. 1998. Assessment of Leachate Collection System Clogging at Florida Municipal Landfills. Report # 98-5. Florida Center for Solid and Hazardous Waste Management, Gainesville, FL. October 30, 1998.

Rowe, R.K. 2005. Long Term Performance of Containment Barrier Systems, Geotechnique, 55, No. 9, pp. 631-678.

R313-24. Uranium Mills and Source Material Mill Tailings Disposal Facility Requirements.

R317-6. Ground Water Quality Protection.

10 CFR Part 40. Domestic Licensing of Source Materials.

Title 40, Chapter 1, Part 264, Subpart K, Sec 264.221

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R313-24-4-23/02: DIKE INTEGRITY

INTERROGATORY STATEMENT:

Please confirm that all critical slopes have been evaluated or are represented by the evaluation of the most critical slope. Provide such analyses for the Division's review. These analyses must include and/or consider the dikes between Cell 1 and Cell 2 and between Cell 1 and the Evaporation and Process Pond Cell (EPPC) and the conditions where the liner is assumed to have failed (e.g., worst case scenario).

Please provide a slope and seismic stability evaluation for Shootaring Canyon Dam, the Cross Valley Berm, the area between the Cell 1 and the EPPC, and any other dams/berms using a failed liner condition under a worst case scenario or similar.

Provide conclusive calculations, models, and statements demonstrating the applicability and adequacy of the existing or new slope stability analysis. Ensure that such calculations, models, and statements address all special conditions that would affect dike and liner system integrity that may exist between Cell 1 and Cell 2 and between Cell 1 and the EPPC.

Response 1

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

In general, the response and revised text in Section 3 address part of the interrogatory statement from Round 1. Another analysis of seismic stability was conducted by Inberg-Miller Engineers [IME] (dated January 2007) with a Safety Factor of 1.18. However, this did not constitute a worst case scenario with a failed liner and leakage as required by Utah Administrative Code and URCR. The new analysis from IME 'assumed no phreatic surface will develop through the earthen dam.' The UDRC rule reads, 'In ensuring structural integrity, it must not be presumed that the liner system will function without leakage during the active life of the impoundment' R313-24-4.

Seismic and slope stability analyses were conducted by the applicant for the Shootaring Canyon Dam and the Cross Valley Berm (section 3 & Appendix A, TMP). The reference documents within the application do not address piping, however this may not be wholly applicable since the cells have double layers (liners) technology. The documents do contain a slope stability analysis for the Cross Valley Berm.

The information requested is needed to demonstrate the long-term stability of the final cover, especially in consideration of the cited passage of URCR on the presumption of leakage of the liner system during the active life of the impoundment.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility," Dated December 2005, Revised April 2007.

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

INTERROGATORY R313-24-4-24/02: BEST AVAILABLE TECHNOLOGY

INTERROGATORY STATEMENT:

Please provide the following:

1. *Estimation of anticipated leachate flow rates and maximum capacity in the leachate collection systems.*

Response 1

This response will be provided in our next submittal.

2. *Complete Liner system design and construction drawings (plans), as well as material and performance specifications. They are to be certified by a Professional Engineer licensed in the State of Utah, and shall include, but not be limited to, cell liner, leachate collection, leak detection, dewatering operations, tailings transfer and management, and storm water control layouts, cross sections, details, and profiles. They must include proposed elevations and horizontal coordinates at all key locations. The specifications must cover (but not limited to) all proposed components and materials, their respective material and equipment and installation requirements.*

Response 2

This response will be provided in our next submittal.

3. *An estimate of volumes and capacities of the cells as well as cut and fill quantities.*

Response 3

This response will be provided in our next submittal.

4. *The adequacy of the HDPE pipe buried at depths of up to 128 feet requires additional consideration. Refer to the discussion in the Basis of Interrogatory.*

Response 4

The analyses included in Appendix J of the Tailings Management Plan have been revised to incorporate an updated maximum overburden on the leachate collection pipes, a change in the selected pipe type for the leachate collection pipes, and a reduction in the modulus of elasticity of HDPE pipe to represent long term conditions.

As noted in Response 1 to Interrogatory R313-24-4-22/02, the drawings in the Tailings Management Plan show the proposed top of tailings elevation as 4455 feet. The lowest elevation of the bottom surface is 4360 feet. Therefore, the maximum anticipated overburden thickness of tailings for the leachate collection piping is approximately 100 feet. The previous value used for the analyses was 128 feet, which is the maximum height of the embankment on the downstream face. This value is greater than the maximum potential thickness of tailings.

The pipe type previously selected for the leachate collection pipes was a 3 or 4 inch diameter corrugated and perforated HDPE pipe. The pipe type has been changed to a 4 inch diameter SDR 11 perforated HDPE pipe.

The modulus of elasticity of HDPE pipe has been reduced by 75 percent to represent long term conditions.

The revised text and calculations are presented in the following updated text for Appendix J.

APPENDIX J

Buried Pipe Loading

J.0 Introduction

The load bearing capacity of the piping that is installed as a component in the leachate collection and recovery system and the sump access pipes must be sufficient to withstand the load imposed by up to 100 feet of overburden above the pipes. The leachate collection pipes are specified as 4 inch diameter SDR 11 perforated HDPE pipe. The sump access pipes are specified as 4 inch or 12 inch diameter SDR 9 HDPE pipe. The method used to evaluate the deflection and potential buckling or crushing of the pipes under the imposed loads is the Modified Iowa Formula as presented in the "Plastic Pipe Design Manual" available on-line from Lamson Vylon Pipe. Section J.1 describes the method of analysis and formulas used in the Modified Iowa Formula. Sections J.2, J.3, and J.4 provide the calculations for the leachate collection pipes, the 12 inch sump access pipes, and the 4 inch sump access pipes, respectively.

J.1 Modified Iowa Formula

J.1.1 Deflection

The Modified Iowa Formula is used to predict the deflection of a flexible pipe. The equation is:

$$\Delta = \left[\frac{D_L \cdot K \cdot P_y}{(0.149 \cdot PS) + (0.061 \cdot E')} \right] \cdot 100$$

where: Δ = Deflection in %
D_L = Deflection Lag Factor
K = Bedding Constant
P_y = Prism Load, in psi
PS = Pipe Stiffness in psi
E' = Soil Modulus in psi

The deflection lag factor (D_L) is set to unity when the prism load is used to calculate deflection. The bedding constant (K) ranges from 0.083 to 0.110 for bedding angles ranging from 180 degrees to 0 degrees. The prism load is calculated as the sum of the static (dead) load and any live load. The soil modulus (E') is generally determined from tabulated values based on the gradation and degree of compaction for the backfill around the pipe. The pipe stiffness (PS) can be a measured value or can be calculated using:

$$PS = \frac{6.71 \cdot E \cdot I}{r^3}$$

where: PS = Pipe Stiffness in psi
E = Modulus of Elasticity in psi
I = Moment of Inertia in cubic inches
r = Mean Pipe Radius in inches

J.1.2 Unconfined Buckling Pressure

The calculation of unconfined buckling pressure is used to determine the maximum thickness of cover or overburden that the pipe can sustain. The calculation does not incorporate the support provided to the pipe by the surrounding soil. The equation is:

$$P_{cr} = \frac{0.447 \cdot PS}{(1 - v^2)}$$

where: P_{cr} = Unconfined Buckling Pressure in psi
PS = Pipe Stiffness in psi
v = Poisson's Ratio (approx. 0.4 for HDPE)

J.1.3 Confined Buckling Pressure

The calculation of confined buckling pressure is used to determine the maximum thickness of cover or overburden that the pipe can sustain and includes the support provided by the bedding surrounding the pipe. The equation is:

$$P_b = 1.15\sqrt{P_{cr} \cdot E'}$$

where: P_b = Confined Buckling Pressure in psi
P_{cr} = Unconfined Buckling Pressure in psi
E' = Soil Modulus in psi

J.1.4 Hydrostatic Buckling Pressure

For the conditions that will be present in the tailings cell(s) the contribution of hydrostatic force to the pipe buckling is considered negligible.

J.1.5 Buckling Resistance

With the total confined buckling pressure and the hydrostatic pressure, the maximum height (thickness) of cover can be calculated as:

$$H = \frac{P_b}{\gamma} \cdot 144$$

where: H = Thickness of Cover in feet
Pb = Confined Buckling in psi
γ = Soil Unit Weight in pcf

J.1.6 Wall Crushing

The wall crushing calculation is basically a comparison of the allowable compressive stress in the pipe wall with the "ring" compressive stress imposed by the loading. The compressive stress is determined by:

$$\sigma = \frac{T}{A}$$

where: σ = Compressive Stress in psi
T = Wall Thrust in lb/inch
A = Area of Pipe Wall in square inches/inch

The wall thrust is calculated as:

$$T = \frac{P_y \cdot D_o}{2}$$

where: T = Wall Thrust in lb/inch
P_y = Vertical Soil Pressure in psi
D_o = Outside Diameter in inches

J.2 Leachate Collection Pipe — Modified Iowa Method

The leachate collection pipe is specified as a 4 inch diameter SDR 11 perforated HDPE pipe. The outside diameter (D0) of a 4 inch SDR 9 pipe is 4.5 inches and the wall thickness is approximately 0.41 inches. The pipe wall area (A) is approximately 0.41 in^2/in. A typical Poisson's Ratio for HDPE is 0.40. On the base of the tailings cell(s), the leachate collection pipe will be bedded in washed gravel which results in a soil modulus (E') of 3000 psi (crushed rock with slight to high compaction). Other relevant properties of the pipe, installation, and loading conditions include: a maximum static load of 100 feet of overburden at an assumed moist density of 100 pcf, a typical deflection lag factor of 1.0, and an intermediate bedding constant, an HDPE modulus of elasticity (E) or 133000, a effective pipe radius of 2.0 inches and a 4 inch pipe moment of inertia (I) of 0.0104 in^3. The modulus of elasticity of the pipe has been reduced in the calculations by 75 percent to represent long term conditions.

J.2.1 Deflection

The predicted deflection in the leachate collection pipe is:

$$\Delta = \left[\frac{D_L \cdot K \cdot P_y}{(0.149 \cdot PS) + (0.061 \cdot E')} \right] \cdot 100$$

The maximum prism load (P_y) is estimated as:

$$P_y = \frac{100 \cdot 100}{144} = 69 \text{ psi}$$

The pipe stiffness is estimated as:

$$PS = \frac{6.71 \cdot E \cdot I}{r^3}$$

$$PS = \frac{6.71 \cdot 33250 \cdot 0.0104}{2.0^3} = 290 \text{ psi}$$

The deflection in the leachate collection pipe is estimated as:

$$\Delta = \left[\frac{1 \cdot 0.1 \cdot 69}{(0.149 \cdot 290) + (0.061 \cdot 3000)} \right] \cdot 100 = 3.1\%$$

Koerner (2005) noted the maximum allowable value of deflection is less than 10 percent. The predicted deflection is smaller than 10% deflection. Therefore, the predicted deflection under the maximum loading condition is acceptable.

J.2.2 Unconfined Buckling Pressure

The unconfined buckling pressure is calculated as:

$$P_{cr} = \frac{0.447 \cdot PS}{(1 - v^2)}$$

$$P_{cr} = \frac{0.447 \cdot 290}{(1 - 0.4^2)} = 154.4 \text{ psi}$$

J.2.3 Confined Buckling Pressure

The confined buckling pressure is calculated as:

$$P_b = 1.15\sqrt{P_{cr} \cdot E'}$$

$$P_b = 1.15\sqrt{154.4 \cdot 3000} = 783 \text{ psi}$$

J.2.4 Hydrostatic Buckling Pressure

For the conditions that will be present in the tailings cell(s), the contribution of hydrostatic force to the pipe buckling is considered negligible.

J.2.5 Buckling Resistance

The total confined buckling pressure can be used to calculate the maximum height (thickness) of cover as:

$$H = \frac{P_b}{\gamma} \cdot 144$$

$$H = \frac{783}{100} \cdot 144 = 1128 \text{ feet} > 100 \text{ feet , therefore OK}$$

J.2.6 Wall Crushing

The wall thrust for a 4 inch inside diameter pipe is calculated as:

$$T = \frac{P_y \cdot D_o}{2}$$

$$T = \frac{69 \cdot 4.5}{2} = 155 \text{ lb/in}$$

The tabulated allowable compressive stress in the HDPE pipe wall is approximately 3000 psi. The predicted compressive stress is calculated as:

$$\sigma = \frac{T}{A}$$

$$\sigma = \frac{155}{0.41} = 378 \text{ psi}$$

The compressive stress is less than the allowable stress of 3000 psi.

J.3 12 inch Sump Access Pipes — Modified Iowa Method

The primary sump access pipes are specified as a 12 inch SDR 9 HDPE pipe. The outside diameter (D_O) of a 12 inch SDR 9 pipe is 12.75 inches and the wall thickness is approximately 1.417 inches. The pipe wall area (A) is approximately 1.417 in^2/in. A typical Poisson's Ratio for HDPE is 0.40. The sump access pipes are routed up 3H:1V slopes so it is not practical to install the pipes in a permanent compacted bedding up the complete length of the slope. However, the Entrada Sand will be used to form a compacted bed around the access pipes from the sump to a maximum distance of 100 feet up the slope to surround, anchor, and protect these access pipes. The surface of the Entrada Sand may be plated with sand and gravel to reduce the erodibility. For the purposes of calculating load bearing capacity, it was assumed that the maximum static load of 100 feet of material is applied to the well-bedded lower section of the access pipe with a soil modulus (E') of 2000 psi. The load bearing capacity and deflection for the upper section of the pipe will be calculated with the reduced overburden thickness of 51 feet and a weaker soil with a modulus (E') of 200 psi. Other relevant properties of the pipe, installation, and loading conditions include: an assumed moist density of 100 pcf for the tailings over the pipe, a typical deflection lag factor of 1.0, an intermediate bedding constant, an HDPE modulus of elasticity (E) or 133000, a effective pipe radius of 5.67 inches and a 12 inch pipe moment of inertia (I) of 0.237 in^3. The modulus of elasticity of the pipe has been reduced in the calculations by 75 percent to represent long term conditions.

J.3.1 Deflection

The predicted deflection in the primary sump access pipe is:

$$\Delta = \left[\frac{D_L \cdot K \cdot P_y}{(0.149 \cdot PS) + (0.061 \cdot E')} \right] \cdot 100$$

The maximum prism load (P_y) for the well bedded lower pipe section is estimated as:

$$P_y = \frac{100 \cdot 100}{144} = 69 \text{ psi}$$

The maximum prism load (P_y) for the upper pipe section is estimated as:

$$P_y = \frac{51 \cdot 100}{144} = 35.4 \text{ psi}$$

The pipe stiffness is estimated as:

$$PS = \frac{6.71 \cdot E \cdot I}{r^3}$$

$$PS = \frac{6.71 \cdot 33250 \cdot 0.237}{5.67^3} = 290 \text{ psi}$$

The deflection for the upper pipe section is estimated as:

$$\Delta = \left[\frac{1 \cdot 0.1 \cdot 69}{(0.149 \cdot 290) + (0.061 \cdot 2000)} \right] \cdot 100 = 4.2\%$$

The deflection for the lower pipe section is estimated as:

$$\Delta = \left[\frac{1 \cdot 0.1 \cdot 35.4}{(0.149 \cdot 290) + (0.061 \cdot 200)} \right] \cdot 100 = 6.4\%$$

The predicted deflections are smaller than 10% deflection. Therefore, the predicted deflections are acceptable.

J.3.2 Unconfined Buckling Pressure

The unconfined buckling pressure for the lower pipe section is calculated as:

$$P_{cr} = \frac{0.447 \cdot PS}{(1 - v^2)}$$

$$P_{cr} = \frac{0.447 \cdot 290}{(1 - 0.4^2)} = 154 \text{ psi}$$

J.3.3 Confined Buckling Pressure

The confined buckling pressure for the lower pipe section is calculated as:

$$P_b = 1.15\sqrt{P_{cr} \cdot E'}$$

$$P_b = 1.15\sqrt{154 \cdot 2000} = 638 \text{ psi}$$

The confined buckling pressure for the upper pipe section is calculated as:

$$P_b = 1.15\sqrt{154 \cdot 200} = 201 \text{ psi}$$

J.3.4 Hydrostatic Buckling Pressure

For the conditions that will be present in the tailings cell(s) the contribution of hydrostatic force to the pipe buckling is considered negligible.

J.3.5 Buckling Resistance

The total confined buckling pressure can be used to calculate the maximum height (thickness) of cover for the lower pipe section as:

$$H = \frac{P_b}{\gamma} \cdot 144$$

$$H = \frac{638}{100} \cdot 144 = 918 \text{ feet} > 100 \text{ feet , therefore OK}$$

The maximum height (thickness) of cover for the upper pipe section is:

$$H = \frac{201}{100} \cdot 144 = 289 \text{ feet} > 51 \text{ feet , therefore OK}$$

J.3.6 Wall Crushing

The maximum wall thrust for the 12 inch pipe is calculated as:

$$T = \frac{P_y \cdot D_o}{2}$$

$$T = \frac{69 \cdot 12.75}{2} = 880 \text{ lb/in}$$

The tabulated allowable compressive stress in the HDPE pipe wall is approximately 3000 psi. The predicted compressive stress is calculated as:

$$\sigma = \frac{T}{A}$$

$$\sigma = \frac{880}{1.417} = 621 \text{ psi}$$

The compressive stress is less than the allowable stress of 3000 psi.

J.4 4 inch Sump Access Pipes — Modified Iowa Method

The secondary sump access pipes are specified as a 4 inch SDR 9 HDPE pipe. The outside diameter (D0) of a 4 inch SDR 9 pipe is 4.5 inches and the wall thickness is approximately 0.50 inches. The pipe wall area (A) is approximately 0.50 in^2/in. A typical Poisson's Ratio for HDPE is 0.40. Like the primary sump access pipes, the secondary access pipes are routed up 3H:1V slopes so it is not practical to install the pipes in a permanent compacted bedding up the complete length of the slope. However, the Entrada Sand will be used to form a compacted bed around the access pipes from the sump to a maximum distance of 100 feet up the slope to surround, anchor, and protect these access pipes. The surface of the Entrada Sand may be plated with sand and gravel to reduce the erodibility. For the purposes of calculating load bearing capacity, it was assumed that the maximum static load of 100 feet of material is applied to the well bedded lower section of the access pipe with a soil modulus (E') of 2000 psi. The load bearing capacity and deflection for the upper section of the pipe will be calculated with the reduced overburden thickness of 51 feet and a weaker soil with a modulus (E') of 200 psi. Other relevant properties of the pipe, installation, and loading conditions include: an assumed moist density of 100 pcf for the tailings over the pipe, a typical deflection lag factor of 1.0, an intermediate bedding constant, an HDPE modulus of elasticity (E) or 133000, a effective pipe radius of 2.0 inches and a 4 inch pipe moment of inertia (I) of 0.0104 in^3. The modulus of elasticity of the pipe has been reduced in the calculations by 75 percent to represent long term conditions.

J.4.1 Deflection

The predicted deflection in the primary sump access pipe is:

$$\Delta = \left[\frac{D_L \cdot K \cdot P_y}{(0.149 \cdot PS) + (0.061 \cdot E')} \right] \cdot 100$$

The maximum prism load (P_y) for the well bedded lower pipe section is estimated as:

$$P_y = \frac{100 \cdot 100}{144} = 69 \text{ psi}$$

The maximum prism load (P_y) for the upper pipe section is estimated as:

$$P_y = \frac{51 \cdot 100}{144} = 35.4 \text{ psi}$$

The pipe stiffness is estimated as:

$$PS = \frac{6.71 \cdot E \cdot I}{r^3}$$

$$PS = \frac{6.71 \cdot 33250 \cdot 0.0104}{2.0^3} = 290 \text{ psi}$$

The deflection for the lower pipe section is estimated as:

$$\Delta = \left[\frac{1 \cdot 0.1 \cdot 69}{(0.149 \cdot 290) + (0.061 \cdot 2000)}\right] \cdot 100 = 4.2\%$$

The deflection for the upper pipe section is estimated as:

$$\Delta = \left[\frac{1 \cdot 0.1 \cdot 35.4}{(0.149 \cdot 290) + (0.061 \cdot 200)}\right] \cdot 100 = 6.4\%$$

The predicted deflections are smaller than 10% deflection. Therefore, the predicted deflections are acceptable.

J.4.2 Unconfined Buckling Pressure

The unconfined buckling pressure for the lower pipe section is calculated as:

$$P_{cr} = \frac{0.447 \cdot PS}{(1 - v^2)}$$

$$P_{cr} = \frac{0.447 \cdot 290}{(1 - 0.4^2)} = 154 \text{ psi}$$

J.4.3 Confined Buckling Pressure

The confined buckling pressure for the lower pipe section is calculated as:

$$P_b = 1.15\sqrt{P_{cr} \cdot E'}$$

$$P_b = 1.15\sqrt{154 \cdot 2000} = 638 \text{ psi}$$

The confined buckling pressure for the upper pipe section is calculated as:

$$P_b = 1.15\sqrt{154 \cdot 200} = 201 \text{ psi}$$

J.4.4 Hydrostatic Buckling Pressure

For the conditions that will be present in the tailings cell(s) the contribution of hydrostatic force to the pipe buckling is considered negligible.

J.4.5 Buckling Resistance

The total confined buckling pressure can be used to calculate the maximum height (thickness) of cover for the lower pipe section as:

$$H = \frac{P_b}{\gamma} \cdot 144$$

$$H = \frac{638}{100} \cdot 144 = 918 \text{ feet} > 100 \text{ feet}\text{ , therefore OK}$$

The maximum height (thickness) of cover for the upper pipe section is:

$$H = \frac{201}{100} \cdot 144 = 289 \text{ feet} > 51 \text{ feet}\text{ , therefore OK}$$

J.4.6 Wall Crushing

The maximum wall thrust for the 4 inch pipe is calculated as:

$$T = \frac{P_y \cdot D_o}{2}$$

$$T = \frac{69 \cdot 4.5}{2} = 155 \text{ lb/in}$$

The tabulated allowable compressive stress in the HDPE pipe wall is approximately 3000 psi. The predicted compressive stress is calculated as:

$$\sigma = \frac{T}{A}$$

$$\sigma = \frac{155}{0.50} = 310 \text{ psi}$$

The compressive stress is less than the allowable stress of 3000 psi.

J.5 References

Plastic Pipe Design Manual, available on-line from www.vylonpipe.com, Lamson Vylon Pipe, Cleveland, Ohio.

Plexco Application Note No. 1, *Pipe Behavior Under Earth Loading,* Chevron Plexco Piping Systems.

BASIS FOR INTERROGATORY:

Review of the responses to the response to Round 1 Interrogatory found that the following concerns remain:

1. *Estimation of anticipated leachate flow rates and maximum capacity in the leachate collection systems has not been identified in the submittal and must be provided. Estimation of the anticipated flows will enable the leachate management system to be properly designed to accommodate the full flow conditions and will ensure that the tailings are dewatered in a reasonable timeframe. This estimation should then also be included as part of the Leachate Monitoring, Operations, Maintenance, and Reporting Plan.*

2. *The liner system design and construction drawings and material and performance specifications need to be developed. These items are currently only addressed for the cover system, but are not included for the liner system. Provide drawings (plans) and specifications in sufficient detail so they could essentially be used for bidding and construction. They are to be certified by a Professional Engineer licensed in the State of Utah. The drawings shall include, but not be limited to, cell liner, leachate collection, leak detection, dewatering operations, tailings transfer and management, and storm water control layouts, cross sections, details, and profiles. They shall include proposed elevations and horizontal coordinates at all key locations. The specifications shall cover (but not limited to) all proposed components and materials, their respective material and equipment and installation requirements*

   In addition, design exercises such as estimating volumes and capacities and creating filling and grading plans in advance of waste generation are critical to a successful project since these exercises help to ensure that estimated volumes are considered and that adequate storage space is planned (even if the storage is temporary). It is common practice to prepare for the estimated contaminated soil volume with a contingency volume included (contingency amount would be based on the confidence in the primary volume estimate). If the contingency volume is not used, then clean or lower level contaminated material can be placed as general fill. These concepts would all be blended into the detailed design drawings and specifications.

3. *The adequacy of the HDPE pipe buried at depths of up to 128 feet requires additional consideration. Various material vendors produce tables of recommended maximum cover depths that contain maximum depth values far less than those specified in the design (ADS-pipe.com, for example). The ADS-pipe.com website contains in it's Technical Note TN2.01, April 2007, "Minimum and Maximum Burial Depth for Corrugated HDPE Pipe", a maximum burial depth for 4 inch HDPE pipe of 44 feet (class I backfill). In addition, the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications Section 12 - "Buried Structures and Tunnel Liners" presents a process for evaluation of pipe strength compared to burial depth. This procedure suggests that the pipe under consideration in place, may be subject to forces in excess of those needed for prevention of crushing. Further review and consideration of this pipe evaluation procedure is necessary.*

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007.

INTERROGATORY R313-24-4-26/02: INFILTRATION AND CONTAMINANT TRANSPORT MODELING

INTERROGATORY STATEMENT:

Please provide sufficient information to demonstrate that the cover system will not experience some potential long-term degradation through one or more processes (as discussed below in the Basis For Interrogatory), when active institutional control is no longer in effect to maintain the cover system.
Provide additional information to identify and evaluate the potential effects of long-term degradation processes on the components of the final cover system.

Conduct and report additional (infiltration sensitivity) analyses to assess the potential affects of such cover system component degradation on long –term infiltration rates through the cover during the cover's design life.

Response 1

This response will be provided in our next submittal.

***BASIS FOR INTERROGATORY**:*

The response does not provide sufficient information to support the contention that the compacted clay layer in the cover system (and/or other layers in the cover system as well) would not experience some potential long-term degradation through one or more processes, under the scenario where there the active institutional controls period is no longer in effect to maintain the cover system. Additional information should be provided to identify and evaluate the potential effects of long-term degradation processes on the compacted clay layer and on other components of the final cover system. Additional (infiltration sensitivity) analyses should be conducted and modeling results from such analyses provided to assess the potential affects of such cover system component degradation on long –term infiltration rates through the cover during the cover's design life. Specific information that should be considered includes the following:

- *Additional information demonstrating that analyses of the closed facility's future performance have considered reasonably foreseeable degraded conditions that could occur within the final cover system after closure (e.g., up to several hundred years following closure) if the closed site were not actively maintained. For example, in the HELP Modeling simulations described in the December 2006 Tailings Reclamation Plan, it is not clear that the HELP Model simulations provided incorporate any reduction in the value of saturated hydraulic conductivity for either the fine sand layer or for the rock mulch capping layer to reflect potential (e.g., partial) clogging of these layers with windblown fines (rock mulch layer) or fines (sand drainage layer) that could invade these layers over time through ecological succession, or an increased value of saturated hydraulic conductivity of the radon barrier layer due to the effects of (e.g., moderately deep or possibly deeper-rooted) plant species. Other cover system physical parameters that could be affected over the long term due to environmental processes, such as porosity, field capacity, and wilting point of various cover layers, should be considered and incorporated as appropriate, into the infiltration analysis.*
- *A biointrusion assessment/analysis, including information regarding the potential for shallow and/or possibly deeper-rooted plant species to become established on the final cover system and an analysis to evaluate the effects of such vegetation on long-term infiltration rates. For example, it has not been demonstrated whether or not it is possible that native vegetation, including one or more deep-rooted species (such as black greasewood in particular, or other deeper-rooted species that might be present in Shootaring Canyon area) might become established on areas of the cover after the 100-year period of institutional control.*
- *If the information compiled above indicates that establishment of moderately deep to deeper-rooted vegetation on the final cover system appears possible, please provide a sensitivity analysis*

in the HELP model to evaluate the effect of such deeper-rooted species becoming established on the final cover during the performance period on long-term infiltration rates through the cover. Phenomena to consider include a network of taproot/possible root decay –induced defects in the radon barrier layer and their effect on hydraulic conductivity of the radon barrier layer.

- *A revised infiltration analysis that considers the potential for partial degradation of the 40-mil HDPE geomembrane, as a result of puncturing damage or other construction-related or post-construction static loading-related damage, if considered possible, as well as long-term deterioration of the HDPE geomembrane liner due to antioxidant depletion, oxidative induction (with resulting HDPE embrittlement and chain scission and environmental stress cracking), and other possible factors (e.g., biological agents).*
- *The possibility of stress cracking with the HDPE geomembrane has not been addressed in the HELP model. Information addressing the issue of potential stress cracking in the geomembrane and its effects on cover infiltration needs to be provided.*
- *A frost depth analysis should be performed to determine the maximum projected frost penetration depth within the final cover.*

REFERENCES:

Badu-Tweneboah, K., Tisinger, L.G., Giroud, J.P., and Smith, B.S., 1999, "Assessment of the Long-Term Performance of Polyethylene Geomembrane and Containers in a Low-Level Radioactive Waste Disposal Landfill," in Proceedings, Geosynthetics '99, Boston, Massachusetts, April 28-30, 1999.

DOE 2001. Disposal Cell Cover Moisture Content and Hydraulic Conductivity, Long-Term Surveillance and Maintenance Program Shiprock, New Mexico, Site, Grand Junction, Colorado. May 2001.

EPA 2002a. "Simulating Radionuclide Fate and Transport in the Unsaturated Zone: Evaluation and Sensitivity Analyses of Select Computer Models". EPA/600/R-02/082. 2002.

EPA 2002b. U.S. Environmental Protection Agency 2002. Assessment and Recommendations for Improving the Performance of Waste Containment Systems. EPA/600/R-02/099. Cincinnati, Ohio. December 2002.

EPA 2004. "Technical Guidance for RCRA/CERCLA Final Covers", USEPA - USACE Superfund Partnership Program Policy, Guidance, and Activities, Chapter 2 and Appendix B. http://hq.environmental.usace.army.mil/epasuperfund/geotech/

Hydro-Engineering, L.L.C. 2006. Ground-Water Monitoring of Shootaring Canyon Tailings Site - 2005.

Koerner et al. 2005. Koerner, R, Hsuan, Y.G., and Koerner, G. 2005. GRI White Paper #6 - on - Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions. Geosynthetic Institute, Folsom, Pennsylvania. June 7, 2005.

National Committee on Radiation Protection, National Bureau of Standards(NBS) Handbook 69 (1959), "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," Superintendent of Documents, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., June 5, 1959.

Plateau Resources, Ltd., "Revised Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December 2006.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R317-6-2.1-27/02: GROUNDWATER MONITORING

INTERROGATORY STATEMENT:

1. *Please provide a proposed sampling and analysis plan for monitoring of the seep (or spring) located south of the mill site near Ant Knolls (as shown on Figure 1-1 of the revised Tailings Management Plan). Please also provide information to indicate whether sampling and analysis of springs or seeps located northwest of the mill site and proposed cells 1 and 2 and the spring or seep located northeast of proposed Cells 1 and 2 (e.g. Lost Spring) would be conducted, for example, for comparison purposes. Alternatively, please provide justification for not monitoring these seep/spring locations.*

   Response 1
   This response will be provided in our next submittal.

2. *Please confirm the location of the point of compliance groundwater monitoring wells.*

   Response 2
   This response will be provided in our next submittal.

3. *Please provide rationale for selecting parameters for groundwater sampling and analysis (as listed in Section 7 and in Appendix D of the Revised Tailings Management Plan (Plateau Resources, Ltd. And Hydro-Engineering, LLC 2007), including parameters to be used as key indicators of performance. Please provide additional information/rationale to support not specifying requirements for analysis of any parameters (e.g., Radium-228 and gross alpha) identified in R317-6-2.1, as applicable parameters for sampling and analysis.*

   Response 3
   This response will be provided in our next submittal.

4. *Please discuss how it will be ensured that monitored parameters would not exceed the Groundwater quality Standards listed Table 1 in R317-6-2.1. Please include information to address the potential for selenium exceedances and the potential applicability of the revised arsenic water quality standard which became enforceable in January of 2006.*

   Response 4
   This response will be provided in our next submittal.

5. *Please provide a proposal detailing the proposed methodology for establishing background groundwater quality for the proposed facility and site. Please provide as part of that methodology information regarding statistical approaches to be used for:*
   - *Determining background groundwater quality characteristics and (background) groundwater quality compliance limits.*
   - *Determining the occurrence of statistically significant temporal trends in groundwater quality at the compliance monitoring wells.*

Response 5

Methodology for Calculating Background Water Quality Characteristics, Ground Water Compliance Limits and Trend Analysis.

The objective of the proposed approach to calculating background water quality characteristics (background) and ground water compliance limits is to establish statistically defensible values that minimize false positives (apparent exceedences) as well as false negatives (potentially undetected contamination). This objective is consistent with the methods for ground water monitoring prescribed in the ASTM method D6313 (ASTM, 2005) and EPA (1989). This objective is accomplished by combining a statistically defensible determination of compliance limits based on background conditions to protect against false positives and control charts to guard against false negatives.

The proposed approach is comprised of a series fundamental steps, presented below.

Statistical Determination of Background

Identification of Water-Bearing Zones. Uranium One will separate water quality data between the principal Entrada Sandstone aquifer and the upper, perched zone. The distinction will be made in recognition of each of these zones being a discreetly identified water-bearing zone.

Determination of Principal Water Types. Uranium One will evaluate the site-wide major ion composition for each water-bearing zone to determine if more than one principal water type is present in each zone. This analysis will be conducted using standard Piper diagrams (Hem, 1985). Once validated, the retained site data for each chemical constituents of concern (COC) will be pooled into a single population (retaining separation of upper and lower water-bearing zones).

Comparison of variance. Early (pre-1997) and late (post-1997) site data for COCs will be used to validate use of early and late data as statistically indistinguishable. The 1997 date is chosen as the break owing the general absence of data over the years 1985 – 2000 for most COCs. Box plots will be used, as described in EPA (1989), using standard statistical computer software (Minitab 14). As part of this analysis, EPA (1992) guidance regarding the treatment of non-detect (ND) results will be followed. Specifically, for COCs with 0-15% ND, ND values will be substituted with one-half the cited ND for the individual analysis. For COCs with greater than 15%, but less than 100% ND, Regression Order Statistics (ROS) will be used to generate values to replace ND values for each COC. The box plots ultimately produced for early and late data will initially identify statistical outliers for each COC in the early and late data. The resulting final box plots will be compared to evaluate the overlap of the 95% confidence intervals of early and late data for each COC. Overlap of these intervals will correspond to a conclusion of statistically indistinguishable data early and late in the period of record. A lack of overlap will correspond to statistically different conditions, and only late (post 1997) data will be retained for further evaluation and development of background.

Test of Normality. In each zone, Uranium One will evaluate the statistical distribution of data for each COC. The evaluation will identify normal and log normal data sets and tagged for subsequent appropriate determination of the mean value and standard deviation (uncertainty), consistent with ASTM (2005). Data sets with no identifiable distribution will be tagged for one-sided (upper) non-parametric analysis using the method of Helsel and Hirsch (2002), consistent with the guidance provided in ASTM (2005).

Determination of Summary Statistics. As indicated above, normally and log-normally distributed data sets will be used to generate summary statistics for each COC, in upper and lower zones separately. Normally distributed data will be used directly to determine the mean, minimum, maximum and upper 95% confidence interval. Log-normally distributed data sets will be used to produce the same summary statistics, but will be log-transformed prior the statistical analysis. Subsequently, the summary statistics will be transformed back to yield the ultimate summary statistic set. Data sets which follow neither a normal or log-normal distribution will be subjected to a one-sided non-parametric analysis (Helsel and Hirsch, 2002) to yield the corresponding summary statistics.

Calculation of Ground Water Compliance Limits.

For all COCs with less than 100% ND, the ground water compliance limit will be computed as the mean (central tendency) plus two standard deviations. This approach, consistent with criteria cited by EPA (1989) and ASTM (2005), by definition yields compliance values for each COC that provide for a false positive rate of 5%. For any COCs that are 100% ND, the compliance limit will be set at 0.1 times the ground water quality standard, or the analytical method detection limit, whichever is greater.

Determination of Statistically Significant Trends

Determination of statistically significant trends represents a viable and useful approach to minimizing the rate of false negative assessment of contamination (potentially undetected contamination). The development and use of control charts (EPA, 1989) is a standard intra well, trend analysis technique that is proposed for the compliance wells at the Shootaring site.

The projected timeline for operations at the site provide for installation of monitoring wells approximately one year prior to operation of the tailings impoundment. This time, in conjunction with ground water travel times on the order of 8 feet per year (Hydro-Engineering, 1998), will provide more than ample time to collect baseline data for each proposed compliance monitoring well. This background, baseline data will form the statistical basis for identifying any statistically significant changes (trends) in water quality.

The methodology for the development and use of control charts at the site is consistent with the approach presented in EPA (1989). Following the collection of at least eight sampling periods of data to establish baseline, construction of the control charts will be initiated. For each subsequent sampling period, the Standardized Mean and the Cumulative Sum statistic will be computed, graphed and compared to statistically derived performance parameter criteria, as cited in EPA (1989).

Comparison of the computed control chart statistics will provide the ability to recognize statistically significant changes in the concentration of COCs in compliance monitoring wells before an exceedence of ground water quality compliance limits occurs. Thus, the control chart will provide an early warning mechanism to identify potential contamination (minimization of false negatives) and allow timely implementation of corrective action while maintaining the corresponding protection against false positives described above.

References

ASTM (2005) Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs. Method D6312-98. American Society for Testing and Materials.

EPA (1989) Statistical Analysis of Ground_Water Monitoring Data at RCRA Facilities Interim Final Guidance. Office of Solid Waste Management, Waste Management Division, U.S. Environmental Protection Agency. April 1989.

EPA (1992) Statistical Analysis of Ground_Water Monitoring Data at RCRA Facilities Addendum to Interim Final Guidance. Office of Solid Waste Management, Waste Management Division, U.S. Environmental Protection Agency. July, 1992.

Helsel, D.R. and Hirsch, R.M. (2002) Statistical Methods in Water Resources. In Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4 Hydrologic Analysis and Interpretation, Chapter A3. United States Geological Survey, Reston, Virginia.

Hem, J.D. (1985) Study and Interpretation of the Chemical Characteristics of Natural Water. United States Geological Survey Professional Paper 2254.

Hydro-Engineering, LLC., “Ground Water Hydrology of Shootaring Canyon Tailings Site”, May 1998.

BASIS FOR INTERROGATORY:

The basis for the above Interrogatory includes information contained in the Basis for Interrogatory that was provided in the Round 1 Interrogatories, which, for convenience, is repeated below:

“A complete and concise plan that includes the details of the proposed groundwater monitoring to be done at the site is needed. It should include rational for monitoring locations, frequency, parameters, sampling and analysis methodology, evaluation of results, reporting and documentation, and parameters limits.

Information needs to be provided detailing the statistical methods that will be used for establishing background water quality limits and for determining statistically significant trends in groundwater quality. NRC 2003, Section 4.2.3, and American Society for Testing and Materials Standard D 6312, provide guidelines regarding statistical analysis methods that can be used for determining background concentrations for constituents of concern and for evaluating potential groundwater quality trends.

Data reported in the "Ground-Water Monitoring Report of Shootaring Canyon Tailings Site – (Hydro-Engineering, L.L.C., February 2006) indicate selenium concentrations in water from Well RM 20 that exceed the currently-specified selenium threshold value (0.022 mg/L). If the licensee desires to have alternate concentration limits included in the GWQDP, as proposed in the 2005 Ground Water Monitoring Report, then the licensee should provide the data and associated analysis including a clear statistical basis for the proposed alternate concentration limits. Also, please clearly state the methodology and statistical basis that will be used to determine the (background) selenium concentration limit.

Uranium One must demonstrate that the GWQSs are not exceeded per R317-6-2.1. This should be demonstrated via sampling and analysis and background determination of the constituents in Table 1 in R317-6-2.1 as appropriate. The GWQDP does not currently specify the requirement for analysis of Radium-228 and gross alpha per R317-6-2.1."

REFERENCES:

ASTM D 6312. "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs". ASTM, West Conshohocken, PA.

Hydro-Engineering, LLC. Ground Water Monitoring of Shootaring Canyon Tailings Site – 2005. February 2006.

NRC 2003. NUREG-1620, Rev. 1, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978." Washington, DC: NRC 2003.

Utah Department of Environmental Quality. Ground Water Quality Discharge Permit. Permit #UGW170003, issued January 14, 2004.

Utah Department of Environmental Quality. Division of Radiation Control. Radioactive Material License UT 0900480, Amendment # 2.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R317-6-6.3F-28/02: INFORMATION ON EFFLUENT DISCHARGE RATES

INTERROGATORY STATEMENT:

Estimate the leakage through the secondary liner in similar fashion to the method used to calculate leakage through the primary liner (Section 5.1.4.7 of the TMP). Prepare the estimate using assumptions of head based on the intended operating conditions within the secondary containment sumps (i.e., head caused by one day of leakage and reasonable assumptions as to the leakage through the liner into the underlying subgrade. State and justify the estimated discharge quality and quantity. State the estimated leakage rate for each of the areas, recognizing that the impoundments each will be lined with secondary containment, and that the ore pad will allow greater leakage through the clay liner

Please provide the maximum daily leachate (gpd) and discharge rate (gpm) in each discharge or combination of discharges. Include in this information any discharge that may result from leakage through the tailings cells liner systems, the ore pad liner, and the Evaporation and Process Pond Cell. Please provide the appropriate calculations for each discharge. Also, please state the expected concentrations of pollutants in each discharge and the basis for the determination.

Response 1

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

Uranium One must provide the above requested information on all discharges of pollutants that impact or have the potential to impact ground water. This information must include all discharges or potential discharges associated with effluent discharge, storage, and liner systems.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY PR R317-6-6.3G-29/02: SURFACE WATER CONTROLS

INTERROGATORY STATEMENT:

Please provide information on how surface water run-on and run-off controls will be applied to control the migration of contaminants from the site and associated operations. This is to include a hydraulic analysis for surface water flow and control that could impact the site during milling operations. The analysis needs to be the same level of detail as provided for the Tailings Reclamation and Decommissioning Plan (Section 6.3), and include:

- *How (specifically) surface water flow from contaminated areas will be handled separately from surface water from non-contaminated areas.*
- *How impounded water will not alter or compromise the groundwater flow directions in the Upper Entrada Aquifer.*
- *Layout of flow patterns for surface water controls*
- *Design and details of surface water control structures and respective flow rates*
- *Design basis*
- *Operation and maintenance involved*

Please justify statements that infer that no storm water will impact "waters of the State" in consideration that surface water will be impounded and has the potential to impact groundwater. This justification could be combined with a response to Interrogatory 28/02.

Response 1

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

Uranium One's response to Round 1 Interrogatory referred to Section 5.1.6 of the TMP that includes a limited summary of the surface water controls to be implemented during operation. No detailed information on the design and sizing of these controls was included, nor were there details on how water from contaminated areas will be kept and handled separately from water from non-contaminated areas. The same type of hydraulic analysis that was done for the Tailings Reclamation and Decommissioning Plan for storm water control after cell closure (Section 6.3) needs to be performed for the storm water control during mill operation.

In addition, the statement is made that no storm water will leave the site as surface discharge. However, water will be impounded and could be discharged to groundwater (see Interrogatory 28/02). According to R313-6-6.3G, the operator is required to determine that discharges will not affect "waters of the State" which includes groundwater.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R313-24-4-30/02: GEOLOGIC, HYDROLOGIC, AND AGRICULTURAL DESCRIPTION

INTERROGATORY STATEMENT:

Please state the status of each well and seep shown in Figure 7-1 of the TRDP. Tie Figure 7-1 into the local survey plat. Include in Figure 7-1 information about the area within a one mile radius of the discharge point or within one mile of the perimeter of the tailing ponds. Include true and magnetic north, with declination and date of declination measurement. Refer to the preliminary findings stated above to ensure the Uranium One provides complete details that should be included in the plat. If a specific item from the preliminary findings is not applicable, clearly state this in both the response and text accompanying the revised Figure 7-1.

Response 1

The attached Drawing 7-1 will be added to the Tailings Reclamation and Decommissioning Plan. This drawing includes all of the requested data.

Additional References (will be added to existing reference list for Tailings Reclamation and Decommissioning Plan)

National Oceanic Atmospheric Administration. 2007. *National Geophysical Data Center, Esimated Value of Magnetic Declination.* http://www.ngdc.noaa.gov

Utah Department of Environmental Quality. 2007. *Source Protection Program, County Source Protection Ordinances.* http://www.drinkingwater.utah.gov

U.S. Geological Survey, 1987. *Lost Spring Quadrangle, Utah – Garfield County, 7.5 Minute Series (Topographic).*

BASIS FOR INTERROGATORY:

Figure 7-1, as provided contained in the TRDP revised December 2006, does not meet the June 2006 interrogatory request (repeated below for convenience).

"Please provide, in a readily accessible format, the hydrologic information specified under the stated requirements. Please also provide a current plat map showing all existing water wells, including the status and use of each well, Drinking Water source protection zones, topography, springs, water bodies, drainages, and man-made structures within a one-mile radius of the discharge (or other information demonstrating that such features do not exist)."

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project – 2005; Garfield County, Utah", Dated December 2005, revised December 2006.

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005.

Plateau Resources, Ltd., "Shootaring Canyon Uranium Processing Facility Environmental Report, Source Material License No. UT0900480", Dated January 2006.

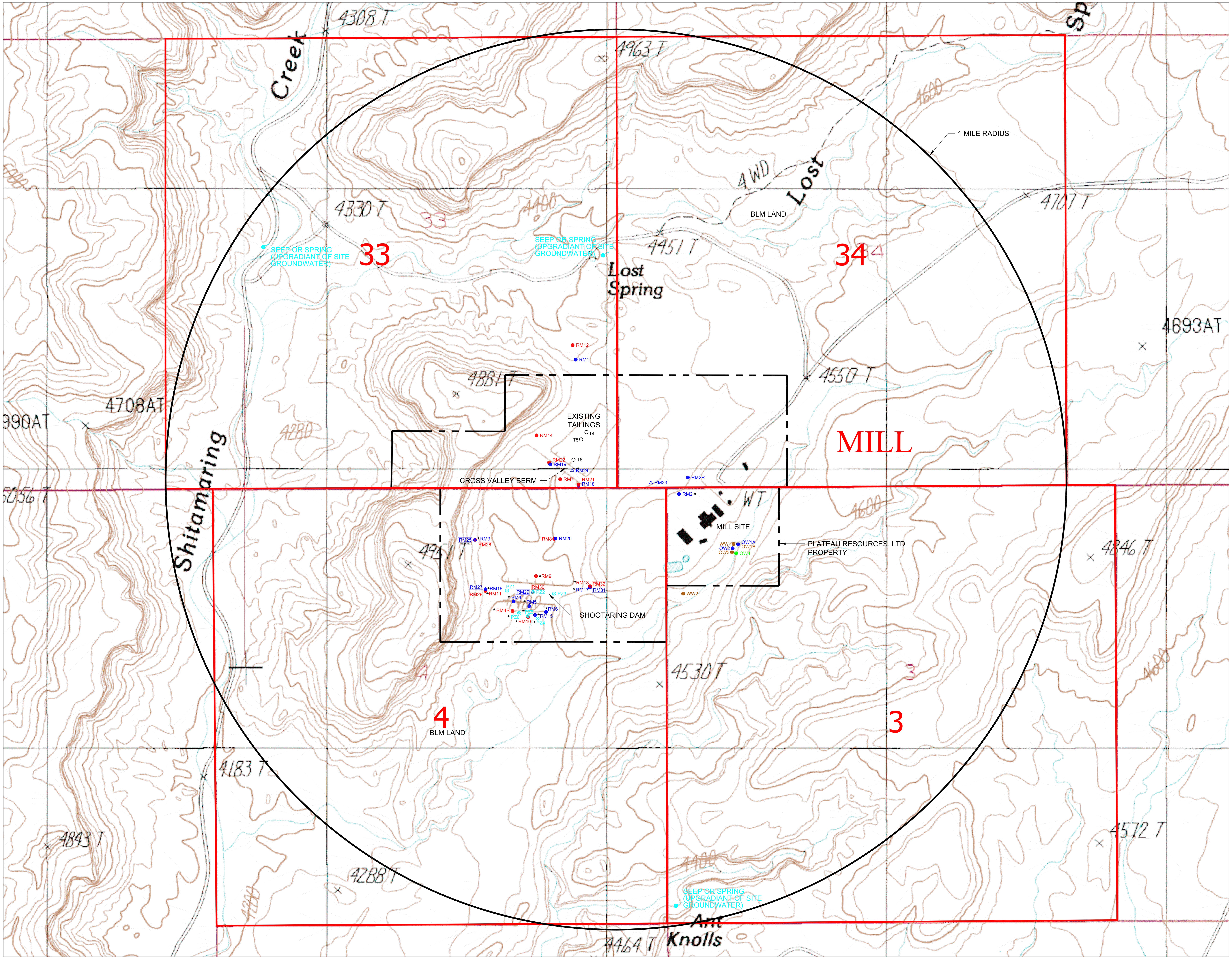

TABLE 1: LOCATION AND DEPTH DATA FOR SHOOTARING WELLS AND PIEZOMETERS

Well Name	North Coord.	East Coord.	Total Depth (ft-mp)	MP Elevation (ft-msl)	Sreen Interval (ft-lsd)
OW1A	57140	63730	300.0	4472.53	200-300
OW1B	57140	63730	798.0	4474.23	648-798
OW2	57094	63667	300.0	4470.70	200-300
OW3	57046	63659	798.0	4470.78	650-798
OW4	57035	63707	570.0	4472.54	435-570
RM1	59307	61827	487.0	4449.20	220-480
RM2*	57731	63040	520.0	4519.76	260-520
RM2R	57924	63142	300.0	4504.86	250-300
RM3*	57193	60647	540.0	4461.32	230-540
RM4*	56472	61099	500.0	4395.50	190-490
RM4R*	56358	61086	160.0	4368.32	110-160
RM5*	56416	61286	440.0	4379.12	150-430
RM6*	56348	61481	460.0	4374.57	175-455
RM7	57904	61645	219.5	4395.86	187-217
RM8	57204	61576	79.1	4381.77	57-77
RM9*	56767	61363	82.8	4369.31	62-82
RM10*	56286	61272	99.0	4343.57	57-97
RM11*	56594	60769	240.0	4436.14	140-180 (180-240#)
RM12	59477	61791	157.0	4415.95	117-157
RM13*	56648	61996	270.0	4434.81	140-180 (180-270#)
RM14	58419	61368	260.0	4450.84	134-174 (174-260#)
RM15*	56311	61354	460.0	4343.75	379-459
RM16*	56615	60772	296.0	4434.95	246-296
RM17*	56636	61993	290.0	4433.58	240-290
RM18	57833	61851	243.3	4421.56	162-242
RM19	58077	61524	236.3	4409.50	155-235
RM20	57208	61592	212.6	4380.83	131-211
RM21	57843	61851	141.3	4421.64	110-140
RM22	58088	61513	120.8	4410.52	90-120
WW1	57144	63677	870.0	4454.79	635-870#
WW2	56562	63086	1000.0	4471.61	602-1000
T4	58456	61953	20.0	4431.20	12.9-17.9
T5	58371	61891	10.0	4425.00	2.5-7.5
T6	58133	61801	11.7	4429.00	3.8-8.8
PZ1	56598	61022	87.0	4434.51	75-85
PZ2	56580	61327	88.0	4434.74	76-86
PZ3	56564	61575	88.0	4435.34	76-86
PZ4	56271	61383	25.0	4347.17	13-23
PZ5	56301	61275	25.0	4344.79	13-23
PZ6	56332	61167	25.0	4362.50	13-23

Notes:
1. Wells RM1 through RM6, RM15 through RM20, OW1A and OW2 are completed in the Entrada Aquifer.
2. Wells RM2R, RM4R, RM7 through RM14, RM21, RM22, and PZ4 through PZ6 are completed in the Upper Entrada Aquifer.
3. Wells WW1, WW2, OW1B and OW3 are completed in the Navajo Aquifer
4. Well OW4 is completed in the Carmel Aquitard.
5. Piezometers PZ1 through PZ3 are Dam Piezometers.
6. Above data compiled from physical measurements, records and site surveys.
7. Definitions:
   mp = measuring point; lsd = land surface datum
   msl = mean sea level; # = open hole
   * = abandoned well

LEGEND

- RM3 ENTRADA WELL
- RM8 UPPER ENTRADA WELL
- RM25 PROPOSED ENTRADA WELL
- RM26 PROPOSED UPPER ENTRADA WELL
- OW4 CARMEL WELL
- WW1 NAVAJO WELL
- * ABANDONED WELL
- PZ1 PIEZOMETER
- T4 TAILINGS WELL

NOTES:

1. NO DRINKING WATER SOURCE PROTECTION ORDINANCES EXIST FOR THE AREA WITHIN A MILE RADIUS OF THE SITE. (http:\\www.drinkingwater.utah.gov)
2. MAGNETIC NORTH CALCULATED ON NOVEMBER 11, 2007 AS 11°37'E. (http:\\www.ngdc.noaa.gov)
3. TOPOGRAPHY FROM USGS LOST SPRING QUADRANGLE, ADJUSTED TO MATCH LOCAL SURVEY DATA. U.S. GEOLOGICAL SURVEY, 1987 "LOST SPRING QUADRANGLE, UTAH - GARFIELD CO., 7.5 MINUTE SERIES (TOPOGRAPHIC)"

11°37'0" DECLINATION
TRUE NORTH
MAGNETIC NORTH

SCALE IN FEET
500 0 1000

PROJECT NO:	181501
DATE:	NOVEMBER 2007
DESIGNED BY:	
DRAWN BY:	TGB
CHECKED BY:	
APPROVED BY:	

PREPARED BY: uraniumone

FIGURE 7-1
LOCATION OF HYDROLOGIC FEATURES

PREPARED FOR:

DRAWING NO. 7-1

INTERROGATORY R313-24-4-33/02: POST-CLOSURE DRAINAGE AND EROSION CONTROLS AND POSTCLOSURE MAINTENANCE

INTERROGATORY STATEMENT:

In accordance with UAC R317-6-6.3.S, please provide a plan for closure and post-closure maintenance that discusses post-closure maintenance requirements and identifies measures that will be taken to prevent groundwater contamination during the facility's closure and postclosure phases and to minimize the need for active maintenance following closure. Maintenance of the cover and erosion control systems should also be addressed.

Response 1

This response will be provided in our next submittal.

Please provide analyses and discussion of the long-term performance of the cover system considering wind erosion, slope stability, settlement, seismic events, etc. Please describe and provide a basis for the demonstration period during the interim period of site transfer to the custodial party. Please demonstrate that the cover system will remain effective for 1000 years, to the extent achievable, and for a minimum of 200 years and require minimal maintenance following closure.

Response 2

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

The licensee should demonstrate that the cover system and other closure design control features will remain effective for 1000 years, to the extent achievable, and for a minimum of 200 years and require minimal maintenance following closure without posing risks due to the release of radiological and potentially hazardous constituents.

The following portion of the 1st Round Interrogatory on Rock Cover (Interrogatory R313-24-4-17/01) is combined and moved to this section - Post-Closure Drainage and Erosion Controls and Post-Closure Maintenance; please provide analyses (or modeling) and discussion of the long-term performance of the cover system and associated erosion controls following closure. Section 6.0 of the Tailings Reclamation and Decommissioning Plan (Hydro-Engineering, L.L.C. 2006) discusses the design of the drainage and erosion control systems for reclamation, however, the section does not appear to thoroughly address post-closure performance required to demonstrate with reasonable assurance that the integrity of the cover system will be maintained and will control radiological and non-radiological hazards for a minimum of 200 years, and to extent achievable, for 1,000 years. Section 6.0 and prior responses indicate that the primary concern for disruption of the cover is erosion by water with the cover designed to accommodate a Probable Maximum Flood (PMF).

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December 2005, Revised December 2006.

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility," Dated December 2005, Revised April 2007.

INTERROGATORY R313-24-4-34/02: RADON RELEASE MODELING

INTERROGATORY STATEMENT:

Please provide additional justification for the moisture content and dry density values proposed or, alternatively, more conservative values should be substituted in the modeling (refer to the discussion included in the Basis for Interrogatory).

Response 1

This response will be provided in our next submittal.

Please provide adequate justification to support taking any credit for the presence of the HDPE geomembrane for reducing radon release in the long-term after the geomembrane's radon release barrier efficiency is essentially no longer effective.

Response 2

This response will be provided in our next submittal.

Provide adequate justification for not completing a radon release simulation where the radon attenuation effects of the cover system layers overlying the radon barrier layer component of the cover are neglected, or include this simulation.

Response 3

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

In their response to Round 1 of this Interrogatory, Uranium One has not demonstrated that the (long-term) moisture content (24 percent) and dry density values (90 percent for Shootaring Canyon Dam-derived clay materials and 86 percent for alternate clay source-derived clay materials) specifically selected for use in the radon release modeling are sufficiently conservative to bound the range of uncertainty associated with the long-term values of moisture content and dry density that could occur in the radon barrier layer. Variations in the moisture content and dry density of the compacted clay cover layer could likely occur over its design life and such variations need to be considered in evaluations performed to estimate long-term radon emission rates through the cover system (DOE 1989, Section 7.1; EPA 2004, Section 2.3.2.2.8). Additional justification should be presented for the values proposed or, alternatively, more conservative values should be substituted.

Applicable/relevant guidance for estimating long-term moisture content and dry density values for radon barrier layers, including the need for considering possible variations in climate, consideration of physical processes that would be involved, and the possibility of using the –15-bar moisture content of the radon barrier material as a reasonable lower bound estimate of the long-term radon barrier layer moisture content for conducting a worst-case radon release model simulation, are given in NRC Regulatory Guide 3.64 (NRC 1989, pp. 3.64-2 through 3.64-9) and DOE (1989, pp.163-176).

The HDPE geomembrane will have a finite effective service life (see Interrogatory R313-24-4-26/01: INFILTRATION AND CONTAMINANT TRANSPORT MODELING above). Therefore the HDPE geomembrane would provide a measure of conservatism for the radon release modeling only during the active service life of that geomembrane. Adequate justification needs to be provided to support taking any credit for the presence of the HDPE geomembrane for reducing radon release in the long-term after the geomembrane's radon release barrier efficiency is essentially no longer effective.

In addition, Uranium One has not provided adequate justification for not completing a radon release simulation where the radon attenuation effects of the cover system layers overlying the radon barrier layer component of the cover are neglected. Performance of such an analysis case is consistent with precedence that has been used for many years on the UMTRA Project where materials above the radon barrier layer were not modeled (DOE 1989, p. 170). Radon release simulations completed for other similar facilities designed and/or constructed in the State of Utah (Monticello tailings repository final cover system – Waugh and Richardson 1997, p. D-41; Moab tailings repository final cover system (Office of Environmental Management 2006) each included one or more simulation cases where the cover layers overlying the radon barrier layer were not included in the radon release modeling.

REFERENCES:

Plateau Resources, Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project", Dated December, 2005.

DOE, 1989, "Technical Approach Document," Uranium Mill Tailings Remedial Action Project, Rev. II, Section 7.1, "Design of the Radon Barrier". U.S. Department of Energy, UMTRA-DOE/AL 050425.0002. Albuquerque, New Mexico. December 1989.

EPA 2004. "Draft Technical Guidance for RCRA/CERCLA Final Covers", USEPA - USACE Superfund Partnership Program Policy, Guidance, and Activities, Chapter 2. http://hq.environmental.usace.army.mil/epasuperfund/geotech/

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility" Amended December, 2005, Revised April 2007.

Plateau Resources, Ltd., Responses to Round 1 TMP Interrogatories, April 2007

INTERROGATORY R313-24-4-36/02: OPERATIONAL DUST CONTROL

INTERROGATORY STATEMENT:

Please provide written procedures, material specifications, and supporting detail on dust suppression methods to be used on the tailings piles and drying and packaging operations. Please state the reasonable requirements for dust suppression for these operations.

Please provide specifications on the alternative reagents that might be used for dust suppression associated with both the tailings piles and the drying and packaging operations.

Include details on methods for dust suppression for interim covering a portion of a cell when not working in the area, and discuss the impact it will have the engineering properties of the tailings (long and short term), and state the justification for the impacts. Also, provide ALARA evaluations performed for dust suppression to ensure that airborne effluent releases are reduced to levels as low as reasonably achievable.

Response 1

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

Sections 4.1.1 and 6.2 of the TMP briefly reference applying agents for dust suppression but do not provide sufficient information. The applicants' initial response stated "The RMTP methodology requires further evaluation and refinement, and the production of dust from the paste or moist tailings is not yet quantified. It will be necessary to conduct testing of the fluid extraction process, reduced moisture tailings properties, and available dust suppression agents prior to operation of the mill."

The Division requires a consideration of airborne effluent releases to ensure they are ALARA and that population exposures are reduced to the maximum extent reasonably achievable.

REFERENCES:

Plateau Resources, Ltd., "Tailings Management Plan for Shootaring Canyon Uranium Processing Facility," Dated December 2005, Revised April 2007.

Regulatory Guide 3.56, "General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills," Task CE 309-4, USNRC, May, 1986.

INTERROGATORY R313-24-4-37/02: COST ESTIMATES FOR DECOMMISSIONING AND RECLAMATION

INTERROGATORY STATEMENT:
After all design changes are made for the facility and its component equipment, structures, and systems pursuant to this and subsequent rounds of interrogatories, please respond to the following general and specific directives and requests:

1. *Provide the basis for EACH quantity, duration, allowance, and lump sum identified in the cost estimates presented in Section 11 of the "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project – Revised 2006." This basis should be related in some way to the quantity of materials to be handled (based on relevant drawings) and a documented productivity for similar activities.*

   Response 1
   This response will be provided in our next submittal.

2. *Estimate and include the cost of providing an appropriate level of security at the facility during reclamation and decommissioning.*

   Response 2
   This response will be provided in our next submittal.

3. *Either (A) make a connection between the structures, components, and systems listed in the second paragraph of Section 8.0 and the cost estimate presented in Section 11.1 OR (B) estimate and include the costs of decommissioning each of the structures, components, and systems listed in the second paragraph of Section 8.0*

   Response 3
   This response will be provided in our next submittal.

4. *Justify and provide references for unit costs used with quantity (hour, volume, area, etc) estimates shown throughout Section 11.*

   Response 4
   This response will be provided in our next submittal.

5. *Include an adder of 31.7 percent in salaries for individuals listed in Sections 11.1.18, 11.2.10, and 11.3.10 to account for total benefits provided to workers by the contractor, consistent with the information provided for construction workers in Table 5 of the report located at page 11 of http://www.bls.gov/news.release/pdf/ecec.pdf*

   Response 5
   This response will be provided in our next submittal.

6. *Justify OR revise and justify the allowance for Living Costs of $40, $67, and $66 per person per day in Sections 11.1.18, 11.2.10, and 11.3.10, respectively. Justify discrepancies between the crew sizes used in Sections 11.2.10 and 11.3.10 for calculating the allowance for Living Costs and the crew sizes stated in Item 1 of Sections 11.2 and 11.3, respectively, OR revise them to make them consistent.*

Response 6
This response will be provided in our next submittal.

7. *Include in the cost of verifying that soils have been properly cleaned up the cost of remedial action support surveys (Section 11.1.16). Justify, on the basis of MARSSIM guidance, the estimate that final status surveys will require only 48 person-hours. Include in the estimate the costs of analyzing remedial action support and final status survey samples.*

Response 7
This response will be provided in our next submittal.

8. *Include the cost of excavating, hauling, spreading, and compacting sandy Interim/Grading material, clay cover material, and Rocky Soil Cover material from local borrow sites, lack of royalty notwithstanding, (Section 11.2.4).*

Response 8
This response will be provided in our next submittal.

9. *Justify that 44 bags of grout per well is adequate for the purposes of abandoning monitoring wells (Sections 11.2.8 and 11.3.8).*

Response 9
This response will be provided in our next submittal.

10. *Ensure that the costs of environmental monitoring are included in closure and decommissioning costs estimates as appropriate.*

Response 10
This response will be provided in our next submittal.

11. *Apply 25 percent of subtotal costs for contingency allowance in Tables 12-1-Cell-1 and 12-1-Cell-2, consistent with relevant NRC guidance on cost estimates supporting determination of financial assurances.*

Response 11
This response will be provided in our next submittal.

12. *Revise the Uranium One Management Overhead percentage allowed in Tables 12-1-Cell-1 and 12-1-Cell-2 to reflect the possibility that the Tailings Reclamation and Decommissioning Plan will be performed by an independent third-party contractor. This percentage should allow for:*
    - *Labor Overhead and Profit*
    - *Materials and Subcontract Overhead and Profit*
    - *General Conditions*
    - *Subcontract Administration and Engineering*
    - *Construction Oversight*

Response 12
This response will be provided in our next submittal.

13. *Ensure that all revisions made in Section 11 and 12 are incorporated into other sections of the Tailings Reclamation and Decommissioning Plan and elsewhere in the License Amendment Request.*

Response 13

This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

As examples of providing the bases for quantities, durations, allowances, and lump sums, consider the following.

- *Uranium One should explain the basis for estimating that the duration of the ore hopper demolition (Section 11.1.4) is two weeks. This duration should be related in some way to the quantities of materials to be handled and a documented productivity for similar activities.*
- *Two examples (from numerous instances) of needed explanations: Uranium One should explain why allowances of $500 per month for Miscellaneous Office Supplies and of $40,000 for the "Environmental Radiological & Other Required Surveying, Quality control & Testing Equipment" (Section 11.1.18) are adequate and appropriate. Where quantity of an individual cost item is readily identifiable (e.g., collecting and analyzing environmental monitoring samples and neutralization), the cost estimate should be identified and supported through reference to those quantities.*

Unit costs presented throughout Section 11 should be justified and referenced to published sources, such as R.S. Means Building Construction Cost Data.

The allowances for contingency, management, and overhead costs are too small and should be increased.

REFERENCES:

US Bureau of Labor Statistics, "Employer Costs for Employee Compensation – March 2007", http://www.bls.gov/news.release/pdf/ecec.pdf as of July 10, 2007.

US Nuclear Regulatory Commission. "NMSS Decommissioning Standard Review Plan," NUREG-1727, September 2000.

US Nuclear Regulatory Commission. "Revised Analyses of Decommissioning Reference Non-Fuel-Cycle Facilities," NUREG/CR-6477, December 2002.

Plateau Resources Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project –2005; Garfield County, Utah", December 2005, Revised: December 2006.

INTERROGATORY R313-24-4-38/02: LONG TERM SURVEILLANCE COSTS

INTERROGATORY STATEMENT:

Justify OR revise and justify the allowance of $752,600 for DOE to provide Long Term Maintenance (as shown in Table 12-1-Cell-1 and 12-1-Cell-2). Base the allowance on EITHER:

1. *A detailed listing of activities and cost components (expressed as quantities with unit costs), together with an orderly estimate of associated costs, including an explanation of basis. This cost estimate should address planned and expected costs for a period of at least 100 years following reclamation and decommissioning and should consider a rate of return on secure financial instruments of 2 percent real.*

   Response 1

   This response will be provided in our next submittal.

2. *Justifying, including explanation of basis*
   - *A value that was acceptable to DOE in 1978,*
   - *That DOE still honors the 1978 basis for determining costs that should be covered for it providing Long Term Maintenance, and*
   - *Cost escalation from 1978 to 2007 using an appropriate construction cost index.*

   Response 2

   This response will be provided in our next submittal.

BASIS FOR INTERROGATORY:

Although the response to Round 1 Interrogatory R313-24-4-38/01 might be reasonable, no basis is provided that allows intelligent evaluation of the allowance for the cost of Long Term Maintenance by DOE. The basis for estimating the present value of costs for DOE to provide long-term surveillance and maintenance should be clearly elaborated.

REFERENCES:

Plateau Resources Ltd., "Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project –2005; Garfield County, Utah", December 2005, Revised: December 2006.

ATTACHMENT A

SOP AP-3
INSPECTION OF TAILINGS OR WASTE RETENTION SYSTEMS

PREPARED BY URANIUM ONE U.S.A.
DATED JUNE 13, 2007

(ATTACHMENT FOR RESPONSE TO INTERROGATORY R313-24-04-05/02: DAILY INSPECTIONS OF WASTE TAILINGS)

Inspections of Tailings or Waste Retention Systems

Procedure AP-3

Prepared by

Uranium One U.S.A.
3801 Automation Way
Suite 100
Fort Collins, CO 80525

June 13, 2007

Revision 2.3

Prepared by: ______________________________ Date: ______________

Project Lead

Approved by: ______________________________ Date: ______________

Corporate Radiation Safety Officer

Approved by: ______________________________ Date: ______________

Mill Superintendent

REVISION HISTORY

Date	Version	Description	Author
June 4, 2007	2.1	Initial Draft	Kenneth R. Baker
June 13, 2007	2.2	Final	Toby Wright
September 26, 2007	2.3	Revised	Kenneth R. Baker

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ACRONYMS, ABBREVIATIONS, AND INITIALISMS

CFR	Code of Federal Regulations
CRSO	Corporate Radiation Safety Officer
RSO	Radiation Safety Officer
UDRC	Utah Division of Radiation Control
UDEQ	Utah Department of Environmental Quality
SOP	Standard Operating Procedure

Standard Operating Procedure AP-3

Inspections of Tailings or Waste Retention Systems

1 PURPOSE

R313-24-4 of the Utah Administrative Code requires the documentation of daily inspections of tailings or waste retention systems and the immediate notification of the Executive Secretary of any failure in a tailings or waste retention system that results in a release of tailings or waste into unrestricted areas, or of any unusual conditions (conditions not contemplated in the design of the retention system) that if not corrected could lead to failure of the system and result in a release of tailings or waste into unrestricted areas. This procedure outlines the methods, equipment, and recordkeeping requirements needed to perform the inspections of tailings or waste retention systems at the Shootaring Canyon Mill Site.

Other related inspection and reporting requirements exist in the Groundwater Discharge Permit No. UGW170003. These requirements may change as the discharge permit is amended. While some of the requirements may in part duplicate those in R313-24-4, this SOP is not intended to assure compliance with the inspection, reporting, or other requirements in the Groundwater Discharge Permit.

2 DEFINITIONS

For the purposes of this procedure, waste or tailings is defined as liquid or solid materials that are a byproduct of the uranium milling process that have been placed in a disposal area. Waste retention systems include berms, liners, tanks, or other containers such that if breached, there is potential for uncontrolled release of waste material or tailings.

Immediate reporting to the Executive Secretary is defined as “within four hours of knowledge of the incident”.

3 APPLICABILITY

This procedure is applicable to managing the waste retention systems at the Shootaring Canyon mill site, as currently configured and to the site after milling operations have resumed.

4 DISCUSSION

A small quantity of tailings had been placed on a synthetic liner above a leachate collection system that drains to a collection sump. Currently, this sump is pumped after or during significant precipitation events with the liquids pumped to a lined evaporation pond placed within the disposal cell. The evaporation pond has been sufficient to evaporate all of the water collected to date. The containment of liquids within the disposal cell is assured by the Main Tailings Dam which has been designed to contain runoff from the drainage area resulting from a maximum precipitation event as long as there exists a freeboard of 13 feet. This SOP covers the inspection of the Main Tailings

Dam, evaporation ponds, the management of the leachate collection system, and the general area within the tailings disposal area.

A new tailings disposal facility has been designed and proposed for use once milling operations resume. The current tailings and cell liner will be removed and reconfigured. This SOP has been written to apply to the new facility as proposed.

This SOP will also apply during the construction of the new tailings facility, during which the integrity of the Main Tailings Dam will be monitored. This SOP, however, in no way is a substitute for a construction quality control plan.

5 RESPONSIBILITY

The General Site Foreman, or equivalent, or his designee is responsible for the inspections as outlined in this procedure. The field inspector has the responsibility of immediately notifying the General Site Foreman of any significant abnormal findings. The General Site Foreman has the responsibility for further investigation and assuring that the information is given to the CRSO in a timely manner so that reportable incidents are reported to the Executive Secretary of the UDEQ-DRC according to the criteria and time schedules given in AP-4 and the Groundwater Discharge Permit. The General Site Foreman has the responsibility to take timely and appropriate corrective actions to correct the deficiencies.

Inspection reports will be submitted to the General Site Foreman with copies to the CRSO.

6 EQUIPMENT AND MATERIALS

- Note Pad
- Clip Board
- Pen
- Digital Camera
- Field Log Book or equivalent

7 PROCEDURE

All observations shall be recorded and any item(s) that are out of normal (defined as not noted during the last inspection or any occurrence that is not within the range of expected observations) shall be recorded and reported to the General Site Foreman immediately. Where appropriate, the observation should be documented by taking a photograph.

7.1 Daily Inspections

Daily Inspections shall include if appropriate:

- Decant systems should be examined for any evidence of clogging of intake; corrosion, cracking, or crushing of decant pipes; and erosion at the discharge point. Compare intake and discharge flow rates for evidence of leaks
- Effluent from underdrain pipes should be examined for evidence of clogging, cracking, and erosion.
- Sumps should be inspected for proper functioning. Report evidence of clogging, freezing, or any other conditions that would make sumps non functional.
- Pond water elevations – record elevation of tailings solution. For the Main Tailings Dam, measure and calculate the height from the tailings solution to the top of the Dam (freeboard) and record. Note that there must be at least 13 feet of freeboard.
- If the tailings are placed as a paste, tailings elevation should be recorded. The tailings height relative to the impoundment perimeter and/or dam crest should be recorded and assessed to ensure placement does not exceed design conditions.
- Slurry transport system– visually inspect pipes and pump intakes for obstructions due to sand clogging or ice accumulation. Inspect pipe couplings for leaks and report any leaks found.
- Visually inspect top of dams and earthen embankments for cracks (especially cracks running parallel with the crest of the dam), embankment settlement, slumping, embankment slope conditions, condition of slope protection and movement of embankment material. Report and document all cracks, slumps, degradation of design conditions or movement;
- Visually inspect all lined evaporation ponds for evidence of exposed liner deterioration or leaks. Exposed liners should have no tears, holes, and should be well anchored. Inspect associated earthen berms for waste water seeps, cracks, slumps or movement.
- Visually inspect area for evidence of burrowing animals, livestock, and other large animals.
- Check safety and performance instrumentation for operability.
- Check Emergency Discharge Facility for Operability
- Other related systems as appropriate

Results of daily inspections shall be documented on Form AP-3A or equivalent.

7.2 Monthly Inspections

Monthly Inspections shall include:

Visually inspect diversion channels for channel bank erosion, bed aggradation or degradation and siltation, obstruction to flow, undesirable vegetation, or any unusual or inadequate operational conditions. This inspection shall be documented in a field log book or equivalent.

7.3 Quarterly Inspections of the Main Tailing Dam and Other Instrumented Berms

Quarterly inspections shall include:

- Measure water elevation, if any, in piezometers and ground water monitoring systems located on Main Tailings Dam or retention berms;
- Survey embankment settlement monuments (MM) installed on top and slope of Main Tailings Dam
- Visually inspect seepage along slope of dam
- Visually inspect slope for erosion, burrowing animals, springs, seeps, brush, and trees

Results of quarterly inspections shall be documented on Form AP-3B or equivalent. Notify the General Site Foreman immediately of an unusual occurrence or an occurrence that was not noticed during the last inspection.

7.4 Special Inspections and Response to Unusual Conditions

The General Site Foreman will authorize special inspections:

- After any unusual event such as significant earthquake, tornado, major flood or intense local rainfall;
- Upon discovery of an unusual condition.

Special inspections will be reported on Form AP-3A.

The General Site Foreman will evaluate any unusual conditions by personally inspecting the condition and/or soliciting the assistance of a qualified person. The RSO and CRSO will be advised of the results of the investigation and, if appropriate, the CRSO will notify the Executive Secretary in accordance with the requirements in R313-24-4 and R313-19-50. SOP AP-4 provides specific notification details regarding these regulatory requirements. The CRSO may appoint a competent person to prepare a Technical Evaluation if warranted.

The General Site Foreman will implement appropriate corrective action and document the conditions and corrective actions on Form AP-3A or using another suitable format.

7.5 Reporting

R313-24-4 of the Utah Administrative Code requires the immediate (within four hours) notification of the Executive Secretary of any failure in a tailings or waste retention system that results in a release of tailings or waste into unrestricted areas, or of any unusual conditions (conditions not contemplated in the design of the retention system) that if not corrected could lead to failure of the system and result in a release of tailings or waste into unrestricted areas. Examples of such events include:

- Liquid levels within 13 feet of top of Main Tailings Dam.
- Questionable integrity of Main Tailings Dam arising from damage from an earthquake or precipitation event
- Erosion of diversion channels making them potentially non-functional
- Loss of tailings liquids from the evaporation pond due to dike failure
- Evidence of leaks from tailings or evaporation ponds in excess of design parameters

All hazardous conditions or potentially abnormal hazardous conditions should be evaluated by the CRSO to determine whether notification of the Executive Secretary in accordance with R313-24-4 and R313-19-50 is required. SOP AP-4 provides specific notification details regarding these regulatory requirements.

Additional reporting requirements exist in the Groundwater Discharge Permit No. UGW170003. Reports of noncompliance must be made within twenty-four hours. Spill Reporting per UCA 19-5-114 of the Utah Water Quality Act requires the immediate reporting of any spill that comes into contact with the ground surface or ground water that causes pollution or has the potential to cause pollution to waters of the state. A follow-up written report is required within five days of the occurrence.

7.6 Technical Evaluation and Annual Best Available Technology (BAT) Report

A competent individual will prepare an evaluation of the existing conditions. This should include storage capacities, water quality, and structural integrity. In addition, surface water and groundwater water quality data should be examined to look for trends that might indicate a changing condition.

This technical evaluation should be made annually unless changing conditions dictate more frequently. Technical evaluation reports shall be prepared for each technical evaluation and should include the inspection data collected since the last report. They shall be maintained at the project office until license termination.

Best Available Technology (BBAT) Reports for the facility may be required by the Groundwater Discharge Permit. The reports may include the inspection technical evaluations described above and shall include

- Completed inspection reports
- Engineering data compilations
- General project data
- As-build drawings and photographs
- Hydrologic and hydraulic data
- Test results
- Applicable correspondence

- Names of the inspector and responsible supervisor

8 QUALITY ASSURANCE

The General Site Foreman will assure quality by:

- Implementing a training program for field inspectors by an experienced professional
- Assigning experienced and competent professionals to perform technical evaluations
- Conducting an Annual Field Inspector Retraining Program
- Adherence to this SOP

9 RECORDS

The following forms will be completed and maintained in the project office with copies sent to the CRSO. These forms shall be retained for three years from the date of inspection.

- Form AP-3A Daily Inspection Form, Tailings and Waste Retention Systems
- Form AP-3B Quarterly Inspection Form, Tailings and Waste Retention Systems

10 REFERENCES

R313-24-4, 10CFR40.26(c)(2)

R313-24-4, 10CFR40 Appendix A(8)(a)

R317-6-6.3 (O)

Shootaring Canyon Mill Groundwater Discharge Permit No. UGW170003.

NRC Regulatory Guide 3.11.1, Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings. Revision 1, October 1980. Office of Standards Development, U. S. Nuclear Regulatory Commission, Washington, DC.

NRC Regulatory Guide 3.11. Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills, Revision 2, December 1977. Office of Standards Development, U. S. Nuclear Regulatory Commission, Washington, DC..

APPENDIX A

DAILY INSPECTION FORM

Form AP-3A

Form AP-3A

Inspection Form
Tailings and Waste Retention Systems Inspection

Daily Inspection ____ (yes or no) Special Inspection____: Reason for Inspection____

Field Inspector___________________________ Date of Inspection__________________________

Main Tailings Dam

Inspections:

- Pond water feet from top of dam _________ft
- Visual dam top; cracks yes/no comments ____
  slumps yes/no comments ____
  movement yes/no comments______________________________________
- Livestock; evidence around dam yes/no comments__________________________________
- Visual inspection; toe seepage yes/no comments __________________________________
  slope seepage yes/no comments __________________________________
- Visual inspection; erosion yes/no comments ______________________________________
  burrowing animals yes/no comments______________________________
  springs yes/no comments ______________________________________
  seeps yes/no comments ____
  brush and trees yes/no comments________________________________

Other Retention Systems

Retention system name__________________(may use one for each system)

Inspections:

- Pond water feet from top of berm _________ft
- Pond liners; exposed surface deterioration/cracks yes/no comments____________________
  Liner well-anchored yes/no comments________________________________
- Visual berm top; cracks yes/no comments ____
  slumps yes/no comments ____
  movement yes/no comments _____________________________________
- Visual inspection; toe seepage yes/no comments___________________________________
  slope seepage yes/no comments __________________________________
- Visual inspection; erosion yes/no comments ______________________________________
  burrowing animals yes/no comments _____________________________

springs yes/no comments ____

seeps yes/no comments ____

brush and trees yes/no comments __________________________________

evidence of live stock/large animals yes/no comments________________

- Slurry transport system– visually inspect pipes and pump intakes for obstructions due to sand clogging or ice accumulation. Inspect pipe couplings for leaks and report any leaks found. Obstructions yes/no comments____

  Leaks yes/no comments____

Under-drain pipes- visually inspect for clogging, cracks, and erosion yes/no
Comments____
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Corrective Actions

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By:________________________________Date:________________________________

APPENDIX B

QUARTERLY INSPECTION FORM

Form AP-3B

AP-3B

Quarterly Inspection Form
Tailings and Waste Retention Systems Inspection Form

Field Inspector___________________________________ Date of Inspection__________________

Retention System (use one for each retention system)

Main Tailings Dam ____

or

____

Inspections:

- Pond water feet from top of dam _________ft
- Visual dam top: cracks yes/no comments ____
  slumps yes/no comments ____
  movement yes/no comments ______________________________________
- Visual slope and toe: toe seepage yes/no comments _______________________________
  slope seepage yes/no comments _________________________________
  erosion yes/no comments ______________________________________
  burrowing animals yes/no comments ____________________________
  springs yes/no comments ______________________________________
  seeps yes/no comments ____
  brush and trees yes/no comments _______________________________
- Livestock: evidence around dam yes/no comments _________________________________

:

- Piezometers: PZ1 water yes/no casing top to water level ___________ft
  PZ2 water yes/no casing top to water level ___________ft
  PZ3 water yes/no casing top to water level ___________ft
  PZ4 water yes/no casing top to water level ___________ft
  PZ5 water yes/no casing top to water level ___________ft
  PZ6 water yes/no casing top to water level ___________ft

- Embankment survey: MM1 X______________, Y ______________, Z _____________
  MM2 X______________, Y ______________, Z _____________
  MM3 X______________, Y ______________, Z _____________
  MM4 X______________, Y ______________, Z _____________
  MM5 X______________, Y ______________, Z _____________
  MM6 X______________, Y ______________, Z _____________
  MM7 X______________, Y ______________, Z _____________
  MM8 X______________, Y ______________, Z _____________
  MM9 X______________, Y ______________, Z _____________
  MM10 X_____________, Y ______________, Z _____________
  MM11 X _____________, Y ______________, Z _____________
  MM12 X _____________, Y ______________, Z _____________

Other Observations:
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Corrective Actions

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By:__________________________________Date:___________________________________

ATTACHMENT B

SOP HP-25
RADIOACTIVE MATERIALS TRACKING AND BALANCE

PREPARED BY URANIUM ONE U.S.A.
DATED NOVEMBER 8, 2007

(ATTACHMENT FOR RESPONSE TO INTERROGATORY R313-24-4-06/02: MAINTAINING RECORDS)

Radioactive Materials Tracking and Balance

Procedure HP-25

Prepared by

Uranium One U.S.A.
3801 Automation Way
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November 8, 2007

Revision 0

Prepared by: ______________________________ Date: ______________
Project Lead

Approved by: ______________________________ Date: ______________
Corporate Radiation Safety Officer

Approved by: ______________________________ Date: ______________
Mill Superintendent

REVISION HISTORY

Date	Version	Description	Author
October 9, 2006	0.1	Initial Draft	Mike Madonia
December 5, 2006	0.2	Incorporate edits and format	Mike Schierman
October 9, 2007	0.3	Incorporate Regulatory Review edits	Ken Baker
November 8, 2007	0.4	Incorporate internal edits	Toby Wright

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ACRONYMS, ABBREVIATIONS, AND INITIALISMS

AEL	Analytical Environmental Laboratory
COC	Certificate of Conformance
CRSO	Corporate Radiation Safety Officer
EVW	Empty Vehicle Weight
GVW	Gross Vehicle Weight
KPA	Kinetic Phosphorescence Analyzer
MBTD	Mass Balance Tracking Database
NTEP	National Type Evaluation Program

Standard Operating Procedure HP-25

Radioactive Materials Tracking and Balance

1 PURPOSE

The purpose of this procedure is to identify processes to document the receipt, transfer and disposal of radioactive materials from the Shootaring Canyon Mill Site, and to identify a means to determine the total amount of radioactive materials present in key areas of the site.

2 DEFINITIONS

MBTD – Mass Balance Tracking Database - a database developed using standard versions of Microsoft Office™ software such as Access™ or Excel™; capable of systematically storing raw data related to radioactive material inventory, transfer and disposal; and containing queries to generate a variety of reports to support inventory management.

3 APPLICABILITY

This procedure is applicable to stored or stockpiled radioactive materials already present, newly received ore and other materials, produced yellowcake, offsite transfer of yellowcake and other products (for sale or otherwise), and tailings products disposed of at the Shootaring Canyon Mill Site.

4 DISCUSSION

This procedure describes the processes to:

1. Document and verify the receipt of radioactive materials contained in uranium ore or other source material,
2. Document and verify the amount of yellowcake produced and transferred offsite for commercial or other purposes,
3. Document and verify the amount of tailings placed in tailings impoundments,
4. Document and verify the amount of liquid discharged to the evaporation pond,
5. Maintain running totals of the inventory of radioactive materials on site; identify significant discrepancies in overall site uranium mass balance; and initiate corrective measures.

Under typical operating mode, the Shootaring Canyon Mill Site will receive uranium ore via truck delivery in preparation for placement into the ore sizing and grinding components of the mill. Under standard operating conditions, the majority of the uranium will be processed into yellowcake and transferred off site for sale and additional processing. It is necessary to verify and document the amount of uranium received and shipped, and that may be present at the site at a given time. Calculation of this "material balance" requires understanding of the amount of radioactive materials associated with ore that has been accepted and/or is in the milling process prior to packaging of yellowcake, yellowcake packages stored on site, minor quantities of uranium discharged with tailings and waste liquids, any previously stored or stockpiled materials, and to a lesser extent, air emissions. Data relating to radioactive material inventory will be entered into a mass balance tracking database (MBTD) that will be maintained by site Analytical Environmental Laboratory (AEL) personnel. When populated, the MBTD will be capable of being queried for material balance related information.

5 RESPONSIBILITY

It is the responsibility of the Corporate Radiation Safety Officer (CRSO) and the environmental staff to implement and follow this procedure.

6 EQUIPMENT AND MATERIALS

- NTEP Certified Truck Scale
- Calibrated Kinetic Phosphorescence Analyzer (KPA) Laboratory System or equivalent
- Site Inventory Mass Balance Tracking Database (MBTD)
- Uranium reference materials.
- Uranium ore, tailings, liquid, and yellowcake sample containers as required by AEL

7 PROCEDURE

7.1 Document and Verify Receipt of Uranium Ore and Other Radioactive Materials

1. Ensure that truck scale has a current NTEP Certificate of Conformance (COC), is under current calibration, and functioning properly.
2. Direct incoming ore truck (or comparable vehicle) onto truck scale and obtain gross vehicle weight (GVW).
3. For each incoming ore truck; identify delivering entity (company affiliation), date, time, vehicle ID number as available, and GVW. Record in MBTD. Note unique delivery ID number generated by MBTD.
4. Driver to designated ore dump pocket/handling zone and offload materials.
5. As necessary, direct truck to portal for surface contamination survey in accordance with SOP HP-9.
6. Direct driver to return to truck scale and collect empty vehicle weight (EVW) measurement. Record in MBTD.
7. Complete and provide driver with delivery ticket as shown in Form U1-25-1. Retain hard copy of delivery ticket for permanent site records.

8. Collect sample of delivered ore for laboratory uranium, thorium, radium, and moisture analyses in accordance with AEL procedures and Analytical Laboratory Quality Assurance Program (QAP).
9. Label samples with unique delivery ID number generated by MBTD. For multiple truck shipments, record all delivery ID numbers. Deliver to site AEL.
10. AEL shall analyze ore samples for total uranium content per procedures and QAP. Upon quality review approval, record total uranium concentration in MBTD for delivery ID number(s).
11. For radioactive source or byproduct material other than uranium ore, the CRSO will be notified in advance of receipt, authorize and verify acceptance of material under license limitations, and enter receipt of material into tracking database.

7.2 Document and Verify the Amount of Yellowcake Produced and Transferred Offsite

1. Yellowcake product shall be packaged in DOT 7A 55-gallon drums or comparable containers.
2. Prior to yellowcake production ensure that adequate numbers of containers are obtained, inspected for integrity, removed from service as necessary, and coded with a unique identification number or bar code tracking number.
3. Production personnel shall fill containers with yellowcake product and seal following yellowcake sample collection to determine sample purity. AEL personnel will split or divide samples as necessary to support customer confirmation laboratory analyses.
4. Each container shall be weighed and the result entered with container tracking number into Form U1-25-2. User shall verify that scale is calibrated and in proper working condition. Automatic scale data recording and logging systems will be used as available.
5. Each yellowcake sample collected for an individual container or lot of containers will be placed in a sample container and submitted to the AEL with Form U1-25-2, which identifies all associated container tracking numbers. As possible, sampling personnel will collect an aliquot of yellowcake from each container.
6. Sample containers shall be cleaned of removable yellowcake, labeled, and transferred to AEL.
7. AEL shall perform uranium analyses in accordance with laboratory procedures, and enter results and associated containers in MBTD. Form U1-25-2 shall be retained for permanent site records.
8. Sealed, sampled containers will be transferred to designated yellowcake storage areas, labeled, and stored in a manner such that all containers associated with a lot are in proximity to one another.
9. On a bi-weekly basis, an inventory list identifying all yellowcake containers that should be currently present on-site shall be generated from the MBTD. A field walkdown and

verification inspection will be performed within one day of list generation. Any discrepancies regarding yellowcake inventory shall be noted and the Mill Superintendent informed.

10. Yellowcake purchase requests shall be forwarded to the Plant Sales Manager. The Plant Sales Manager shall complete Form U1-25-3 – Yellowcake Purchase Ticket and provide copy to AEL. Form U1-25-3 shall identify desired yellowcake quantity, estimated date of pick-up, sample splits and requirements for customer, and special considerations and requests.
11. AEL shall review sampling requests and assign on-site inventory for customer shipment; provide analytical data to customer; or transfer yellowcake samples to offsite customer laboratory.
12. Following AEL assignment of containers to customer order in conjunction with sampling requirements, the AEL shall notify the Mill Superintendent with all container tracking numbers, the estimated date of pickup or shipment, and any special handling requests.
13. The Mill Superintendent or designee shall tag all yellowcake containers associated with a customer purchase with unique identifying marks and basic information as noted in Section 7.2, step 11 above, and prepare a draft transportation manifest/bill of lading.
14. Upon arrival for pickup, customer representative is required to show credentials and demonstrate that vehicles are in safe, working condition prior to proceeding to yellowcake loading area. Required credentials include hazardous material training, Department of Transportation (DOT) required training, commercial driver's license (CDL), training on the site emergency response plan, and other credentials as determined by the CRSO. The same requirement applies for delivery personnel under subcontract to Uranium One.
15. Designees of the Mill Superintendent shall remove customer-assigned yellowcake containers to the loading area and perform U.S. Department of Transportation (DOT) surveys in accordance with SOP HP-4.
16. Following DOT surveys, Mill Superintendent or designee shall complete the transportation manifest/bill of lading, sign and provide copies to driver and to AEL. Obtain driver signature for receipt. Original copies are to be filed in the permanent site record.
17. Verify that proper transportation placards are on vehicle in accordance with site procedures.
18. As necessary, allow driver and vehicle to use truck scale to determine EVW and GVW.
19. As necessary, direct truck to portal for surface contamination survey in accordance with SOP HP-9.
20. Following release of shipment, AEL personnel shall enter information from SOP HP-4 and the manifests into the MBTD.

7.3 Document and Verify the Amount of Tailings Placed in Tailings Impoundments

1. Execute tailings sampling and analyses procedure on a daily basis, or other frequency as determined by mill plant operator considering events such as changes in operational

production rates, shut down, etc. Coordination with the mill operator is necessary to assure that a minimum of one sample is taken to represent non-changing conditions of the mill output. A new sample should be taken soon after it has been determined that a change in tailings output has occurred. These data along with data from the previous sample will be used by the MBTD to calculate the mass and activity of the tailings disposed.

2. Collect sample of tailings at number 6 CCD thickener underflow by an automatic single stage slurry sampler system and submit for moisture content, uranium, thorium, and radium analyses in accordance with AEL procedures.
3. Should the Number 6 CCD thickner not be in use or otherwise inactive, take one sample of tailings plus liquids at the Number 5 thickener underflow or other representative location in the discharge system.
4. For each sample collected, the sampling technician shall document on Form U1-25-4 the sample identifier, date, and time that the sample was taken. The total tailings discharged shall be calculated by the MBTD from the duration between this sample and the previous sample and the flow rate from the previous sample. The disposal activity will be calculated by taking the product of the mass disposed and the radionuclide concentrations from the previous sample. Note: tailings quantities may require subtraction of liquid routed from dewatering process from total input tailings mass associated with gallons of discharge. Also, the MBTD will allow for subtracting the duration of periods where no tailings are discharged, such as for a shutdown of the mill.
5. Upon completion of laboratory analyses and quality assurance review, the AEL shall enter the sample results and data into the MBTD.

7.4 Document and Verify the Amount of Liquid Discharged to the Evaporation Pond

Execute liquid discharge sampling and analyses procedure on a daily basis, or other frequency as determined by mill plant operator due to changes in operational production rates, shut down, etc. This sampling process may be performed in conjunction with tailings sampling specified in Section 7.3. The tailing discharge will be verified by a Mass flow meter which is linked to the Mass Balance Tracking Database. The tailing will be discharged from CCD thickener (shown on drawing 400-4301.) These meters will feed a signal to the Excel speed sheets DX2422,DE2422 which feeds the density to DIT2422.This feeds a Density Recorder DR2422. The density meter will be calibrated the first year 2 different times. Every year there after it will be calibrated 1 times per year. The solution can be calculated from the meters.

The flow is measured in FE2422 and feed a FIT2422 which feeds a Flow Recorder 2422. The flow meter will be calibrated each month.

There is a single stage Sampler 400-3020 which will take a final tailing sample. The finial tailing sample will be composted on a daily basis and sent to the lab for analysis.

1. The data should be entered on the appropriate section of Form U1-25-4.

2. Collect liquid sample(s) at dewatering press discharge to evaporation pond or other bypass points in discharge lines from the mill that are directed to the evaporation pond. Submit samples for total dissolved solids (TDS), uranium, thorium, and radium analyses in accordance with AEL procedures and Analytical Laboratory Quality Assurance Program (QAP).
3. For each sample collected, the sampling technician shall document on Form U1-25-4 the sample identifier, date, and time that the sample was taken. The total liquids discharged shall be calculated by the MBTD from the duration between this sample and the previous sample and the flow rate from the previous sample. The disposal activity will be calculated by taking the product of the volume disposed and the radionuclide concentrations from the previous sample. The MBTD will allow for subtracting the duration of periods where no tailings are discharged, such as for a shutdown of the mill.
4. Upon completion of laboratory analyses and quality assurance review, the AEL shall enter the sample results and information from Form U1-25-4 data into the MBTD.

7.5 Maintain Running Totals of the Inventory of Radioactive Materials on Site

1. Information gathered in procedure steps 7.1 through 7.4 shall be entered into the MBTD by trained individuals.
2. Through the operation of the mill, quantities of radioactive materials may be inadvertently introduced to systems or site areas and may not readily be removed until shutdown; thus they become static component of site inventory until cleanup. The location of and radiological inventory associated with these areas will be determined by the CRSO during implementation of the radiation protection program. These quantities and location attributes shall be entered into the MBTD.
3. Through operation of the mill, other sources of radioactive material may be received, stored and used at the site. Receipt, storage, use and disposal of these sources shall be authorized and supervised by the CRSO in accordance with the terms of the radioactive materials license. The quantities and source characteristics shall be entered into the MBTD. Records of receipt and disposition of these materials will be stored with the radioactive materials license and with the permanent record.
4. As desired, MBTD users shall be able to generate the following outputs:
    a. Total Uranium Inventory On ite
    b. Total Weight and Average Grade of All Ore Received
    c. Total Uranium Activity and Mass of Ore Received
    d. Total Weight and Activity of Yellowcake Sold and/or Transferred Offsite
    e. Total Weight and Activity of Yellowcake On Hand
    f. Total Uranium, Radium-226 and Thorium-230 Activity Contained in Tailings Cells and Evaporation Pond

g. Total On-Site Radioactivity Associated with Non-Ore or Yellowcake Sources

5. The CRSO or their appointee may add or modify queries and outputs from the database to support the material tracking program. Modifications shall be subject to quality control reviews of calculations, modifications to stored data, and report output validity. An annual validation process for the MBTD shall be performed.

8 QUALITY ASSURANCE

Quality assurance will be maintained by following the above procedures. Prior to performing work, technicians will be trained and certified as competent in procedures by the CRSO and/or an independent auditor. Noncompliance will be documented and corrected.

9 RECORDS

The radionuclide inventory at the site will be determined from reports generated by the MBTD. The data base will be supported by production data, laboratory data, and data from forms in this SOP provided in Appendix A. These forms, or their equivalent, will be completed and maintained in the project files. The forms include the following.

- Form U1-25-1, Uranium Ore Delivery Ticket
- Form U1-25-2, Yellowcake Container Sampling and Tracking
- Form U1-25-3, Yellowcake Purchase Ticket
- Form U1-25-4, Tailings and Tailings Liquids Disposal Samples

These records, along with the MBTD, will be retained until the license is terminated according to Utah Administrative Code R13-12-51 and 10 CFR Part 40.61. Should the license be transferred to a new licensee, ownership of these records will also be transferred.

10 REFERENCES

Utah Administrative Code R13-12-51, Records.

10 CFR 40.61 Records.

APPENDIX A
RADIOACTIVE MATERIALS TRACKING FORMS

Form U125-1

Uranium Ore Delivery Ticket

GENERAL DELIVERY INFORMATION

Date of Delivery:__________________ Time of Delivery:_______________

Delivering Company:_______________ Scale ID Number________________

Other Information:____

WEIGHT INFORMATION

Current Scale Certification/Calibration ? Yes No

Vehicle Number/Description:_________________________

Incoming Gross Vehicle Weight (GVW) in Pounds:____________________

Material Balance Tracking Database (MBTD) Number:__________________________

Outgoing Empty Vehicle Weight (EVW) in Pounds:______________________

CERTIFICATION

Uranium One Representative

Name:_________________________

Signature:______________________

Delivering Company Representative

Name:________________________

Signature:______________________

Note: Copy to be provided to delivering company representative.

Form U125-2

Yellowcake Container Sampling and Tracking

Container Number	Pass Inspection?	Filled Container Weight (lbs)	Scale ID Number	Scale Calibrated?

SAMPLE ID NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __

DATE:__________________

SAMPLE COLLECTED BY:________________________

SIGNATURE:_______________________

DATE RECEIVED IN AEL:___________________

Note 1: Sample ID shall include date in numeric form (010106) with no spaces, military time (1300, etc), and sequential sample number collected during day (ie., 01, 02, 03, etc.)

Note 2: Sample should include aliquot from each container as possible

Form U1 25-3

Yellowcake Purchase Ticket

GENERAL PURCHASE AND ORDER INFORMATION

Purchasing Company:__________________ **Desired Pickup or Ship Date:_____________**

Company Contact:_____________________ **Telephone Number:______________________**

Desired Quantity in Pounds:_____________ **Desired Container Type:_________________**

Requested Analytical Services and Reports:____

Special Packaging and Other Requests:____

Order Taken by:______________________ **Date:___________________________________**

AEL INVENTORY ASSIGNMENT

Allocated Container No(s):_____________ **Allocated Container No(s):_____________**

Total Weight in Pounds:________________ **Total Weight in Pounds:________________**

Yellowcake Sample ID No:_____________ **Yellowcake Sample ID No:_____________**

Allocated Container No(s):_____________ **Allocated Container No(s):_____________**

Total Weight in Pounds:________________ **Total Weight in Pounds:________________**

Yellowcake Sample ID No:______________ **Yellowcake Sample ID No:______________**

Total Weight All Allocated Containers in Pounds:____________________

Yellowcake ID No(s) Split for Outside Laboratory Analyses:____________

Analytical Laboratory Destination:_________________________________

Date and Time Sample Shipped:____________________________________

AEL Representative Name:____

Signature:____________________ **Date of Assignment:____________**

Form U1 25-4

Tailings and Tailings Liquids Disposal Samples

Dewatered Tailings Sample

SAMPLE ID NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __

DATE: _________________TIME:________________

SAMPLE NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __ (PREVIOUS SAMPLE)

AVERAGE FLOW RATE _________________(FROM MILL OPERATOR)

SAMPLE LOCATION/DESCRIPTION____

SAMPLE COLLECTED BY:________________________

Tailings Liquid Sample

SAMPLE ID NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __

DATE: __________________TIME:________________

SAMPLE NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __ (PREVIOUS SAMPLE)

AVERAGE FLOW RATE _________________(FROM MILL OPERATOR)

SAMPLE LOCATION/DESCRIPTION____

SAMPLE COLLECTED BY:________________________

Other Sample (Describe:____)

SAMPLE ID NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __

DATE: __________________TIME:________________

SAMPLE NUMBER: __ __ __ __ __ __- __ __ __ __ - __ __ (PREVIOUS SAMPLE)

AVERAGE FLOW RATE _________________(FROM MILL OPERATOR)

SAMPLE LOCATION/DESCRIPTION____

SAMPLE COLLECTED BY:________________________

Comment____

____

ATTACHMENT C

SOP AP-4
REGULATORY NOTIFICATIONS

PREPARED BY URANIUM ONE U.S.A.
DATED JUNE 13, 2007

(ATTACHMENT FOR RESPONSE TO INTERROGATORY R313-24-4-07/02: NOTIFICATION REQUIREMENT)

Regulatory Notifications

Procedure AP-4

Prepared by

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June 13, 2007

Revision 2.4

Prepared by: ______________________________ Date: ______________
Project Lead

Approved by: ______________________________ Date: ______________
Corporate Radiation Safety Officer

Approved by: ______________________________ Date: ______________
Mill Superintendent

REVISION HISTORY

Date	Version	Description	Author
June 4, 2007	2.1	Initial Draft	Michael J. Schierman
June 13, 2007	2.2	Final	Toby Wright
August 30, 2007	2.3	Incorporated Regulatory review comments	Michael Schierman
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ACRONYMS, ABBREVIATIONS, AND INITIALISMS

ALI	Annual Limit on Intake
CFR	Code of Federal Regulations
CRSO	Corporate Radiation Safety Officer
UDRC	Utah Division of Radiation Control
UDEQ	Utah Department of Environmental Quality

Standard Operating Procedure AP- 4
Regulatory Notifications

1 PURPOSE

This procedure outlines the notification requirements and time frame for radiological and non-radiological incidents at the Shootaring Mill site as required by Utah Administrative Rules on Radiation Control R-313.

2 DEFINITIONS

Immediate Notification: As soon as possible but not later than 4 hours after first knowledge of an incident described in Section 7.1 of this procedure.

Equipment: Mechanical equipment and other constructed and/or engineered system.

3 APPLICABILITY

This procedure is applicable to all radiological and non-radiological incidents as described in Utah Administrative Rule R313-15 and R313-19 at the Shootaring Mill site which require regulatory agency notification. This procedure address constructed and engineered systems, in addition to mechanical equipment.

4 DISCUSSION

None

5 RESPONSIBILITY

It is the responsibility of the Corporate Radiation Safety Officer or his designee to ensure implementation of and compliance with the requirements of this procedure.

6 EQUIPMENT AND MATERIALS

None

7 PROCEDURE

7.1 Immediate Notifications

The following incidents require immediate notification to the Executive Secretary of the UDEQ-DRC at 801-536-4123:

Incident	Notification Method
An individual receives or threatened to receive a total effective dose equivalent of 25 rem or more.	Telephone
An individual receives or threatened to receive a lens dose equivalent of 75 rem or more.	Telephone
An individual receives or threatened to receive a shallow dose equivalent of 75 rem or more.	Telephone
An individual receives or threatened to receive a shallow dose equivalent to the skin or extremities or a total organ dose equivalent of 250 rad or more.	Telephone
The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the occupational ALI.*	Telephone
Stolen, lost, or missing licensed radioactive material in an aggregate quantity equal to or greater than 1000 times the quantity specified in Appendix C of 10 CFR 20 (i.e. 0.1 Ci for natural uranium)	Telephone
Events that prevent immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of licensed material that could exceed regulatory limits such as fires, explosions, toxic gas releases, etc.	Telephone

* This provision does not apply to locations where personnel are not normally stationed during routine operations.

7.2 24 Hour Notification

The following incidents require, at a minimum, notification to the Executive Secretary of the UDEQ-DRC within 24 hours of discovery of the event at 801-536-4123:

Incident	Notification Method
An individual receives or threatened to receive in a period of 24 hours, a total effective dose equivalent of 5 rem or more.	Telephone
An individual receives or threatened to receive in a period of 24 hours, a lens dose equivalent of 15 rem or more.	Telephone
An individual receives or threatened to receive in a period of 24 hours, a shallow dose equivalent of 50 rem or more.	Telephone
The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational ALI.*	Telephone
An unplanned contamination event that requires access to the contamination area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area.	Telephone

Incident	Notification Method
An unplanned contamination event that has access to the area restricted for a reason other than to allow radionuclides with a half-life of less that 24 hours to decay prior to decontamination.	Telephone
An unplanned contamination event that involves a quantity of material greater than five times the lowest annual limit on intakes specified in Appendix B of 10 FR 20 for the material (0.1 μCi for Natural Uranium).	Telephone
An event in which equipment, is disabled or fails to function as designed when the equipment is required by rule or license condition to prevent releases exceeding regulatory limits, to prevent exposures to radiation and radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident.	Telephone
An event in which equipment is disabled or fails to function as designed when the equipment is required by rule or license condition to be available and operable and no redundant equipment is available and operable to perform the required safety function.	Telephone
An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on clothing or body.	Telephone
An unplanned fire or explosion damaging licensed material or a device, container, or equipment containing licensed material when the quantity of material involved is greater than five times the lowest annual limit on intake specified in appendix B of 10 CFR 20 and the damage effects the integrity of the licensed material or its container.	Telephone

*This provision does not apply to locations where personnel are not normally stationed during routine operations.

7.3 Verbal Report Contents

For the incidents describe in Section 7.1 and 7.2, verbal reports shall be made by telephone to the Executive Secretary of the Utah Division of Radiation Control (801-536-4123) and to the extent that information is available shall include:

- The caller’s name and call back telephone number
- A description of the event including date and time
- The exact location of the event
- The radionuclides, quantities, and chemical and physical form of the licensed material
- Available personnel radiation exposure data

This information should be documented on Form AP-4A prior to making the call to the Executive Director.

7.4 30 Day Written Notification

A written report shall be submitted to the Executive Secretary of the UDEQ-DRC within 30 days of knowledge of the following occurrences:

Occurrence	Notification Method
Incidents for which notification is required in Section 7.1 and 7.2 of this procedure.	Written Report
Doses in excess of any occupational dose limits for adults, minors or embryo/fetus of a declared pregnant woman.	Written Report
Doses in excess of an individual member of the public.	Written Report
Doses in excess of any applicable limit in the license.	Written Report
Doses in excess of ALARA constraints for air emissions.	Written Report
Levels of radiation or concentrations of radioactive material in a restricted area in excess of applicable limits in the license.	Written Report
Levels of radiation or concentrations of radioactive material in a unrestricted area in excess of ten times the applicable limit set fourth in Rule R313-15 or in the license, whether or not involving exposure of any individual in excess public dose limits.	Written Report
Levels or radiation or releases of radioactivity in excess of standards in 40 CFR 190, or of license conditions related to those standards.	Written Report

The contents of the report include the following information as applicable:

- A description of the event including the probable cause and the manufacturer and model number, if applicable, of equipment that failed or malfunctioned
- The exact location of the event
- The radionuclides, quantities, and chemical and physical form of the licensed material
- Date and time of the event
- Corrective actions taken or planned and results of evaluations or assessments
- The extent of exposure of individuals to radiation or radioactive materials without identification of individuals by name including
    - Estimates of each individuals dose
    - The levels of radiation and concentrations of radioactive material involved
    - The cause of the elevated exposures, dose rates, or concentrations
- For occupationally overexposed individuals only, the following information shall be submitted and stated in a separate and detachable portion of the report:

- Name of individual or with respect to the limit for the embryo/fetus the name of the declared pregnant woman
- Social Security account number
- Date of birth

8 QUALITY ASSURANCE

Not applicable

9 RECORDS

Form AP-4A: Incident Reporting Log

Incident Reports

10 REFERENCES

Utah Administrative Code R-313-15 ***Standards for Protection against Radiation***

Utah Administrative Code R-313-15 ***Requirements of General Applicability to Licensing of Radioactive Materials.***

APPENDIX A

INCIDENT REPORTING LOG

Form AP-4A

Form AP-4A

Incident Reporting Form

Nature of
Incident____

Time and Date of Incident____

Exact Location of Incident (sketch on back if req'd) __________________________________

Reporting Employee Name/Title ____

Telephone Number ________________________________

Releases Only:

Radionuclides Released____

Estimated Quantities (Ci)____

Chemical and Physical Form____

Description of Available Personnel Radiation Exposure
Data:____

Regulatory Agency Contacted____

Time:____

Date____

Contact Person: ____

Remarks: ____

By ____ Date _________________________

ATTACHMENT D

SEISMIC HAZARD ANALYSIS FOR SHOOTARING CANYON URANIUM PROCESSING FACILITY

PREPARED BY TETRA TECH
DATED NOVEMBER 12, 2007

(ATTACHMENT FOR RESPONSE TO INTERROGATORY R313-24-4-16/02: SEISMIC HAZARD CHARACTERIZATION)

Seismic Hazard Analysis for Shootaring Canyon Uranium Processing Facility

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November 12, 2007

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1.0 INTRODUCTION

The Shootaring Canyon Uranium Processing Facility is currently in Standby status. Uranium One, Inc. is proposing to convert the present license to Operational status. This seismic hazard analysis has been prepared to characterize the peak horizontal ground acceleration (PGA) for use in seismic stability analyses of the facility.

1.1 Project Location

The site is located in a sparsely populated area of Garfield County, southeastern Utah, approximately 50 miles south of Hanksville, Utah. A small town, Ticaboo, is located 2.6 miles south of the site. For the purposes of these analyses, the central location of the facility has coordinates of 37.72°N latitude and 110.70°W longitude.

1.2 Previous Work

Seismicity of the Shootaring site has been discussed in several previous consultants' reports. The Tailings Management Plan (Plateau Resources, Ltd et al., 2007) included results of several tailings stability and deformation analysis in Appendix A of the referenced report. Appendix A.1 includes results from a January 9, 1997 pseudostatic analysis of the Shootaring Canyon Dam. The analysis was performed using a horizontal seismic coefficient of 0.19 g based on a published report by Lawrence Livermore National Laboratories (Bernreuter et al., 1995). Appendix A.4 includes a June 14, 1999 deformation analysis on the Shootaring Canyon Dam. The analyses were performed using a peak acceleration of 0.33 g based on a U.S. Geological Survey (USGS) Peak Acceleration Map.

1.2.1 Lawrence Livermore National Laboratories

Lawrence Livermore National Laboratories performed a seismic hazard analysis for the Shootaring Canyon site as part of a study of all Title II sites performed for the U.S. Nuclear Regulatory Commission (NRC). The purpose of the study was to evaluate the seismic design assumptions for mining sites where uranium tailings are being stored by performing simplified deterministic and probabilistic analyses. Results of this study concluded that the PGA using deterministic methods is 0.3 g (1-sigma) and using probabilistic methods is 0.19 g for an annual probability of exceedance (PE) of $1x10^{-4}$.

The deterministic analysis concentrated on three faults of the Bright Angel fault system. The three faults evaluated include the fault closest to the site, and then two larger, but more distant, faults of the system. This analysis concluded that the closest fault (4 km long, located 9 km from the site) has the greatest potential impact on the site. Attenuation equations used in the analysis were not specified.

The probabilistic analysis considered the pattern of random earthquakes occurring in an undefined source zone around the site. Earthquake catalogs from the past 30 years (presumably from 1965 to 1995) were used to estimate a recurrence model for the area. The fault splays were not incorporated into the probabilistic analysis.

1.2.2 USGS

The source of the Peak Acceleration Map is not well documented, nor is it clear whether the reported peak acceleration has an associated return period. However, the reported peak acceleration of 0.33 g correlates fairly well with data obtained from the USGS National Seismic Hazard Mapping Project (NSHMP) website for 1996 Interactive Deaggragations (USGS, 2007a) for an associated return period of 4975 years. Using 1996 data, the mapping project reports an acceleration of 0.34 g. The hazard is almost entirely (99.0 percent) attributed to random seismicity of the central and eastern United States (CEUS). In 2002, the NSHMP was updated. Using 2002 data (USGS, 2007b), the acceleration for a return period of 4975 years was modified to 0.32 g. The hazard is almost entirely (99.2 percent) attributed to random seismicity. The output for this data is included in Appendix A. The Shootaring Canyon site is located just within the CEUS area, approximately 40 miles from the CEUS and western United States (WUS) boundary developed by USGS for the NSHMP.

2.0 REGIONAL PHYSIOGRAPHIC AND TECTONIC SETTING

The Shootaring Canyon site is located within the Colorado Plateau physiographic province in southeastern Utah. Wide areas of nearly flat-lying rocks separated by abrupt monoclinal flexures form the broad uplifts and intervening basins common to this province. Igneous intrusions have formed several mountains, such as the Henry Mountains, near the facility.

The site is located near the southern end of the Henry Mountains' structural basin. The basin contains sedimentary rocks ranging from Mesozoic to Cenozoic in age, which are cut by the Tertiary intrusives forming the Henry Mountains, including Mt. Ellsworth. Fault development in the area is associated with the intrusive igneous centers of the Henry Mountains. These faults commonly have a northeasterly or northwesterly strike and do not generally extend far from the intrusive bodies. Faults are not known to exist within the site.

3.0 SEISMICITY

3.1 Earthquake Catalogs

This seismic hazard analysis for the site included a review of historic earthquakes which have occurred within 200 miles of the site. Catalogs from the USGS NSHMP for the Western United States (WUS) and Central and Eastern United States (CEUS) (Mueller et al., 1997) were used. These catalogs, compiled by the USGS for their study, included removal of repeat occurrences from different reporting stations as well as aftershocks and foreshocks related to the primary earthquake events. The database includes historical seismic events over the period from 1787 through December 2001. The WUS and CEUS catalogs were supplemented with events occurring between January 2002 and September 2007 by searching the National Earthquake Information Center database, also maintained by the USGS. This supplemental search resulted in three additional earthquakes. The catalog searches were limited to events with moment magnitude (Mw) greater than or equal to 4.0. A total of 114 events are included in the record. Earthquake activity is relatively diffuse and generally of low intensity, as shown in Figure 1. The earthquakes are tabulated in Appendix B. The largest event is estimated in the WUS catalog to have an Mw of 6.5, and occurred approximately 105 miles northwest of the site. The event closest to the site had an epicenter about 20 miles southeast of the site. This earthquake, which occurred on August 22, 1986, had an Mw of 4.0.

3.2 Quaternary Faults and Folds

Quaternary faults were identified using the USGS Quaternary Fault and Fold database (USGS et al. 2006). Faults within 200 miles of the site are shown in Figure 1. A tabulated list of the faults is included in Appendix C.1.

4.0 SEISMIC HAZARD ANALYSIS

Seismic hazard analyses are typically conducted using one of two methods: (1) deterministic analysis or (2) probabilistic analysis. In the deterministic analyses, the maximum credible earthquake (MCE) associated with capable faults are attenuated to the site. A capable fault is defined by the United States Nuclear Regulatory Commission (NRC), in Appendix A to Part 100—Seismic and geologic siting criteria for Nuclear Power Plants, as a fault that has exhibited one or more of the following characteristics: 1) movement at or near the ground surface at least once within the past 35,000 years, or movement of a recurring nature within the past 500,000 years; 2) macroseismicity (magnitude 3.5 or greater) determined with instruments of sufficient precision to demonstrate a direct relationship with the fault; or 3) a structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other. The maximum credible earthquake associated with the fault is attenuated to the site using established attenuation equations. In deterministic analyses, typically mean plus sigma peak ground accelerations are reported.

Background, or floating, earthquakes are evaluated by placing the largest earthquake that can be assumed to occur unassociated with a known fault directly under the site at a depth of 15 km (a typical depth of epicenters in the region). In areas of low seismic activity, deterministic analyses tend to significantly overestimate ground accelerations.

In probabilistic analyses, characteristic ground motions and the associated probability of exceedance are estimated in order for the amount of risk, or chance of exceedance, associated with the seismic hazard to be evaluated. As specified by the U.S. Environmental Protection Agency (EPA) Promulgated Standards for Remedial Actions at Inactive Uranium Processing Sites (40 CFR 192), the controls of residual radioactive material are to be effective for up to 1,000 years, to the extent reasonably achievable and, in any case, for at least 200 years. For the purpose of the seismic hazard evaluation, a 1,000-year design life is adopted. The associated probability of exceedance for a 10,000-year return period is 10%. Building codes typically utilize 10% chance of exceedance within the life of the structure as a design parameter. In keeping with a 10% chance of exceedance within the life of the structure, a 10,000-year return period is used for long term stability analysis. Assuming a 100-year life during operation, a 1,000-year return period is appropriate for operational considerations.

Seismic hazard analysis was performed using software EZ-FRISK, version 7.23 (Risk Engineering, Inc, 2007).

4.1 Seismic Sources

4.1.1 Active Faults

Faults from the Quaternary fault and fold database, as described in Section 3, were considered as seismic sources for the deterministic seismic hazard analysis. The MCE associated with each fault was calculated based on correlations between fault length and magnitude, as developed by Wells and Coppersmith (1994). All faults from the database were included in the deterministic analysis. This is a conservative approach, as the definition of a Quaternary fault is movement within the past 1.8 million years, and the definition of an active fault, as described in Section 4.0, is between 35,000 and 500,000 years.

For the probabilistic analysis, faults that could produce peak ground accelerations of 0.05 g or greater (based on deterministic methods) were included in the probabilistic model. This criteria resulted in the inclusion of the following seven faults:

1) Bright Angel fault system, Fault 1, (2514),
2) Bright Angel fault system, Fault 2, (2514);
3) Bright Angel fault system, Fault 3, (2514);
4) Needles fault zone, (2507);
5) Shay graben, (2513);
6) Aquarius and Awapa plateau faults, (2505); and
7) Thousand Lakes fault (2506).

These faults are shown in Figure 2. These faults were not considered in the USGS NSHMP because their activity in the Quaternary is suspect, or because their movement in the mid to late Quaternary did not meet the USGS definition of an active fault.

The three faults of the Bright Angel fault system are included in the hazard analysis due to their proximity to the site and potential impacts. This fault system is classified as Class B. The definition of Class B faults is geologic evidence that demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deeply enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A. The fault system is described as an expansive area of poorly understood suspected Quaternary faults in the Colorado Plateau. The faults are entirely within bedrock, thus Quaternary deformation can not be proven. Because of the questionable timing of fault movement, the fault is assigned a probability of being active of 0.5. The Needles fault zone and Shay graben faults are handled similarly. Descriptions of the faults (USGS et al. 2006) are included in Appendix D. Additional uncertainties in the fault characteristics are incorporated into the probabilistic analysis by representing the possible scenarios with a weight value. The magnitudes of earthquakes considered corresponded to the Wells and Coppersmith (1994) relations ± 0.3. Slip rates varied from 0.005 mm/yr to 0.3 mm/yr. The parameters used in the probabilistic analysis are summarized in Appendix C.2.

4.1.2 Background Event

Many earthquakes occur that are not associated with a known structure. These events are termed background events, or floating earthquakes. Evaluation of the background event allows for potential low to moderate earthquakes not associated with tectonic structures to contribute to the seismic hazard of the site. Because these events are not associated with a known structure, the location of these events is assumed to occur randomly. The maximum magnitude for these background events within the Intermountain U.S. ranges between local magnitude (M_L) 6.0 and 6.5 (Woodward-Clyde 1996). Larger earthquakes would be expected to leave a detectable surface expression, especially in arid to semiarid climates, with slow erosion rates and limited vegetation. In seismically less active areas such as the Colorado Plateau, the maximum magnitude associated with a background event is assumed to be 6.3, consistent with that used in seismic evaluations performed for uranium tailing sites in Green River (DOE 1991a, pg. 26), Grand Junction (DOE 1991b, pg. 71), and Moab (Woodward-Clyde 1996, pg. 4-19).

The background earthquake magnitude and recurrence interval were assessed by looking at the earthquake record within 200 miles of the site, filtered to include only events with Mw values equal or greater than 4.0, as described in Section 3.1. The entire 200-mile radius circle about the site was evaluated as a source zone with uniformly distributed seismicity. As shown in Figure 1, the NW quadrant of the 200-mile radius circle has a high concentration of Quaternary faults and historical earthquake events. This zone corresponds to the Intermountain Seismic Belt, an area of significant earthquake activity. Including these events is conservative, as the recurrence interval of events in the remaining portion of the circle, including around the site, is overestimated.

In computation of background seismicity recurrence, all events know to be associated with faults considered in the hazard analysis should be removed from the analysis. On November 14, 1901, an earthquake with an estimated Mw of 6.5 occurred in Sevier County at an approximate location of 38.7° latitude and -112.1° longitude. As shown in Figure 2, this location is close to several Quaternary faults (Joseph Flats area faults and syncline - 2468), Elsinore fault - 2470, Dry Wash fault and syncline - 2496, Annabella graben - 2472, and Sevier fault northern portion - 2355). The earthquake record shows a total of 9 earthquakes with Mw equal or greater than 4.0 in this immediate area. The Mw 6.5 event has been removed from the background analysis since it is likely related to one of these structures, and an event of this magnitude will likely have a surface expression. For conservatism, the other eight events of lesser magnitude have been retained in the analysis.

The earthquake recurrence of the source zone was described by the truncated-exponential form of the Gutenberg-Richter relationship of log N = a - bM. The completeness periods for various magnitudes were estimated by Mueller et al. (1997). Table 2 gives the completeness period dates and the number of earthquakes during each period. Figure 3 shows the temporal distribution of earthquakes within the study area, and Figure 4 shows the incremental recurrence curve.

Table 1 Completeness Periods and Event Counts Used in Recurrence Calculations

Magnitude Range (Mw)	Completeness Period	Number of Earthquakes
4.0-4.9	1/1963 - 8/2007	56
5.0-5.9	1/1930 - 8/2007	22
6.0-7.0	1/1850 - 8/2007	1

4.2 Attenuation Relations

Attenuation of ground motions from the location of a seismic event to the site was calculated using attenuation relations. Due to the absence of abundant strong ground motion records, no specific attenuation relation exists solely for Utah; thus, several attenuation relations from other areas were considered for use at the site. For the purposes of this study, the following three attenuation relationships were used: Spudich et al. (1999), Abrahamson and Silva (1997), and Campbell and Bozorgnia (2003). The empirical attenuation relations are appropriate for soft rock sites in the western U.S. An important consideration in the selection of appropriate attenuation relationships is that the area is located in an extensional tectonic regime where fault type is predominately normal. Spudich et al. (1999) was developed from an extensional earthquake database. Abrahamson and Silva (1997) and Campbell and Bozorgnia (2003) include normal faulting factors in the relations.

4.3 Peak Ground Acceleration

Based on deterministic methods, the background event results in a PGA of 0.25 g. Seven faults are identified as potentially capable of producing site PGA of 0.05 g or greater, and are summarized in Table 3.

Table 2 PGA for Significant Faults, Deterministic Analysis

Source Name	ID No.	Distance from Site (km)	MCE	PGA (mean)	PGA (mean +1SD)
Background Event	---	15	6.30	0.15	0.25
Bright Angel, Fault 1	2514	9	5.78	0.17	0.28
Bright Angel, Fault 2	2514	13	6.24	0.17	0.28
Bright Angel, Fault 3	2514	35	6.66	0.08	0.13
Needles Fault	2507	60	6.77	0.05	0.08
Thousand Lake Fault	2506	90	7.03	0.04	0.06
Shay graben Fault	2513	88	6.93	0.04	0.06
Aquarius and Awapa Fault	2505	89	6.88	0.03	0.05

As compared to the background event, only the faults of the Bright Angel Fault Zone result in PGA values of comparable magnitude. However, the likelihood of any of these events occurring within the design life of the project can only be evaluated by looking at the probabilistic analysis.

Table 3 PGA for Significant Faults at $1x10^{-4}$ PE, Probabilistic Analysis

Source Name	ID No.	Distance from Site (km)	PGA
Background Event	---	15	0.21
Bright Angel, Fault 1	2514	9	<0.01
Bright Angel, Fault 2	2514	13	<0.01
Bright Angel, Fault 3	2514	35	<0.01
Needles Fault	2507	60	<0.01
Thousand Lake Fault	2506	90	0.02
Shay graben Fault	2513	88	<0.01
Aquarius and Awapa Fault	2505	89	0.02
Total Hazard	---	---	0.22

Using a 10,000 year return period (or $1x10^{-4}$ annual PE) as the design event, the PGA is estimated to be 0.22 g. The total hazard curve is shown in Figure 5 and the source contribution is shown in Figure 6. As shown in Figure 6, at this frequency, the hazard is almost entirely contributed to the background event. Input to the EZ-FRISK analysis is included in Appendix E.

4.4 Amplification

Geologic maps of the area (Hackman and Wyant, 1973) indicate that the site is underlain by Lower Cretaceous Morrison and Upper Jurassic Summerville formation of sandstones, mudstones, and siltstones. As defined in Campbell and Bozorgnia (2003), the site is categorized as a firm rock site, based on underlying geologic unit consisting of pre-Tertiary sedimentary rock. As such, further amplification of ground motions due to underlying soils was not considered. If further investigations indicate that the materials within the upper 30 meters are not classified as firm rock, soil amplification should be considered.

5.0 RESULTS AND CONCLUSIONS

Based on the probabilistic analysis, a PGA (at an annual PE of $1x10^{-4}$) of 0.22 g should be used for long-term seismic stability analyses. The U.S. Department of Energy (DOE, 1989) recommends that a seismic coefficient of two-thirds of the peak acceleration be used to analyze long-term, pseudostatic stability analyses. Therefore, for long-term pseudostatic analyses, a seismic coefficient of 0.15 g is recommended.

The value of 0.22 g is lower than the 0.32 g from the USGS 2002 Interactive Deaggragations (USGS, 2007a). It is likely that the majority of the difference is a result of using different attenuation relationships. As discussed in Section 1.2.2, the site is very close to the border drawn by USGS between the WUS and CEUS zones. Because the site lies within the CEUS area, the USGS applied attenuation relations developed for the CEUS. However, it is the opinion of the author that using attenuation relations that are specific to normal extentional faulting is appropriate. This is supported by other studies done in the area (e.g Halling 2002, Wong et al. 2004).

During operational conditions, designing for an annual PE of $1x10^{-3}$, or a 1000-year return period would correlate roughly to a 10 percent chance of exceedance in 100 years. Using this criteria, the PGA is 0.11 g and the seismic coefficient is 0.07 g.

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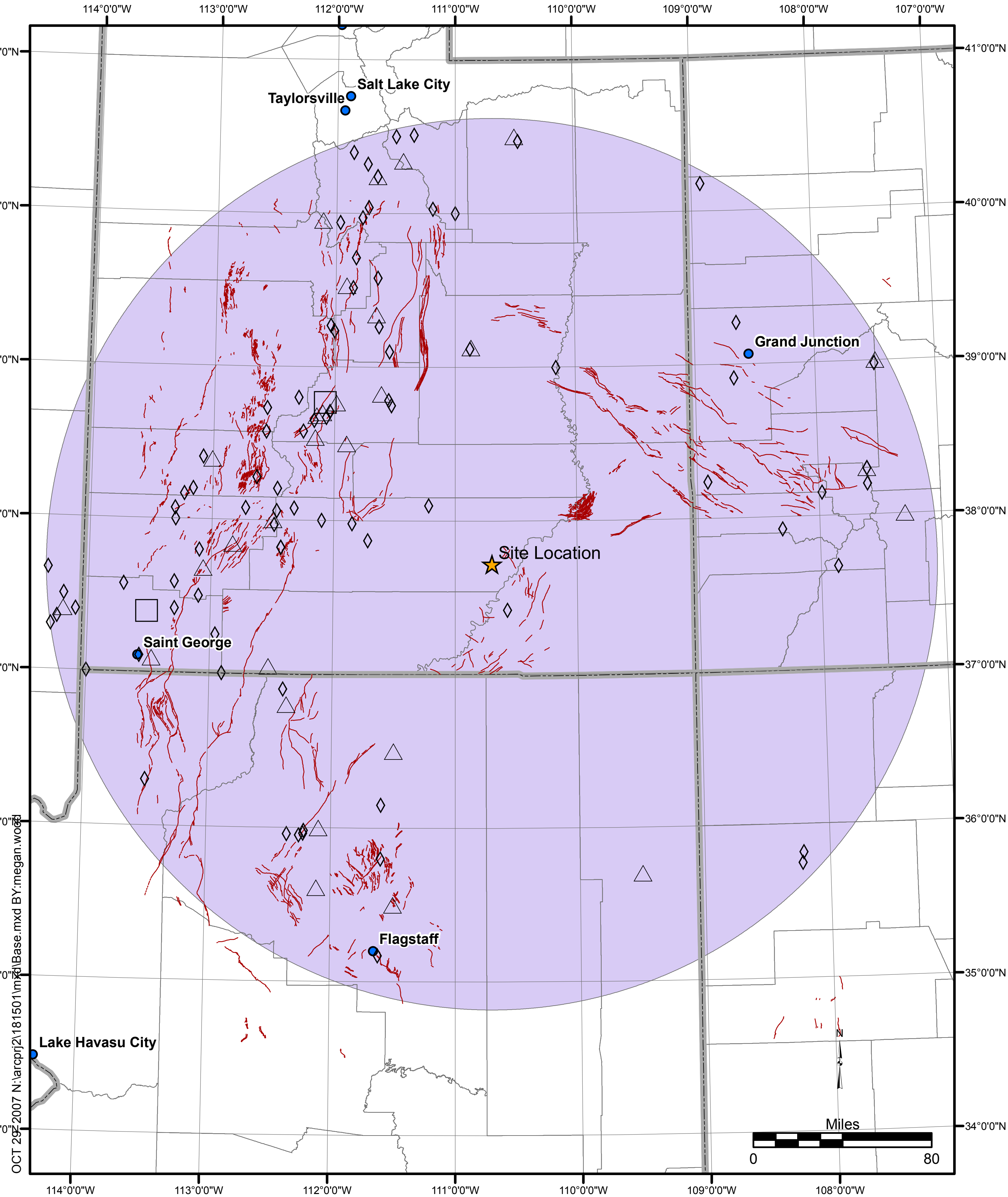


Earthquakes (Moment Magnitude)

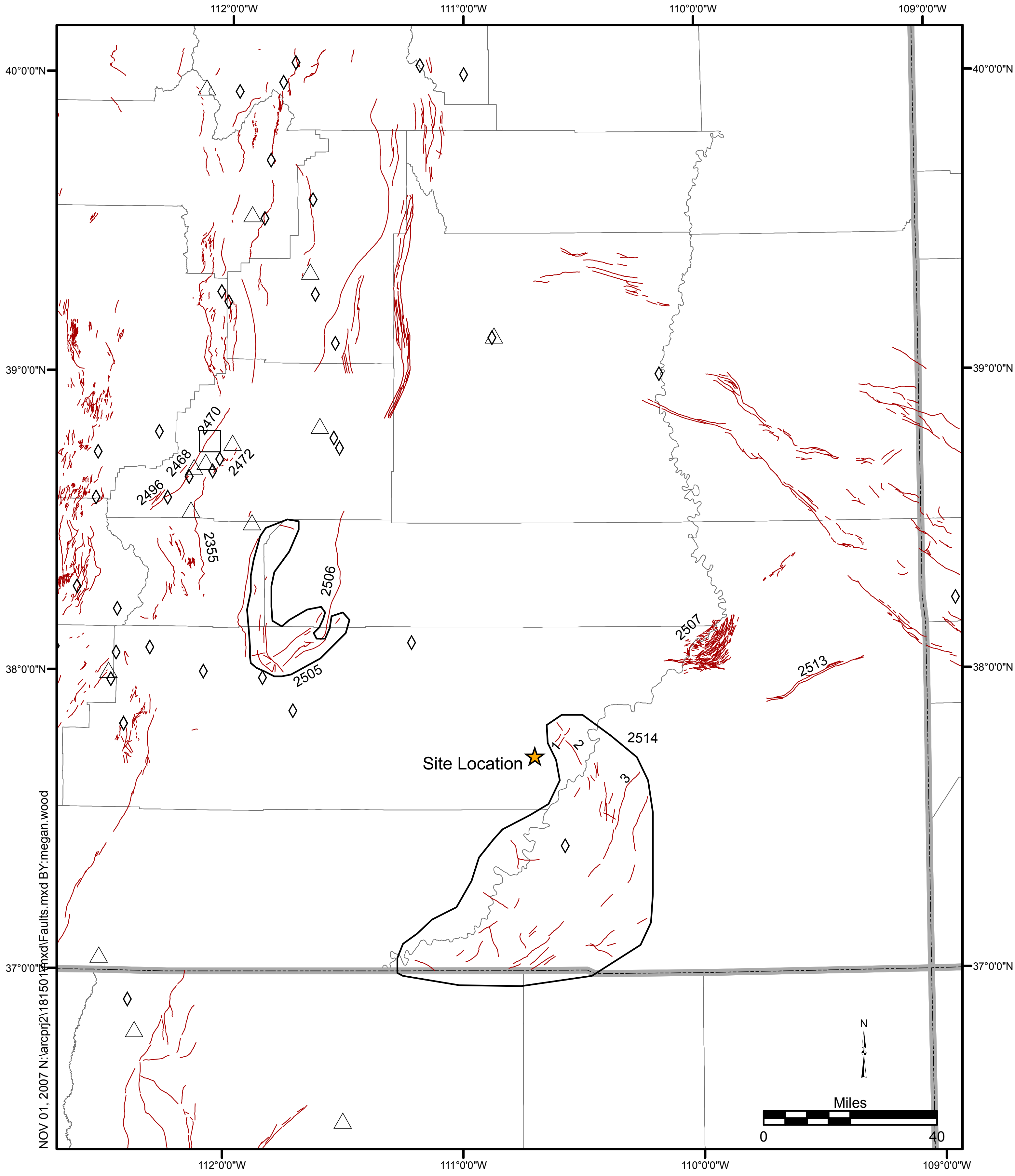
- 4-4.9
- 5-5.9
- 6-6.9
- Quaternary Faults and Folds

OCT 29, 2007

FIGURE 1

HISTORICAL EARTHQUAKES AND QUATERNARY FAULTS WITHIN 200 MILES OF SHOOTARING CANYON SITE

SHOOTARING 181501



Earthquakes (Moment Magnitude)

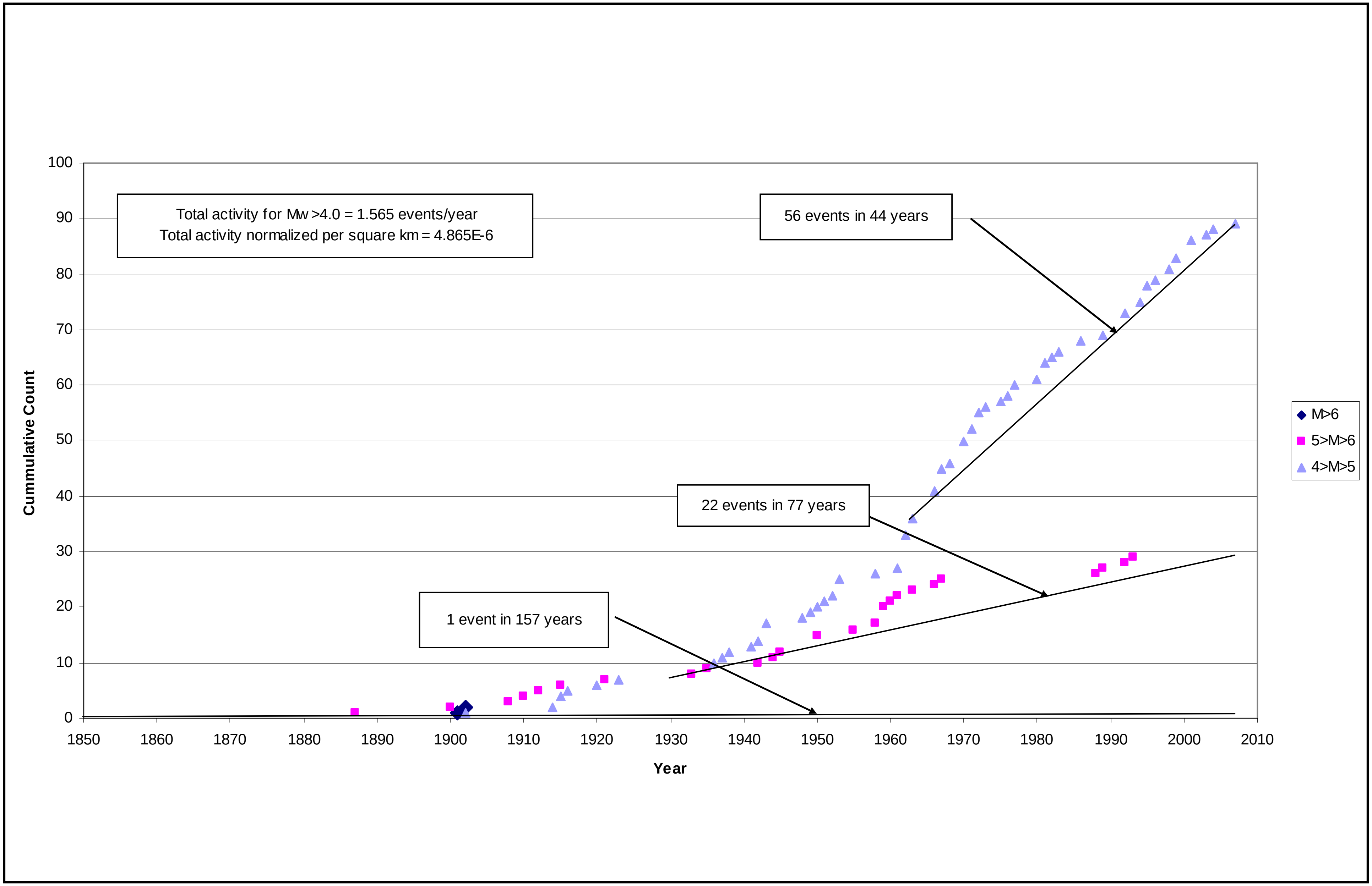
- 4-4.9
- 5-5.9
- 6-6.9
- Quaternary Faults and Folds

NOV 01, 2007

FIGURE 2

FAULTS DISCUSSED IN SEISMIC HAZARD ANALYSIS

SHOOTARING 181501



Project No: 181501

November 2007

FIGURE 3
TEMPORAL DISTRIBUTION OF EARTHQUAKES WITHIN 200 MILES OF SHOOTARING CANYON SITE

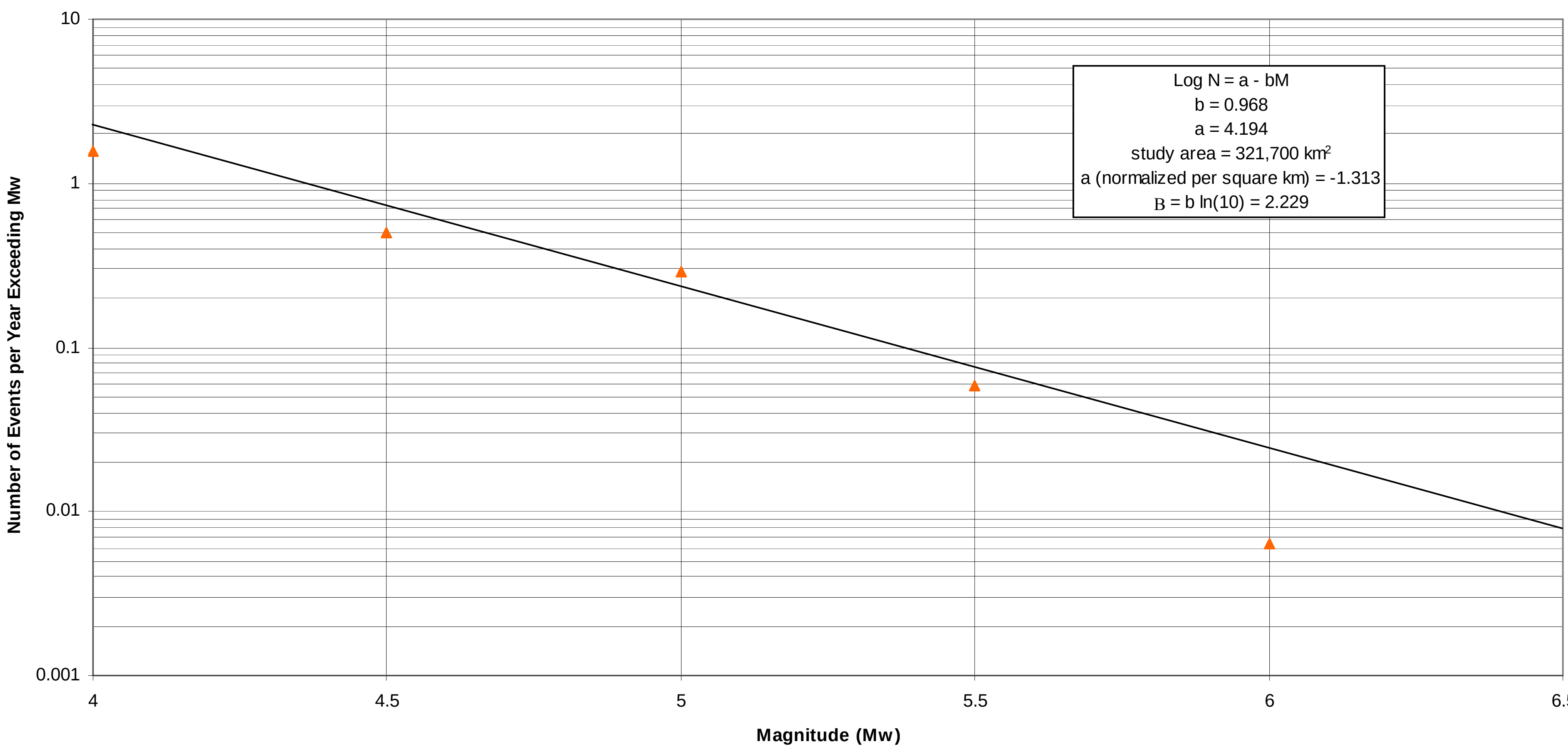


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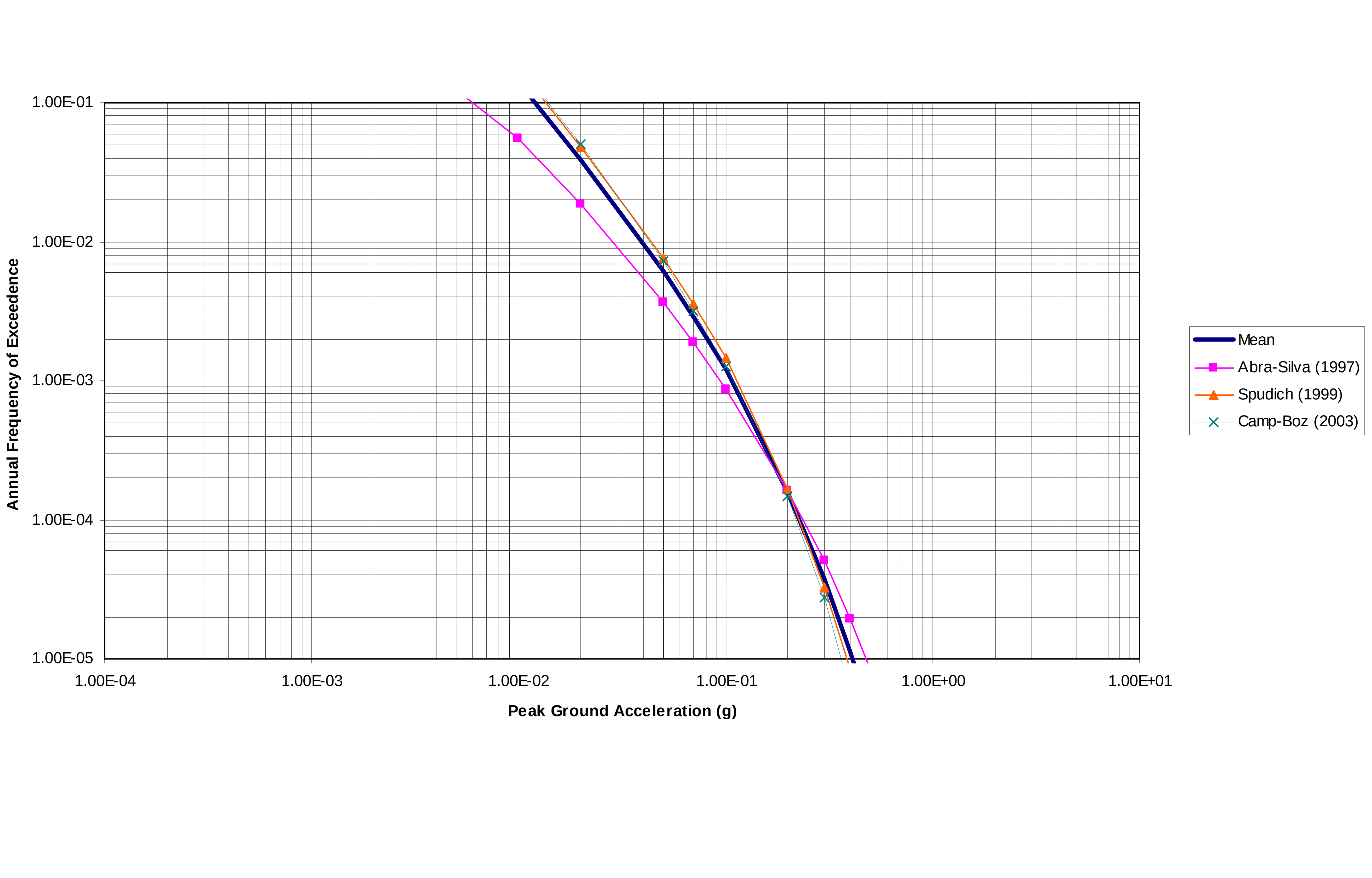
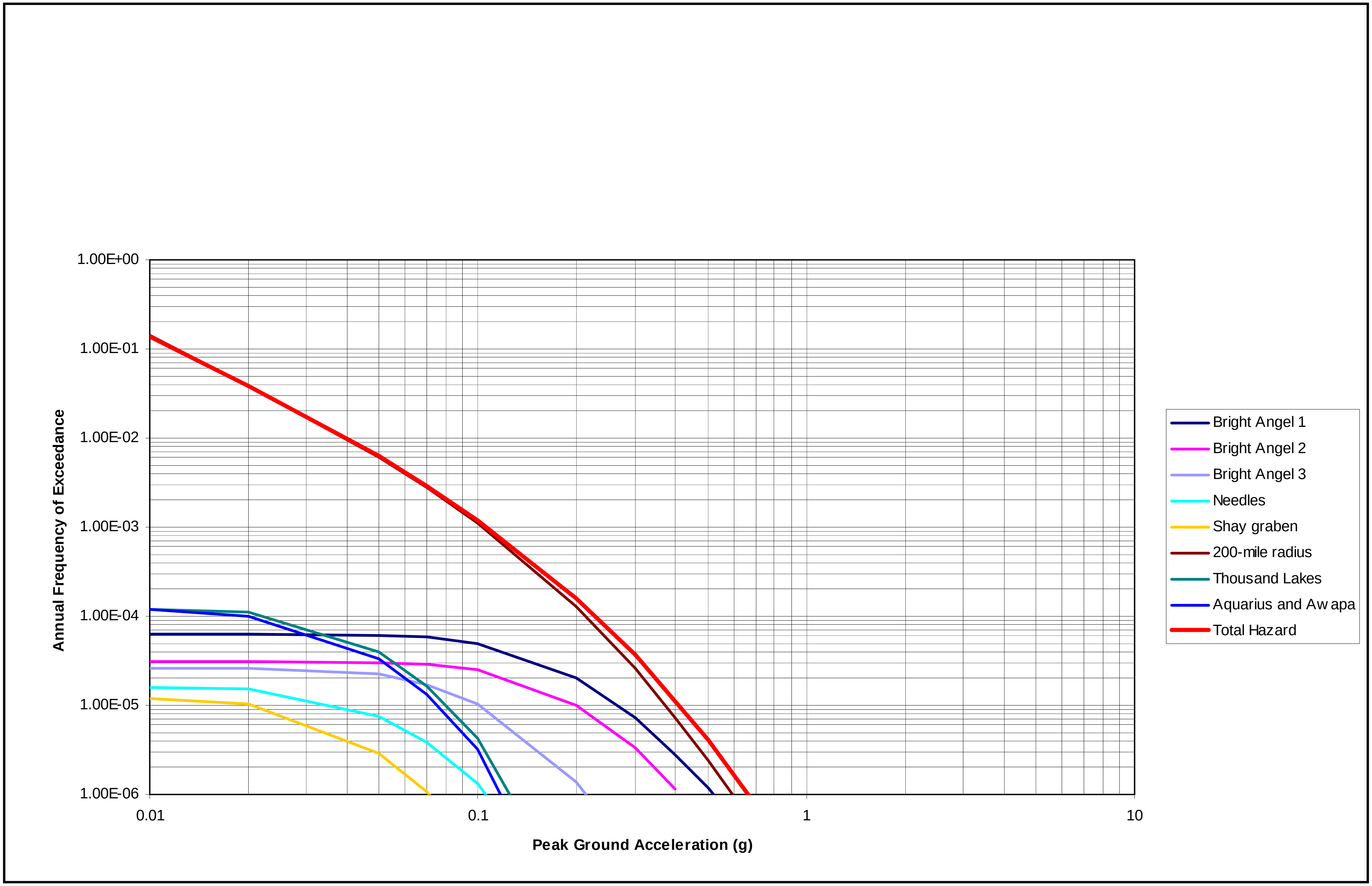
FIGURE 4
RECURRENCE CURVE FOR EARTHQUAKES WITHIN 200 MILES OF SHOOTARING CANYON SITE



Project No: 181501

November 2007

FIGURE 5
TOTAL SEISMIC HAZARD CURVE
SHOOTARING CANYON SITE



Project No: 181501

November 2007

FIGURE 6
SOURCE CONTRIBUTION TO TOTAL SEISMIC HAZARD
SHOOTARING CANYON SITE

APPENDIX A
DEAGGREGATION OF SEISMIC HAZARD FOR PGA FROM USGS NATIONAL SEISMIC HAZARDS MAPPING PROJECT

Deaggregation of Seismic Hazard for PGA & 2 Periods of Spectral Accel.
Data from U.S.G.S. National Seismic Hazards Mapping Project, 2002 version
PSHA Deaggregation. %contributions. site: Shootaring long: 110.700 W., lat: 37.720 N.
USGS 2002-03 update files and programs. dM=0.2. Site descr:ROCK
Return period: 4975 yrs. Exceedance PGA =0.3227 g.
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00478

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
11.0	4.60	6.015	0.739	2.631	2.261	0.368	0.016	0.000
27.0	4.61	0.266	0.266	0.000	0.000	0.000	0.000	0.000
12.0	4.80	13.152	1.476	5.427	5.169	1.031	0.049	0.000
29.9	4.80	0.580	0.580	0.000	0.000	0.000	0.000	0.000
12.3	5.03	11.236	0.788	4.426	4.679	1.251	0.092	0.000
29.7	5.03	1.448	0.986	0.462	0.000	0.000	0.000	0.000
12.8	5.21	4.981	0.306	1.750	2.237	0.639	0.049	0.000
29.9	5.22	0.971	0.499	0.472	0.000	0.000	0.000	0.000
13.3	5.40	8.620	0.393	2.670	4.115	1.356	0.085	0.001
31.3	5.40	2.355	0.972	1.383	0.000	0.000	0.000	0.000
55.4	5.41	0.070	0.070	0.000	0.000	0.000	0.000	0.000
13.0	5.62	4.794	0.153	1.145	2.418	1.016	0.060	0.002
30.6	5.62	2.361	0.595	1.467	0.300	0.000	0.000	0.000
57.6	5.63	0.124	0.124	0.000	0.000	0.000	0.000	0.000
14.4	5.81	5.249	0.159	1.222	2.641	1.130	0.094	0.004
33.1	5.80	2.273	0.512	1.468	0.293	0.000	0.000	0.000
58.3	5.82	0.208	0.193	0.014	0.000	0.000	0.000	0.000
15.4	6.01	4.942	0.133	1.060	2.434	1.183	0.127	0.004
35.6	6.01	1.738	0.294	1.168	0.276	0.000	0.000	0.000
57.8	6.01	0.255	0.188	0.067	0.000	0.000	0.000	0.000
81.6	6.02	0.067	0.067	0.000	0.000	0.000	0.000	0.000
14.3	6.21	4.533	0.086	0.802	2.099	1.360	0.180	0.005
34.2	6.21	2.512	0.283	1.395	0.834	0.000	0.000	0.000
59.7	6.22	0.393	0.235	0.157	0.000	0.000	0.000	0.000
85.3	6.23	0.086	0.084	0.002	0.000	0.000	0.000	0.000
14.4	6.42	3.253	0.050	0.503	1.420	1.085	0.189	0.005
34.5	6.42	2.209	0.177	1.010	0.968	0.054	0.000	0.000
60.6	6.42	0.475	0.185	0.291	0.000	0.000	0.000	0.000
88.3	6.42	0.089	0.082	0.007	0.000	0.000	0.000	0.000
115.2	6.43	0.061	0.061	0.000	0.000	0.000	0.000	0.000
14.2	6.59	2.058	0.033	0.290	0.850	0.738	0.144	0.004
34.4	6.59	1.603	0.102	0.623	0.809	0.069	0.000	0.000
58.6	6.60	0.338	0.084	0.246	0.008	0.000	0.000	0.000
84.0	6.59	0.129	0.083	0.045	0.000	0.000	0.000	0.000
119.6	6.60	0.076	0.072	0.003	0.000	0.000	0.000	0.000
14.8	6.79	3.162	0.033	0.393	1.296	1.177	0.254	0.008
36.0	6.78	2.185	0.126	0.759	1.169	0.131	0.000	0.000
60.1	6.79	0.603	0.113	0.445	0.045	0.000	0.000	0.000
85.0	6.79	0.219	0.101	0.119	0.000	0.000	0.000	0.000
115.5	6.80	0.124	0.081	0.042	0.000	0.000	0.000	0.000
14.9	6.98	1.734	0.012	0.194	0.712	0.656	0.155	0.005
36.3	6.98	1.226	0.059	0.341	0.666	0.147	0.012	0.000
60.5	6.98	0.418	0.056	0.286	0.076	0.000	0.000	0.000
85.7	6.97	0.153	0.047	0.106	0.000	0.000	0.000	0.000
115.0	6.95	0.066	0.033	0.033	0.000	0.000	0.000	0.000
126.8	7.00	0.071	0.040	0.031	0.000	0.000	0.000	0.000
63.6	7.16	0.055	0.007	0.035	0.012	0.000	0.000	0.000
62.8	7.32	0.055	0.005	0.031	0.019	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Mean src-site R= 20.3 km; M= 5.63; eps0= 0.07. Mean calculated for all sources.
Modal src-site R= 12.0 km; M= 4.80; eps0= 0.31 from peak (R,M) bin
Gridded source distance metrics: Rseis Rrup and Rjb
MODE R*= 13.6km; M*= 4.80; EPS.INTERVAL: 1 to 2 sigma % CONTRIB.= 5.427

Principal sources (faults, subduction, random seismicity having >10% contribution)

Source Category:	% contr.	R(km)	M	epsilon0 (mean values)
Midwest/CEUS gridded	99.20	20.4	5.62	0.07

Individual fault hazard details if contrib.>1%:
******************** Intermountain Seismic Belt***********************************

Deaggregation of Seismic Hazard for PGA & 3 Periods of Spectral Accel.
Data from U.S.G.S. National Seismic Hazards Mapping Project, 1996 version
PSHA Deaggregation. %contributions. site: Shootaring long: 110.7000 W., lat: 37.7200 N.
Return period: 4975yrs. Exceedance PGA=0.3396090g. Computed annual rate=.20093E-03

DIST(KM)	MAG(MW)	ALL-EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
11.7	4.84	25.886	5.081	12.688	8.053	0.064	0.000	0.000
37.1	4.86	1.119	1.119	0.000	0.000	0.000	0.000	0.000
57.5	4.87	0.096	0.096	0.000	0.000	0.000	0.000	0.000
11.0	5.24	20.617	1.336	7.575	10.030	1.675	0.000	0.000
29.5	5.26	7.455	3.431	3.938	0.086	0.000	0.000	0.000
58.5	5.29	0.365	0.365	0.000	0.000	0.000	0.000	0.000
11.8	5.70	13.565	0.580	3.236	7.129	2.591	0.029	0.000
31.2	5.73	9.444	2.048	5.774	1.622	0.000	0.000	0.000
59.5	5.76	0.983	0.924	0.059	0.000	0.000	0.000	0.000
88.3	5.78	0.102	0.102	0.000	0.000	0.000	0.000	0.000
12.3	6.22	7.887	0.307	1.494	3.448	2.414	0.224	0.000
32.9	6.24	9.304	0.874	4.602	3.700	0.129	0.000	0.000
60.6	6.27	1.872	0.940	0.931	0.000	0.000	0.000	0.000
88.7	6.28	0.297	0.292	0.005	0.000	0.000	0.000	0.000
112.7	6.29	0.167	0.167	0.000	0.000	0.000	0.000	0.000
13.1	6.79	0.222	0.038	0.084	0.078	0.022	0.000	0.000
73.0	6.76	0.080	0.028	0.052	0.000	0.000	0.000	0.000
89.0	6.75	0.089	0.046	0.043	0.000	0.000	0.000	0.000
113.5	6.75	0.055	0.044	0.011	0.000	0.000	0.000	0.000
89.4	7.09	0.051	0.011	0.041	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Mean src-site R= 19.7 km; M= 5.45; e0= 0.51; e= 1.22 for all sources.
Modal src-site R= 11.7 km; M= 4.84; e0= 0.79 from peak (R,M) bin
Primary distance metric: EPICENTRAL
MODE R*= 12.1km; M*= 4.83; EPS.INTERVAL: 1 to 2 sigma % CONTRIB.= 12.688

Principal sources (faults, subduction, random seismicity having >10% contribution)

Source:	% contr.	R(km)	M	epsilon0 (mean values)
CEUS gridded seismicity,Frankel	61.52	19.9	5.44	0.42
CEUS gridded seismicity,Toro att	37.51	19.7	5.45	0.65

APPENDIX B
EARTHQUAKE EVENTS WITH MAGNITUDE GREATER OR EQUAL TO 4.0 OCCURRING WITHIN 200 MILES OF SHOOTARING CANYON SITE

Appendix B: Earthquake events with Magnitude greater or equal to 4.0 occurring within 200 miles of Shootaring Canyon site

Source:
Open-File Report 97-464 "Preparation of Earthquake Catalogs for the National Seismic-Hazard Maps: Contiguous 48 States" by Charles Mueller, Margaret Hopper, and Arthur Frankel.
Western US Moment Magnitude Catalog

WUS > 4 Mw
BOLD data is more recent than January 1996

Magnitude (Mw)	Longitude (degree, west)	Latitude (degree, north)	Depth (km)	Year	Month	Day	Hour	Minute	Second	Catalog
5.7	-112.522	37.047	0	1887	12	5	15	30	0	DNAG
5.7	-112.114	39.952	0	1900	8	1	7	45	0	DNAG
6.5	-112.083	38.769	0	1901	11	14	4	39	0	DNAG
4.3	-112.639	38.279	0	1902	7	31	7	0	0	DNAG
6.3	-113.52	37.393	0	1902	11	17	19	50	0	DNAG
5	-113.007	38.393	0	1908	4	15	0	0	0	DNAG
5	-112.149	38.682	0	1910	1	10	13	0	0	DNAG
5.7	-111.5	36.5	0	1912	8	18	21	12	0	DNAG
4.3	-113.713	37.572	0	1914	12	14	5	30	0	DNAG
5	-111.655	40.239	0	1915	7	15	22	0	0	DNAG
4.3	-111.781	39.972	0	1916	2	5	6	25	0	DNAG
4.3	-113.573	37.106	0	1920	11	26	0	0	0	DNAG
5.2	-112.1	38.7	0	1921	9	29	14	12	0	USHIS
4.3	-113.233	38.166	0	1923	5	14	12	10	0	DNAG
5	-112.827	37.842	0	1933	1	20	13	10	0	DNAG
5	-112.1	36	0	1935	1	10	8	10	0	DNAG
4.3	-113.5	36.3	0	1936	1	22	3	38	0	SRA
4.3	-112.958	37.25	0	1936	5	9	10	25	0	DNAG
4.7	-113.3	38	0	1936	9	21	6	20	0	USHIS
4.3	-112.433	37.822	0	1937	2	18	4	15	0	DNAG
4	-114	37	0	1938	12	28	4	37	36	DNAG
4	-114.3	37.3	0	1941	5	6	3	11	42	CDMG
4.3	-111.65	39.58	0	1942	6	4	22	4	0	DNAG
5	-113.065	37.682	0	1942	8	30	22	8	0	DNAG
4	-114.1	37.4	0	1943	3	6	20	14	30	SRA
4.3	-112.26	38.58	0	1943	11	3	9	30	0	DNAG
4	-114.25	37.35	0	1943	11	6	3	55	0	CDMG
5	-111.986	38.765	0	1945	11	18	1	15	0	DNAG
4.3	-111.637	39.263	0	1948	11	4	13	18	0	DNAG
4.7	-113.1	37.5	0	1949	11	2	2	29	29	CDMG
4.3	-111.729	40.038	0	1950	5	8	22	35	0	DNAG
5	-111.9	38.5	0	1950	11	18	1	15	0	DNAG
4.3	-111.655	40.239	0	1951	8	12	0	26	0	DNAG
4.3	-111.86	40.396	0	1952	9	28	20	0	0	DNAG
4.3	-111.5	40.5	0	1953	5	24	2	54	29	DNAG
4.3	-112.433	37.822	0	1953	10	22	3	0	0	DNAG

Appendix B: Earthquake events with Magnitude greater or equal to 4.0 occurring within 200 miles of Shootaring Canyon site

5	-107.3	38	0	1955	8	3	6	39	42	DNAG
5	-111.44	40.341	0	1958	2	13	22	52	0	DNAG
4.3	-111.833	39.711	0	1958	11	28	13	30	39	DNAG
5	-112.5	38	0	1959	2	27	22	19	52	DNAG
5.6	-112.37	36.8	0	1959	7	21	17	39	29	USHIS
5	-111.5	35.5	0	1959	10	13	8	15	0	USHIS
5	-111.66	39.34	0	1961	4	16	5	2	39.3	DNAG
4.3	-114.333	37.667	0	1961	9	26	21	46	20	CDMG
4.7	-107.6	38.2	25	1962	2	5	14	45	51.1	USHIS
4.4	-112.9	37	21	1962	2	15	9	6	45.1	SRA
4.5	-112.4	36.9	26	1962	2	15	7	12	42.9	USHIS
4.5	-112.1	38	33	1962	6	5	22	29	45	USHIS
4.4	-114.2	37.5	0	1962	7	8	15	58	6	CDMG
4.3	-111	40	33	1962	9	7	8	47	19	DNAG
5	-111.91	39.53	7	1963	7	7	19	20	39.6	USHIS
4	-111.19	40.03	7	1963	7	9	20	25	25.8	SRA
4	-111.55	39.1	7	1966	4	23	20	20	53.3	SRA
4.2	-111.85	37.98	7	1966	5	20	13	40	47.9	SRA
5.4	-114.2	37.4	33	1966	9	22	18	57	36.5	USHIS
4.4	-111.6	35.8	34	1966	10	3	16	3	50.9	SRA
4.2	-113.16	38.2	7	1966	10	21	7	13	48.9	SRA
4.2	-112.3	38.8	33	1967	6	22	21	51	29.9	DNAG
4.2	-111.6	36.15	33	1967	9	4	23	27	46.2	SRA
5.6	-112.16	38.54	7	1967	10	4	10	20	12.8	USHIS
4	-112.04	39.27	7	1968	1	16	9	42	52.1	SRA
4	-113.082	38.407	0	1970	3	30	15	15	52.7	DNAG
4.1	-111.72	37.87	7	1970	4	18	10	42	11.5	SRA
4.2	-112.47	38.06	7	1970	5	23	22	55	23.2	SRA
4.1	-113.1	37.8	7	1971	11	10	14	10	23	SRA
4.5	-112.17	38.65	7	1972	1	3	10	20	38.9	USHIS
4.3	-112.07	38.67	7	1972	6	2	3	15	48.2	SRA
4.5	-111.35	40.51	7	1972	10	1	19	42	29.5	USHIS
4.6	-111.97	39.94	5	1980	5	24	10	3	36.3	SRA
4.3	-111.74	40.32	1	1981	2	20	9	13	1.2	USHIS
4.4	-113.3	37.59	1	1981	4	5	5	40	39.7	USHIS
4.3	-111.62	35.17	0	1981	12	6	9	9	20.3	DNAG
4.3	-112.04	38.71	5	1982	5	24	12	13	26.6	USHIS
4	-112.565	38.577	0	1983	12	9	8	58	40.7	SRA
4.6	-112.009	39.236	1	1986	3	24	22	40	23.4	USHIS
5.3	-111.614	38.824	10	1989	1	30	4	6	22.7	USHIS
4	-112.257	35.952	5	1989	3	5	0	40	30.8	PDE
4	-112.355	35.96	5	1992	3	14	5	13	31.6	PDE
4.4	-111.554	38.783	0	1992	6	24	7	31	20.2	PDE
4	-112.219	35.982	5	1992	7	5	18	17	29.9	PDE
5.7	-113.472	37.09	15	1992	9	2	10	26	20.9	PDE
5.3	-112.112	35.611	10	1993	4	29	8	21	0.8	PDE
4.1	-112.327	38.078	5	1994	9	6	3	48	37.6	PDE

Appendix B: Earthquake events with Magnitude greater or equal to 4.0 occurring within 200 miles of Shootaring Canyon site

4	-112.223	35.964	5	1995	4	17	8	23	46.2	PDE
4	-113.294	37.416	5	1995	6	8	8	29	16.5	PDE
4.5	**-112.467**	**38.206**	**5**	**1998**	**1**	**2**	**7**	**28**	**29**	**PDE**
4.1	**-112.49**	**37.97**	**2**	**1998**	**6**	**18**	**11**	**0**	**40**	**PDE**
4.2	**-112.727**	**38.077**	**5**	**1999**	**10**	**22**	**17**	**51**	**15.6**	**PDE**
4	**-111.53**	**38.75**	**2**	**1999**	**12**	**22**	**8**	**3**	**31**	**PDE**
4.1	**-112.56**	**38.73**	**0**	**2001**	**2**	**23**	**21**	**43**	**50**	**PDE**
4.4	**-111.521**	**38.731**	**3**	**2001**	**7**	**19**	**20**	**15**	**34**	**PDE**

Appendix B: Earthquake events with Magnitude greater or equal to 4.0 occurring within 200 miles of Shootaring Canyon site

Source:
Open-File Report 97-464 "Preparation of Earthquake Catalogs for the National Seismic-Hazard Maps: Contiguous 48 States" by Charles Mueller, Margaret Hopper, and Arthur Frankel.
Central/Eastern US Bodywave Magnitude Catalog

CEUS > 4 mb
BOLD data is more recent than January 1996

Magnitude (mb)	Longitude (degree, west)	Latitude (degree, north)	Depth (km)	Year	Month	Day	Hour	Minute	Second	Catalog
5	-107.5	39	0	1944	9	9	4	12	20	DNAG
5	-109.5	35.7	0	1950	1	17	0	51	0	DNAG
5.3	-110.5	40.5	0	1950	1	18	1	55	51	USHIS
4.3	-110.163	38.997	0	1953	7	30	5	45	0	DNAG
5.5	-107.6	38.3	49	1960	10	11	8	5	30.5	USHIS
4.3	-111.22	38.1	7	1963	9	30	9	17	39.3	SRA
4.2	-107.6	38.3	33	1966	9	4	9	52	34.5	SRA
4.4	-107.51	38.98	33	1967	1	12	3	52	6.2	SRA
4.1	-107.86	37.67	33	1967	1	16	9	22	45.9	SRA
4	-108.31	37.92	33	1970	2	3	5	59	35.6	SRA
4	-108.68	38.91	5	1971	11	12	9	30	44.6	SRA
4.1	-108.65	39.27	5	1975	1	30	14	48	40.3	SRA
4.6	-108.212	35.817	0	1976	1	5	6	23	33.9	SNMX
4.2	-108.222	35.748	0	1977	3	5	3	0	55.8	SNMX
4.8	-110.47	40.47	6	1977	9	30	10	19	20.4	USHIS
4	-110.574	37.42	5	1986	8	22	13	26	33.3	SRA
5.4	-110.869	39.128	10	1988	8	14	20	3	3.9	USHIS
4.5	-107.976	38.151	10	1994	9	13	6	1	23	PDE
4.1	-108.925	40.179	5	1995	3	20	12	46	16.3	PDE
4.2	**-110.878**	**39.12**	**0**	**1996**	**1**	**6**	**12**	**55**	**58.6**	**PDE**

Appendix B: Earthquake events with Magnitude greater or equal to 4.0 occurring within 200 miles of Shootaring Canyon site
Source: NEIC Earthquake search

FILE CREATED: Mon Sep 17 20:44:04 2007
Circle Search Earthquakes= 649
Circle Center Point Latitude: 37.720N Longitude: 110.700W
Radius: 320.000 km
Catalog Used: PDE
Data Selection: Historical & Preliminary Data
BOLD data is more recent than January 1996

Magnitude (Mw)	Longitude (degree, west)	Latitude (degree, north)	Depth (km)	Year	Month	Day	Hour	Minute	Second	Catalog
4.6	**-111.857**	**39.516**	**0**	**2003**	**4**	**17**	**1**	**4**	**19**	**PDE**
4.1	**-108.915**	**38.236**	**0**	**2004**	**11**	**7**	**6**	**54**	**59**	**PDE**
4.1	**-113.305**	**38.071**	**7**	**2007**	**8**	**18**	**13**	**16**	**31**	**PDE-Q**

APPENDIX C
QUATERNARY FAULTS AND FOLDS WITHIN 200 MILES OF SHOOTARING CANYON SITE

APPENDIX C.1
DETERMINISTIC CHARACTERISTICS

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA							
								Spudich et al. (1999) for rock sites		Abrahamson and Silva (1997) for normal faults		Campbell and Bozorgnia (2003) corrected		Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
Random Earthquake						15	6.30	0.121	0.193	0.195	0.330	0.142	0.229	0.153	0.251
Fault 1, Bright Angel Fault Zone (Class B)	2514	Class B	<0.2	4.0	N	9	5.78	0.135	0.215	0.196	0.355	0.168	0.281	0.166	0.284
Fault 2, Bright Angel Fault Zone (Class B)	2514	Class B	<0.2	10.0	N	13	6.24	0.132	0.210	0.213	0.362	0.157	0.255	0.167	0.276
Fault 3, Bright Angel Fault Zone (Class B)	2514	Class B	<0.2	23.0	N	35	6.66	0.065	0.105	0.098	0.157	0.076	0.120	0.080	0.127
Needles fault zone (Class B)	2507	Class B	<0.2	28.5		60	6.77	0.040	0.064	0.058	0.093	0.047	0.073	0.049	0.077
Thousand Lake fault	2506	<750,000	<0.2	48.3		90	7.03	0.030	0.048	0.044	0.068	0.036	0.056	0.037	0.057
Shay graben faults (Class B)	2513	Class B	<0.2	39.5		88	6.93	0.029	0.046	0.042	0.065	0.035	0.054	0.035	0.055
Aquarius and Awapa Plateaus faults	2505	<1,600,000	<0.2	35.7		89	6.88	0.028	0.045	0.041	0.064	0.033	0.052	0.034	0.053
Paunsaugunt fault	2504	<1,600,000	<0.2	44.1		114	6.99	0.023	0.037	0.034	0.052	0.028	0.043	0.028	0.044
Sevier/Toroweap fault zone, Sevier section	997a	<130,000	0.2-1	88.7		142	7.34	0.022	0.035	0.034	0.053	0.028	0.042	0.028	0.043
Moab fault and Spanish Valley faults (Class B)	2476	Class B	<0.2	72.4	N	137	7.24	0.021	0.034	0.033	0.050	0.027	0.041	0.027	0.042
West Kaibab fault system	994	<1,600,000	<0.2	82.9	N	152	7.31	0.020	0.032	0.031	0.048	0.025	0.038	0.025	0.039
Wasatch monocline (Class B)	2450	<1,600,000	<0.2	103.5		164	7.42	0.020	0.031	0.031	0.048	0.025	0.038	0.025	0.039
Joes Valley fault zone, west fault	2453	<15,000	0.2-1	57.2		137	7.12	0.020	0.032	0.030	0.047	0.025	0.038	0.025	0.039
Southern Joes Valley fault zone	2456	<750,000	<0.2	47.2		137	7.02	0.019	0.031	0.028	0.044	0.023	0.036	0.024	0.037
Central Kaibab fault system	993	<1,600,000	<0.2	71.5	N	157	7.23	0.019	0.030	0.029	0.044	0.023	0.035	0.024	0.036
Salt and Cache Valleys faults (Class B)	2474	Class B	<0.2	57.9	N	147	7.12	0.019	0.030	0.028	0.043	0.023	0.035	0.023	0.036
Lisbon Valley fault zone (Class B)	2511	<1,600,000	<0.2	37.5		134	6.91	0.019	0.030	0.027	0.042	0.022	0.034	0.022	0.035
Lockhart fault (Class B)	2510	Class B	<0.2	15.7		107	6.47	0.019	0.030	0.026	0.042	0.021	0.033	0.022	0.035
Sevier fault	2355	<1,600,000	<0.2	41.3	N	139	6.95	0.018	0.029	0.027	0.041	0.022	0.034	0.022	0.035
Sevier Valley-Marysvale-Circleville area faults	2500	<750,000	<0.2	34.9		137	6.87	0.018	0.028	0.026	0.040	0.021	0.032	0.021	0.034
Ten Mile graben faults (Class B)	2473	Class B	<0.2	34.6	N	137	6.87	0.018	0.028	0.025	0.040	0.021	0.032	0.021	0.033
Joes Valley fault zone, east fault	2455	<15,000	0.2-1	56.6		159	7.11	0.017	0.028	0.026	0.040	0.021	0.032	0.021	0.033
Markagunt Plateau faults (Class B)	2535	<750,000	<0.2	56.4		162	7.11	0.017	0.027	0.025	0.039	0.021	0.032	0.021	0.033
Paradox Valley graben (Class B)	2286	<1,600,000	<0.2	56.4	N	162	7.11	0.017	0.027	0.025	0.039	0.021	0.032	0.021	0.033
Sevier/Toroweap fault zone, northern Toroweap section	997b	<130,000	<0.2	80.9		182	7.29	0.016	0.026	0.026	0.040	0.021	0.031	0.021	0.032
Eminence fault zone	992	<1,600,000	<0.2	36.0		155	6.89	0.016	0.025	0.023	0.035	0.019	0.029	0.019	0.030
Price River area faults (Class B)	2457	<1,600,000	<0.2	50.9	N	174	7.06	0.015	0.024	0.023	0.035	0.019	0.028	0.019	0.029
Bright Angel fault zone	991	<1,600,000	<0.2	66.0	N	193	7.19	0.015	0.023	0.023	0.035	0.018	0.028	0.019	0.029
Sevier Valley faults and folds (Class B)	2537	<130,000	<0.2	23.6		145	6.67	0.015	0.024	0.021	0.034	0.017	0.027	0.018	0.028
Big Gypsum Valley graben (Class B)	2288	Class B	<0.2	33.1		160	6.84	0.015	0.024	0.021	0.033	0.017	0.027	0.018	0.028
Sinbad Valley graben (Class B)	2285	<1,600,000	<0.2	31.8		163	6.82	0.014	0.023	0.021	0.032	0.017	0.026	0.017	0.027
Valley Mountains monocline (Class B)	2449	<1,600,000	<0.2	38.6		174	6.92	0.014	0.023	0.021	0.032	0.017	0.026	0.017	0.027
Ryan Creek fault zone	2263	<1,600,000	<0.2	39.5	N	181	6.93	0.014	0.022	0.020	0.031	0.016	0.025	0.017	0.026
Tushar Mountains (east side) fault	2501	<1,600,000	<0.2	18.5		148	6.55	0.014	0.022	0.019	0.031	0.015	0.025	0.016	0.026

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA							
								Spudich et al. (1999) for rock sites		Abrahamson and Silva (1997) for normal faults		Campbell and Bozorgnia (2003) corrected		Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
Beaver Basin faults, eastern margin faults	2492a	<15,000	<0.2	34.2		175	6.86	0.014	0.022	0.020	0.031	0.016	0.025	0.016	0.026
Elsinore fault (fold)	2470	<1,600,000	<0.2	28.1		166	6.76	0.014	0.022	0.019	0.030	0.016	0.025	0.016	0.026
Beaver Basin faults, intrabasin faults	2492b	<15,000	<0.2	38.9		184	6.92	0.013	0.021	0.019	0.030	0.016	0.025	0.016	0.025
Joes Valley fault zone, intragraben faults	2454	<15,000	<0.2	34.0		181	6.86	0.013	0.021	0.019	0.030	0.015	0.024	0.016	0.025
Snow Lake graben	2452	<15,000	<0.2	25.4		167	6.71	0.013	0.021	0.018	0.029	0.015	0.024	0.016	0.025
Unnamed faults east of Atkinson Masa	2269	<1,600,000	<0.2	41.1	N	194	6.95	0.013	0.021	0.019	0.029	0.015	0.024	0.016	0.024
Gunnison fault	2445	<15,000	<0.2	42.0	N	197	6.96	0.013	0.020	0.019	0.029	0.015	0.023	0.015	0.024
Japanese and Cal Valleys faults	2447	<750,000	<0.2	30.1		182	6.80	0.013	0.020	0.018	0.028	0.015	0.023	0.015	0.024
Doloras fault zone (Class B)	2289	Class B	<0.2	15.2		151	6.45	0.013	0.021	0.017	0.028	0.014	0.023	0.015	0.024
Paragonah fault	2534	<130,000	0.2-1	27.2		178	6.74	0.013	0.020	0.018	0.028	0.014	0.023	0.015	0.024
White Mountain area faults	2451	<1,600,000	<0.2	16.4		157	6.49	0.013	0.020	0.017	0.028	0.014	0.022	0.014	0.023
Dry Wash fault and syncline	2496	<130,000	<0.2	18.6		165	6.55	0.012	0.020	0.017	0.027	0.014	0.022	0.014	0.023
Unnamed fault near Pine Mountain	2267	<1,600,000	<0.2	30.7		192	6.81	0.012	0.019	0.017	0.027	0.014	0.022	0.014	0.023
Main Street fault zone	1002	<130,000	<0.2	87.3	N	266	7.33	0.011	0.018	0.018	0.028	0.014	0.022	0.015	0.023
Mineral Mountains (west side) faults	2489	<15,000	<0.2	36.6		203	6.89	0.012	0.019	0.017	0.027	0.014	0.022	0.014	0.022
Fisher Valley faults (Class B)	2478	Class B	<0.2	15.9		162	6.47	0.012	0.019	0.016	0.026	0.013	0.021	0.014	0.022
Castle Valley faults (Class B)	2477	Class B	<0.2	12.4		151	6.35	0.012	0.019	0.015	0.026	0.013	0.021	0.014	0.022
Sand Flat graben faults	2475	<1,600,000	<0.2	23.1	N	183	6.66	0.012	0.019	0.016	0.026	0.013	0.021	0.014	0.022
Granite Creek fault zone	2265	<1,600,000	<0.2	22.7	N	184	6.65	0.012	0.019	0.016	0.026	0.013	0.021	0.014	0.022
Cedar City-Parowan monocline (and faults)	2530	<15,000	<0.2	24.8		188	6.70	0.012	0.019	0.016	0.026	0.013	0.021	0.014	0.022
Sevier/Toroweap fault zone, central Toroweap section	997c	<15,000	<0.2	60.4	N	247	7.15	0.011	0.018	0.017	0.026	0.014	0.021	0.014	0.021
Annabella graben faults	2472	<15,000	<0.2	12.5		157	6.35	0.012	0.019	0.015	0.025	0.013	0.020	0.013	0.021
Cove Fort fault zone (Class B)	2491	Class B	<0.2	22.2		187	6.64	0.011	0.018	0.015	0.025	0.013	0.020	0.013	0.021
Clear Lake fault zone (Class B)	2436	<15,000	<0.2	35.5		215	6.88	0.011	0.018	0.016	0.025	0.013	0.020	0.013	0.021
Hurricane fault zone, Shivwitz section	998d	<130,000	<0.2	56.5	N	252	7.11	0.011	0.017	0.016	0.025	0.013	0.020	0.013	0.021
Unnamed faults near San Miguel Canyon (Class B)	2284	Class B	<0.2	32.1		213	6.83	0.011	0.017	0.015	0.024	0.013	0.020	0.013	0.020
Pavant faults	2438	<15,000	<0.2	30.1		211	6.80	0.011	0.017	0.015	0.024	0.013	0.020	0.013	0.020
Hurricane fault zone, Anderson Junction section	998c	<15,000	0.2-1	42.2		233	6.97	0.011	0.017	0.016	0.024	0.013	0.020	0.013	0.020
Hurricane fault zone, Ash Creek section	998b	<15,000	<0.2	32.0		217	6.83	0.011	0.017	0.015	0.024	0.012	0.019	0.013	0.020
Wasatch fault zone, Levan section	2351i	<15,000	<0.2	30.1		213	6.80	0.011	0.017	0.015	0.024	0.012	0.019	0.013	0.020
Pleasant Valley fault zone, unnamed faults	2425	<1,600,000	<0.2	31.0	N	217	6.81	0.011	0.017	0.015	0.024	0.012	0.019	0.013	0.020
Wasatch fault zone, Provo section	2351g	<15,000	1-5	58.8		264	7.13	0.010	0.016	0.016	0.024	0.013	0.019	0.013	0.020
Black Mountains faults	2487	<750,000	<0.2	25.9		207	6.72	0.011	0.017	0.015	0.023	0.012	0.019	0.012	0.020

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA							
								Spudich et al. (1999) for rock sites		Abrahamson and Silva (1997) for normal faults		Campbell and Bozorgnia (2003) corrected		Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
Drum Mountains fault zone	2432	<15,000	<0.2	51.5	N	254	7.07	0.010	0.016	0.015	0.024	0.012	0.019	0.013	0.020
Wasatch fault zone, Nephi section	2351h	<15,000	1-5	43.1		240	6.98	0.010	0.017	0.015	0.024	0.012	0.019	0.013	0.020
Parowan Valley faults	2533	<15,000	<0.2	16.3		183	6.49	0.011	0.017	0.014	0.023	0.012	0.019	0.012	0.020
San Francisco Mountains (west side) fault	2486	<750,000	<0.2	41.4		238	6.96	0.010	0.017	0.015	0.023	0.012	0.019	0.013	0.020
Cricket Mountains (west side) fault	2460	<15,000	<0.2	41.0		238	6.95	0.010	0.017	0.015	0.023	0.012	0.019	0.013	0.020
Wah Wah Mountains faults	2483	<1,600,000	<0.2	53.6		260	7.09	0.010	0.016	0.015	0.024	0.012	0.019	0.013	0.020
Wah Wah Mountains (south end near Lund) fault	2485	<130,000	<0.2	40.2		239	6.94	0.010	0.016	0.015	0.023	0.012	0.019	0.012	0.019
Monitor Creek fault	2268	<1,600,000	<0.2	30.1		221	6.80	0.010	0.017	0.015	0.023	0.012	0.019	0.012	0.019
Hurricane fault zone, southern section	998f	<1,600,000	<0.2	66.6	N	282	7.20	0.010	0.016	0.015	0.024	0.012	0.019	0.013	0.019
Cataract Creek fault zone	990	<1,600,000	<0.2	51.1	N	261	7.06	0.010	0.016	0.015	0.023	0.012	0.018	0.012	0.019
Unnamed faults of Pinto Mesa	2277	<1,600,000	<0.2	19.7		205	6.58	0.010	0.016	0.013	0.022	0.011	0.018	0.012	0.018
Unnamed fault at Red Canyon	2279	<1,600,000	<0.2	24.2		217	6.69	0.010	0.016	0.014	0.022	0.011	0.018	0.012	0.018
Faults of Cove Creek Dome	2462	<1,600,000	<0.2	18.8		203	6.56	0.010	0.016	0.013	0.022	0.011	0.018	0.011	0.018
Maple Grove faults	2443	<15,000	<0.2	12.8		182	6.36	0.010	0.016	0.013	0.021	0.011	0.018	0.011	0.018
Gray Mountain faults	1018	<1,600,000	<0.2	23.6		217	6.67	0.010	0.016	0.013	0.022	0.011	0.018	0.012	0.018
Wasatch fault zone, Fayette section	2351j	<15,000	<0.2	15.6		194	6.46	0.010	0.016	0.013	0.021	0.011	0.017	0.011	0.018
Cedar Valley (north end) faults	2529	<130,000	<0.2	15.5		195	6.46	0.010	0.016	0.013	0.021	0.011	0.017	0.011	0.018
Sevier Valley fault	2502	<1,600,000	<0.2	7.4		150	6.09	0.011	0.017	0.011	0.019	0.011	0.018	0.011	0.018
Enoch graben faults	2528	<15,000	<0.2	17.2		201	6.51	0.010	0.016	0.013	0.021	0.011	0.017	0.011	0.018
Gooseberry graben faults	2424	<750,000	<0.2	22.6		218	6.65	0.010	0.015	0.013	0.021	0.011	0.017	0.011	0.018
Pavant Range fault	2442	<15,000	<0.2	14.2		194	6.42	0.010	0.016	0.013	0.021	0.011	0.017	0.011	0.018
East Tintic Mountains (west side) faults	2420	<750,000	<0.2	33.1		246	6.84	0.009	0.015	0.013	0.021	0.011	0.017	0.011	0.018
Unnamed fault near Wolf Hill	2266	<1,600,000	<0.2	15.2		198	6.45	0.010	0.015	0.013	0.021	0.011	0.017	0.011	0.018
Little Valley faults	2439	<15,000	<0.2	19.2		213	6.57	0.010	0.015	0.013	0.021	0.011	0.017	0.011	0.018
Little Doloras River fault	2251	<1,600,000	<0.2	15.7	R	202	6.47	0.010	0.015	0.012	0.021	0.011	0.017	0.011	0.018
Washington fault zone, northern section	1004a	<15,000	<0.2	36.2	N	257	6.89	0.009	0.015	0.013	0.021	0.011	0.017	0.011	0.017
Red Hills fault	2532	<130,000	<0.2	13.8		197	6.40	0.010	0.015	0.012	0.020	0.010	0.017	0.011	0.017
Mesa Butte North fault zone	987	<1,600,000	<0.2	22.6		225	6.65	0.009	0.015	0.013	0.020	0.011	0.017	0.011	0.017
Unnamed faults south of Love Mesa	2271	<1,600,000	<0.2	17.6		212	6.52	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017
Sevier Valley faults north of Panguitch	2536	<130,000	<0.2	6.2		148	6.00	0.010	0.017	0.010	0.017	0.011	0.018	0.010	0.017
Kolob Terrace faults	2525	<750,000	<0.2	12.1		190	6.34	0.010	0.015	0.012	0.019	0.010	0.017	0.010	0.017
Mineral Mountains (northeast side) fault (Class B)	2490	Class B	<0.2	14.2		201	6.42	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017
Roubideau Creek fault	2270	<15,000	<0.2	20.5		224	6.60	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017
Black Point/Doney Mountain fault zone	957	<750,000	<0.2	23.8	N	234	6.68	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA: Spudich et al. (1999) for rock sites Mean	PGA: Spudich et al. (1999) for rock sites Mean +1SD	PGA: Abrahamson and Silva (1997) for normal faults Mean	PGA: Abrahamson and Silva (1997) for normal faults Mean +1SD	PGA: Campbell and Bozorgnia (2003) corrected Mean	PGA: Campbell and Bozorgnia (2003) corrected Mean +1SD	PGA: Average Mean	PGA: Average Mean +1SD
Antelope Range fault	2517	<750,000	<0.2	24.5		236	6.69	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017
House Range (west side) fault	2430	<15,000	<0.2	45.5	N	283	7.00	0.009	0.014	0.013	0.020	0.011	0.016	0.011	0.017
Redlands fault complex	2252	<1,600,000	<0.2	21.1	N,R	227	6.62	0.009	0.015	0.012	0.020	0.010	0.016	0.011	0.017
Beaver Ridge faults	2464	<130,000	<0.2	14.2		204	6.42	0.009	0.015	0.012	0.020	0.010	0.016	0.010	0.017
Aubrey fault zone	995	<130,000	<0.2	53.1		299	7.08	0.009	0.014	0.013	0.020	0.011	0.016	0.011	0.017
Strawberry fault	2412	<15,000	<0.2	31.9		257	6.82	0.009	0.014	0.013	0.020	0.010	0.016	0.011	0.017
Red Rocks fault	2291	<1,600,000	<0.2	38.3		271	6.92	0.009	0.014	0.013	0.020	0.010	0.016	0.011	0.017
Red Canyon fault scarps	2471	<15,000	<0.2	9.4		177	6.21	0.010	0.015	0.011	0.018	0.010	0.017	0.010	0.017
Pleasant Valley fault zone, graben	2426	<750,000	<0.2	17.6		221	6.52	0.009	0.014	0.012	0.019	0.010	0.016	0.010	0.016
Leupp faults	1017	<750,000	<0.2	32.2		262	6.83	0.009	0.014	0.012	0.019	0.010	0.016	0.010	0.016
Scipio fault zone	2441	<15,000	<0.2	12.5		201	6.35	0.009	0.014	0.011	0.019	0.010	0.016	0.010	0.016
Lockwood Canyon fault zone	974	<1,600,000	<0.2	20.8		234	6.61	0.009	0.014	0.012	0.019	0.010	0.016	0.010	0.016
Washington fault zone, Sullivan Draw section	1004c	<130,000	<0.2	34.5	N	273	6.86	0.009	0.014	0.012	0.019	0.010	0.016	0.010	0.016
Hurricane fault zone, Cedar City section	998a	<15,000	<0.2	13.2		208	6.38	0.009	0.014	0.011	0.019	0.010	0.015	0.010	0.016
Ridgway fault	2276	<1,600,000	<0.2	23.8		246	6.68	0.009	0.014	0.012	0.019	0.010	0.015	0.010	0.016
Sunshine faults	1000	<130,000	<0.2	29.2	N	261	6.78	0.009	0.014	0.012	0.019	0.010	0.015	0.010	0.016
Pine Ridge faults (Class B)	2512	Class B	<0.2	5.5		151	5.94	0.010	0.016	0.009	0.016	0.010	0.017	0.010	0.016
White Sage Flat faults	2467	<130,000	<0.2	11.8		201	6.32	0.009	0.014	0.011	0.018	0.010	0.016	0.010	0.016
Unnamed fault at Hanks Creek	2281	<1,600,000	<0.2	17.5		228	6.52	0.009	0.014	0.011	0.019	0.010	0.015	0.010	0.016
Fremont Wash faults	2495	<750,000	<0.2	7.2		170	6.07	0.009	0.015	0.009	0.016	0.010	0.016	0.009	0.016
Cedar Valley (west side) faults	2527	<750,000	<0.2	12.8		214	6.36	0.009	0.014	0.011	0.018	0.009	0.015	0.009	0.015
Shadow Mountain grabens	989	<750,000	<0.2	10.4		199	6.26	0.009	0.014	0.010	0.017	0.009	0.015	0.009	0.015
Hurricane fault zone, Whitmore Canyon section	998e	<15,000	<0.2	28.5		271	6.77	0.008	0.013	0.011	0.018	0.009	0.015	0.010	0.015
Spry area faults	2498	<750,000	<0.2	5.1		155	5.90	0.009	0.015	0.008	0.014	0.010	0.016	0.009	0.015
Utah Lake faults	2409	<15,000	<0.2	30.8		281	6.81	0.008	0.013	0.011	0.018	0.009	0.015	0.010	0.015
Unnamed fault at Little Dominquez Creek	2261	<1,600,000	<0.2	14.2		232	6.42	0.008	0.013	0.010	0.017	0.009	0.014	0.009	0.015
Long Ridge (northwest side) fault	2422	<1,600,000	<0.2	20.8		259	6.61	0.008	0.013	0.011	0.017	0.009	0.014	0.009	0.015
Unnamed fault of Lost Horse Basin	2264	<1,600,000	<0.2	8.1		190	6.13	0.009	0.014	0.009	0.015	0.009	0.015	0.009	0.014
Cameron graben and faults	988	<750,000	<0.2	10.8		212	6.28	0.008	0.013	0.009	0.016	0.009	0.014	0.009	0.014
Unnamed faults near Cottonwood Creek	2278	<1,600,000	<0.2	10.8		214	6.28	0.008	0.013	0.009	0.016	0.009	0.014	0.009	0.014
Uinkaret Volcanic field faults	1012	<1,600,000	<0.2	18.5		256	6.55	0.008	0.012	0.010	0.017	0.009	0.014	0.009	0.014
Dutchman Draw fault	1003	<130,000	<0.2	16.3	N	248	6.49	0.008	0.012	0.010	0.017	0.009	0.014	0.009	0.014
Unnamed fault at northwest end of Paradox Valley (Class B)	2287	Class B	<0.2	5.1		164	5.90	0.009	0.014	0.008	0.013	0.009	0.015	0.008	0.014
Long Ridge (west side) faults	2421	<750,000	<0.2	15.2		243	6.45	0.008	0.012	0.010	0.016	0.009	0.014	0.009	0.014

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA							
								Spudich et al. (1999) for rock sites		Abrahamson and Silva (1997) for normal faults		Campbell and Bozorgnia (2003) corrected		Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
Busted Boiler fault	2274	<130,000	<0.2	18.0		256	6.54	0.008	0.012	0.010	0.016	0.009	0.014	0.009	0.014
Cimmarron fault, Poverty Mesa section (Class B)	2290b	Class B	<0.2	24.1		279	6.68	0.008	0.012	0.010	0.016	0.009	0.014	0.009	0.014
Little Diamond Creek fault	2411	<750,000	<0.2	20.0		266	6.59	0.008	0.012	0.010	0.016	0.009	0.013	0.009	0.014
Large Whiskers fault zone	972	<1,600,000	<0.2	11.6		225	6.31	0.008	0.013	0.009	0.016	0.008	0.014	0.009	0.014
Michelbach Tank faults	978	<750,000	<0.2	13.4		238	6.39	0.008	0.012	0.010	0.016	0.008	0.013	0.009	0.014
Pearl Harbor fault zone	981	<1,600,000	<0.2	15.3		248	6.45	0.008	0.012	0.010	0.016	0.008	0.013	0.009	0.014
Sunshine Trail graben and faults	999	<130,000	<0.2	17.0	N	256	6.51	0.008	0.012	0.010	0.016	0.008	0.013	0.009	0.014
Johns Valley fault (Class B)	2539	Class B	<0.2	2.1		125	5.45	0.009	0.015	0.006	0.011	0.009	0.016	0.008	0.014
Unnamed faults east of Roubideau Creek (Class B)	2272	Class B	<0.2	11.7		228	6.32	0.008	0.012	0.009	0.015	0.008	0.014	0.008	0.014
SP fault zone	958	<130,000	<0.2	12.5		237	6.35	0.008	0.012	0.009	0.015	0.008	0.013	0.008	0.014
Pleasant Valley fault zone, Dry Valley graben	2427	<750,000	<0.2	12.4		236	6.35	0.008	0.012	0.009	0.015	0.008	0.013	0.008	0.014
Lake Mary fault zone	971	<130,000	<0.2	25.0	N	292	6.70	0.007	0.012	0.010	0.016	0.008	0.013	0.009	0.014
Tabernacle faults	2465	<15,000	<0.2	7.9		204	6.12	0.008	0.013	0.008	0.014	0.008	0.014	0.008	0.013
Sage Valley fault	2444	<1,600,000	<0.2	10.5		228	6.26	0.008	0.012	0.008	0.014	0.008	0.013	0.008	0.013
Juab Valley (west side) faults (Class B)	2423	<750,000	<0.2	13.2		249	6.38	0.007	0.012	0.009	0.015	0.008	0.013	0.008	0.013
Fish Springs fault	2417	<15,000	<0.2	29.7		315	6.79	0.007	0.011	0.010	0.016	0.008	0.013	0.008	0.013
Glade Park fault	2254	<1,600,000	<0.2	9.4	R	219	6.21	0.008	0.012	0.008	0.014	0.008	0.013	0.008	0.013
Unnamed fault near Bridgeport	2259	<1,600,000	<0.2	11.0		235	6.29	0.007	0.012	0.008	0.014	0.008	0.013	0.008	0.013
Cimmarron fault, Blue Mesa section	2290c	<1,600,000	<0.2	22.5		295	6.65	0.007	0.011	0.009	0.015	0.008	0.013	0.008	0.013
Topliff Hill fault zone	2407	<130,000	<0.2	19.9		286	6.59	0.007	0.011	0.009	0.015	0.008	0.012	0.008	0.013
Cedar Wash fault zone	962	<750,000	<0.2	11.6		242	6.31	0.007	0.012	0.008	0.014	0.008	0.013	0.008	0.013
Bill Williams fault	956	<750,000	<0.2	21.0	N	293	6.61	0.007	0.011	0.009	0.015	0.008	0.012	0.008	0.013
Black Rock area faults	2461	<130,000	<0.2	8.2		214	6.14	0.008	0.012	0.008	0.013	0.008	0.013	0.008	0.013
Campbell Francis fault zone	959	<750,000	<0.2	10.1		232	6.25	0.007	0.012	0.008	0.014	0.008	0.013	0.008	0.013
Crater Bench faults	2433	<15,000	<0.2	15.9		273	6.47	0.007	0.011	0.009	0.015	0.008	0.012	0.008	0.013
Unnamed faults at Clay Creek	2283	<1,600,000	<0.2	9.2		226	6.20	0.007	0.012	0.008	0.013	0.008	0.013	0.008	0.013
Koosharem fault	2503	<1,600,000	<0.2	2.2		138	5.48	0.008	0.013	0.005	0.010	0.008	0.014	0.007	0.013
Sevier/Toroweap fault zone, southern Toroweap section	997d	<750,000	<0.2	18.8		293	6.56	0.007	0.011	0.009	0.014	0.008	0.012	0.008	0.012
Gyp Pocket graben and faults	1001	<130,000	<0.2	11.8	N	254	6.32	0.007	0.011	0.008	0.014	0.008	0.012	0.008	0.012
Scipio Valley faults	2440	<15,000	<0.2	7.3		213	6.08	0.007	0.012	0.007	0.012	0.008	0.013	0.007	0.012
Unnamed fault north of Horsefly Creek	2280	<1,600,000	<0.2	8.1		223	6.13	0.007	0.012	0.007	0.012	0.008	0.012	0.007	0.012
Cedar Ranch fault zone	961	<750,000	<0.2	10.2		247	6.25	0.007	0.011	0.008	0.013	0.007	0.012	0.007	0.012
Buckskin Valley faults (Class B)	2499	Class B	<0.2	3.5		170	5.71	0.008	0.012	0.006	0.010	0.008	0.013	0.007	0.012

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Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA: Spudich et al. (1999) for rock sites		PGA: Abrahamson and Silva (1997) for normal faults		PGA: Campbell and Bozorgnia (2003) corrected		PGA: Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
North of Wah Wah Mountains faults	2459	<750,000	<0.2	12.5		270	6.35	0.007	0.011	0.008	0.013	0.007	0.012	0.007	0.012
Unnamed faults southeast of Montrose (Class B)	2273	Class B	<0.2	9.2		241	6.20	0.007	0.011	0.007	0.012	0.007	0.012	0.007	0.012
Joseph Flats area faults and syncline (Class B)	2468	Class B	<0.2	3.2		166	5.67	0.008	0.012	0.005	0.010	0.008	0.013	0.007	0.012
Washington fault zone, Mokaac section	1004b	<130,000	<0.2	11.2	N	263	6.30	0.007	0.011	0.008	0.013	0.007	0.011	0.007	0.012
Rimmy Jim fault zone	984	<1,600,000	<0.2	8.2		234	6.14	0.007	0.011	0.007	0.012	0.007	0.012	0.007	0.012
Hidden Tank fault zone	970	<750,000	<0.2	10.2		255	6.25	0.007	0.011	0.007	0.012	0.007	0.012	0.007	0.012
Cimmarron fault, Bostwick Park section (Class B)	2290a	Class B	<0.2	11.2		272	6.30	0.006	0.010	0.007	0.012	0.007	0.011	0.007	0.011
Escalante Desert faults (Class B)	2488	Class B	<0.2	6.6		224	6.03	0.007	0.011	0.006	0.011	0.007	0.012	0.007	0.011
Log Hill Mesa graben	2275	<130,000	<0.2	9.5		257	6.21	0.006	0.010	0.007	0.012	0.007	0.011	0.007	0.011
Escalante Desert (east side) faults	2526	<15,000	<0.2	6.4		222	6.02	0.007	0.011	0.006	0.011	0.007	0.012	0.007	0.011
Cross Hollow Hills faults	2524	<1,600,000	<0.2	5.3		210	5.92	0.007	0.011	0.006	0.010	0.007	0.012	0.007	0.011
Mormon Lake fault zone	979	<1,600,000	<0.2	15.0	N	311	6.44	0.006	0.010	0.007	0.012	0.007	0.010	0.007	0.011
Ladder Creek fault	2255	<1,600,000	<0.2	6.2		226	6.00	0.007	0.011	0.006	0.010	0.007	0.011	0.006	0.011
Lee Dam faults	973	<1,600,000	<0.2	7.6		245	6.10	0.006	0.010	0.006	0.011	0.007	0.011	0.006	0.011
Deseret faults	2435	<750,000	<0.2	7.1		239	6.07	0.006	0.010	0.006	0.010	0.007	0.011	0.006	0.011
Unnamed fault near Johnson Spring	2282	<1,600,000	<0.2	7.1		239	6.07	0.006	0.010	0.006	0.010	0.007	0.011	0.006	0.011
Bangs Canyon fault	2256	<1,600,000	<0.2	6.3		229	6.01	0.007	0.010	0.006	0.010	0.007	0.011	0.006	0.011
North Hills faults	2522	<750,000	<0.2	5.0		214	5.89	0.007	0.011	0.005	0.010	0.007	0.011	0.006	0.011
Sheeprock fault zone	2405	<130,000	<0.2	11.7		295	6.32	0.006	0.009	0.007	0.011	0.006	0.010	0.006	0.010
Bellemont fault	955	<130,000	<0.2	11.0	N	288	6.29	0.006	0.010	0.007	0.011	0.006	0.010	0.006	0.010
Meadow-Hatton area faults	2466	<15,000	<0.2	4.0		201	5.78	0.007	0.011	0.005	0.009	0.007	0.011	0.006	0.010
Babbitt Lake fault zone	954	<750,000	<0.2	7.6		257	6.10	0.006	0.010	0.006	0.010	0.006	0.011	0.006	0.010
Simpson Mountains faults	2418	<750,000	<0.2	10.8		296	6.28	0.006	0.009	0.006	0.011	0.006	0.010	0.006	0.010
Rock House fault	985	<130,000	<0.2	8.0	N	275	6.13	0.006	0.009	0.006	0.010	0.006	0.010	0.006	0.010
Double Knobs fault	966	<1,600,000	<0.2	6.0		250	5.98	0.006	0.009	0.005	0.009	0.006	0.010	0.006	0.010
Double Top fault zone	965	<1,600,000	<0.2	6.1		259	5.99	0.006	0.009	0.005	0.009	0.006	0.010	0.006	0.009
Casner Cabin fault zone	960	<750,000	<0.2	10.0	N	312	6.24	0.005	0.009	0.006	0.010	0.006	0.009	0.006	0.009
Malpais Tank faults	975	<750,000	<0.2	4.6		239	5.85	0.006	0.009	0.004	0.008	0.006	0.010	0.005	0.009
Arrowhead fault zone	953	<130,000	<0.2	5.2		250	5.91	0.006	0.009	0.005	0.008	0.006	0.010	0.005	0.009
Unnamed fault at Big Dominquez Creek	2260	<1,600,000	<0.2	3.9		229	5.77	0.006	0.009	0.004	0.007	0.006	0.010	0.005	0.009
Citadel Ruins fault zone	963	<1,600,000	<0.2	4.5		246	5.84	0.006	0.009	0.004	0.008	0.006	0.009	0.005	0.009
Sheeprock Mountains fault	2419	<1,600,000	<0.2	6.7		284	6.04	0.005	0.009	0.005	0.008	0.006	0.009	0.005	0.009
Oak Creek North fault zone	980	<1,600,000	<0.2	7.0	N	293	6.06	0.005	0.008	0.005	0.008	0.005	0.009	0.005	0.008

Appendix C.1: Quaternary faults and folds within 200 miles of Shootaring Canyon site - Deterministic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Slip-rate (mm/yr)	Fault Length (km)	Fault Type	Distance from site to surface trace of fault, (km)	MCE[2]	PGA: Spudich et al. (1999) for rock sites		PGA: Abrahamson and Silva (1997) for normal faults		PGA: Campbell and Bozorgnia (2003) corrected		PGA: Average	
								Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD	Mean	Mean +1SD
Metz Tank fault zone	977	<750,000	<0.2	7.0	N	297	6.06	0.005	0.008	0.005	0.008	0.005	0.009	0.005	0.008
Sinagua faults	986	<130,000	<0.2	4.9		265	5.88	0.005	0.008	0.004	0.007	0.005	0.009	0.005	0.008
Escalante Desert faults near Zane	2518	<130,000	<0.2	3.9		248	5.77	0.005	0.008	0.004	0.007	0.005	0.009	0.005	0.008
Sugarville area faults	2437	<15,000	<0.2	4.3		258	5.81	0.005	0.008	0.004	0.007	0.005	0.009	0.005	0.008
Andrus Canyon fault	1013	<1,600,000	<0.2	5.6		294	5.95	0.005	0.008	0.004	0.007	0.005	0.008	0.005	0.008
Volcano Mountain faults	2520	<750,000	<0.2	2.9		239	5.62	0.005	0.008	0.003	0.006	0.005	0.009	0.004	0.008
Red House faults	983	<750,000	<0.2	3.4		252	5.70	0.005	0.008	0.003	0.006	0.005	0.009	0.004	0.008
Phone Booth faults	982	<1,600,000	<0.2	6.0	N	309	5.98	0.005	0.008	0.004	0.007	0.005	0.008	0.005	0.008
Cricket Mountains (north end) faults	2434	<750,000	<0.2	2.8		240	5.60	0.005	0.008	0.003	0.006	0.005	0.009	0.004	0.007
Maverick Butte faults	976	<750,000	<0.2	3.7		264	5.74	0.005	0.008	0.003	0.006	0.005	0.008	0.004	0.007
Garland Prairie faults	968	<1,600,000	<0.2	5.0	N	299	5.89	0.005	0.007	0.004	0.006	0.005	0.008	0.004	0.007
Ebert Tank fault zone	967	<750,000	<0.2	3.1		261	5.65	0.005	0.008	0.003	0.005	0.005	0.008	0.004	0.007
Cactus Park fault	2258	<1,600,000	<0.2	1.9		229	5.40	0.005	0.008	0.002	0.005	0.005	0.008	0.004	0.007
Swasey Mountain (east side) faults	2431	<750,000	<0.2	3.8		296	5.75	0.004	0.007	0.003	0.005	0.004	0.007	0.004	0.007
Unnamed fault east of Whitewater	2257	<1,600,000	<0.2	1.9		238	5.40	0.005	0.007	0.002	0.004	0.005	0.008	0.004	0.007
Cedar Valley (south side) fault	2408	<750,000	<0.2	2.8		279	5.60	0.004	0.007	0.003	0.005	0.004	0.007	0.004	0.006
Wah Wah Valley (west side) faults (Class B)	2484	Class B	<0.2	2.1		258	5.45	0.004	0.007	0.002	0.004	0.004	0.007	0.004	0.006
Garland Prairie West faults	969	<750,000	<0.2	3.0	N	299	5.63	0.004	0.007	0.002	0.004	0.004	0.007	0.004	0.006
Unnamed fault near Escalante	2262	<1,600,000	<0.2	1.6		245	5.32	0.004	0.007	0.002	0.004	0.004	0.007	0.003	0.006
Deadman Wash faults	964	<1,600,000	<0.2	1.8		256	5.38	0.004	0.007	0.002	0.004	0.004	0.007	0.003	0.006
Ellison Gulch scarp (Class B)	2304	Class B	<0.2	1.2		275	5.17	0.003	0.006	0.001	0.003	0.003	0.006	0.003	0.005

[1] ya = years ago

[2] Wells and Coppersmith, 1994

Class B=Geologic evidence demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deeply enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.

Fault Type: N=normal, R=reverse

APPENDIX C.2
PROBABILISTIC CHARACTERISTICS

Appendix C.2: Quaternary faults and folds capable of generating 0.05 g or greater at Shootaring Canyon site - Probabilistic Characteristics

Name of Fault	ID Number	Age of Most Recent Prehistoric Deformation (ya)[1]	Probability of Activity	Rate of Activity (mm/yr)[2]	MCE[2,3]
				0.02 (0.6)	5.78 (0.6)
				0.1 (0.1)	5.48 (0.2)
Fault 1, Bright Angel Fault Zone (Class B)	2514	Class B	0.5	0.005 (0.1)	6.08 (0.2)
				0.02 (0.6)	6.24 (0.6)
				0.1 (0.1)	6.54 (0.2)
Fault 2, Bright Angel Fault Zone (Class B)	2514	Class B	0.5	0.005 (0.1)	5.94 (0.2)
				0.02 (0.6)	6.66 (0.6)
				0.1 (0.1)	6.96 (0.2)
Fault 3, Bright Angel Fault Zone (Class B)	2514	Class B	0.5	0.005 (0.1)	6.36 (0.2)
				0.02 (0.6)	6.77 (0.6)
				0.1 (0.1)	7.07 (0.2)
Needles fault zone (Class B)	2507	Class B	0.5	0.005 (0.1)	6.47 (0.2)
				0.2 (0.6)	7.03 (0.6)
				0.3 (0.1)	7.33 (0.2)
Thousand Lake fault	2506	<750,000	1	0.1 (0.1)	6.73 (0.2)
				0.02 (0.6)	6.93 (0.6)
				0.1 (0.1)	7.23 (0.2)
Shay graben faults (Class B)	2513	Class B	0.5	0.005 (0.1)	6.63 (0.2)
				0.2 (0.6)	6.88 (0.6)
				0.3 (0.1)	7.18 (0.2)
Aquarius and Awapa Plateaus faults	2505	<1,600,000	1	0.1 (0.1)	6.58 (0.2)

[1] ya = years ago
[2] Number in parentheses represents weights for each parameter
[3] Wells and Coppersmith, 1994
Class B=Geologic evidence demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deeply enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.

APPENDIX D
DESCRIPTION OF FAULTS WITHIN PROJECT AREA, FROM USGS ET AL. 2006

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Complete Report for Bright Angel fault system (Class B) No. 2514

Brief Report ||Partial Report

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., and Hecker, S., compilers, 1999, Fault number 2514, Bright Angel fault system, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 10/15/2007 12:30 PM.**

Synopsis	Expansive area of poorly understood suspected Quaternary faults in the Colorado Plateau near the junction between the Colorado and San Juan Rivers. Owing to uncertainties in the timing of fault movement, we consider these faults to be Class B structures.
Name comments	**Fault ID Comments:** Refers to fault number 15-1 in Hecker (1993 #642).
County(s) and State (s)	GARFIELD COUNTY, UTAH KANE COUNTY, UTAH SAN JUAN COUNTY, UTAH
AMS sheet(s)	Escalante
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Good Compiled at 1:500,000 scale. *Comments:* Mapped or discussed by Hintze (1963 #4991), Shoemaker and others (1978 #2155), and Woodward-Clyde Consultants (1982 #5025). Fault traces from 1:250,000-scale geologic mapping of Hintze (1963 #4991).
Geologic setting	Diffuse area of bedrock faults of varying orientation in the Monument upwarp/Glen Canyon area of the Colorado Plateaus in southeastern Utah.
Length (km)	102 km.
Average strike	N6°W
Sense of movement	Normal

Dip	*Comments:* Varies.
Paleoseismology studies	
Geomorphic expression	Faults are entirely within bedrock, thus Quaternary deformation can not be proven. The geometry and orientation of the faults are similar to known or questionable Quaternary structures in the San Francisco volcanic field in Arizona (Menges and Pearthree, 1983 #2073). A drainage system in the Cataract Creek basin in Arizona(?) appears to be older than movement on the fault system. Fold activity in the region is possible, although uncertain. Owing to uncertainties in the timing of fault movement, we consider these faults to be Class B structures.
Age of faulted surficial deposits	Jurassic, Quaternary(?)
Historic earthquake	
Most recent prehistoric deformation	Quaternary (<1.6 Ma) *Comments:* Based on geometry and orientation, and antecedent drainage.
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr
Date and Compiler (s)	1999 Bill D. Black, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
References	#642 Hecker, S., 1993, Quaternary tectonics of Utah with emphasis on earthquake-hazard characterization: Utah Geological Survey Bulletin 127, 157 p., 6 pls., scale 1:500,000. #4991 Hintze, L.H., compiler, 1963, Geologic map of southwestern Utah: Utah State Land Board, 1 sheet, scale 1:250,000. #2073 Menges, C.M., and Pearthree, P.A., 1983, Map of neotectonic (latest Pliocene-Quaternary) deformation in Arizona: Arizona Bureau of Geology Mineral Technology Open-File Report 83-22, 48 p., scale 1:500,000. #2155 Shoemaker, E.M., Squires, R.L., and Abrams, M.J., 1978, Bright Angel and Mesa Butte fault systems in northern Arizona, in Smith, R.B., and Eaton, G.P., eds., Cenozoic tectonics and regional geophysics of the Western Cordillera: Geological Society of America Memoir 152, p. 341-367. #5025 Woodward-Clyde Consultants, 1982, Geologic characterization report for the Paradox Basin study region, Utah study areas, volume II, Gibson Dome: Technical report to Battelle Memorial Institute, Office of Nuclear Waste Isolation, under Contract ONWI-290, variously paginated, scale 1:340,000.

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Complete Report for Needles fault zone (Class B) No. 2507

Brief Report ||Partial Report

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., DuRoss, C.B., and Hecker, S., compilers, 2004, Fault number 2507, Needles fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 10/31/2007 04:12 AM.**

Synopsis	Poorly understood diffuse zone of suspected Holocene faulting along the Colorado River, which may have formed from gravity tectonics and salt flowage. Because of their possible non-seismogenic origin, we considered these features to be Class B structures.
Name comments	**Fault ID Comments:** Refers to fault number 18-11 in Hecker (1993 #642).
County(s) and State(s)	GARFIELD COUNTY, UTAH SAN JUAN COUNTY, UTAH WAYNE COUNTY, UTAH
AMS sheet(s)	Salina Moab Escalante
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Poor Compiled at 1:340,000 scale. *Comments:* Mapped or discussed by Baker (1933 #4973), McGill and Stromquist (1974 #5000), Stromquist (1976 #5011), Hite (1982 #4992), Huntoon (1982 #586; 1988 #4994), Woodward-Clyde Consultants (1982 #5025), Biggar (1987 #4975), and Oviatt (1988 #5006). Fault traces from 1:340,000-scale geologic mapping of Woodward-Clyde Consultants (1982 #5025).
Geologic setting	The Needles fault zone consists of a diffuse zone of east- to northeast-oriented normal faults along Cataract Canyon, in and adjacent to Canyonlands National Park, in the Paradox Basin of eastern Utah. Extensional faulting may have initiated by a combination of (1) gravitational slip of sedimentary strata on evaporite deposits (Huntoon, 1982 #586, 1988 #4994; Crider and others, 2002 #6759), (2) mobilization and down-dip flowage of

	evaporites toward the Colorado River (Baker, 1933 #4973, McGill and Stromquist, 1974 #5000; Stromquist, 1976 #5011), and/or (3) salt dissolution and collapse (Hite, 1982 #4992). The gravitational-slip model may explain the formation of the anticlines resulting from compression across the floors of Cataract Canyon and its deep tributary canyons (Huntoon, 1982 #586, 1988 #4994). Extension may have begun in the late Cenozoic, and is considered active today (Huntoon, 1988 #4994; Crider and others, 2002 #6759).
Length (km)	29 km.
Average strike	N10°E
Sense of movement	Normal
Dip	*Comments:* Varies.
Paleoseismology studies	
Geomorphic expression	The faults bound grabens of varying ages. Youthfulness of faulting is suggested by good preservation of an abandoned, pre-graben drainage network and persistence of grabens as closed depressions. Sinkholes, some which may be historical, in many closed graben valleys may have formed by opening of bedrock fissures or, alternatively, by periodic flushing of material from old fissures. Stream braiding and aggradation within the grabens also suggest recent (Holocene?) subsidence. Changes in drainage patterns from north to south and the relatively simple, linear pattern of grabens at the eastern margin of the area suggest graben formation has progressed northward and eastward, away from the river. The oldest grabens (closest to the river) are inferred to have begun forming between about 1.4 Ma (based on a conservatively high estimate of canyon incision) and 85 ka (extrapolated from a 65 ka age for shallow graben sediments located a quarter of the distance from the river to the eastern margin of the graben system). Thus, some grabens may have formed as early as during early Pleistocene time. The long-term rate of extension across the fault zone is estimated at 2-20 mm/yr, based on geodetic and satellite radar interferometry (InSAR) monitoring of the deformation (Crider and others, 2002 #6759).
Age of faulted surficial deposits	Holocene(?).
Historic earthquake	
Most recent prehistoric deformation	Latest Quaternary (<15 ka) *Comments:* Based on drainage disruption, 14C and TL ages, and soil development.
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr *Comments:* Development of extensional grabens from west to east has apparently occurred at accelerated rates of 5-14 mm/yr associated with downcutting episodes on the Colorado River, and the process may be ongoing. However, any slip rate associated with deep tectonic processes is probably <0.2 mm/yr.
Date and Compiler (s)	2004 Bill D. Black, Utah Geological Survey Christopher B. DuRoss, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
References	#4973 Baker, A.A., 1933, Geology and oil possibilities of the Moab District, Grand and San Juan Counties, Utah: U.S. Geological Survey Bulletin 841, 95 p.

#6759 Crider, J.G., Owen, S.E., and Marsic, S.D., 2002, Monitoring active deformation in the grabens of Canyonlands National Park: Online, Geological Society of America Abstracts with Programs, , accessed November 3, 2004.

#642 Hecker, S., 1993, Quaternary tectonics of Utah with emphasis on earthquake-hazard characterization: Utah Geological Survey Bulletin 127, 157 p., 6 pls., scale 1:500,000.

#4992 Hite, R.J., 1982, Task 1B--Geology, technical progress report for the quarter 1 July-30 September, 1982: Unpublished consultant's report for Battelle Memorial Institute, Office of Nuclear Waste Isolation, ONWI-9.

#4994 Huntoon, P., 1988, Late Cenozoic gravity tectonic deformation related to the Paradox salts in the Canyonlands area of Utah, in Doelling, H.H., Oviatt, C.G., and Huntoon, P.W., eds., Salt deformation in the Paradox region: Utah Geological and Mineral Survey Bulletin 122, p. 79-93.

#586 Huntoon, P.W., 1982, The Meander anticline, Canyonlands, Utah--An unloading structure resulting from horizontal gliding on salt: Geological Society of America Bulletin, v. 93, p. 941-950.

#5000 McGill, G.E., and Stromquist, A.W., 1974, A model for graben formation by subsurface flow; Canyonlands National Park, Utah: Amherst, University of Massachusetts, Department of Geology and Geography Contribution No. 15, p. 79.

#5011 Stromquist, A.W., Jr., 1976, Geometry and growth of grabens, lower Red Lake Canyon area, Canyonlands National Park, Utah: University of Massachusetts Department of Geology and Geography Contribution 28, p. 118.

Complete Report for Shay graben faults (Class B) No. 2513

Brief Report ||Partial Report

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., and Hecker, S., compilers, 1999, Fault number 2513, Shay graben faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 10/31/2007 04:14 AM.**

Synopsis	Poorly understood suspected Quaternary faults that bound a graben on the northern side of Shay Mountain in eastern Utah. Because of their possible non-seismogenic origin, we considered these features to be Class B structures.
Name comments	**Fault ID Comments:** Refers to fault number 19-1 in Hecker (1993 #642).
County(s) and State (s)	SAN JUAN COUNTY, UTAH
AMS sheet(s)	Cortez Moab
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Good Compiled at 1:170,000 scale. *Comments:* Mapped by Woodward-Clyde Consultants (1982 #5025). Fault traces from 1:170,000- scale mapping of Woodward-Clyde Consultants (1982 #5025).
Geologic setting	Northeast-trending graben-bounding faults along the northern side of Shay Mountain in the Paradox Basin of eastern Utah.
Length (km)	40 km.
Average strike	N66°E
Sense of movement	Normal
Dip	
Paleoseismology studies	

Geomorphic expression	The faults form scarps that bound and define a northeast-trending graben. The north Shay fault has generally poorer surface expression than the south fault and is less likely to have had Quaternary displacement. The south Shay fault exhibits dip-slip displacement totaling less than 100 m and is regarded as a possible seismotectonic feature. Because of their possible non-seismogenic origin, we considered these features to be Class B structures.
Age of faulted surficial deposits	Quaternary pediment gravels
Historic earthquake	
Most recent prehistoric deformation	Quaternary (<1.6 Ma) *Comments:* Based on escarpment morphology and estimated age of displaced pediment surfaces.
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr
Date and Compiler (s)	1999 Bill D. Black, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
References	#642 Hecker, S., 1993, Quaternary tectonics of Utah with emphasis on earthquake-hazard characterization: Utah Geological Survey Bulletin 127, 157 p., 6 pls., scale 1:500,000. #5025 Woodward-Clyde Consultants, 1982, Geologic characterization report for the Paradox Basin study region, Utah study areas, volume II, Gibson Dome: Technical report to Battelle Memorial Institute, Office of Nuclear Waste Isolation, under Contract ONWI-290, variously paginated, scale 1:340,000.

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Complete Report for Thousand Lake fault (Class A) No. 2506

Brief Report ||Partial Report

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., and Hecker, S., compilers, 1999, Fault number 2506, Thousand Lake fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 10/30/2007 01:53 PM.**

Synopsis	Poorly understood Quaternary fault that bounds the western side of Thousand Lake and the Boulder Mountains.
Name comments	**Fault ID Comments:** Refers to fault number 14-1 in Hecker (1993 #642).
County(s) and State(s)	GARFIELD COUNTY, UTAH SEVIER COUNTY, UTAH WAYNE COUNTY, UTAH
AMS sheet(s)	Delta
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Mapped or discussed by Smith and others (1963 #4582), Anderson and Barnhard (1986 #895), Harty (1987 #4580), and Sergent, Hauskins, and Beckwith (1991 #4581). Fault traces from 1:250,000-scale mapping of Williams and Hackman (1971 #4578).
Geologic setting	Long, generally north-trending, sinuous range-front fault along the west side of Thousand Lake and Boulder Mountains, west of Capitol Reef.
Length (km)	48 km.
Average strike	N10°E
Sense of movement	Normal
Dip	

Paleoseismology studies	
Geomorphic expression	Remnants of Fremont River strath terraces (presumably truncated by faulting) may date from early Wisconsin time (>30 ka to 130 ka) and correlate with terraces on the downthrown side of the fault (Smith and others, 1963 #4582), but supporting evidence appears tenuous (Harty, 1987 #4580; Sergent and others, 1991 #4581). Projection of the terrace profiles suggests about 85 m of vertical displacement during late Pleistocene (post-early Wisconsin) to Holocene time (Smith and others, 1963 #4582). The extent of possible late Quaternary faulting is unknown, but based on the estimated terrace displacement and the distribution of total post-Oligocene throw along the fault, Anderson and Barnhard (1986 #895) postulated that Pleistocene displacements may exceed 100 m along the northern portion of the fault.
Age of faulted surficial deposits	Middle to late Quaternary.
Historic earthquake	
Most recent prehistoric deformation	Middle and late Quaternary (<750 ka) *Comments:*
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr
Date and Compiler (s)	1999 Bill D. Black, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
References	#895 Anderson, R.E., and Barnhard, T.P., 1986, Genetic relationship between faults and folds and determination of Laramide and neotectonic paleostress, western Colorado Plateau-transition zone, central Utah: Tectonics, v. 5, p. 335-357. #2479 Dohrenwend, J.C., and Moring, B., C., 1993, Reconnaissance photogeologic map of late Tertiary and Quaternary faults in Nevada: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 31. #4580 Harty, K.M., 1987, Field reconnaissance of Thousand Lake fault zone: Utah Geological and Mineral Survey, memorandum, 2 p. #642 Hecker, S., 1993, Quaternary tectonics of Utah with emphasis on earthquake-hazard characterization: Utah Geological Survey Bulletin 127, 157 p., 6 pls., scale 1:500,000. #4581 Sergent, Hauskins, and Beckwith, 1991, Report for final preliminary engineering geology, geoseismic, and geotechnical study, proposed Torrey Dam and Reservoir, approximately one mile west of Torrey, Utah, for Wayne County Conservancy District: Salt Lake City, consultant's report prepared for Utah Department of Natural Resources, Division of Water Resources, SHB Job No. E90-2027, 18 p. #4582 Smith, J.F., Jr., Huff, L.C., Hinrichs, E.N., and Luedke, R.G., 1963, Geology of the Capitol Reef area, Wayne and Garfield Counties, Utah: U.S. Geological Survey Professional Paper 363, 102 p. #4578 Williams, P.L., and Hackman, R.J., 1971, Geology, structure, and uranium deposits of the Salina quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-591, scale 1:250,000.

Complete Report for Aquarius and Awapa Plateaus faults (Class A) No. 2505

Brief Report ||Partial Report

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., and Hecker, S., compilers, 1999, Fault number 2505, Aquarius and Awapa Plateaus faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 10/30/2007 01:54 PM.**

Synopsis	Poorly understood Quaternary(?) faults in the Aquarius and Awapa Plateaus.
Name comments	**Fault ID Comments:** Refers to fault number 14-2 in Hecker (1993 #642).
County(s) and State(s)	GARFIELD COUNTY, UTAH PIUTE COUNTY, UTAH WAYNE COUNTY, UTAH
AMS sheet(s)	Salina
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Mapped or discussed by Williams and Hackman (1971 #4578) and Luedke and Smith (1978 #4579). Fault traces from 1:250,000-scale mapping of Williams (1964 #2789) and Williams and Hackman (1971 #4578).
Geologic setting	Diffuse area of normal faulting in Tertiary and Quaternary volcanic rocks in the Aquarius and Awapa Plateaus near the eastern boundary of the Basin and Range province.
Length (km)	36 km.
Average strike	N19°E
Sense of movement	Normal
Dip	

Paleoseismology studies	
Geomorphic expression	Faults displace or define the margins of Tertiary to Quaternary (<5 Ma) basalts.
Age of faulted surficial deposits	Quaternary(?)
Historic earthquake	
Most recent prehistoric deformation	Quaternary (<1.6 Ma) *Comments:*
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr
Date and Compiler(s)	1999 Bill D. Black, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
References	#642 Hecker, S., 1993, Quaternary tectonics of Utah with emphasis on earthquake-hazard characterization: Utah Geological Survey Bulletin 127, 157 p., 6 pls., scale 1:500,000. #4579 Luedke, R.G., and Smith, R.L., 1978, Map showing distribution, composition, and age of late Cenozoic volcanic centers in Colorado, Utah, and southwestern Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-1091-B, scale 1:1,000,000. #2789 Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations I-360. #4578 Williams, P.L., and Hackman, R.J., 1971, Geology, structure, and uranium deposits of the Salina quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-591, scale 1:250,000.

APPENDIX E
EZ-FRISK SOFTWARE INPUT

```
*********************************************
*****              EZ-FRISK            *****
***** SEISMIC HAZARD ANALYSIS DEFINITION *****
*****        RISK ENGINEERING, INC.     *****
*****           BOULDER, CO  USA        *****
*********************************************
```

PROGRAM VERSION
  EZ-FRISK 7.23

ANALYSIS TITLE:
  Seismic Hazard Analysis 2

ANALYSIS TYPE:
  Single Site Analysis

SITE COORDINATES
  Latitude 37.72
  Longitude -110.7

HAZARD DEAGGREGATION
  Status: ON
  Period: PGA
  Amplitude: 0.2
  Bin Configuration
    Magnitude
      Scale: Moment Magnitude
      Lowest Value: 5 Mw
      Highest Value: 9 Mw
      Bin Size: 0.1
    Distance
      Lowest Value: 0 km
      Highest Value: 102.5 km
      Bin Size: 2.5 km
    Epsilon
      Lowest Value: -2.2
      Highest Value: 4.2
      Bin Size: 0.2

SOIL AMPLIFICATION
  Method: Do not use soil amplification

ATTENUATION EQUATION SITE PARAMETERS
  Vs30 (m/s): 760

AMPLITUDES - Acceleration (g)
  0.0001
  0.001
  0.01
  0.02
  0.05
  0.07
  0.1
  0.2
  0.3
  0.4
  0.5

```
  0.7
  1
  2
  3

PERIODS (s)
  PGA

DETERMINISTIC FRACTILES

PLOTTING PARAMETERS
  Period at which to plot PGA: 0.0001

CALCULATIONAL PARAMETERS
  Fault Seismic Sources -
    Down dip integration increment        :   1 km
    Horizontal integration increment      :   1 km
    Number rupture length per EarthQuake  :   4
    Include near-source directivity       :   NO
  Area Seismic Sources -
    Maximum inclusion distance            :   1000 km
    Vertical integration increment        :   3 km
    Number of rupture azimuths            :   3
    Minimum epicentral distance step      :   0.5 km
    Maximum epicentral distance step      :   10 km
  Background Seismic Sources -
    Maximum inclusion distance             :   400 km
    Default number of rupture azimuths     :   10
    Maximum distance for default azimuths  :   20 km
    Minimum distance for one azimuth       :   70
  All Seismic Sources -
    Magnitude integration step            :   0.1 M
    Apply magnitude scaling               :   NO

ATTENUATION EQUATIONS

  Name: Abra.-Silva (1997) Rock USGS 2002
  Database: C:\Program Files\EZ-FRISK 7.23\Files\standard.bin-attendb
  Base: Abrahamson-Silva 1997
  Truncation Type: Trunc Sigma*Value
  Truncation Value: 3
  Magnitude Scale: Moment Magnitude
  Distance Type: Distance To Rupture

  Name: Campbell-Bozorgnia (2003) USGS 2002
  Database: C:\Program Files\EZ-FRISK 7.23\Files\standard.bin-attendb
  Base: Campbell-Bozorgnia 2003-2
  Truncation Type: Trunc Sigma*Value
  Truncation Value: 3
  Magnitude Scale: Moment Magnitude
  Distance Type: Distance To Rupture

  Name: Spudich 1999 Rock
  Database: C:\Program Files\EZ-FRISK 7.23\Files\standard.bin-attendb
  Base: Spudich 1997/99
  Truncation Type: No Truncation
  Truncation Value: 0
```

Magnitude Scale: Moment Magnitude
Distance Type: Horizontal Distance To Rupture

SEISMIC SOURCES

Name: Bright Angel Fault Zone - Fault 1
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 0.50000000
Deterministic Magnitude: 5.78

Fault Profile Parameters:

Dip1	Dip2	Depth1	Depth2	Depth3
60	60	0	0.1	15

Magnitude Recurrence Distributions:

ModelType	Weight	RateType	Rate	MinMag	MaxMag	Beta	Mean	Sigma	Delta1	Delta2
Exponential	0.3	Slip	2.000e-002	5.480000	6.080000	1.842100	5.780000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	5.000e-003	5.480000	6.080000	1.842100	5.780000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	1.000e-001	5.480000	6.080000	1.842100	5.780000	0.120000	0.000000	0.000000
Normal	0.300000	Slip	2.000e-002	5.480000	6.080000	0.000000	5.780000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	5.000e-003	5.480000	6.080000	0.000000	5.780000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	1.000e-001	5.480000	6.080000	0.000000	5.780000	0.120000	0.000000	0.000000

Rupture Length Parameters

Al	Bl	Sigl	Aw	Bw	Sigw	Aa	Ba	Sigw
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000

Trace Coordinates:

Latitude	Longitude
37.7529	-110.6011
37.7824	-110.5764

Attenuation Equations for Source:

Name: Abra.-Silva (1997) Rock USGS 2002
Name: Spudich 1999 Rock
Name: Campbell-Bozorgnia (2003) USGS 2002

****

Name: Bright Angel Fault Zone - Fault 2
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 0.50000000
Deterministic Magnitude: 6.24

Fault Profile Parameters:

Dip1	Dip2	Depth1	Depth2	Depth3
60	60	0	0.1	15

Magnitude Recurrence Distributions:

ModelType	Weight	RateType	Rate	MinMag	MaxMag	Beta	Mean	Sigma	Delta1	Delta2
Exponential	0.3	Slip	2.000e-002	5.940000	6.540000	1.842100	6.240000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	5.000e-003	5.940000	6.540000	1.842100	6.240000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	1.000e-001	5.940000	6.540000	1.842100	6.240000	0.120000	0.000000	0.000000
Normal	0.300000	Slip	2.000e-002	5.940000	6.540000	0.000000	6.240000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	5.000e-003	5.940000	6.540000	0.000000	6.240000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	1.000e-001	5.940000	6.540000	0.000000	6.240000	0.120000	0.000000	0.000000

Rupture Length Parameters

Al	Bl	Sigl	Aw	Bw	Sigw	Aa	Ba	Sigw
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000

Trace Coordinates:

Latitude	Longitude
37.7711	-110.4588
37.6928	-110.5039

```
Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

*******************************************

Name: Bright Angel Fault Zone - Fault 3
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk
Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 0.50000000
Deterministic Magnitude: 6.66

Fault Profile Parameters:
        Dip1       Dip2     Depth1     Depth2     Depth3
         120        120          0        0.1         15

Magnitude Recurrence Distributions:
        ModelType    Weight    RateType        Rate     MinMag     MaxMag
Beta       Mean     Sigma    Delta1    Delta2
      Exponential       0.3        Slip  2.000e-002  6.360000  6.960000
1.842100  6.660000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  5.000e-003  6.360000  6.960000
1.842100  6.660000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  1.000e-001  6.360000  6.960000
1.842100  6.660000  0.120000  0.000000  0.000000
           Normal  0.300000        Slip  2.000e-002  6.360000  6.960000
0.000000  6.660000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  5.000e-003  6.360000  6.960000
0.000000  6.660000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  1.000e-001  6.360000  6.960000
0.000000  6.660000  0.120000  0.000000  0.000000

Rupture Length Parameters
          Al        Bl       Sigl         Aw         Bw       Sigw
Aa        Ba       Sigw
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000

Trace Coordinates:
  Latitude   Longitude
    37.3762  -110.4136
    37.6652  -110.2589
```

```
Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

******************************************

Name: Needles
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk
Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 0.50000000
Deterministic Magnitude: 6.77

Fault Profile Parameters:
        Dip1      Dip2    Depth1    Depth2    Depth3
          60        60         0       0.1        15

Magnitude Recurrence Distributions:
        ModelType    Weight    RateType        Rate    MinMag    MaxMag
Beta      Mean     Sigma    Delta1    Delta2
      Exponential        0.3        Slip  2.000e-002  6.470000  7.070000
1.842100  6.770000  0.120000  0.000000  0.000000
      Exponential  0.100000         Slip  5.000e-003  6.470000  7.070000
1.842100  6.770000  0.120000  0.000000  0.000000
      Exponential  0.100000         Slip  1.000e-001  6.470000  7.070000
1.842100  6.770000  0.120000  0.000000  0.000000
           Normal  0.300000         Slip  2.000e-002  6.470000  7.070000
0.000000  6.770000  0.120000  0.000000  0.000000
           Normal  0.100000         Slip  5.000e-003  6.470000  7.070000
0.000000  6.770000  0.120000  0.000000  0.000000
           Normal  0.100000         Slip  1.000e-001  6.470000  7.070000
0.000000  6.770000  0.120000  0.000000  0.000000

Rupture Length Parameters
          Al         Bl       Sigl         Aw         Bw       Sigw
Aa        Ba       Sigw
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000

Trace Coordinates:
  Latitude   Longitude
    38.1900  -109.8600
```

38.0400 -110.1600

Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

****

Name: Shay graben
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 0.50000000
Deterministic Magnitude: 6.93

Fault Profile Parameters:

Dip1	Dip2	Depth1	Depth2	Depth3
120	120	0	0.1	15

Magnitude Recurrence Distributions:

ModelType	Weight	RateType	Rate	MinMag	MaxMag	Beta	Mean	Sigma	Delta1	Delta2
Exponential	0.3	Slip	2.000e-002	6.630000	7.230000	1.842100	6.930000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	5.000e-003	6.630000	7.230000	1.842100	6.930000	0.120000	0.000000	0.000000
Exponential	0.100000	Slip	1.000e-001	6.630000	7.230000	1.842100	6.930000	0.120000	0.000000	0.000000
Normal	0.300000	Slip	2.000e-002	6.630000	7.230000	0.000000	6.930000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	5.000e-003	6.630000	7.230000	0.000000	6.930000	0.120000	0.000000	0.000000
Normal	0.100000	Slip	1.000e-001	6.630000	7.230000	0.000000	6.930000	0.120000	0.000000	0.000000

Rupture Length Parameters

Al	Bl	Sigl	Aw	Bw	Sigw	Aa	Ba	Sigw
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000
4.000000	0.000000	0.010000	4.000000	0.000000	0.010000	0.000000	0.000000	0.000000

Trace Coordinates:
  Latitude Longitude

```
    38.0400  -109.2800
    37.9100  -109.7200

Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

*******************************************

Name: Thousand Lakes
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk
Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 1.00000000
Deterministic Magnitude: 7.03

Fault Profile Parameters:
        Dip1      Dip2    Depth1    Depth2    Depth3
          60        60         0       0.1        15

Magnitude Recurrence Distributions:
        ModelType    Weight    RateType        Rate    MinMag    MaxMag
Beta      Mean     Sigma    Delta1    Delta2
      Exponential       0.3        Slip  2.000e-001  6.730000  7.330000
1.842100  7.030000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  3.000e-001  6.730000  7.330000
1.842100  7.030000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  1.000e-001  6.730000  7.330000
1.842100  7.030000  0.120000  0.000000  0.000000
           Normal  0.300000        Slip  2.000e-001  6.730000  7.330000
0.000000  7.030000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  3.000e-001  6.730000  7.330000
0.000000  7.030000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  1.000e-001  6.730000  7.330000
0.000000  7.030000  0.120000  0.000000  0.000000

Rupture Length Parameters
          Al        Bl      Sigl        Aw        Bw      Sigw
Aa        Ba      Sigw
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000

Trace Coordinates:
```

```
  Latitude   Longitude
    38.1200  -111.5900
    38.5500  -111.5200

Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

*******************************************

Name: Aquarius and Awapa plateau
Region: Utah
Category: Fault Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk
Engineering\EZ-FRISK\Regions\Utah\Utah.bin-faultdb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 1.00000000
Deterministic Magnitude: 6.88

Fault Profile Parameters:
        Dip1      Dip2    Depth1    Depth2    Depth3
          60        60         0       0.1        15

Magnitude Recurrence Distributions:
        ModelType    Weight    RateType        Rate    MinMag    MaxMag
Beta      Mean     Sigma    Delta1    Delta2
      Exponential       0.3        Slip  2.000e-001  6.580000  7.180000
1.842100  6.880000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  3.000e-001  6.580000  7.180000
1.842100  6.880000  0.120000  0.000000  0.000000
      Exponential  0.100000        Slip  1.000e-001  6.580000  7.180000
1.842100  6.880000  0.120000  0.000000  0.000000
           Normal  0.300000        Slip  2.000e-001  6.580000  7.180000
0.000000  6.880000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  3.000e-001  6.580000  7.180000
0.000000  6.880000  0.120000  0.000000  0.000000
           Normal  0.100000        Slip  1.000e-001  6.580000  7.180000
0.000000  6.880000  0.120000  0.000000  0.000000

Rupture Length Parameters
          Al        Bl      Sigl        Aw        Bw      Sigw
Aa        Ba      Sigw
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
    4.000000  0.000000  0.010000  4.000000  0.000000  0.010000
0.000000  0.000000  0.000000
```

Trace Coordinates:

Latitude	Longitude
38.0300	-111.7800
38.1700	-111.5200

Attenuation Equations for Source:
  Name: Abra.-Silva (1997) Rock USGS 2002
  Name: Spudich 1999 Rock
  Name: Campbell-Bozorgnia (2003) USGS 2002

****

Name: 200-mile radius circle around Shootaring
Region: Utah
Category: Area Seismic Source
Database: C:\Documents and Settings\rstern\Application Data\Risk Engineering\EZ-FRISK\Files\user.xml-areadb
Fault Mechanism: Normal
Magnitude Scale: Moment Magnitude
Probability of Activity: 1
Minimum Depth: 3 km
Maximum Depth: 20 km

Boundary Coordinates:

Latitude	Longitude
-109.6290	40.4976
-109.5150	40.4693
-108.4690	40.0373
-107.6650	39.3720
-107.1800	38.5446
-107.0530	37.6406
-107.2820	36.7494
-107.8350	35.9565
-108.2390	35.6021
-108.6510	35.3360
-109.4470	35.0011
-110.7480	34.8185
-111.8400	34.9685
-112.8290	35.3814
-113.6260	36.0196
-114.1520	36.8245
-114.3510	37.7207
-114.1920	38.6220
-113.6760	39.4386
-112.8470	40.0860
-111.7850	40.4946
-109.6290	40.4976

Magnitude Recurrence Distribution:
  Minimum Magnitude: 4 Mw
  Maximum Magnitude: 6.3 Mw
  Activity Rate: 2.2
  Beta: 2.23
  A1: -4
  B1: 0

Attenuation Equations for Source:

Name: Abra.-Silva (1997) Rock USGS 2002
Name: Spudich 1999 Rock
Name: Campbell-Bozorgnia (2003) USGS 2002

****

Echo File Creation Time: 10:28:36 Wednesday, October 31, 2007

ATTACHMENT E

SEISMIC HAZARD ANALYSIS OF TITLE II RECLAMATION PLANS

PREPARED BY D. BERNREUTER, E. MCDERMOTT, AND J. WAGONER
LAWRENCE LIVERMORE NATIONAL LABORATORY
DATED JUNE 26, 1994

(ATTACHMENT FOR RESPONSE TO INTERROGATORY R313-24-4-16/02: SEISMIC HAZARD CHARACTERIZATION)

00-100

File 100538
Non-Project
NRC-Misc

Seismic Hazard Analysis of Title II Reclamation Plans

Prepared by
D. Bernreuter, E. McDermott, and J. Wagoner

Prepared for
U.S. Nuclear Regulatory Commission

FESSP
Fission Energy and Systems Safety Program
Lawrence Livermore National Laboratory

Disclaimer

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Seismic Hazard Analysis of Title II Reclamation Plans

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ABSTRACT

Over the years, mining sites located in New Mexico, Utah, South Dakota and Wyoming have had uranium producing ore extracted and uranium tailings stored on sites. The tailings were usually stored in big piles of material with sometimes no particular considerations for their design with respect to dynamic loading such as seismic events.

In its effort to evaluate the risk associated with those piles, the NRC sponsored the Lawrence Livermore National Laboratory to perform a simplified seismic hazard analysis for all the sites. The emphasis of the study was to review the geology, seismicity and tectonics of the regions, to establish the bases for the selection of the design criteria, when they existed, and to determine whether the perception of the seismic hazard had changed since the last analyses were performed. For example, newly discovered active faults running close to a site could have an important impact on the perception of the hazard at a specific site.

LLNL reviewed all the available literature, interviewed local experts geology, seismicity and ground motion estimation and developed an estimate of the current design criteria for each site. The adequacy of the as built design criteria were then determined on a site by site basis.

For several sites it was found that current practice would call for higher ground motion values than those believed to have been used for the design, or review, of the piles. In addition, it was found that several sites had faults under the piles. None of these faults were considered as active, however, in the event of a nearby earthquake they can be the source of differential compaction across the faults.

EXECUTIVE SUMMARY

The purpose of this study was to evaluate the seismic design assumptions for mining sites in the seismic evaluation of Title II Reclamation Plans where uranium tailings are being stored generally in piles of material. The evaluation consisted in estimating the design ground motion independently, using simplified deterministic and probabilistic techniques and compare them to the actual design assumptions used for a determination of adequacy. The approach used consists of a review of the literature, contacting regional experts to obtain their insights and potential concerns, and also performing both a simplified deterministic and probabilistic hazard analysis for each site. Our primary goal was to provide sufficient information for the NRC staff to make the necessary safety assessments.

In order to arrive at an appropriate estimate for the ground motion it was necessary to have appropriate criteria to use to make the necessary judgments needed to perform the hazard analyses. Our criteria are based on 10 CFR 40 Appendix A. Using a 10^{-4} probability of exceedance (PE) in a year met the criteria of 10 CFR 40 Appendix A. We described how these criteria are used in the deterministic analysis where probability of occurrence of events is not a parameter.

Since the choice of criteria was subjective, we provide the results of a sensitivity analysis for NRC to make decisions. In addition, we included the uncertainty on the estimates to reflect the uncertain nature of the process. This was done by using simplified procedures. Our results for each site are summarized in Table 1.

We found that at most sites the estimates for the peak ground acceleration (PGA) are higher than the PGA values used in design. There are several reasons for this. For example, it is not clear what criteria were used by the licensee to arrive at the design value. Our criteria was to estimate the PGA level that had a 10^{-4} PE level per year. Our criteria may be more conservative than that used for design. In addition, several seismic zones or active faults were found to be much closer to the sites than assumed in the original studies. The historical earthquake catalog we used was significantly better and more complete than the one used in the original design reports. Hence our rates of activity are higher than used in the design reports.

At five sites (see from Table E-1) there is data showing that faults or fracture zones run under tailings piles or dams. Based on our review of the literature and discussions with regional experts, none of these faults were judged to be currently active, meaning that it is the likely source of an earthquake or a capable source by NRC reactor standards described in 10 CFR 100 Appendix A. However, in the event of a nearby earthquake where the site experiences ground motion approaching the 10^{-4} PE level there is considerable concern that this could introduce differential settlement across these faults. This in turn could cause some damage or lead to the rupture of the piles or dams.

This problem should be addressed on a case-by-case basis. Our most serious concerns are: (1) with the Moab fault under the Atlas site because it is a major fault that has shown Quaternary settlement due to salt tectonics and (2) with the potential for large ground motion at the site in the event of a nearby earthquake.

The stability of the tailings piles and the safety of any other critical facilities needs to be evaluated at most sites. The highest priority should be given to the Atlas site in Utah, the Sohio Site in New Mexico and the Western Nuclear site in Wyoming. These sites have the highest hazard.

TABLE E.1
SUMMARY OF RESULTS

Site Name	Location	Values Used In Design	PGA at PE 10^{-4}	PGA at PE $5x10^{-4}$	Deterministic 1-SigmaPGA	Deterministic Median PGA	Fault or Fracture Zone Under Facilities
Arco	NM	0.21 - 0.1	0.18	0.08	0.15	0.08	Yes fault
Homestake	NM	0.1	0.18	0.08	0.18	0.1	Yes fault
Quivira	NM	0.1	0.18	0.08	0.18	0.1	Yes faults
Sohio	NM	0.1	0.20	0.11	0.42	0.23	No
United Nuclear	NM	N/C	0.16	0.07	0.07(1)	0.07	Yes fracture zones
Edgemont	SD	0.05 - dam ok to 0.2	0.12	0.06	N/A(2)	N/A(2)	No
Atlas	UT	0.1	0.15	0.06	0.4	0.22	Yes
Rio Algom	UT	0.09	0.15	0.06	0.26	0.14 to 0.16(3)	No
Energy Fuels Nuclear	UT	0.1	0.12	0.05	0.12	0.07	No
Plateau Resources	UT	0.1	0.19	0.09	0.3	0.19	No
Western Nuclear	WY	0.08	0.33	0.18	0.55	0.3	No
Kennecott	WY	0.1	0.33	0.18	0.33	0.18	No
Pathfinder SB	WY	0.25	0.33	0.18	(4)	(4)	No
Petrotomics	WY	N/C	0.33	0.18	(4)	(4)	No
Exxon	WY	N/C	0.27	0.13	(4)	(4)	No
Union Pacific	WY	0.05	0.27	0.13	(4)	(4)	No
American Nuclear	WY	N/C	0.33	0.18	0.3	0.17	No
Pathfinder Lucky -Mc	WY	0.15	0.33	0.18	0.3	0.17	No
Umetco	WY	0.05	0.33	0.18	0.3	0.17	Yes

NC: Not considered in design.
PE: Annual Probability of Exceedance
(1) Based on a median estimate - see text 5.9.4.
(2) Deterministic estimate not considered applicable see text 6.5.
(3) Two different eartquakes involved - see text 7.6.2.
(4) Only large distant earthquake considered. Not comparable to probabilistic analysis.

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1.0 INTRODUCTION

1.1 Seismic Evaluation of Title II Reclamation Plans

As part of an ongoing program, Lawrence Livermore National Laboratory (LLNL) is responsible for characterizing seismic hazards at the uranium mine tailings sites using updated seismic information. A major part of this effort is the identification of documented Quaternary faults which have not been previously considered in the seismic evaluation of these sites. Results of this effort with an assessment of revised estimates of the seismic hazard (expressed in terms of Peak Ground Acceleration) using new information are provided to NRC Staff to make necessary judgments about the adequacy of the Title II Reclamation Plans. The ultimate objective of this effort is to develop guidelines which will ensure the long term stability of the uranium mine tailings piles.

For purpose of evaluating seismic hazards at these sites, a two phase process is considered. First, a seismic hazard characterization of the sites is performed. This effort consists of a preliminary seismic hazard assessment that provides bounding estimates of the site design basis as specified in Appendix A of 10 CFR 40. This analysis is conducted using published and unpublished information and interviewing local seismologists. Both a preliminary deterministic and probabilistic seismic hazard assessment is provided in this report.

Based on the results of these preliminary analyses, a decision can be reached whether existing seismic site design criteria are sufficient.

If the findings of this preliminary seismic hazard analysis indicate that seismic hazards are capable of damaging mine tailings on site, LLNL will develop estimates of the design parameters consistent with current seismic hazard characterizations.

This report describes the scope, evaluation procedures, and results of the preliminary site seismic hazard analyses.

1.2 Scope and Goals of this Study

The scope of this analysis is limited to a review of all available published and unpublished information and to provide preliminary deterministic and probabilistic seismic hazards which will be used as bounding values.

The primary goal of this study is to give sufficient information to decide whether a detailed seismic hazard analysis is required for some sites (if any) to develop estimates of ground motion levels which will be used in safety assessments of tailing piles. This report deals specifically with part of the preliminary assessment to be used in the seismic bounding assessment. For example, if assumptions in this report imply that the site-specific design criteria are not satisfied, then more site-specific studies will be needed to address this issue.

1.3 Report Organization

Section 2 of this report provides a glossary of terms.

Section 3 presents an overview of the evaluation procedures and methodologies that are used to perform a preliminary seismic hazard assessment at the sites. Both procedures to estimate preliminary probabilistic and deterministic seismic hazard assessments for each site are described in this section. These assessments are used to assess the ground motion level for use in the determination of the adequacy of existing seismic design parameters. No assessments are made in this report on whether the site-specific seismic criteria are satisfied. For this reason, bounding estimates of the site-specific ground motion levels are provided in this report.

Existing design criteria for each of the sites under study are summarized in Section 4.

Sections 5 to 8 describe the preliminary seismic hazard analyses for each site. For purpose of clarity, sites are first grouped in each section by the state they are within. Within each section, site are grouped by geographic location.

Section 9 presents conclusions and recommendations on the seismic design criteria of each site under study. These conclusions are based on the authors' judgment on the fault characteristics, tectonic and regional seismicity after a review of the available information. Because all the sites in this study are located in low seismicity regions, there are limited studies which have been performed. Should future studies being carried out, their results might significantly impact the preliminary results presented in this study.

2.0 GLOSSARY OF TERMS

There are a few symbols and acronyms that we use throughout this report which require definitions.

Active or Potential Faults — Faults which are considered capable of having earthquakes with magnitudes greater than 5 and/or potential for surface displacement. No fixed criteria was used in this report to make the assessment. See Section 3.4.2, 8.2 and 9.0 for added discussion.

Capable Tectonic Source — A "capable tectonic source" is a tectonic structure that can generate both vibratory ground motion and tectonic surface deformation such as faulting or folding at or near the earth's surface in the present seismotectonic regime. It is described by at least one of the following characteristics:

(a) Presence of surface or near-surface deformation of landforms or geologic deposits of a recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

(b) A reasonable association with one or more large earthquakes or sustained earthquake activity that are usually accompanied by significant surface deformation.

(c) A structural association with a capable tectonic source having characteristics of section a in this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geological evidence of past activity at or near the ground surface along a particular capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these, cases, evidence may exist elsewhere along the structure form which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence is to be used in determining whether the structure is a capable tectonic source within this definition.

Notwithstanding the foregoing paragraphs, structural association of a structure with geological structural features that are geologically old (at least pre-Quaternary), such as many of those found in the Central and Eastern region of the United States will, in the absence of conflicting evidence, demonstrate that the structure is not a capable tectonic source within this definition.

M — Magnitude of an earthquake. Generally, the moment magnitude scale is used for the deterministic seismic hazard analysis. No attempt has been made to try to convert the magnitudes recorded in the catalog to the same magnitude scale. Consequently, several magnitude scales have been used in the probabilistic seismic hazard analysis.

M_L — Local (Richter) magnitude

M_u — The largest possible earthquake (regardless of occurrence rate)for a fault or region. Also referred to as the upper magnitude cutoff.

PGA — Peak ground acceleration. Strictly speaking it is not the peak but the average of the two horizontal peaks.

PE — Probability of exceedance - used in conjunction with the criteria to assess the ground motion level from the seismic hazard results.

Tectonic Structure — A tectonic structure is a large-scale dislocation or distortion, usually within the earth's crust. Its extent may be on the order of tens of meters (yards) to kilometers (miles).

3.0 METHODOLOGY

3.1 Overview

The purpose of this analysis is to perform simplified deterministic and probabilistic seismic hazard analyses at uranium mine tailings sites which will be used in an evaluation of the site-specific seismic design criteria.

This analysis is divided into a series of steps designed to proceed through the data collection and review process, seismic hazard assessment, and an updated assessment of the site seismic design basis. The simplified seismic hazard analysis is carried out in three phases. They are:

Phase	Task
1	Identification of seismic sources
2	Risk criteria for performing seismic hazard assessment
3	Simplified deterministic and probabilistic site seismic hazard analysis

An important part of this project is to review all relevant information, either published or not. Because the sites under study are in regions of relatively low seismicity, most recent information may likely not be published and/or readily available. For this reason, geologists and seismologists at each of the state surveys were interviewed for explanations and clarification.

The next sections describe in detail each of these steps.

3.2 Phase 1 - Identification of Seismic Sources

The objective of this phase is to identify site data and to gather appropriate information on regional and site specific information on topography, tectonics, seismic faults, and historical seismicity, results of previous seismic analysis, etc., that are necessary to identify and later analyze possible sources of seismic ground motion that may impact the sites.

The first effort is to obtain environmental impact reports, Reclamation Plans reports, and all other documents available from NRC dockets.

The LLNL library performed a site specific literature search on thirty-eight technical and scientific catalogs, which are listed in Appendix A. The search was not very successful due to the narrow scope of the subject and a general lack of written material on each region of interest. However, the LLNL library was able to obtain various articles and books through interlibrary loan from U.C. Berkeley, the USGS, and the state survey libraries. Various maps and publications used in this study are listed by state in the reference section at the end of this report.

3.3 REGIONAL EXPERTS

Various telephone conversations and meetings with field researchers were conducted to augment information collected from Phase 1. The focus of these interactions is to obtain recent results of current seismic research in the areas of interest. main contacts for the regions under study are:

<u>New Mexico Bureau of Mines and Mineral Resources:</u>

Dave Love

New Mexico Institute of Mining and Technology:
Allan R. Sanford

Los Alamos National Laboratory
Scott Baldrege

South Dakota Geological Survey:
Dick Hammond

Utah Geological Survey (UGS):
Gary Christensen, Michael Ross, and Hellmut Doelling.

University of Utah
Walter Arabasz

Wyoming Geological Survey:
James Case

A number of issues were discussed with other researchers and field workers specialized in the areas under study. One important question that was asked to all researchers was whether they knew of any evidence or had any concerns that active faulting existed near any of the sites under study in this report.

Glen Reagor of the USGS National Earthquake Information Center (NEIC) performed a seismicity search and generated corresponding seismicity maps within a two degree radius of the each site or each cluster of sites. The results of this analysis are used to assess historical seismicity at each of these sites.

3.4 Phase 2 - Risk criteria for performing seismic hazard assessment

No specific risk criteria are currently available to be used in the definition of the site specific seismic design criteria. As a consequence, risk criteria are developed in this study to select ground motion levels and whether a fault is judged active or not.

3.4.1 Determination of Ground Motion Level from Probabilistic Analysis

10 CFR 40 Appendix A provides the criteria to be used in selecting the appropriate level of ground motion to check the safety of the tailings piles. The criteria stipulates that the design be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years. The assumption made in this study is that a high degree of confidence is desired that the ground motion level will not be exceeded in the 200 year time frame and that there is a reasonable assurance that it will not be exceeded in the 1000 year time frame. A selection for the probability of exceedance (PE) for PGA in the 10^{-4} range would give a high degree (considering the conservatism's in the design analysis process) of assurance for the 200 year period and in our opinion would meet the 1000 year criteria.

More specifically, a 10^{-4} PE level corresponds to approximately a 2% chance of exceeding the selected ground motion level in 200 years and a 10% chance in 1000 years. Building codes are developed with a 10% chance of exceedance for the lifetime of the structure (usually taken as 50 years) as meeting the reasonable assurance criteria.

Ground motion estimates in terms of PGA are provided at a PE level of 10^{-4} per year for each site. In addition, it could be argued that because of the relatively low risk posed by the tailings piles, the choice of a PE level of 10^{-4} might be too conservative. For this reason estimates of the ground motion at that $5x10^{-4}$ level are also provided.

3.4.2 Determination of Ground Motion Level from Deterministic Analysis

In performing a deterministic analysis, it is often difficult, (particularly in a limited study in regions of low seismic activity) to be able to determine if a fault is active or not active or what the largest earthquake in the next 1000 years will be. The use of an upper bound is generally too conservative given the above criteria and judgment is required. One approach to address these issues is to reasonably identify which sites require a detailed study and to identify a ground motion level which, if used to assess the stability of the tailings piles, is appropriately conservative. However, because field studies and modification of any tailings piles are very expensive, one of our goals is to be sure that there is indeed a reasonable concern that there is a problem, based on the above criteria.

The assumption made is that 10^{-4} total probability of exceedance means that a relatively high degree of confidence must exist in the judgmental decisions at every step of the analysis. For example, relative to the determination whether a fault is potentially active or not active, a high degree of confidence must exist that the fault is not active to consider it as not active.

However, it is important to note that considering a fault as potentially active does not mean that there is much confidence that it is indeed active. In fact our best judgment might be that it is inactive, however, the uncertainty about what is known about the fault is generally large. These uncertainties can become important at 10^{-4} hazard levels required by the criteria. Hence its activity cannot be excluded. These important judgmental decisions are noted and quantified, when presented.

The above discussion does not really provide a criteria to determine if a fault is active or inactive. For example, in the siting of nuclear power reactors, 10 CFR 100 Appendix A provides more definitive criteria to determine if a fault is capable. In general there simply was not enough data to use to apply any type of definitive criteria. The approach used in this analysis is judgmental and based on assessments from the literature which used varying criteria. Generally speaking, this is not a very satisfactory approach as it could lead to significant variation between sites. This point is discussed in some detail in the Conclusions section, in which the implications of the judgments made relative to calling a fault "active" or "potentially active" are examined.

In section 3.5.1 below, we outline in detail how the PGA estimates are determined for the deterministic analysis. Generally we used the 1-sigma level for our estimates. However, as noted above, it could be argued that, because of the relative low risk posed by the tailings piles, the choice of a PE level of 10^{-4} might be too conservative. For this reason, estimates of the ground motion at $5x10^{-4}$ PE are also provided. If this criteria is used, then the deterministic estimate for the ground motion should be selected at the median estimate.

3.5 Phase 3 - Simplified Deterministic and Probabilistic Site Seismic Hazard Analysis

A typical seismic analysis for the sites follows the following steps:

1) Identification of the faults around each site and determination of which faults should be considered potentially active given that available field data, the large uncertainties introduced due to the very limited field data available, and criteria used for this study.

2) For each fault identified as potentially active, estimation of the largest earthquake that can be reasonably expected to occur based on the criteria used in this study and estimation of the ground motion at the site.

3) Identification of which, if any, potentially active faults passes through the site and represents a surface rupture hazard.

4) Identification of any concentration of seismicity that may exist around the site which indicates an active buried fault. Estimation of largest earthquake that could be reasonably expected and the resulting ground motion at the site.

5) Because there appears to be little correlation between the observed seismicity and the known faults around the sites in the study, it is necessary to perform a hazard analysis for a random earthquake. The appropriate ground motion level from the random earthquake is based on the hazard curve and the probability of exceedance criteria discussed below.

3.5.1 Deterministic Analysis

Steps 1 to 4 comprise the deterministic elements of the seismic study. Based on literature reviews, discussions with local experts, and the criteria defined above, faults near the site are first identified as whether, for the purposes of this report, they must be considered active. Once these potentially active faults have been identified, it is possible to estimate the largest earthquake that can be reasonably expected to occur. It should be noted that the assessment of maximum earthquake magnitude is a professional judgment that incorporates an understanding of specific fault characteristics, the regional tectonic environment with comparison with other faults of known seismic potential, and data on regional seismicity.

At present, there are no uniquely accepted methods for assigning a maximum earthquake magnitude to a given fault. Various approaches have been developed based on the geologic characteristics and earthquake history of the fault and were summarized most recently by Wells and Coppersmith (1994). These approaches rely on empirical relationships developed between earthquake magnitude and specific fault parameters, including fault rupture length, fault displacement per event, rupture area and seismic moment. Compilations of these data for worldwide historical earthquakes have been used to develop linear regressions of earthquake magnitude on length, magnitude on displacement, and magnitude on area for faults in different tectonic settings. Each approach has its limitations, such as uniformity in the quality of the empirical data, a limited data set, and possibly an inconsistent grouping of data from different tectonic environments.

Values for magnitudes derived from these relationships represent expected (mean) values. It is a generally accepted practice to use mean values from these relationships to evaluate the maximum earthquake on individual structures because the values for the fault parameters used in these relationships are the maximum values that are geologically reasonable. For the most part in this study, so little is known about the actual fault geometry's that one must rely on a simpler correlation between rupture length and magnitude.

Several methods are commonly used to estimate the maximum length of a fault that can rupture during a single event. Wentworth and others (1969) propose that 50 percent of the total length is a conservative estimate of the maximum rupture length. Slemmons (1982) has proposed empirical relationships that relate rupture lengths to a percentage of the total length. More recently, however, geologists and seismologists have recognized the significance of fault barriers that limit the amount of rupture during individual earthquakes (e.g., Schwartz and Coppersmith, 1984). Where sufficient data exist to define fault barriers and fault segments, the fault segmentation method provides a more reliable estimate of the maximum length of the fault that can be expected to rupture during a single event. Otherwise, we use our judgment to assess the expected rupture length and the relations given in Wells and Coppersmith (1994).

The following judgmental procedure is adopted in this report. If no segmentation data or other compelling data is available the best estimates for M_u are made assuming that 50 percent of the total length of the fault will rupture. An estimate for the possible uncertainty on M_u is made by assuming that the entire fault will rupture in a single event or that two segments will rupture. This term is defined as the upper bound magnitude M_{UB}.

There is not enough reliable information about any of the faults identified as potentially active to estimate the recurrence interval of the largest earthquake. One expects that the largest earthquake possible on any of the faults falls in what might be termed as the characteristic earthquake for the fault (see Schwartz and Coppersmith (1984) and Youngs and Coppersmith (1985)). For the purposes of this analysis the characteristic earthquake implies that two processes are ongoing. First, small to moderate earthquakes in a region follow the usual Gutember Richter Law for the distribution of magnitude

$$\log N = a - bM \qquad (3.1)$$

where N = number of events greater or equal to M

M = magnitude of the earthquake

a,b = constants

The characteristic earthquake does not follow the above relation but has its own characteristic return interval different than implied by the above equation. Generally, the characteristic return period must be determined by geological means - such as observing repeated offsets across a given fault. Often, the characteristic repeat time of large earthquakes is more frequent than would be estimated by use of Eq. (3.1).

Once the magnitude of the earthquake for a given fault has been determined, it is then used to make a ground motion estimate. A number of relations exist to do this. For this report the 1981 Joyner Boore relation is used. Any estimate for the ground motion is highly uncertain given all of the judgmental assessments that must be made. Thus, it is not very useful to use numerous ground motion relations and average the results in this type of analysis.

As outlined above, the deterministic approach often results in two estimates for the maximum earthquake: (1) the best estimate value M_u and (2) the upper bound value M_{UB}. Although the recurrence interval for M_u is generally not known, the upper bound earthquake M_{UB} must have a much lower probability even than M_u. To account for this the ground motion for the best estimate of M_u using the 1 - sigma estimate of the ground motion given the magnitude M_u and distance of the closest approach of the causative fault to site, and for M_{UB} using the median estimate of the ground motion. This is an ad hoc procedure - but in our judgment is a reasonable way to appropriately assess the ground motion.

It should be noted that the use of the 1-sigma level as the appropriate estimate for ground motion has its roots in the safety assessment of nuclear power reactors. Nuclear power reactors pose a much greater risk than posed by the tailings piles. Thus it is not evident that the 1-sigma level is necessarily the most appropriate value to use. For that reason we report a range giving both the median and 1-sigma levels where appropriate. However, when we make our estimates, based on M_{UB} we only give the median estimate.

3.5.2 Probabilistic Analysis

The earthquakes in the regions around the sites studied in this report show a relatively poor correlation with known geology. Thus one must expect that a random earthquake could occur almost anywhere. To develop the earthquake recurrence model using Eq. (3.1) in the analysis for each site, both the regional geology and pattern of seismicity must be examined. First, a region from which historical earthquakes occurrences will be used to develop the parameters a and b of Eq. (3.1) must be selected. Since the seismic activity is low, a large region needs to be used to provide reasonable estimates for a and b parameters. Regions which had similar geological and seismological characteristics to the region around the site were selected . For example, for both the sites located in Utah and Wyoming, the earthquakes in the very active Intermountain Seismic Belt were excluded. The USGS catalog obtained from Glen Reagor is used for all of the analyses, except for the South Dakota site.

One of the major problems in developing the recurrence relation in Eq. (3.1), in regions of low seismicity and low population density is the completeness of the catalog. To test for completeness, the procedure developed by Stepp (1972) was used. This procedure, based on Poisson statistics, determines the time period over which the earthquake catalog is assumed complete as a function of magnitude level. This procedure has been applied in numerous previous studies. According to Stepp's method, when the mean rate of earthquake occurrence is constant, the standard deviation of the estimate of that mean rate varies as $1/\sqrt{T}$, where T is the time interval of the sample. Thus, on a plot of standard deviation versus time, stable occurrence rate is indicated by a $1/\sqrt{T}$ slope. Fig. 3.1 is such a plot for the Wyoming region and the time intervals of stable occurrence estimates at different magnitude levels are shown by heavy lines of $1/\sqrt{T}$ slopes. Given these rate estimates, the log N versus M relationship can be determined with more confidence. From Fig. 3.1, earthquakes with magnitudes about 2.25 are fully reported for only about the last 10 years and earthquakes with magnitudes below 4.75 are fully reported for about 30 years.

The record for largest events is incomplete because the time frame for which good coverage exists is too short to have a sufficient number of larger earthquakes for establishing a mean rate.

The a and b values are estimated by judgment using the data for which the record is judged to be sufficiently complete. The fact that the b-value is generally around -1.1 to -0.7 was also used to constrain the b-values.

No attempt is made to remove aftershocks as no large recent events which might have a number of aftershocks were in the catalog. To properly cull the catalog would require considerable effort. Leaving in aftershocks may lead to a somewhat higher seismicity rate (conservative) but also to a steeper slope (not conservative at relatively high ground motion levels).

In addition to the recurrence model, an estimate for the largest random earthquake that can occur is needed. This question was discussed at length with Dr. W.J. Arabasz. He concurred with our assessment of the literature that one could expect earthquakes in the 5.5 to 6.5 range anywhere. Generally, earthquakes larger than 6.5 lead to surface faulting, and smaller earthquakes may or may not lead to surface faulting.

The problem with the recurrence model given by Eq. (3.1) is that there are no limits to the size of the earthquake that can occur. Most regions are characterized by some maximum earthquake, M_u, that can occur. To account for this, a truncated exponential model is used in the hazard analysis. As can be seen from Fig. 3.2, the truncated exponential model starts to depart from the straight line given by Eq. (3.1) approximately 3/4 a magnitude unit from M_u. For Fig. 3.2 $M_u = 5.75$.

Because of the limited nature of this study and the lack of data, no attempt to perform an uncertainty analysis was made. Such uncertainty analyses are very important but very costly to perform properly. A poorly performed uncertainty analysis provides no information. Thus at best, this analysis for the random earthquake is only a simple estimate for the central value of the hazard. Its main use is to determine if a detailed study is needed, that is if the estimates for the ground motion are used for safety assessments. If the factor of safety is not well above 1, then a careful study should be performed.

Some uncertainty parameters were included in the analysis. A factor of ± 2 is used on the seismicity rate. The b value is kept constant and a factor of ± 0.25 units is used on M_u. In addition, to see the sensitivity to M_u, analyses are performed for four values of M_u, 5.5, 5.75, 6.25, and 7. $M_u = 7$ is and upper limit and is used to bound the importance of M_u. As noted above, the most likely values for M_u are in the 5.75 to 6.25 range. For the most part, the results are not too sensitive to the value of M_u.

Finally, since the goal of this report is to assess the appropriate ground motion for tailings piles, liquefaction or other forms of soil or slope stability, only the contributions to the hazard from earthquakes $M \geq 5$ are calculated. Small earthquakes can contribute to the probability of exceeding a given ground motion but these small earthquakes are of short duration and unlikely to induce significant liquefaction or slope movement. Thus they are not included in the analysis.

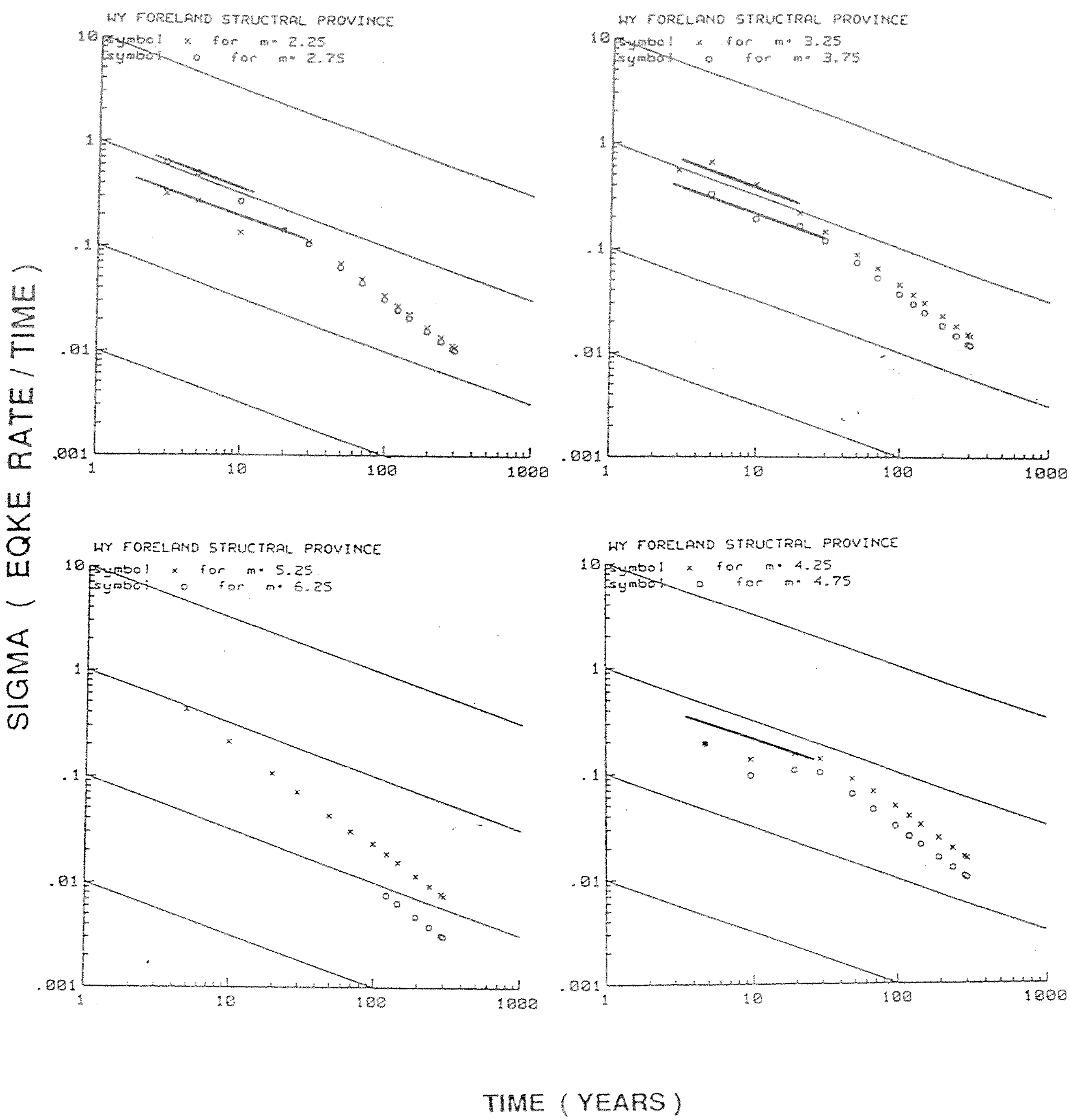


Figure 3.1 Stepp [1972] plots (sigma is the standard deviation of the estimate of the mean rate of earthquake occurrence ($\sqrt{\lambda}/T$, where λ is mean rate of earthquake occurrence and T is time interval of the sample)

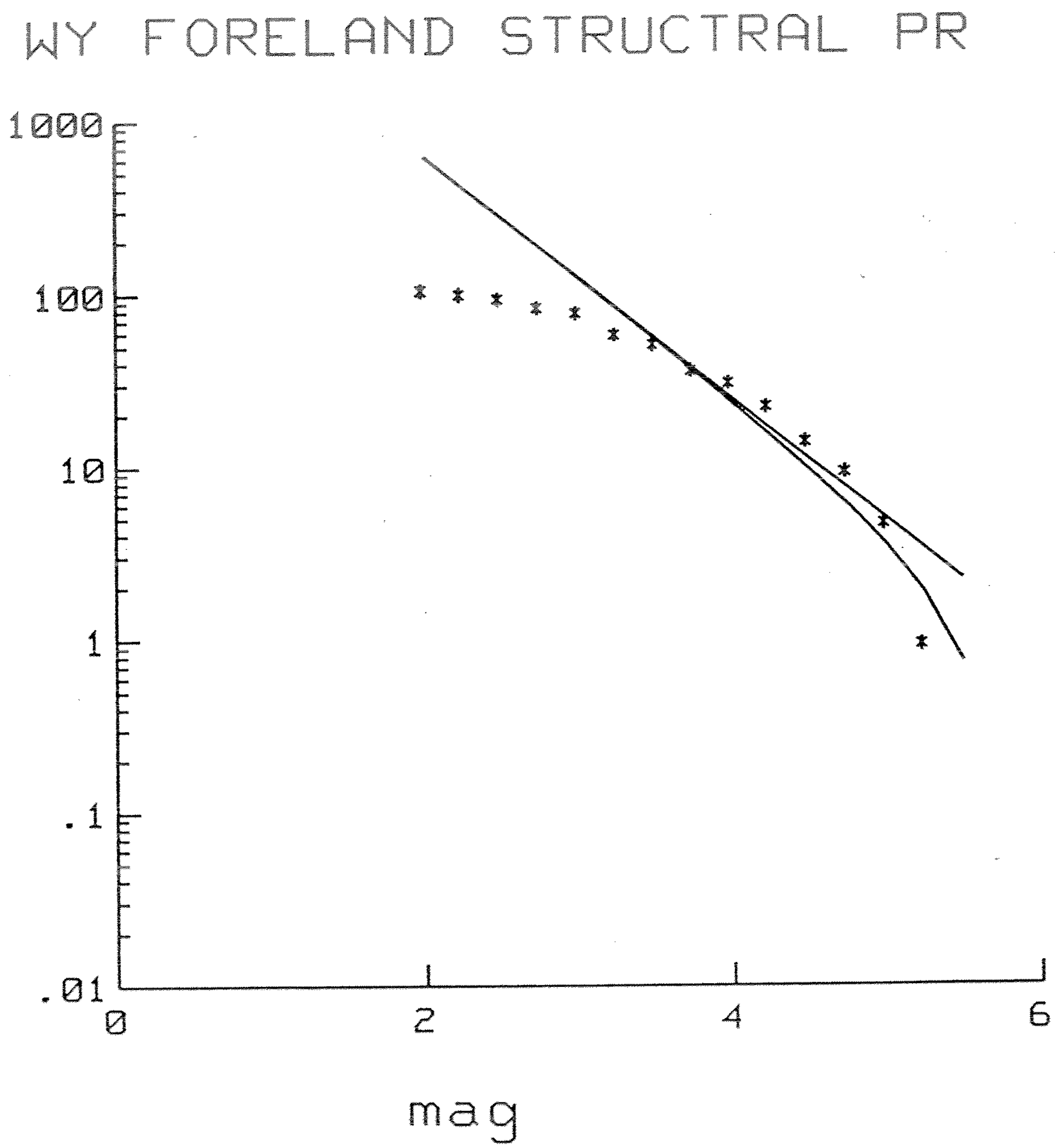


Figure 3.2 Comparison of the Richter log N = a-bM model to the truncated exponential model with M_u= 5.75

4.0 SUMMARY OF DESIGN CRITERIA USED AT EACH SITE

Various submittals for each site available in the NRC Docket Room were reviewed and the design criteria used for each site were identified. This task is a difficult one because more than one ground motion level are given for some sites and none for others. For sites with more than one value it was generally difficult to determine how all the values were actually used. The results of the review are summarized below.

4.1 New Mexico

4.1.1 Atlantic Richfield Bluewater Uranium Project

Sources: Dames & Moore, 1988, Local Fault Capability Assessment, Arco Coal Company (1990a)

Design Criteria:

- A horizontal acceleration of 0.06g is used in the pseudo-static stability analysis.
- A pseudo-static coefficient of 0.10 is recommended and is used in the slope stability analysis.
- The mean peak horizontal ground acceleration level expected at the site is 0.21g. This value is used in the reclamation design.
- The above criteria determined by Dames and Moore in 1988 are based on three factors:
  - A possible local earthquake
  - Attenuation from an earthquake 60 km to the east
  - "Local" faults within 30 km of the site

4.1.2 Homestake - Grants

Source 1: State of New Mexico Uranium Mill License Renewal Application, 1992

Design Criteria:

- Horizontal Acceleration = .02-.05 g.
- Maximum peak acceleration = 0.04 g (Algermissen and Perkins, 1976).
- Maximum peak acceleration = 0.05 g (Applied Technology Council, 1978).
- Effective peak horizontal acceleration of magnitude 6.0 earthquake originating 45 miles from the site = 0.10 g.

Source 2: D'Appolonia Stability Assessment, 1980

Design Criteria:

Maximum horizontal acceleration of 0.1g and a vertical acceleration of 0.067g are used as the seismic coefficients for the dynamic stability.

4.1.3 Quivira - Ambrosia Lake

Source: Kerr McGee Nuclear Company, 1993

Design Criteria:

Effective peak horizontal ground acceleration = 0.10 g. is used in the pseudo-static stability analysis.

4.1.4 Sohio Western, L-Bar

Source: L-Bar Uranium Mine Reclamation and Closure Plan, Intera Technologies (1989)

Design Criteria:

- The tailings impoundment itself is designed (and retrofitted with under drains) to withstand a Peak Ground Acceleration of 0.1 g.
- The Peak Ground Acceleration at the site due to the potential movement on the upper Rio Grande Valley fault is 0.07 g.

4.1.5 United Nuclear - Church Rock

Source: Canonie Environmental (1987)

Design Criteria:

0.05g

4.2 South Dakota

4.2.1 TVA - Edgemont

Source: Edgemont Mill Decontamination and Decommissioning Final Report, TVA (1990)

Design Criteria:

A value of PGA of 0.05 g is used for the design. However, a stability analysis shows that "critical" maximum ground acceleration for the containment dam is about 0.2 g, approximately four times greater than the design acceleration for the Edgemont area which is 0.05 g.

4.3 Utah

4.3.1 Atlas - Moab

Source: Atlas Minerals "Division of Atlas Corporation Source Material License Renewal." (1984)

Design Criteria:

- For a liquefaction potential evaluation, maximum ground acceleration is 0.08 g for the postulated design earthquake.
- Horizontal accelerations is than .05 g.

4.3.2 Plateau Resources - Shootaring Canyon

Source: Plateau Resources Environmental Report, 1979

Design Criteria:

- Specific design number are not given.
- The chance of exceeding 0.04 g horizontal acceleration at the site in the next 50 years is 10 percent or less (Algermissen and Perkins, 1976).
- Reference indicates that the PGA level of 0.04g is too small to be a design consideration.

4.3.3 Rio Algom - Lisbon

Source: Dames & Moore (1980)

Design Criteria:

- In the stability analyses, maximum ground surface acceleration of 0.09 g is used as the estimated design value for the tailings deposit as it is based on data for sites with considerable depths of soil where the local amplification effects have already been included.
- For structures at the site found directly on rock, the value 0.05 g would be compatible with the 0.09 g value used to analyze the stability of the tailings.

4.3.4 Energy Fuels Nuclear-White Mesa

Source: White Mesa Mill License Application, Umetco (1991)

Design Criteria:

- Specific design number not present in available literature.
- Horizontal ground accelerations would not exceed 0.10 g but would probably range between 0.05 and 0.09 g.
- Estimated peak horizontal acceleration at a distance of 57 km away from the epicenter would be 0.07 g.

4.4 Wyoming

4.4.1 American Nuclear-Gas Hills

Source: N/A

Design Criteria:

Review of Docket suggests that as with many other Wyoming sites the seismic ground motion was considered to be so low that is had no impact on design.

4.4.2 Exxon-Highlands

Source: Exxon Minerals Co. (1978)

Design Criteria:

Put in UBC region 1 - very low seismic hazard. Seismic ground motion not included in design.

4.4.3 Kennecott-Sweetwater

Source: Minerals Exploration Co. (1982)

Design Criteria:

Horizontal acceleration for the site has been estimated to be less than 0.04 g (Algermissen and Perkins, 1976), thus not considered significant in design.

4.4.4 Pathfinder-Shirley Basin-Sweetwater

Source: Shirley Basin Mine Tailings Reclamation Plan, Hydro-Engineering (1993)

Design Criteria:

Horizontal acceleration = 0.025 g. Used in static and earthquake loading condition analysis.

4.4.5 Pathfinder-Lucky Mc

Source: Lucky Mc Mine Tailings Reclamation Plan, Hydro-Engineering (1992)

Design Criteria:

Seismic coefficient of 0.15g was used in pseudo-static stability analysis.

4.4.6 Petrotomics - Shirley Basin

Source: Environmental Report for Source Material Lic. SUA-551 Petrotomics Mill, Getty (1981)

Design Criteria:

Put in UBC zone 1. Not considered significant in the design.

4.4.7 Umetco-Gas Hills

Source: Embankment Stability Report, Water, Waste and Land (1993)

Design Criteria:

- Maximum acceleration on structures has been estimated at less than 0.04 g.
- Earthquake coefficient of 0.05 g was used in an end-of-construction, steady state and earthquake conditions analysis.

4.4.8 Union Pacific-Bear Creek

Source: Environmental Statement: Related to Bear Creek Project. Rocky Mt. Energy Co. (1977).

Design Criteria:

A seismic coefficient of 0.05g was used.

4.4.9 Western Nuclear-Split Rock

Source: Canonie Environmental "Liquefaction and Seismic Analysis Evaluation," 1977

Design Criteria:

- The postulated design seismic event is considered to have peak horizontal accelerations of about 0.08 g.

7.0 UTAH

7.1 Introduction

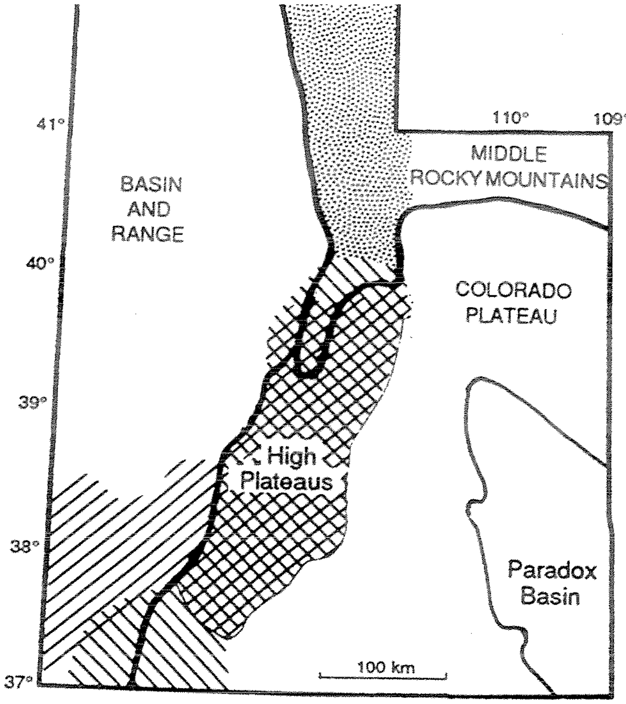
The Atlas Corporation Uranium Mill Tailings site, the Rio Algom Mining Company Lisbon Uranium Mill Tailings site, and the Umetco White Mesa Uranium Mill Tailings site are all located in the Paradox Basin. The Plateau Resources Shootering Canyon Uranium Mill Tailings site is located southwest of the Paradox Basin in the Henry Mountains Basin.

7.2 Regional Geology

Utah is subdivided into three major physiographic and tectonic provinces: the Basin and Range, Middle Rocky Mountains, and Colorado Plateau. The boundary between the Basin and Range and the other two provinces is a zone of transitional physio-tectonic characteristics (Fig. 7.1A).

Western Utah lies within the northern Basin and Range Province. The province is noted for its regularly spaced (20 to 50-kilometers apart), north-trending, elongate mountain ranges and intervening broad, sediment-filled basins. The ranges are bounded on one or, less commonly, both sides by major normal faults that have moderate to steep dips at the surface. Much of the region, known also as the Great Basin, is internally drained. The northeast corner of Utah lies within the Middle Rocky Mountains Province, a region of mountainous terrain, stream valleys, and alleviated structural basins. Principal geographic features of the Middle Rocky Mountains in Utah are the geologically dissimilar north-trending Wasatch Range and east-trending Uinta Mountains. The northern Colorado Plateau of southeastern Utah is distinguished by its relatively high, generally flat topography and deeply incised canyons. Bedrock of the Plateau is spectacularly exposed, whereas surficial deposits characteristically are thin, localized, or absent (Hecker, 1993).

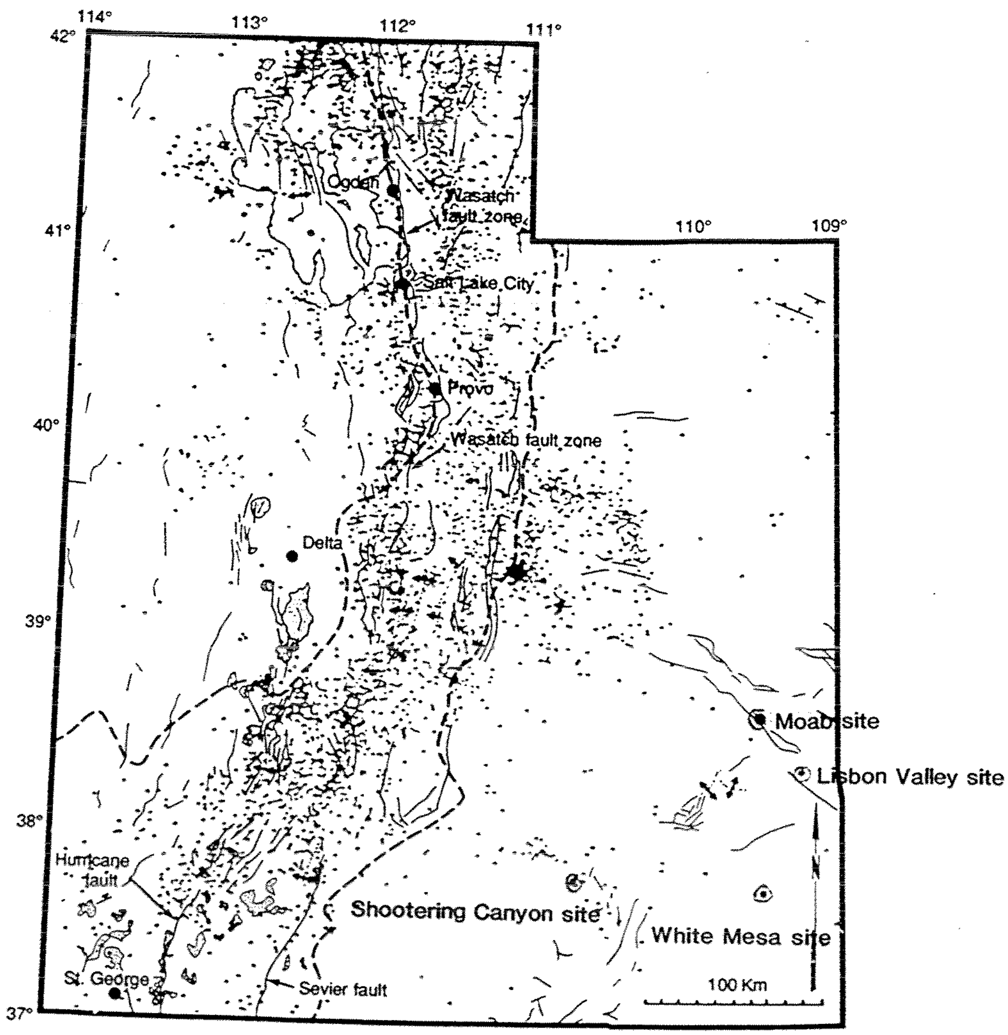
The distinctive physiography of the Basin and Range Province is the product of roughly east-west horizontal extension during the late Cenozoic (Zoback and Zoback, 1989). This latest landscape-shaping period of tectonic deformation is part of an ill-defined, extensively debated history of middle and late Cenozoic crustal rifting. One view maintains that extensional faulting has had a distinct two-part history: block-faulting on widely spaced, mainly high-angle normal faults, which is responsible for the existing topography and continues to the present; and an earlier phase (post -30 million years; pre-10 to -15 million years) of intense deformation associated with closely spaced low-angle faults (Zoback and others, 1981; Eaton, 1982). A quite different perspective is that low- and high-angle faults have formed concurrently as part of the process of extension on large-displacement, low-angle shear zones which penetrate deep into the lithosphere (Wernicke, 1981). With time, both faulting and predominately basaltic volcanism have tended to become concentrated in relatively narrow zones along the margins of the province (Christiansen and McKee, 1978).



A.

Figure U-1 *(A) Major physiographic boundaries in Utah (bold lines) with respect to the transition zone between the Basin and Range Province and (1) the Middle Rocky Mountains Province (stippled area) and (2) Colorado Plateau Province (hachured areas). Alternative interpretations of the Basin and Range - Colorado Plateau transition zone are indicated by hachure patterns (northeast-trending, after Stokes, 1977; northwest-trending, after Anderson and Barnhard, 1992). Area of overlap (cross-hachure pattern pattern) coincides with the High Plateaus region. The Paradox Basin is a major region of the Colorado Plateau. (B) Quaternary tectonic features (simplified from plates 1 and 2) and seismicity (1962-1989; magnitude > 2) of Utah with respect to the Basin and Range - Colorado Plateau - Middle Rocky Mountains transition zone (area between dashed lines). Seismicity from the University of Utah Seismograph Stations catalog (Susan J. Nava, written communication, 1990)*

(from Hecker, 1993)



B.

Figure 7.1a. Major physiographic boundaries in Utah; 7.1b. Major quaternary features in Utah

Block faulting, which is the hallmark of the Basin and Range Province, extends tens of kilometers into the Middle Rocky Mountains and Colorado Plateau Provinces, forming a 100 km-wide zone of transitional tectonics and physiography (Fig. 7.1A). This north-trending boundary zone coincides with the southern portion of the Intermountain seismic belt, a broad zone of diffusely distributed earthquake epicenters (Fig. 7.1B), and it is associated with geophysical characteristics that are consistent with active extension (Smith and others, 1989). Much of the transition zone lies beyond the regime of strongest basin-range deformation and, as a result, extensional structures overprint relatively intact compressional features formed during the Sevier orogeny. The structural fabric of the zone is largely a relict of eastward-directed, thin-skinned thrust sheets, portions of which appear to have accommodated movement in the reverse direction during basin-range extension (Hecker, 1993).

The physiographic boundary between the Basin and Range and Middle Rocky Mountains Provinces in Utah is considered to be the Wasatch Front, the prominent west-facing escarpment that follows the 340 km long Wasatch fault zone (Fig. 7.1B). East of the transition zone, the Colorado Plateau is a relatively coherent and tectonically stable block which has experienced 2 km of epeirogenic uplift during the Cenozoic (Morgan and Swanberg, 1985). The region is underlain by generally horizontal sedimentary strata, disrupted locally by early Tertiary Laramide basement-block uplifts and Oligocene igneous intrusions. The domal, fault-bounded uplifts have variable trends and include the east-trending Uinta Mountains north of the Colorado Plateau. The modern stress field of the Plateau interior was originally thought to be compressive (Thompson and Zoback, 1979; Zoback and Zoback, 1980). However, recent evidence from small-magnitude earthquakes indicates that, although differential stresses are apparently low and variable in magnitude, most of the region may be characterized by horizontal northeast-oriented extension occurring on a combination of normal and strike-slip faults (Wong and Humphrey, 1989; Zoback and Zoback, 1989). Outside of the Paradox Basin, the interior of the Colorado Plateau in Utah appears to be virtually unaffected by recent crustal deformation. Only a few areas have evidence, generally subtle or ambiguous, of minor amounts of possible Quaternary faulting (Hecker, 1993).

A zone of late Paleozoic and younger deformation within the Paradox Basin, a late Paleozoic depositional trough interior to the Colorado Plateau (Fig. 7.1A), is related to the mobility and solubility of evaporites. Major structures of the Paradox Basin include large salt anticlines and faults related both to late Cenozoic dissolutional collapse along the crests of the anticlines and to older, deep-seated tectonics. The structural grain of this subprovince has a northwest orientation, distinct from the western margin of the Colorado Plateau, where most faults trend north to northeast (Hecker, 1993).

7.3 Geology and Structure of the Paradox Basin

The Paradox Basin is characterized by several large anticlinal structures which are the result of regional folding and salt intrusion (Fig. 7.2). The origin of the folds and faults in the Paradox belt is considered to be related to stresses associated with Laramide tectonics and plastic deformation, flowage, and solution of relatively shallow salt deposits of Pennsylvanian age. Tertiary laccolithic intrusions in the La Sal Mountains have caused local radial uplift of pre-Tertiary rocks.

The dominant features are the diapiric salt anticlines. Many closely spaced faults parallel these diapiric structures. The rocks are tilted from gentle to vertical angles and strike mostly parallel to the major structures. Most of these faults have small displacement, but a few, such as the Moab fault, have large displacements (up to 790 m). Between the diapiric salt, the structure is relatively simple; the rocks are gently warped into synclines and are in some places cut by short faults of small displacement (Doelling, Oviatt, and Huntoon, 1988).

The most important faults in the region are the series of northwest-trending faults or flexures (Fig. U-3) that lowered surfaces to form the Paradox Basin (Szabo and Wengerd, 1975). These are presently buried by post-Pennsylvanian sedimentary rocks. They were intermittently active from

Mississippian to Triassic time and were probably reactivated in Tertiary time. In addition, northeast-trending lineaments were simultaneously developed across the region related to basement wrench-faulting (Hite, 1975). Most of the northwest-trending sub-salt faults have their downthrown blocks to the northeast (at least those with the greatest displacements), so that the deeper part of the Paradox Basin is on the northeast side. Seismic data suggest that they die out upward in the Paradox salt beds and most investigators show these faults as high angle normal faults (Doelling, Oviatt, and Huntoon, 1988).

During Tertiary time, lengthy faults with relatively large displacements were formed. McKnight (1940) thought that this faulting was the result of tensional stress that developed after regional compressional stress had gently folded the rocks. The tensional stress was the result of a relaxation at the end of a compressional tectonic phase and was undoubtedly relieved along the old buried "basement" faults. The tectonic fault ruptures were influenced by the salt; some rupturing proceeded directly through the thick salt bodies and other fractures were deflected to the margins. These Tertiary faults can be differentiated from the salt tectonic or dissolution faults by their greater displacement. Faulting induced solely by salt is principally due to collapse of strata above areas where the salt has been dissolved away. Tectonically induced stress that developed in the strata above the salt was relieved by faulting which mostly developed along the flanks of the thick salt accumulations (where the rocks would be weaker). These faults are presently intercalated with others created by salt dissolution.

The most prominent of the Tertiary tectonic faults is the Moab fault. It extends N45W from the Colorado River (southwest side of Moab Valley) for about 67 km, forming several curving branches to the northwest (Fig. 7.4). Dipping from 50 to 75 degrees to the northeast, it reaches a maximum displacement of about 790 m between the Arches National Park Visitor Center and Sevenmile Canyon. Like the Lisbon Valley fault zone to the south, the Moab fault is probably related to salt dissolution, but may have a tectonic component. Studies (Jones, 1959, Shoemaker and others, 1958) indicate that the Moab fault may extend below the salt, offsetting pre-Paradox Formation strata. An unusual saddle and gradient anomalies in Bull Lake age terrace remnants may reflect faulting. Furthermore, several small (10 cm) displacements were observed in the middle to late Pleistocene deposits. Fine-grained late Pleistocene to early Holocene sediments deposited along Bartlett Wash near the northern end of the Moab fault may indicate displacement-related ponding. If so, the sense of movement is opposite to that during the Mesozoic (Hecker, 1993). The age of most recent movement is Late Quaternary.

A series of northwest-trending faults cuts the steep southwest flank of the Moab anticline, north of Moab Valley (Fig. 7.9). These are probably adjustment faults that relieved stresses related to folding of the involved brittle sandstone units. The cross sectional exposure of Glen Canyon Group rocks at the south end of the Moab anticline shows the dips of these faults to range from 35 degrees to vertical, usually to the northeast, and down-dropped on the northeast toward the anticlinal axis. Part of the faulting may be due to local salt dissolution and such faults are mostly found adjacent to the Moab fault (Doelling, Oviatt, and Huntoon, 1988).

A regional compressional tectonic event folded rocks in the region in early to mid-Tertiary time, forming synclines between the salt anticlines and accentuating the diapiric salt anticlines. The Kings Bottom syncline trends N 55-60° W between Moab Valley (Moab anticline) and the Cane Creek anticline. The axis of the Cane Creek anticline is present to the southeast. Most of the faults in the synclines between the salt anticlines are short in length and have small normal displacements. In most cases it is impossible to ascertain if they are adjustments over salt or if they were formed during McKnight's (1940) Tertiary tensional episode.

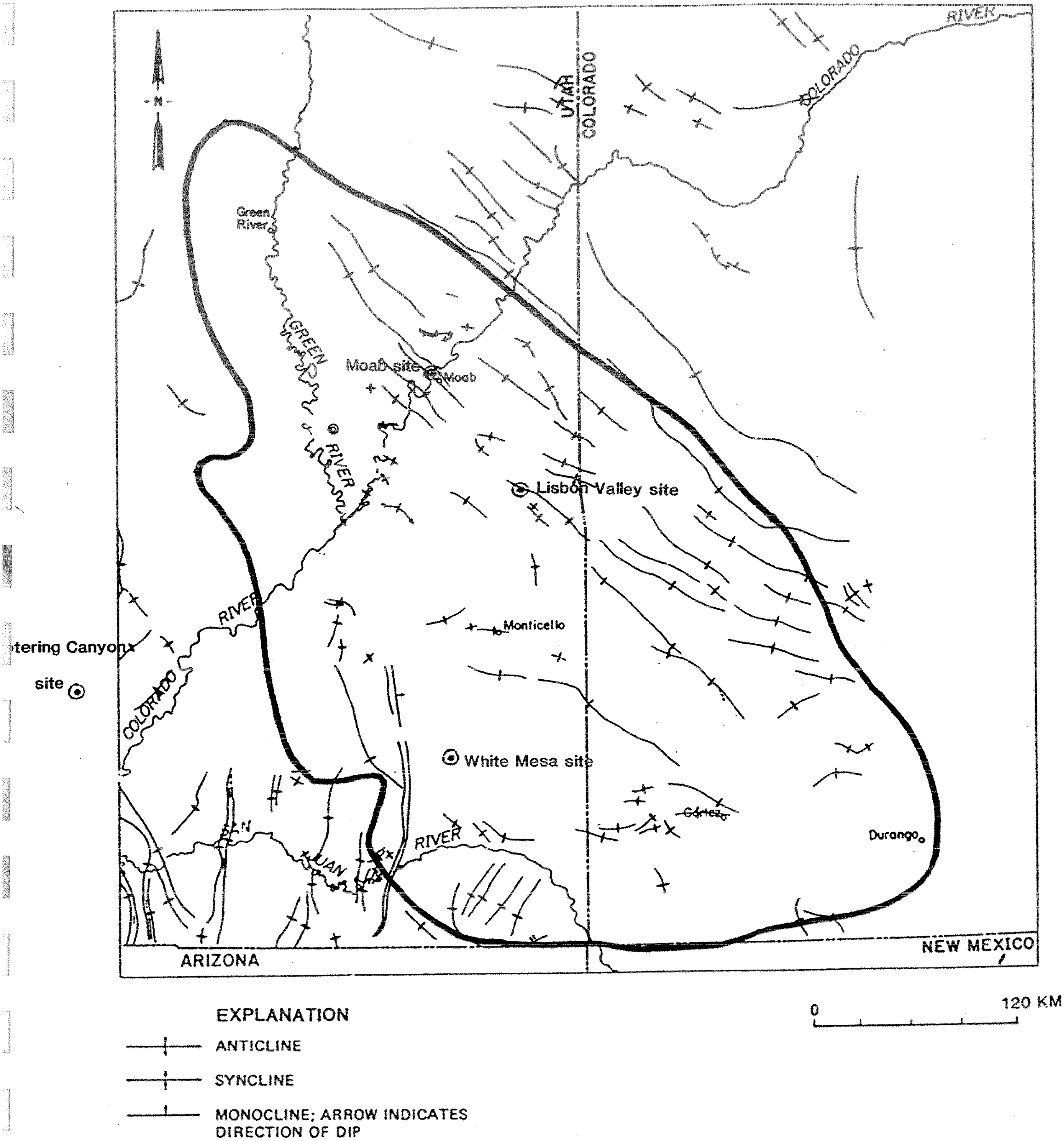
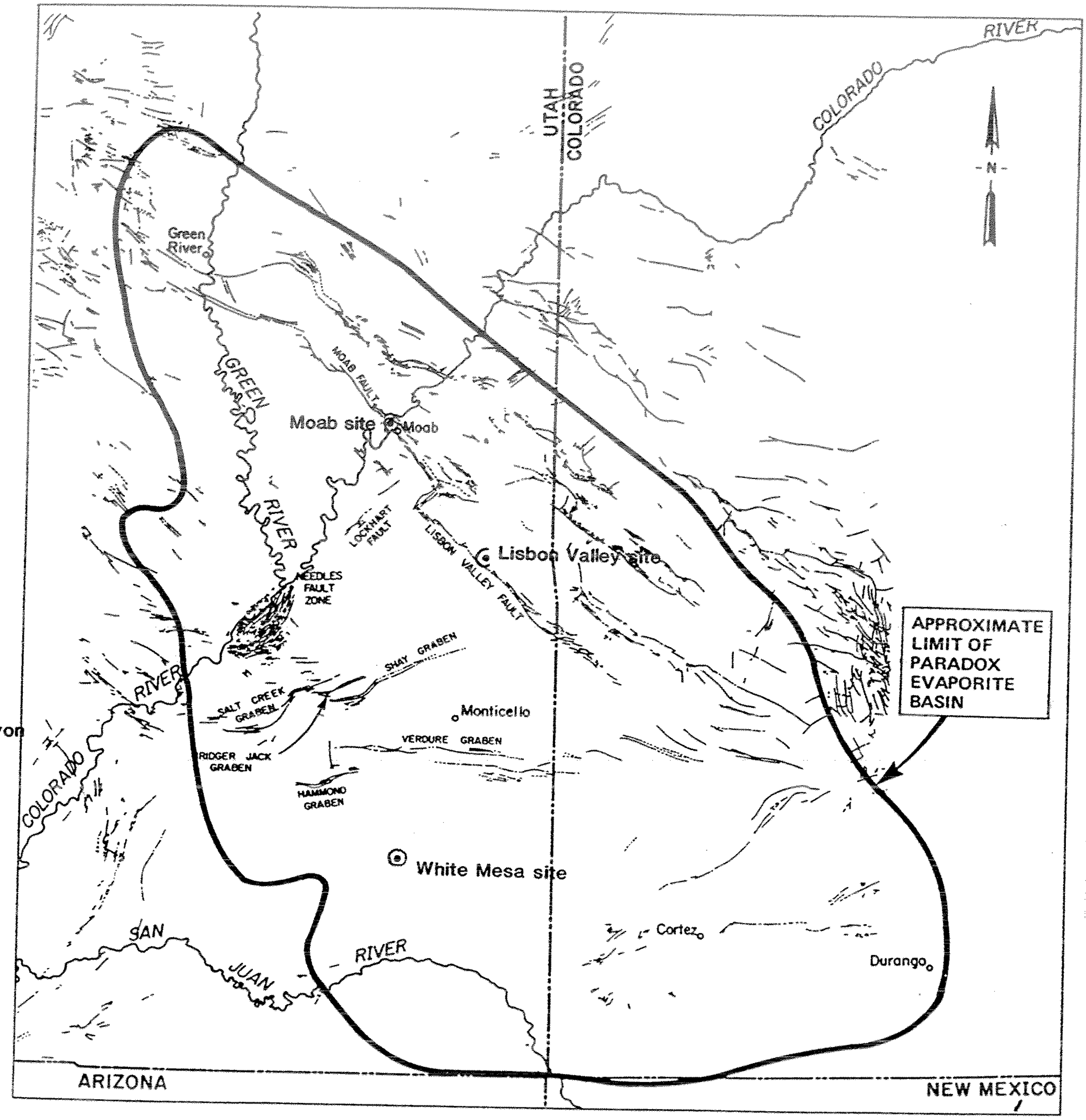


Figure 7.2 Folded structures of the Paradox Basin (from Kitcho, 1981).



EXPLANATION

FAULT, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED

0 120 KM

Figure 7.3 Faults of the Paradox Basin (from Kitcho, 1981).

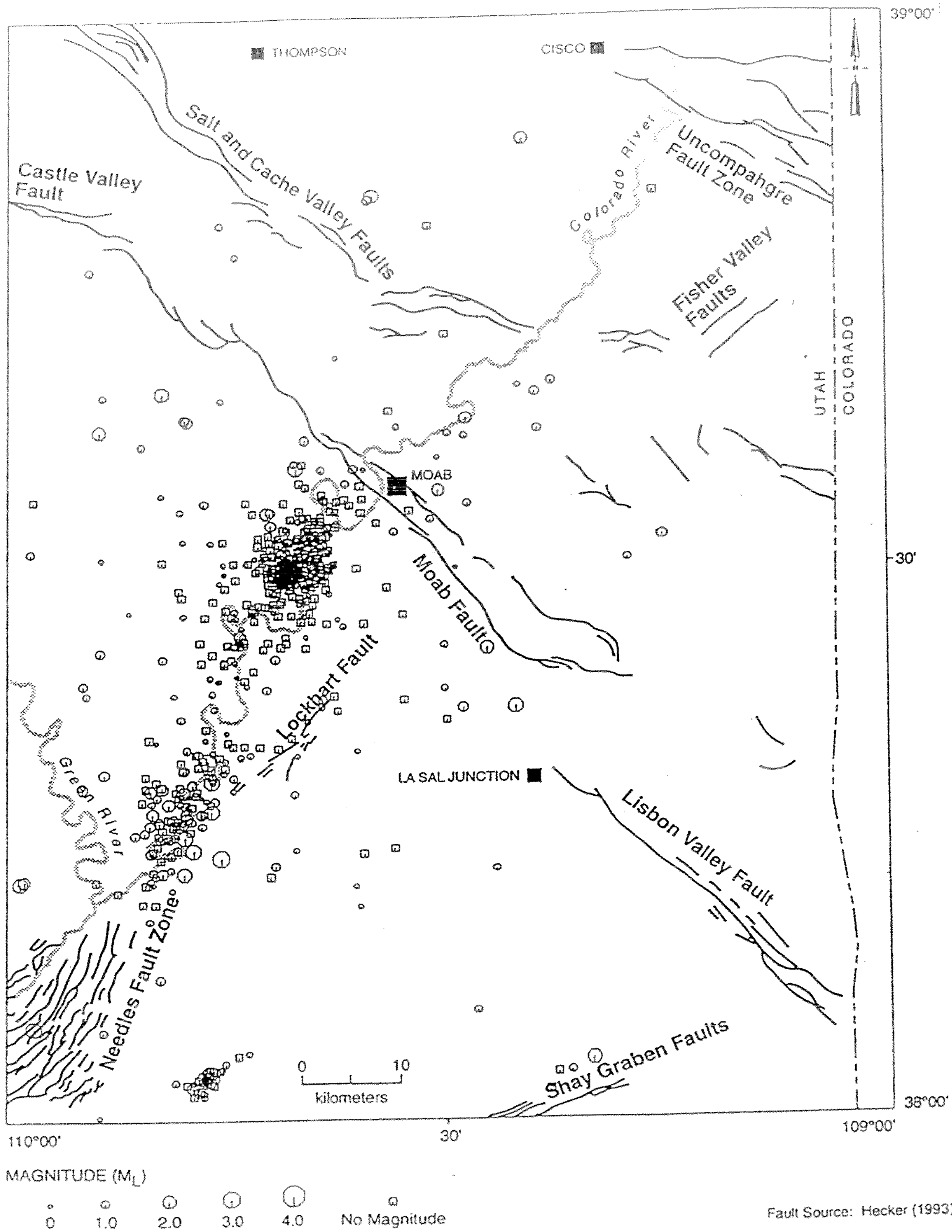


Figure 7.4 Seismicity, 1979-1993, and Late Quaternary faults of the northern Paradox Basin (from Woodward-Clyde Federal Services).

The Moab anticline, as opposed to the larger Moab salt anticline, clearly indicates participation in the compressional event. It trends N 45-50° W and extends from just north of the Colorado River for 9.6 km to about a 800 m north of Sevenmile Wash. Closely spaced paralleling faults have developed, especially along its southwest flank, on which only minor displacements have occurred. They represent minor movement on fractures initially formed as joints.

Prominent joints have formed as a result of the folding and are most pronounced in the brittle sandstone units A little movement has occurred on some, such as over the Moab anticline. These parallel the northwest trends of the folding and do not bend with the salt anticlines where they deviate from this trend(Doelling, Oviatt, and Huntoon, 1988).

7.4 Relationship of Earthquakes to Tectonic Structures

The majority of recorded earthquakes in Utah have occurred along an active belt of seismicity that extends from the Gulf of California, through western Arizona, central Utah, and northward into western British Columbia. The seismic belt is possibly a branch of the active rift system associated with the landward extension of the East Pacific Rise (Cook and Smith, 1967). This belt is the Intermountain seismic belt shown in Fig. 7.5 (Smith, 1978). It is significant to note that the seismic belt forms the boundary zone between the Basin and Range Great Basin Provinces and the Colorado Plateau - Middle Rocky Mountain Provinces. This block-faulted zone is about 75 to 100 km wide and forms a tectonic transition zone between the relatively simple structures of the Colorado Plateau and the complex fault-controlled structures of the Basin and Range Province (Cook and Smith, 1967).

Case and Joesting (1972) have called attention to the fact that regional seismicity of the Colorado Plateau includes a component added by basement faulting. They inferred a basement fault trending northeast along the axis of the Colorado River through Canyonlands. This basement faulting may be part of the much larger structure that Hite (1975) examined and Warner (1978) named the Colorado lineament (Fig. 7.6). This 2100 km long lineament that extends from northern Arizona to Minnesota is suggested to be a Precambrian wrench-Fault System formed some 2.0 to 1.7 billion years before present. While it has been suggested that the Colorado lineament is a source zone for larger earthquakes ($m = 4$ to 6) in the west-central United States, the observed spatial relationship between epicenters and the trace of the lineament does not prove a causal relation (Brill and Nuttli, 1983). In terms of contemporary seismicity, the lineament does not act as a uniform earthquake generator. Only specific portions of the proposed structure can presently be considered seismic source zones and each segment exhibits seismicity of distinctive activity and character (Wong, 1981). This is a reflection of the different orientations and magnitudes of the stress fields along the lineament. The interior of the Colorado Plateau forms a tectonic stress province, as defined by Zoback and Zoback (1980), that is characterized by generally east-west tectonic compression. Only where extensional stresses from the Basin and Range province of the Rio Grande rift extend into the Colorado Plateau would the Colorado lineament in the local area be suspected of having the capability of generating a large magnitude earthquake (Wong, 1984).

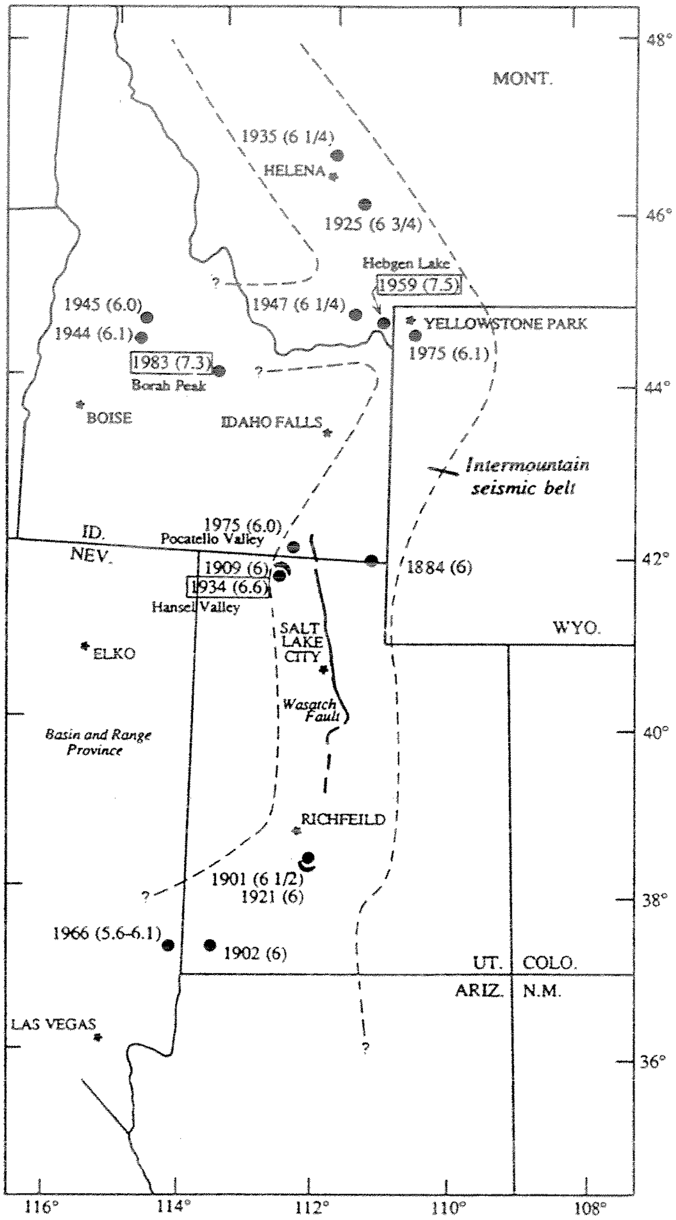


Figure 7.5 Index map of the intermountain seismic belt and historical earthquakes of magnitude 6.0 and greater (solid circles) (from Arabasz and other, 1991).

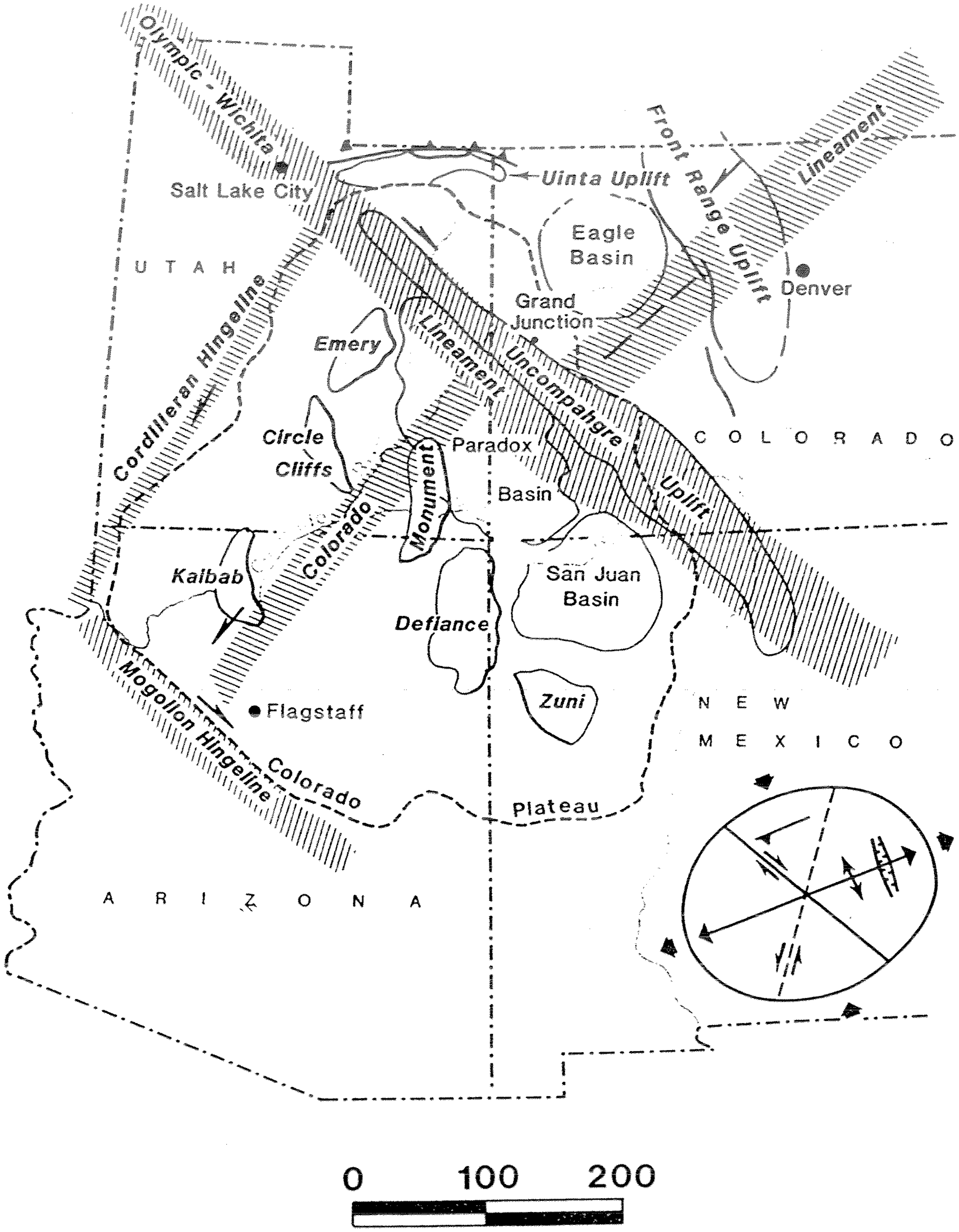


Figure 7.6 Map showing location of Colorado lineament, in relation to the Paradox Basin (from Baars and Stevenson, 1981).

Hazard Analysis for Random Earthquakes

The White Mesa site is located in the Paradox Basin approximately 115 km south of the Atlas site. The discussion given in the Section 7.5.2 for the random earthquake hazard analysis for the Atlas site applies for the Umetco site. The hazard curves are given in Fig. 7.12. Because no major basement faults are postulated to exist in the vicinity of the Umetco site, we select $M_u = 5.75$ as the most appropriate hazard curve to use for the WHITE MESA site. This leads to slightly lower ground motion estimates for the Umetco site. We see from Fig. 7.12 that at a PE level of 10^{-4}, the estimate for PGA is about 0.12g and at a PE level of $5x10^{-4}$ the estimated PGA is 0.05g.

7.7.4 Conclusions

There appear to be no faults in the vicinity of the site which could introduce surface rupture through the site and tailings piles. Our estimate for the range of appropriate PGA to use is 0.05 to 0.12g. The (see Section 4.3.4) facilities appear to have been designed to a PGA of 0.1g. However, the actual design calculations need to be reviewed to determine if that is the case, or if that is not possible an assessment of the initial facilities is needed to determine that sufficient margins exist.

7.8 Plateau Resources Limited Shootering Canyon Site

7.8.1 Introduction

Plateau Resource's Shootering Canyon site is located in southeastern Utah near Mount Ellsworth in the Henry Mountains Basin of the Colorado Plateau (Figs. 7.3 and 7.15). Most of the province exceeds 1500 m in elevation and reaches a maximum elevation of more than 3900 m. About 90 percent of the province is drained by the Colorado River and its tributaries. The mill itself is located on a low mesa, and the tailings impoundment rests in a small drainage basin which drains into Shootering Creek.

7.8.2 Local Geology

The site is located in rugged terrain about 8 km southwest of Mount Ellsworth (Fig. 7.15). The bluffs and mesas in the vicinity are typical of the landscape that characterizes much of southeastern Utah. The tailings impoundment site is in a small, isolated catchment that presently drains into Shootering Creek.

The geologic Formations on the site are generally rather simple structurally, with sediments dipping gently westward at about 2 degrees . To the east of the site the sediments tilt up sharply against the diorite porphyry intrusion of Mount Ellsworth, which has forced the sediments up to angles averaging approximately 40 degrees. Some local structural warping has occurred in the area, apparently as an accommodation to the necessary crustal shortening brought on by the intrusion of the laccoliths. Some of this warping may be seen in the minor folding in the lower members of the Summerville and upper Entrada Formations under the butte west of the tailings impoundment site and along the east edge of Shootering Creek, as well as in the upper Summerville immediately underlying the Salt Wash Member of the Morrison in the vicinity of the Plateau Resources Limited mines. The axis of this warp or fold appears to parallel Shootering Creek for some distance and may have oriented the flow of the creek during past geologic time.

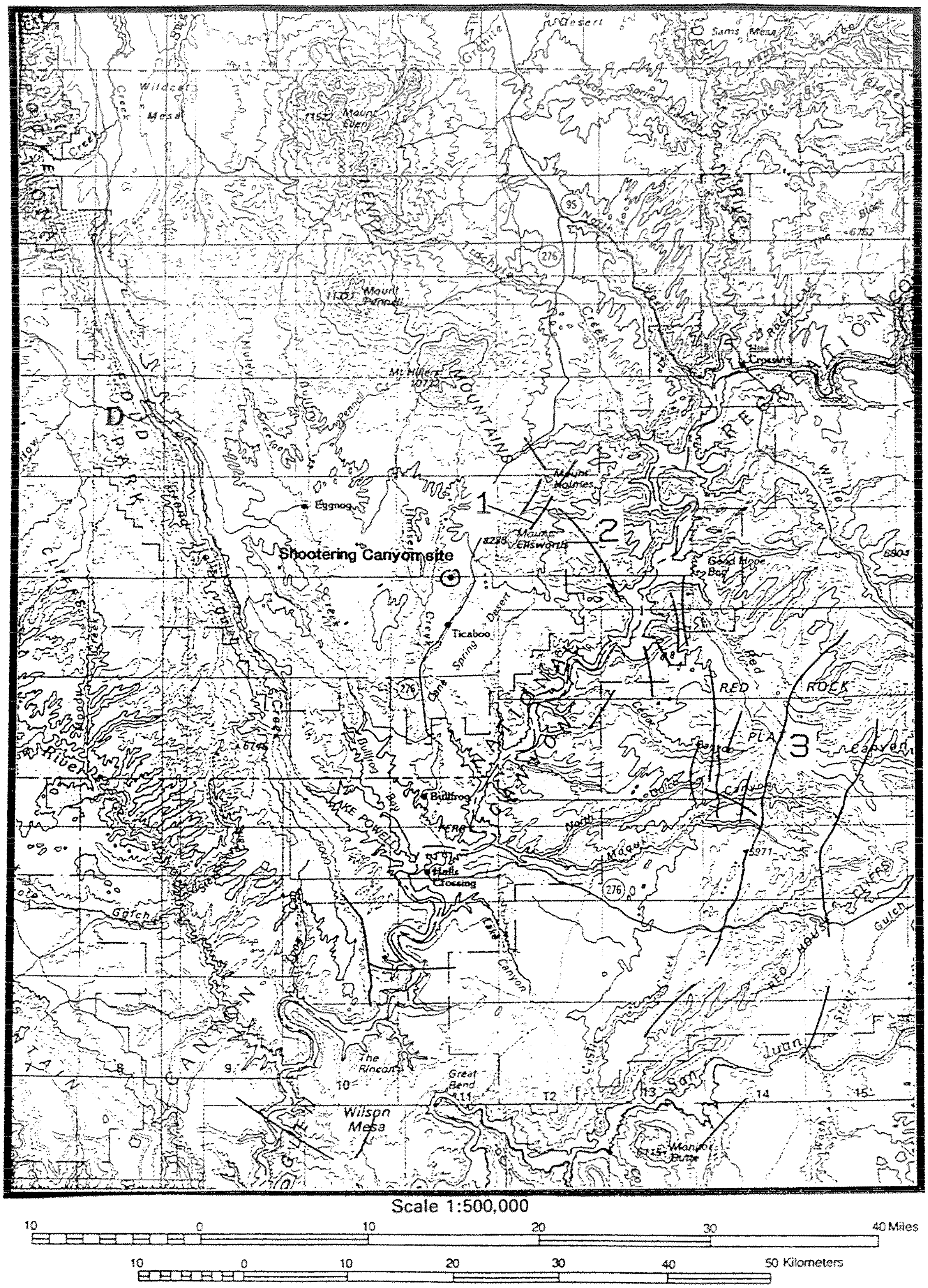


Figure 7.15 Location of the Plateau Resources Shootering Canyon site, with faults having potential Quaternary movement (from Hecker, 1993).

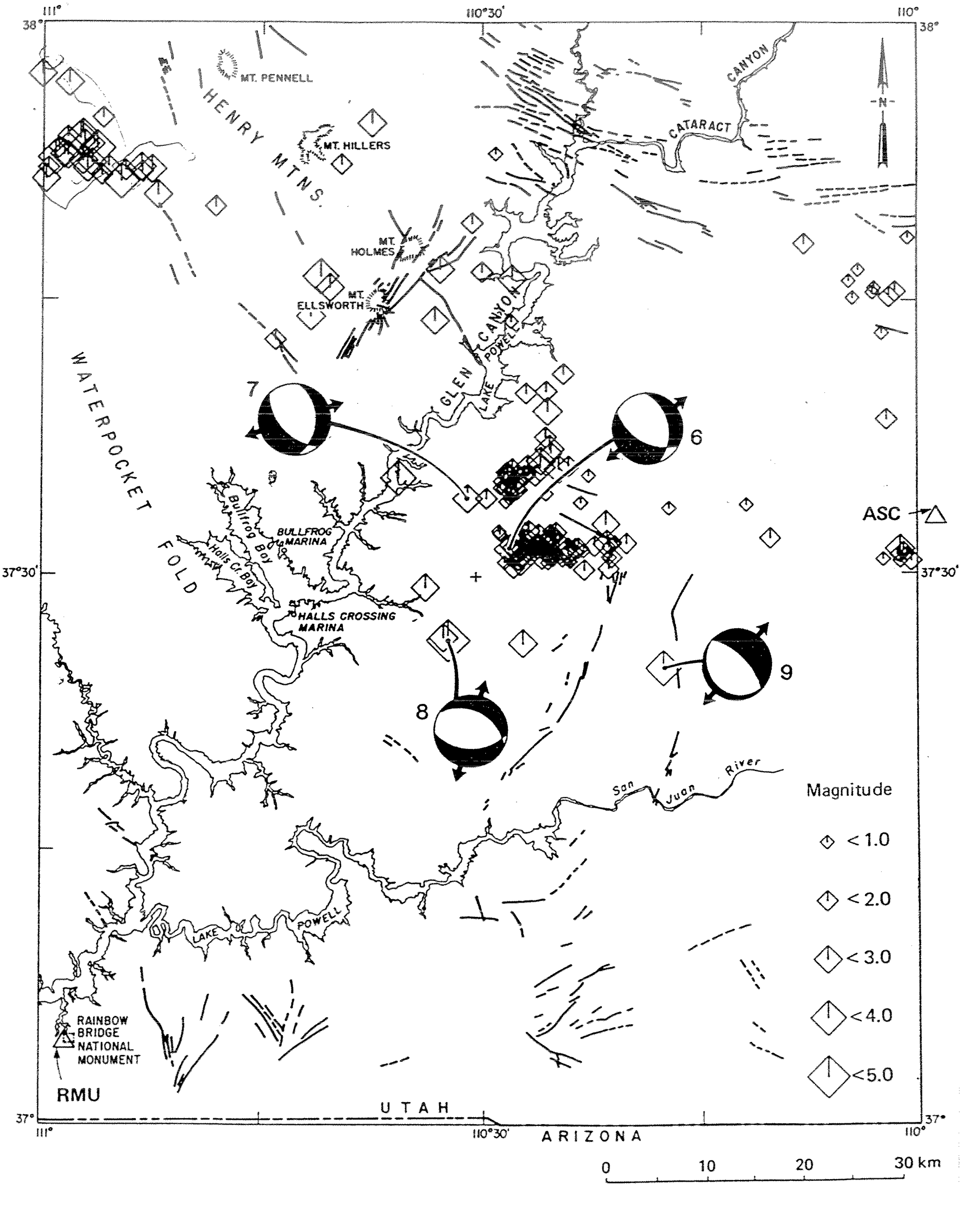


Figure 7.16 Seismicity and focal mechanisms of the Glen Canyon region, July 1979-December, 1986 (from Wong and Humphrey, 1989).

7.8.3 Geology and Fault Characteristics of the Henry Mountains Basin

The Henry Mountains Basin is one of seven major basins that make up approximately one-third of the Colorado Plateau. The basin is bounded on the east by the Monument Uplift, and on the west by the north/south trending Waterpocket Fold. The only faults in the basin are near Mount Holmes, Mount Ellsworth, and the San Rafael Swell. These faults trend west-northwest to east-southeast, and displacements along them range from several meters to several hundred meters.

The closest Quaternary fault to this site is located ~8.8 km N33E (Fig. 7.15). This fault segment is only 4 km total length and strikes N34E. There are only short segments associated with the fault, all near Mount Ellsworth and Mount Holmes. Another longer fault is located east of the site, with a closest approach of 12 km. This fault is ~10.5 km long and strikes N32W. All of these faults are within a 16 km radius of the site, and have been determined to have potential Quaternary movement (<1,650,000) yrs (Hecker, 1993).

Within a 32 km radius of the site are 9 additional short (<11 km long) segments, all of which strike generally N-S, and are located SE of the site. The longest fault with Quaternary(?) movement is located SE of the site, with a closest approach of 34.5 km. The fault is composed of 3 segments, with a cumulative total length of 43 km. The fault strikes N20E.

The regional seismicity map (Fig. 7.16) shows the greatest amount of activity associated with the relatively short faults located 24-40 km SE of the site. The activity is generally < 3.0 magnitude. There are a few "random" events just north of the site (<3 km) with magnitudes of <4.0. These events do not appear to be associated with known surface structures. To the NW, there is a series of 2.0-4.0 events that appear to trend NW/SE. Wong and Humphrey (1989) mapped several short faults near the epicenters (NW strike), but these did not appear on the Hecker (1993) map. The largest nearby event was a magnitude <5.0, and is located ~33.5 km S25E of the site (Wong and Humphrey, 1989).

7.8.4 Seismicity and Earthquake Hazard Analysis

There is a relatively poor correlation between mapped Quaternary faults and mapped faults in general and the regional seismicity. However, there are several centers of relatively high activity (compared to the rest of the Colorado Plateau) around the Plateau Resources site. As discussed in the geology section, there are a number of relatively small Quaternary faults around the site. The fault plane solutions presented by Wong and Humphrey (1989) suggest that northwest trending faults appear to be most favorably oriented with the regional stress field.

Deterministic Analysis

We have singled out three faults for analysis. The first fault which lies approximately 9 km from the site is the nearest to the site. The other two faults are possible Quaternary faults which could have some activity associated with them. They were selected because they were the largest two Quaternary faults around the site. See Fig. 7.15 for the relative location of these faults. They are labeled 1, 2, and 3.

Fault 1

Fault 1, which is approximately 9 km from the site, trends to the northeast and is not favorably oriented with the regional stress field. Hence if it has an earthquake we would expect it to be somewhat smaller than the largest one could expect from a 4 km long fault. The Wells and Coppersmith correlation indicate that a 4 km fault could lead to M~5.8 earthquake. Because of its unfavorable orientation with the stress field, we would expect a smaller earthquake, say M~5.5. The 1-sigma estimate for PGA for a M<5.5 earthquake located on this fault at this site is 0.3g. For the larger M~5.8 event, we use the median estimate to account for its much lower probability of occurring. This leads to an estimate for PGA of 0.19g.

Fault 2

Fault 2 trends northwest hence it is favorably oriented with the stress field. The fault is approximately 10 km long. If the entire fault ruptured in a single event this could lead to a M~6.25 earthquake. If we assume only one-half of the fault ruptures, this leads to a M~5.9 earthquake. The fault is approximately 13 km from the site. The 1-sigma estimate for PGA at the site from a M~5.9 earthquake located on what we have labeled fault 2 is 0.28g. Because of its lower probability of occurrence, we use the median estimate for M_u~6.25 which is 0.19g. The median estimate for a M~5.9 event is 0.16g.

Fault 3

This fault is almost due east of the site. The fault is listed as a possible Quaternary fault by Hecker (1993) and could have some seismicity associated with it. The fault trends northeast and hence not in the most likely direction for earthquakes. Thus it is not a likely candidate for earthquakes. However, it is included in the analysis for completeness. The fault has a length of approximately 23 km and lies approximately 35 km from the site. If we assume the entire fault ruptured, this would give rise to a 6.7 earthquake. This is larger than might be expected, at least based on the historical record. However, as we pointed out in the methodology section, it is not clear that the historical record gives a good indication of the largest event that could occur because we expect that the largest possible event would be a characteristic earthquake governed by its own characteristic return interval. If we use a distance of 35 km and M = 6.7 in the Joyner - Boore model, we get 1-sigma estimate of 0.14g.

Random Earthquake Analysis

Based on the geology and pattern of seismicity around the Plateau Resources site, we selected a source zone which seemed reasonable to use to develop our recurrence model. As described in the methodology section we applied Stepp's method to try and determine the completeness of the earthquake catalog. There is no data in the catalog before 1963 for the selected zone. Stepp's method indicated that the catalog was reasonably complete for events of about magnitude 3 for the last 10 to fifteen years. The smaller events did not appear to be complete. Fig. 7.17 shows the data for the last 30 years. Also shown is the truncated exponential model that we use with $M_u = 5.75$. The model appears to fit the data reasonably well. The simple Richter form of the model normalized to a per year basis is

$$\log N = 2.43 - 0.92M$$

We used this recurrence model to develop the seismic hazard for the region around the Plateau Resources site as outlined in our methodology section. Fig. 7.18 gives the hazard curves for values of M_u = 5.5, 5.75, 6.25, and 7. We see from the hazard curves that at a PE level of 10^{-4} the PGA varies between 0.17g to 0.24g. As there are no major faults in the vicinity of the site our preferred choice for M_u is 5.75. This leads to 0.19g estimate for the ground motion at the site from the random earthquake at a PE level of 10^{-4}. At a PE level of 5×10^{-4} the PGA varies between 0.08g to 0.12g depending upon the choice of M_u with a value of 0.09g at $M_u = 5.75$.

7.8.5 Conclusions

There appear to be no faults through the site that could cause problems. Our deterministic analysis lead to an estimate for PGA of 0.16g to 0.3g. The random earthquake analysis gives a lower estimate of 0.17 g to 0.24 g. There is a possibility of a larger earthquake in the vicinity of the site, which is included in the analysis for random earthquakes, however the likelihood is sufficiently low that in our opinion the M~5.5 earthquake meets our criteria.

As indicated in Section 4.3.2, we were unable to determine what the facilities were designed for. It appears that the Licensee considered the postulated ground motion at the site from an earthquake to be so low that it was not a design consideration. In view of our estimates for PGA this is of considerable concern and the critical facilities need to be evaluated to determine if sufficient margins exist or if some remedial action is required.

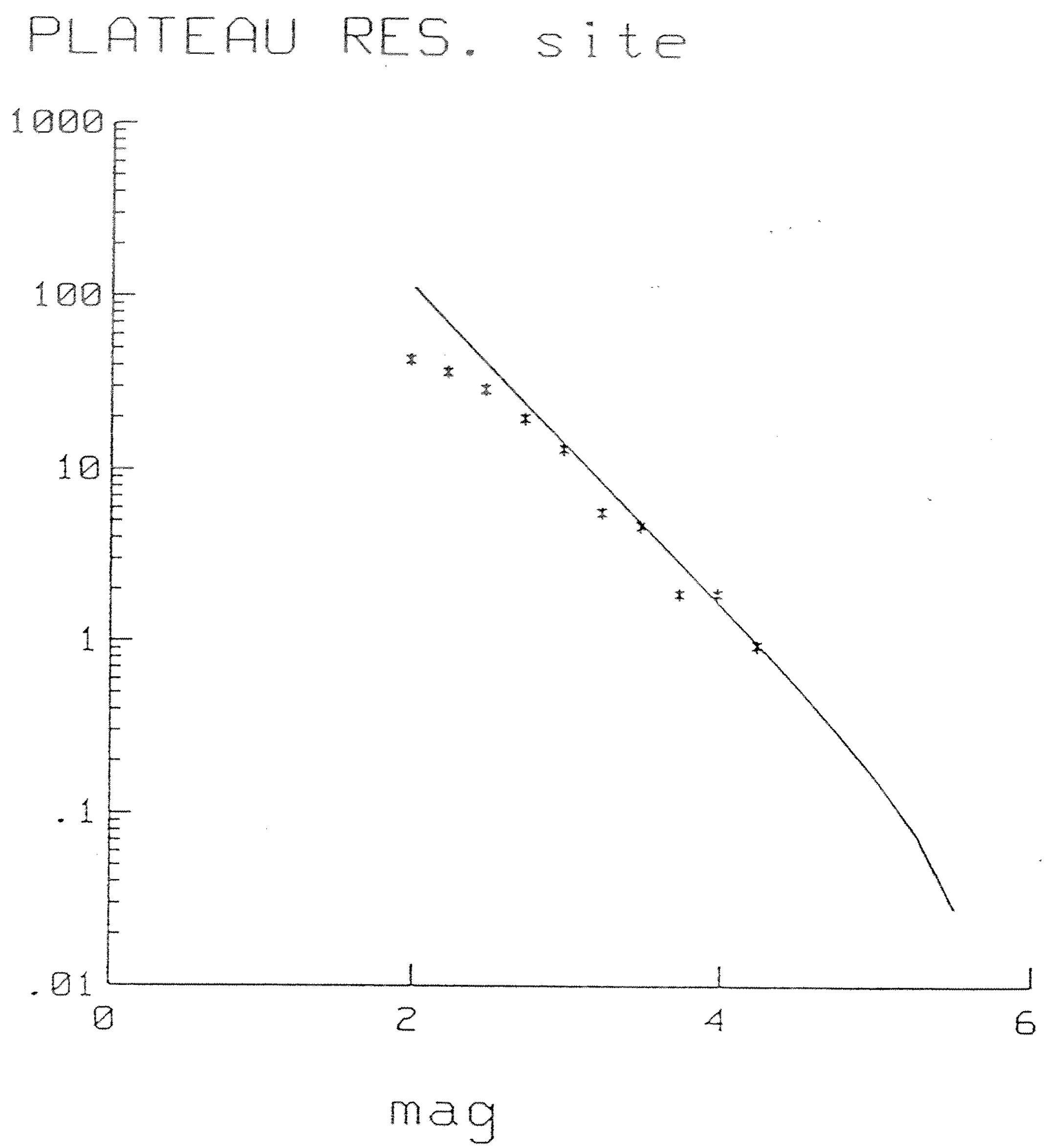


Figure 7.17 Fit of the truncated exponential model with $M_u = 5.75$ used in the hazard analysis for random earthquakes around the Plateau Resources Site. The data shown are for the last 30 years.

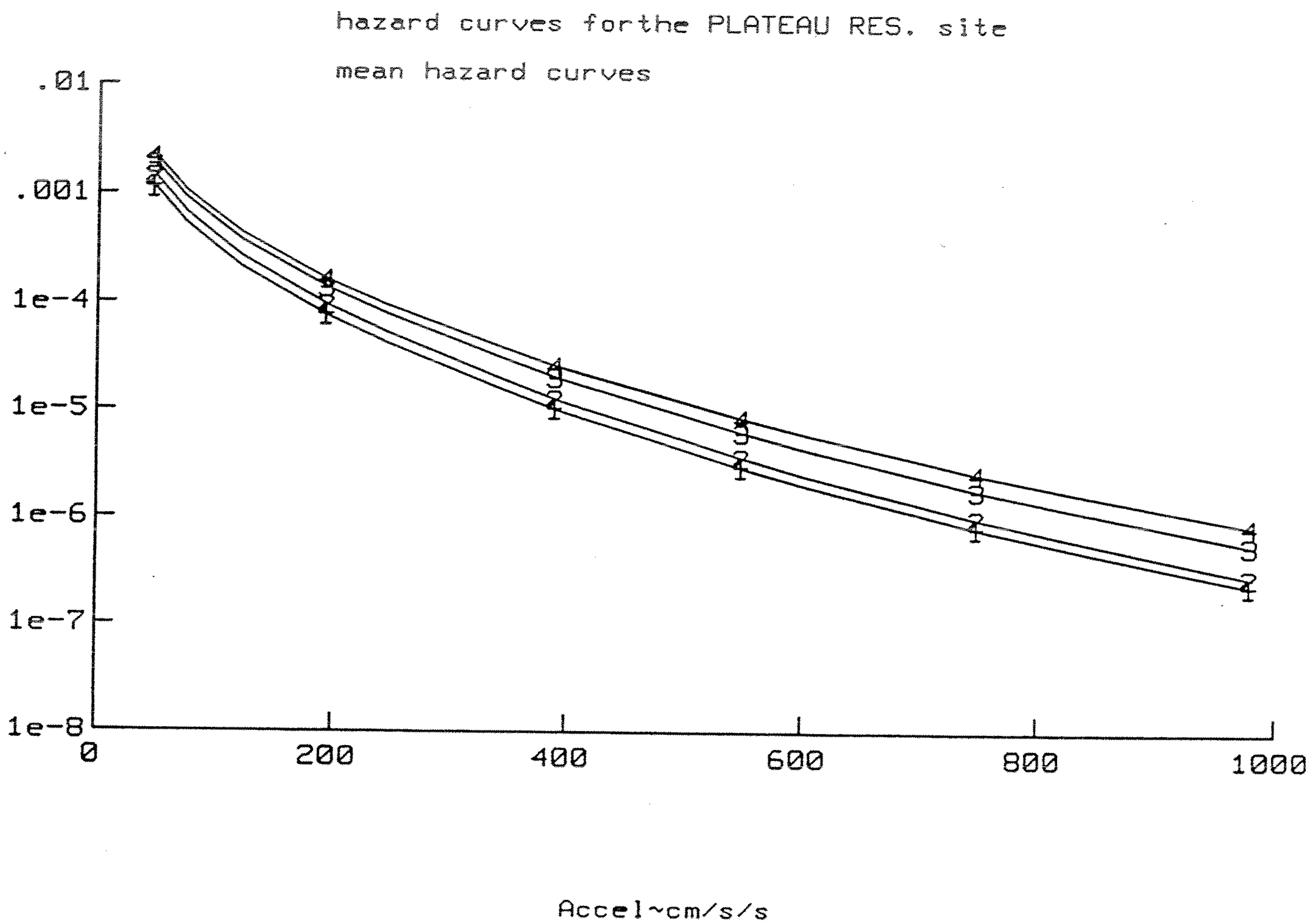


Figure 7.18 Hazard for peak ground acceleration (PGA) for the Plateau Resources Site for various best estimates for M_u . 1—1 $M_u = 5.5$, 2—2 $M_u = 5.75$, 3—3 $M_u = 6.25$, 4—4 $M_u = 7$.