STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

In the Matter of:	)	
PROPOSED AMENDMENT TO 20.6.2 NMAC (Copper Rule)	)	No. WQCC 12-01(R)

WRITTEN TESTIMONY OF JAMES C. SCOTT

I. BACKGROUND

My name is James C. Scott. I am a Principal Geotechnical Engineer with URS. I have worked in this capacity for the past 36 years. I have a Bachelor of Science degree in engineering from Arizona State University (1975) and a Master of Science in Civil Engineering degree from Purdue University (1977). I am a registered Professional Engineer in New Mexico, Colorado, Arizona, and British Columbia.

I have been involved with engineering analyses and design for many types of development, operation, reclamation, and closure projects for the mining industry. I have managed and participated in numerous projects that have included geotechnical investigations, site characterizations, siting and design, and construction observation/oversight of mine processing and mine waste facilities from mills to tailing storage impoundments. My project experience includes services for base metals, precious metals, phosphate, coal, uranium, and oil shale resources.

My New Mexico mining project experience also includes engineering and design work at the Chino Mine, Cobre Mine, Tyrone Mine, Hidalgo Smelter, Alamitos Canyon Mine, Questa Mine, York Canyon Mine, and Four Corners Generating Facility. In 2006, I was the project peer reviewer and URS Principal-In-Charge for the historical Hurley tailing impoundments reclamation project at the Chino Mine.

I have been the project engineer/project manager on seven dams in Grant County, New Mexico subject to jurisdiction of the New Mexico State Engineer. These include the following dams: (1) Chino Tailing Pond No. 7 (1987-present); (2) Chino Reservoir No. 3A

(1987-1989); (3) Chino West Dump Seepage Retention Structures, Dam Nos. 10 and 11 (1990-1991); and (4) Cobre Mine Stormwater Containment Facilities Site Nos. 1, 2, and 3 (2001-2003).

I am currently the URS Principal-In-Charge for work at the Bagdad Mine in Arizona which has three centerline method tailing impoundments: Mammoth (1,000 acres, active); Upper Mammoth (990 acres, under construction); and Mulholland (515 acres, inactive). I am the engineer-of-record for the new Upper Mammoth tailing dam (494 million tons storage) that is currently under construction. A copy of my current Curriculum Vitae showing my professional training, certifications, professional affiliations, and publications is attached as Exhibit Scott-A.

I am familiar with the proposed Copper Mine Rule in this matter and participated in stakeholder meetings that preceded its issuance. Namely, I participated in the May 2012 and June 2012 Technical Committee Presentation and Copper Rules Advisory Committee meetings in Albuquerque and Santa Fe. I made presentations at those meetings that were titled: (1) Tailing Dam Design, Construction, and Operation (May 2012) and (2) Closure Discussion Tailing Dams and Mine Rock Stockpiles (June 2012). Copies of these presentations are attached as Exhibit Scott-B.

My direct testimony will focus on the portions of the proposed Copper Mine Rule that apply to tailing dam design, construction, operation, and closure. I also will discuss mine rock stockpiles. My written testimony incorporates the language of the proposed Copper Mine Rule from Attachment 1 to the New Mexico Environment Department's (NMED) Petition in this matter dated October 30, 2012 (Proposed Rule). This language is incorporated into my testimony for ease of reference, and so that if any changes to the Proposed Rule are considered by the Water Quality Control Commission (WQCC), the record is clear regarding the exact language to which my testimony applies.

II. <u>TAILINGS IMPOUNDMENT FACILITIES (20.6.7.22 NMAC)</u>

I will address the design, construction, operation, and closure of conventional, large unlined copper tailing impoundments in the southwestern United States, and specifically in New Mexico. The Proposed Rule defines "tailings" and "tailings impoundments" as follows:

20.6.7.7 DEFINITIONS:

A. Terms defined in the Water Quality Act and 20.6.2.7 NMAC shall have the meanings as given in such.

B. A term defined in this part shall have the following meaning.

. . . .

(57) "Tailings" means finely crushed and ground rock residue and associated fluids discharged from an ore milling, flotation beneficiation and concentrating process.

(58) "Tailings impoundment" means an impoundment that is the final repository of tailings.

These are accurate and reasonable definitions of these terms. Tailing are crushed rock particles that are transported hydraulically in a slurry form to a tailing impoundment or storage facility. The tailing solids are a mixture of sand, silt, and clay size particles. Tailings are sent to a tailing impoundment for disposition.

My testimony will focus on the following topics relevant to tailing, tailing impoundments, and the Proposed Rule: (A) New Mexico Office of the State Engineer (NMOSE) Dam Safety Design and Operation Criteria; (B) a description of the design and operation of Tailing Pond No. 7 at the Chino Mine – the only currently active copper tailing storage facility in New Mexico; (C) state-of-the-practice design, construction, and operation of conventional copper tailing impoundments; and (D) closure of tailing impoundments.

A. NMOSE Design and Operation Criteria

The requirements applicable to tailing impoundment facilities are outlined as follows in 20.6.7.22 NMAC:

20.6.7.22 REQUIREMENTS FOR COPPER CRUSHING, MILLING, CONCENTRATOR, SMELTING AND TAILINGS IMPOUNDMENT FACILITIES

A. Engineering design requirements. At a minimum, the following requirements shall be met in designing crushing, milling, concentrating, smelting and tailings facilities at copper mine facilities unless the applicant or permittee can demonstrate that an alternate design will provide an equal or greater level of containment.

. . . .

(4) **New tailings impoundments.** Tailings impoundments shall be designed according to the following requirements.

(a) The applicant shall submit design plans signed and sealed by a licensed New Mexico professional engineer along with a design report that describes how the following features were considered in developing the design plans: . . .

In New Mexico, all tailing impoundments are under the jurisdiction of NMOSE. The applicable NMOSE regulations are attached as Exhibit Scott-C. As these regulations demonstrate, NMOSE has developed criteria concerning the design, construction, operation, and closure of tailing impoundments and dams. New Mexico's design procedures and criteria for dams are, in my opinion, second to none in the western United States. Their design criteria include the following: hazard potential classification (low, medium, or high); hydrologic analyses (consideration of how the dam will perform under flood conditions); geotechnical field and laboratory investigations; foundation conditions (geotechnical and geological assessment of the site); seepage analysis (effects of seepage and internal drainage and the potential for internal erosion); embankment stability (static and seismic stability analyses); surface water diversion channels (design flood hydrographs and sizing); design report (construction drawings, specifications, and cost estimate); construction completion report (progress reports, as-builts, certificate of completion); operation and maintenance manual (documents information for operation, maintenance, and monitoring the dam); and downstream conditions (emergency action plan developed including dam break analysis and flood inundation maps). In addition, NMOSE's design review checklists provide the owner/designer a clear path to successful dam projects (*See* Exhibit Scott-D). NMOSE's detailed regulations for tailing impoundments and dams will work in tandem with the Proposed Rule to ensure that tailing impoundments are properly designed, constructed, operated, and closed.

B. <u>Design and Operation of Tailing Pond No. 7 at the Chino Mine</u>

Tailing Pond No. 7 at the Chino Mine demonstrates that these criteria are reasonable and practical, as it has been designed, permitted, constructed and operated under both the NMOSE regulations and the WQCC's discharge permit regulations under the Water Quality Act. It also demonstrates how these criteria work in tandem with NMOSE regulations to ensure safe design and operation. An innovative tailing disposal facility, Chino Pond No. 7, was commissioned at the Chino Mines Company property in 1988. Three notable features of this project were the use of site specific rainfall data for the calculation of the probable maximum flood (PMF); a flood protection berm was constructed to protect the facility from erosion in the event of rainfall occurrences in excess of the 100-year storm; and, lastly, state-of-the-practice high density polyethylene pipe (HDPE) and suspended cyclone clusters used for distribution and deposition of the tailing, respectively.

A variety of construction method options were evaluated including centerline, downstream, and upstream construction methods. The upstream deposition method utilizing cyclones was chosen for a 1,600 acre site located adjacent to and south of Chino's existing tailing ponds. Figures 1, 2, and 3 show a plan of the Pond No. 7 tailing storage facility. Key features of the facility include the following: 24,000-foot perimeter; 9,000-foot long diversion channel along the east side of the impoundment; 4,200-foot long starter dam near the southeast corner; and a seepage interceptor well system south of the impoundment. A synthetic liner system for this facility was not considered due to the size of the facility, foundation drainage, and the lack of proven technology to design, maintain, and prevent clogging of a granular drainage system on top of the liner as necessary to maintain stability consistent with NMOSE requirements.

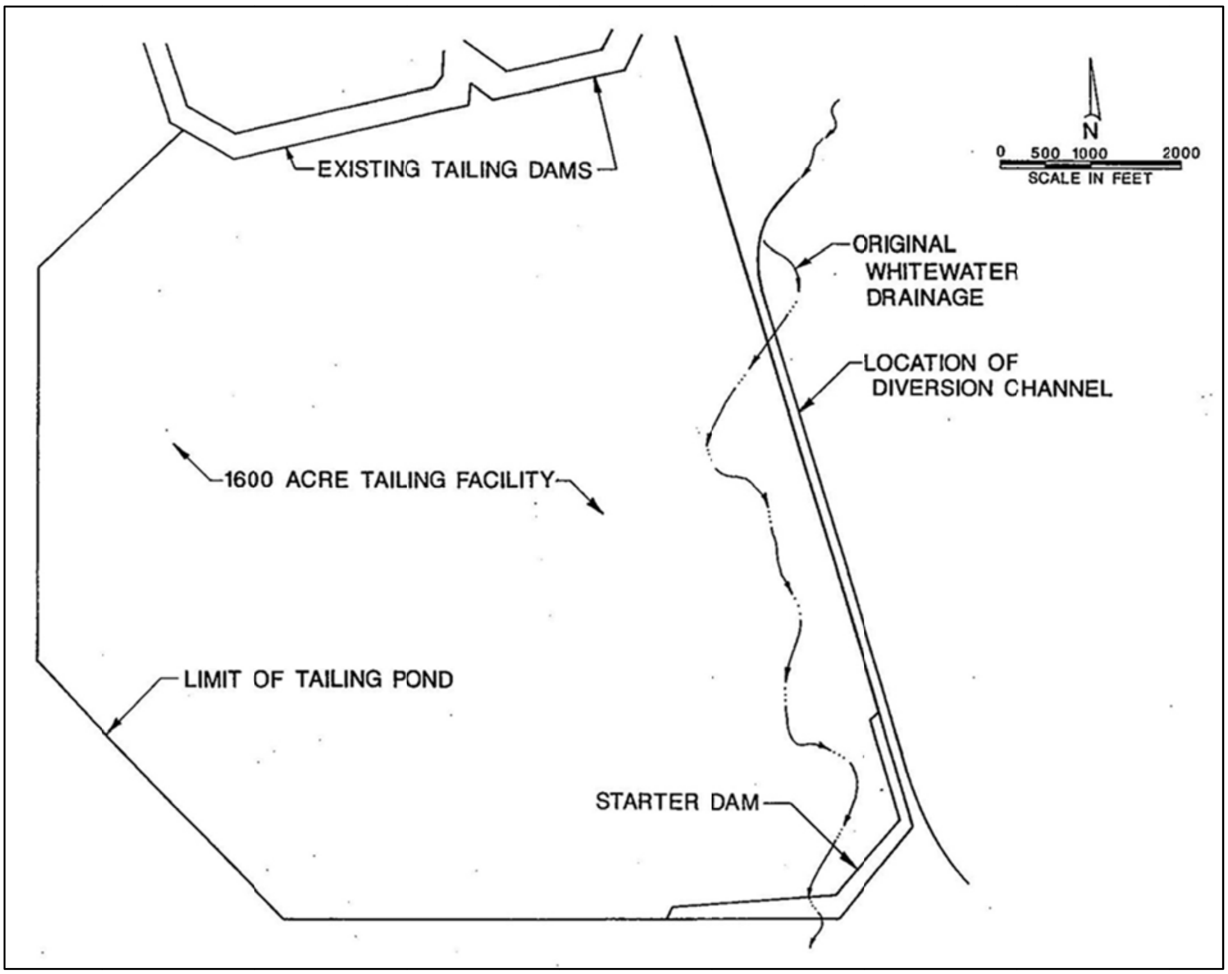

Figure 1. Tailing Pond No. 7

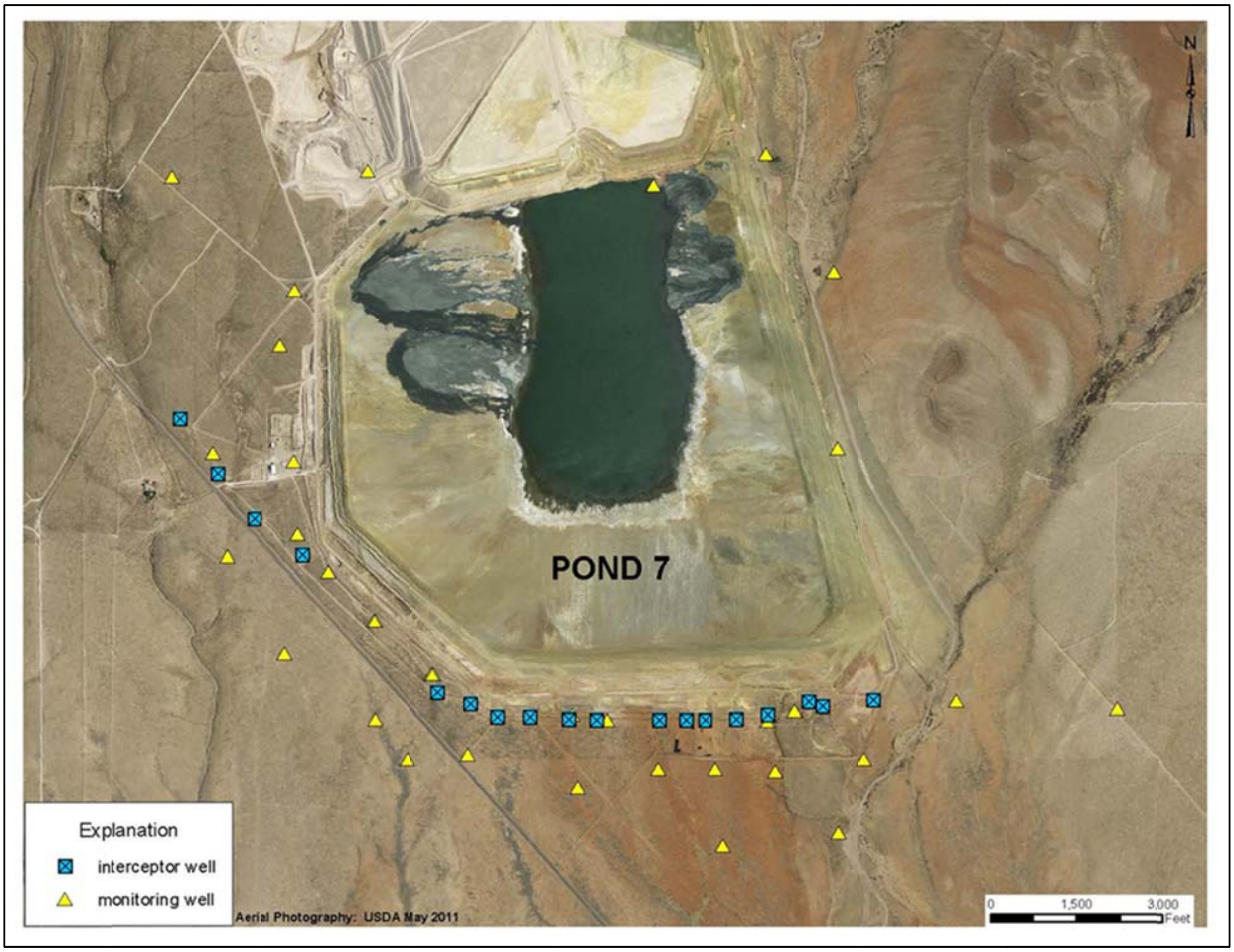

Figure 2. Tailing Pond No. 7 Interceptor Well

Figure 3. Plan View Tailing Pond No. 7

Geotechnical studies included geologic mapping, drilling test holes for foundation studies, excavating test pits for construction material evaluations, seismic refraction surveys along the diversion canal alignment to evaluate excavation conditions, laboratory testing to establish material characteristics, and associated stability studies and design reports.

Investigations showed the natural soils and bedrock were capable of supporting the planned tailing pond and diversion facility. Pond No. 7 includes a 38-foot high (max.) homogeneous starter dam with 2:1 upstream and 3:1 downstream slopes, a 28-foot crest width, and a drain beneath and extending up the upstream face. A slimes separation dike was provided near the upstream toe. The starter dam and slimes separation dike were designed and constructed using compacted Gila Conglomerate. Ample materials suitable for starter dam embankment and drain construction were available from on-site sources. On-site drain material sources required processing. Figure 4 illustrates a cross-section through the starter dam, drain, slimes separation dike, and upstream method dam.

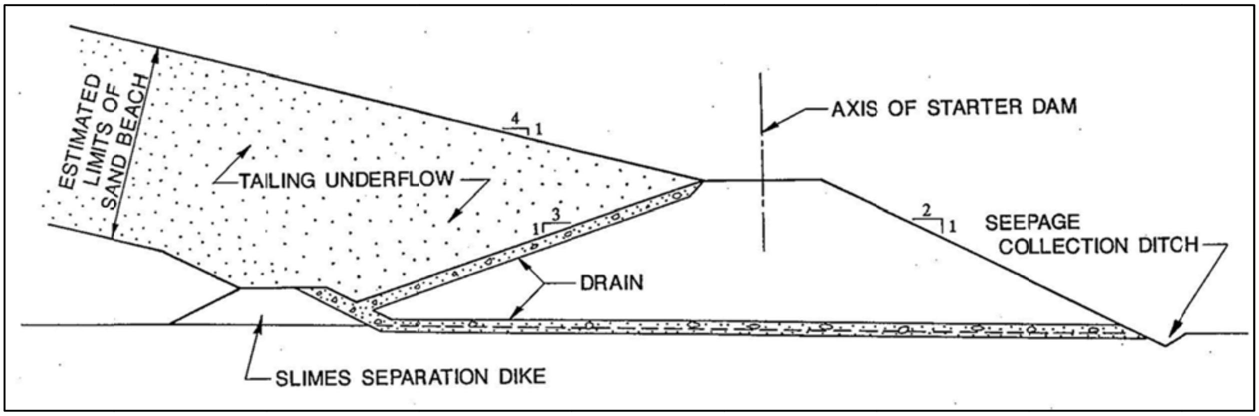

Figure 4. Tailing Pond No. 7 Starter Dam

The tailing pond utilizes cyclone deposition using the upstream method with an overall exterior slope of 4H:1V. Key design criteria included the following: 45,000 tons per day (tpd); 415 million tons storage capacity; 25-year facility life based on continuous operation at design capacity; on-berm cyclones; and a raise rate ≤ 10 feet/year. This results in a 230-foot high impoundment. Static stability analyses showed results consistent with criteria established by NMOSE. Dynamic stability analyses were conducted consistent with NMOSE's established criteria, and were based on residual strength characteristics of the tailing under earthquake conditions.

NMOSE requires tailing impoundments and appurtenant facilities be designed to handle runoff resulting from the probable maximum precipitation (PMP) event. Channels and spillways must also be sized for the storm which provides the greatest peak discharge. The construction site for Pond No. 7 required that the Whitewater Creek drainage be diverted around the facility. An open channel capable of handling the 100-year storm of about 7,900 cfs was excavated east of the starter dam alignment. Runoff in excess of the 100-year storm is conveyed along the same alignment utilizing the excavated channel, an overbank flow area, and a flood protection berm to protect the tailing dam from toe scour and potential failure from flows exceeding the 100-year event, including the PMF. The design of this flood protection berm was the first of its kind in New Mexico. A diversion channel with 1:1 side slopes and 75-foot bottom width was constructed. A section of the diversion channel overbank flow area and flood protection berm in shown on Figure 5.

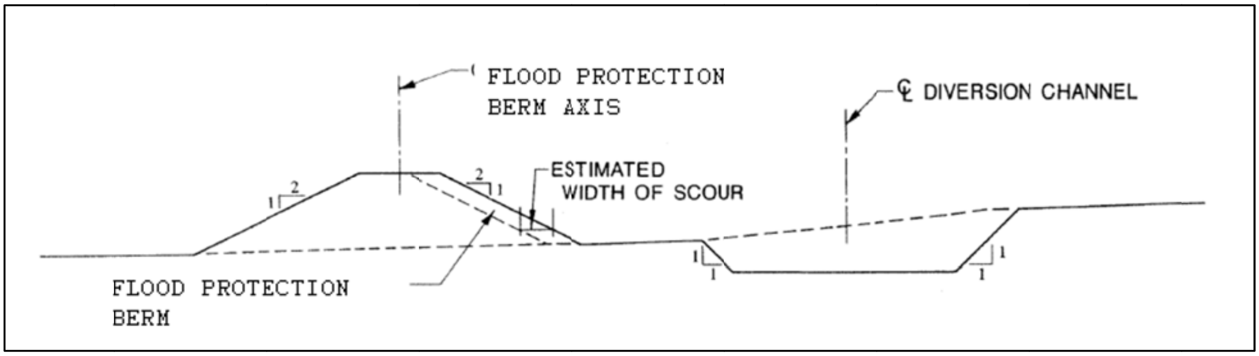

Figure 5. Section through Diversion Channel

Reports, plans, and specifications, accompanied by appropriate documentation, were provided to NMOSE in support of all necessary permits. The permits from NMOSE were acquired in two separate submissions. The first concerned the actual construction of the starter dam and the diversion channel. Documentation addressing the static and dynamic (seismic) stability of the starter dam and tailing dam was completed prior to construction. The second concerned the permitting of the ongoing construction of the tailing impoundment itself (raise plans and specifications).

Since seepage occurs from the facility as a result of its design to maintain stability, a groundwater discharge plan was required for the New Mexico Environmental Improvement Division (now NMED) to satisfy the requirements of the WQCC Regulations and the Water Quality Act. Monitor wells were drilled around the perimeter of the proposed pond a year before construction of the facility began, to provide background information. As required by the discharge plan, Chino constructed a pumpback seepage interceptor well system located about 500 feet south of the impoundment. Earthwork construction began in December 1987, and was completed in February 1988. This phase of the project consisted of the starter dam, slimes separation dike, flood protection berm, and the Whitewater drainage diversion channel. The volumes of material placed or excavated for each portion of the project are outlined as follows:

TABLE 1
EARTHWORK QUANTITIES

Feature	Volume (cubic yards)
Diversion Channel	241,580 (excavated)
Flood Protection Berm	166,970
Starter Dam	199,000
Sand Drain	64,300

Upon completion of the earthwork, distribution and decant return water pipework commenced. The distribution piping system was unique as the first production run of 32-inch diameter HDPE pipe in the world. Two specific runs were made: one consisting of about 15,500 feet of low pressure (100 pounds per square inch [psi]) delivery line from the termination box, and the second consisting of about 32,200 feet of high pressure (160 psi) distribution pipe around the perimeter of the pond. Pinch valves are utilized throughout the system for control of the tailing slurry. This final portion of the construction was completed midsummer of 1988. Tailing deposition commenced on July 1, 1988.

Deposition of tailing is via cyclones, a simple device that uses the centrifugal separation principle to separate the coarser particles (underflow sands) from the overflow (fine-grained tailing or slimes). Chino is using a unique method which was developed by personnel at the Morenci Mine in Arizona. This method utilizes a cyclone cluster which combines eight 10-inch cyclones on a pod depicted in Figures 6 and 7. This unit is then suspended about 30 feet out into the interior of the pond by a 45-ton crane. A large sand cone (underflow sands) is deposited requiring the machine to be moved laterally once or twice every 24 hours. The slimes from each cyclone are combined into a single overflow pipe and carried further out into the interior of the pond. Crane-mounted cyclone pods are being used to handle the tailing deposition.

Figure 6. Crane-Mounted Cyclone Deposition

Figure 7. Cyclone Cluster

Pond No. 7 is an upstream method dam. Three internal zones are developed during deposition and hydraulic particle separation. These include, going in an upstream direction, the following, which are depicted in Figures 8 and 9: a wide sand beach shell (underflow sands) – high permeability; an interlayered zone of sands and finer-grained tailing – intermediate permeability; and finer-grained tailing or slimes – low permeability. The high permeability of the sand shell and the pervious foundation soils at the site result in a low or deep water table, commonly referred to as the phreatic surface, in the embankment which is important to stability.

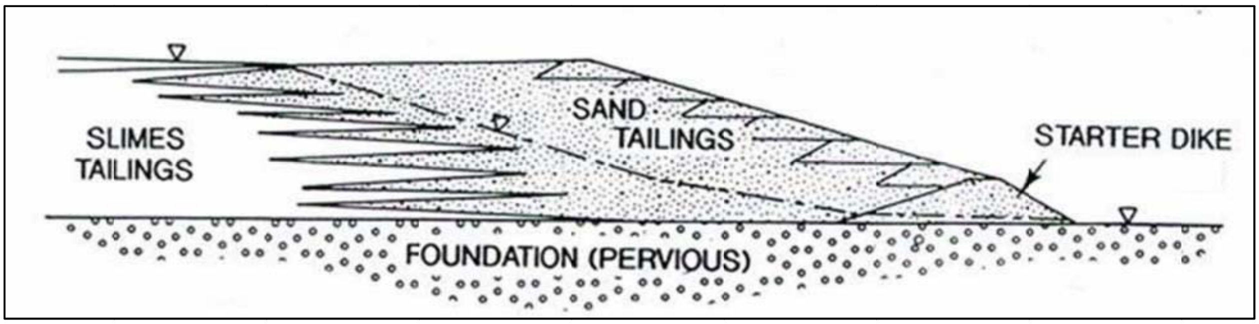

Figure 8. Typical Upstream Method Dam

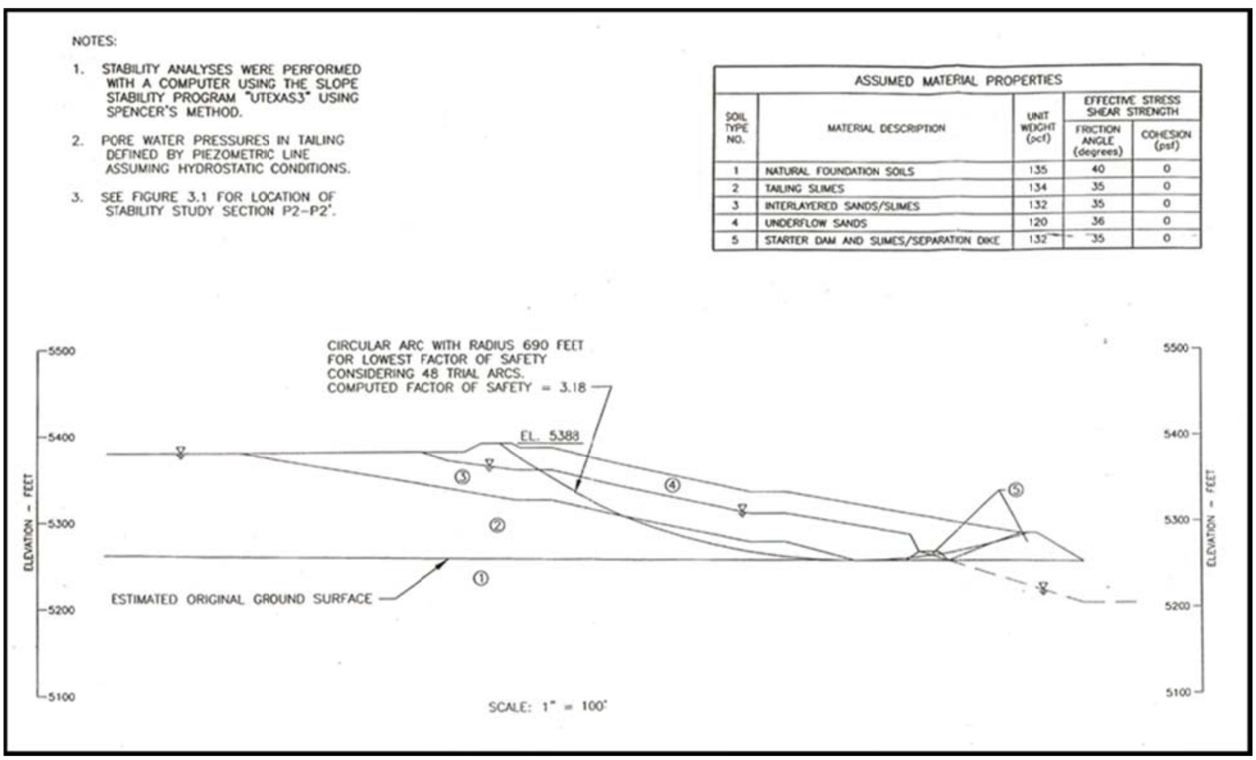

Figure 9. Tailing Pond No. 7 Study Section

Pond No. 7 demonstrates that the criteria set forth in the Proposed Rule, along with NMOSE regulations, work in tandem to ensure tailing impoundments at copper mining facilities are designed, constructed, and operated in a safe manner.

C. Design, Construction, and Operation of Tailing Impoundments

In addition to NMOSE regulations, under the Proposed Rule, new tailing impoundments must meet the following design and construction requirements:

> **A. Engineering design requirements.** At a minimum, the following requirements shall be met in designing crushing, milling, concentrating, smelting and tailings facilities at copper mine facilities unless the applicant or permittee can demonstrate that an alternate design will provide an equal or greater level of containment.
>
> . . .
>
> (4) **New tailings impoundments.** Tailings impoundments shall be designed according to the following requirements.
>
> (a) The applicant shall submit design plans signed and sealed by a licensed New Mexico professional engineer along with a design report that describes how the following features were considered in developing the design plans:
>
> (i) the annual volumes and daily maximum design rates of tailings and effluent to be deposited in the impoundment;
>
> (ii) the topography of the site where the impoundment will be located;
>
> (iii) hydrologic characteristics of the site, including depth to and quality of ground water;
>
> (iv) the geology of the site;
>
> (v) the design of drainage collection systems, to be proposed based on consideration of site-specific conditions and if drainage will be collected or will report at or above the ground surface;
>
> (vi) the design of seepage collection systems, to be proposed based upon consideration of site-specific conditions where substantial seepage may report to ground water, including a design report that includes an aquifer evaluation to demonstrate that interceptor wells will be able to efficiently capture seepage such that applicable standards will not be exceeded at monitor well locations specified by 20.6.7.28 NMAC. The aquifer evaluation shall include a description of aquifer characteristics, hydrogeologic controls for seepage containment and capture, and an analysis of well spacing and capture rates. The interceptor well system shall be designed to maximize seepage capture and efficiency: and
>
> (vii) a hydrologic analysis of drainage and seepage from the tailings impoundment based on the proposed design.
>
> (b) If the permittee or the department determines that the proposed tailings impoundment, when operated in accordance with the design plan specified in Subparagraph (a) of this Paragraph, would result in discharges of seepage or leachate that would cause ground water to exceed applicable standards at a monitoring well located pursuant to 20.6.7.28 NMAC, the permittee may propose, or the department may require as an additional condition in accordance with Subsection I of 20.6.7.10 NMAC, additional controls, including but not limited to, a liner system.

B. **Construction.**

(1) **New crushing, milling, concentrating, smelting, or tailings impoundment facility.** Construction of a new crushing, milling, concentrating, smelting, or tailings impoundment facility shall be performed in accordance with the applicable engineering requirements of Subsection A of 20.6.7.22 and 20.6.7.17 NMAC.

(2) **Existing crushing, milling, concentrating, smelting or tailings impoundments.** A tailings impoundment at an existing copper mine facility in existence on the effective date of the copper mine rule is not required to meet the liner, design, and construction requirements of Subsection A of 20.6.7.20 NMAC and may continue to operate as previously permitted under a discharge permit subject to compliance with the contingency requirements of 20.6.7.30 NMAC. Permit conditions contained in an existing discharge permit may be included in a discharge permit issued under the copper mine rule, and such conditions shall not be considered to be "additional conditions" under Subsection I of 20.6.7.10 NMAC.

Based upon my academic and professional experiences, it is my opinion these design and construction requirements are reasonable and appropriate. They are intended to maintain the stability of the tailing impoundment, which is protective of ground water quality by operating a safe and stable tailing impoundment and maintaining control of seepage. Under the Proposed Rule, the engineer responsible for the design of a tailing impoundment will consider several key factors relating to both the stability of the impoundment and protection of ground water. The engineer will prepare a design report identifying how those factors were considered in the design of the facility. Key fundamentals and criteria for the safe design, construction, and operation of tailing impoundments include the following:

(1) The development of a wide drained tailing sand beach formed by hydraulic separation, keeping the water table low or deep in the embankment and increasing stability;

(2) providing a pervious foundation and sufficient underdrainage (such as Gila Conglomerate at Tailing Pond No. 7); this maintains a relatively drained sand shell (low phreatic surface) and prevents seepage emerging on the face of the tailing dam;

(3) keep raise rates slow enough to allow dissipation of pore water pressures;

(4) regular performance monitoring, reviews, investigations, ongoing operator/designer involvement (inspections/piezometers read monthly);

(5) upstream (U/S) construction method not for moderate to high seismicity areas;

(6) the establishment of consistent design requirements, including minimum sand beach widths, reclaim pond location away from crest, minimum freeboard, and maximum side slopes; and

(7) good understanding of internal pore pressures and hydraulic gradients (low phreatic surface, acceptable stability) through monitoring and investigations.

The design criteria would be presented in a written design report subject to review by NMED. As mentioned above, a key fundamental for the safe design, construction, and operation is regular performance monitoring. Engineering practice and the NMOSE require monitoring. Tailing Pond No. 7 currently has 18 study sections in place with a total of 82 piezometers to monitor the phreatic surface. *See* Figure 10. Over 80 percent of the piezometers are currently dry. In December 2012, an additional 54 piezometers were installed.

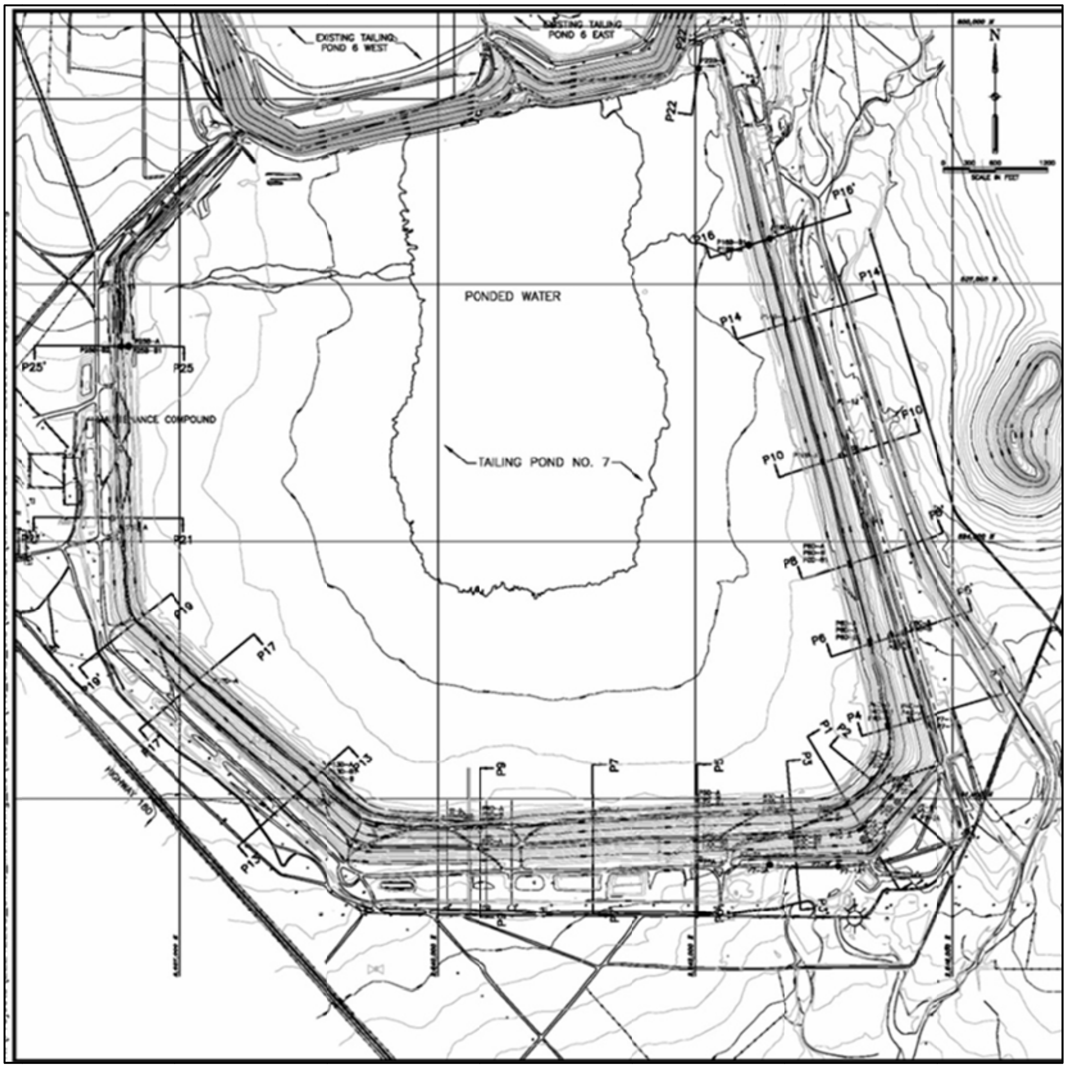

Figure 10. Tailing Pond No. 7 Study Sections

As discussed in separate testimony, facility design will include features to manage and contain seepage, including a seepage interceptor well system if needed. Depending upon site specific conditions, seepage may be collected on the surface, or it may report to ground water. Depending upon the volume of the seepage as it relates to ground water flow, a seepage interceptor well system may be needed. A separate witness will present testimony regarding the design and operation of a seepage interceptor well system.

All major copper tailing impoundments in the southwestern United States are unlined. Many use seepage interceptor well systems along with other discharge controls. Discharge controls can include such items as: seepage interceptor well system (Tailing Pond No. 7); procedures for the sequencing of cycloning/spigotting tailing; water management – maintaining relatively small pond to minimize seepage; minimize discharge heads using drains at/near starter dam base; seepage collection ponds located downstream to collect seepage; and promoting rapid dewatering after closure – minimize infiltration, covers, and slope top surfaces to minimize ponding. Aside from the issue of the scale of copper mine tailing impoundments, designing and constructing a tailing impoundment with a synthetic liner system poses a particular issue in that a granular drainage system would be required to remove water from the top of the liner and keep a low or deep phreatic surface within the embankment. Otherwise, water would collect on top of the liner and then move upward and outward, threatening the stability of the impoundment. Fine particles contained in the tailing and deposition of sulfates tend to clog granular drainage systems. This would raise the phreatic level in the dam and reduce dam stability. Since there is no known proven technology to repair a drainage system of this scale, the impoundment might have to cease operation and another means of drainage would have to be developed, including possibly puncturing the liner to achieve drainage required for stability.

Tailing impoundments also must meet the following operation requirements set forth in the Proposed Rule:

C. Operational Requirements.

(1) **Tailings impoundment operating requirements.** A permittee operating a tailings impoundment shall operate the impoundment pursuant to the following requirements.

(a) The tailings impoundment shall remain within the area identified in the discharge permit.

(b) The perimeter of the tailings impoundment and any associated solution collection system facilities shall be inspected monthly.

(c) Any evidence of instability in the tailings impoundment that could potentially result in a dam failure and an unauthorized discharge shall be reported to the department as soon as possible, but not later than 24 hours after discovery.

(d) Any leaks or spills outside the tailings impoundment or drainage containment system shall be recorded and reported pursuant to 20.6.2.1203 NMAC.

(e) If seeps occur, they shall be monitored on a monthly basis and an estimate of the seep flow rate shall be made. Monthly records of the seep inspections and flow rates shall be maintained and included in the site monitoring reports.

(f) The monthly volume of tailings placed in the impoundment shall be recorded, maintained, and included in the site monitoring reports.

(g) Tailings deposition rates shall not exceed the maximum rates approved in the discharge permit.

(h) The daily tailings deposition and associated solution system collection rate shall be determined using flow meters installed in accordance with Paragraph (5) of Subsection C of 20.6.7.17 NMAC.

(i) The average daily rate and monthly volume of tailings deposited and solution collected shall be recorded, maintained, and included in the site monitoring reports.

(j) The placement of tailings and effluent shall be in accordance with an operating plan that describes the sequencing of tailings deposition on an annual basis, measures to manage the surface impoundment area to maintain adequate freeboard, operation of drainage collection system, operation of systems to return water to the concentrator or other locations as appropriate, and any other water management features.

(k) If an interceptor well system to manage fluids that have migrated into ground water exists at a tailings impoundment, the permittee shall submit an interceptor well management plan that shall include:

(1) well completion drawings and well performance information, recommended equipment including pumps and meters, recommended pump settings and pumping rates, and methods for data collection;

(2) a monitoring plan detailing the monitoring system, metering requirements and recordkeeping, a water level monitoring program including methods and frequency of monitoring; and

(3) an annual performance evaluation plan to evaluate the performance of individual wells, a review of the tailings facility water balance, evaluation of monitoring data to determine capture efficiency, and recommendations for maintaining and improving capture efficiency.

Based upon my academic and professional experiences, it is my opinion these operational requirements are reasonable and appropriate. The following five major factors that influence the stability and safe performance of tailing impoundments: shear strength of the slope/embankment materials; pore pressure conditions/phreatic surface location; slope angle; unit weight of materials in the slope; and loading condition (static, seismic). The Proposed Rule requires an operating plan, considering these and other factors specified in the Proposed Rule, that would be developed by the engineer for review by NMED. In addition, if a seepage interceptor well system is used, the Proposed Rule requires an interceptor well system management plan to ensure it is operated as intended. This approach is consistent with the conditions of Discharge

Permit DP-484, the discharge permit that governs the operation of Tailing Pond No. 7, which is attached as Exhibit Scott-E.

Discharge controls are employed in tailing storage facilities using various methods and technologies. Considerations commonly evaluated include the following: controls do not jeopardize stability, practical, constructible, proven, cost-effective, and timely.

In summary, the key fundamentals for successful and safe performance of tailing dams include the following: wide drained tailing sand beach (low phreatic surface), well-drained foundation, minimizing dam slope underlain by fine-grained tailing (slimes), and preventing seepage from emerging on dam face.

D. Closure Requirements for Tailings Impoundments (20.6.7.33 NMAC)

Next, I will next discuss the following closure issues for tailing impoundments and dams in New Mexico: NMOSE criteria, design storm events (surface water conveyance), and top surface grading.

As discussed previously, in New Mexico, all tailing dams are under NMOSE's jurisdiction. NMOSE publishes construction and closure criteria in their design publications for tailing impoundments. After construction of a tailing impoundment is completed, a mine operator must submit a completion report, materials test data and photographs, as-built drawings, and a certificate of completion. NMOSE publishes closure criteria that requires a mining operator to prepare and submit a closure or reclamation plan. The plan must address long-term stability (static and dynamic conditions), control of surface runoff to minimize erosion, plan for long-term monitoring, and an engineer to supervise construction of plan. These are detailed requirements that ensure tailing impoundments are properly constructed, closed, and reclaimed.

The Copper Rule contains the following requirements that tailing impoundments be designed to convey water during storm events:

> **20.6.7.33 CLOSURE REQUIREMENTS FOR COPPER MINE FACILITIES:** An applicant or permittee shall submit a closure plan for all portions of a copper mine facility covered by a discharge permit that addresses the following requirements.

> **A.** **Design storm event.** Permanent storm water conveyances, ditches, channels and diversions required for closure of a discharging facility at a copper mine facility shall be designed to convey the peak flow generated by the 100 year return interval storm event. The appropriate design storm duration shall be selected based on the maximum peak flow generated using generally accepted flood routing methods. Sediment traps or small basins intended as best management practices may be exempt from this requirement.

It is my professional opinion these requirements are reasonable. Tailing impoundments are designed with spillways/diversion channels that are ½ PMF to PMF (based on hazard potential). The state-of-the-practice (surface channels/ditches) in New Mexico is as follows: Chino Mine (100-year return period), Tyrone Mine (100-year return period), Cobre Mine (100-year return period), and the New Mexico Mining Act (100-year return period [stream diversions]). Elsewhere, the state-of-the-practice is as follows: Arizona BADCT (100-year return period), MSHA/OSM (100-year return period), and British Columbia (200-year return period). Closure of tailing impoundments also must be designed to consider the stability of channels/ditches. A good maintenance program also is just as necessary as good design and construction.

The Proposed Rule requires that tailing impoundments must be constructing to ensure stability and safe performance. Specifically, 20.6.7.33.B NMAC requires:

> **B.** **Slope stability.** At closure, tailings impoundment(s) not regulated by the office of the state engineer, leach stockpile(s) or waste rock stockpile(s) shall be constructed to promote the long-term stability of the structure. Closure of all critical structures at a copper mine facility shall be designed for a long-term static factor of safety of 1.5 or greater and non-critical structures shall be designed for a long-term static factor of safety of 1.3 or greater. The facilities being closed shall also be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. A stability analysis shall be conducted for the facility that shall include evaluation for static and seismic induced liquefaction.

It is my professional opinion these requirements are reasonable and appropriate. Major factors influencing the stability and safe performance in closure include the following: shear strength of slope/embankment/foundation materials; pore pressure/phreatic surface location in the embankment/foundation; slope angle; unit weight of materials in slope; loading condition (steady-state, seismic); factor of Safety (NMOSE), 1.5 (steady-state), and 1.1 (seismic). NMOSE criteria also includes liquefaction potential evaluation.

The vast majority of liquefaction hazards are associated with saturated sandy and silty soils of low density. Facility foundation areas at mine sites in the western United States are typically dense granular soils or bedrock and are not susceptible to liquefaction.

The Proposed Rule provides that tailing impoundments must be regraded and covered during closure. Specifically, 20.6.7.33.C NMAC requires:

> **C.** **Surface re-grading:** During closure of any tailings impoundment, waste rock pile or leach stockpile at a copper mine facility, the surface shall be re-graded to a stable configuration that minimizes ponding and promotes the conveyance of surface water off the facility. The operator may propose for department approval a grading plan that allows ponding as an appropriate part of closure provided additional ground water protection measures, such as synthetic liner systems, are included as part of the design.

It is my professional opinion these requirements are reasonable and appropriate. The objective is to recontour the top surface to reduce ponding and promote evaporation. The first step is to develop post-settlement contours for use in the grading plan and drainage system. An estimate of settlement due to (1) drain down of the phreatic surface and (2) weight of top surface cover (typically 2 to 3 feet thick). The state-of-the-practice is to grade top surfaces to 0.5 to one percent (largely driven by scale of tailing storage facilities). This helps minimize excavations into the underlying softer tailing and increases construction safety. Large slopes of two to five percent generally come from RCRA landfills where much of the settlement was due to compression of the "cavity" or void spaces. I understand these closure criteria are addressed in more detail in the testimony of other witnesses.

III. MINE ROCK STOCKPILES (20.6.7.33 NMAC)

I will next discuss the following issues related to mine rock stockpiles: non-water impounding structures; investigations; stability; and acceptable factors of safety. Mine rock stockpiles differ from tailing impoundments in that they are non-water impounding structures. Unlike tailing storage facilities, they are not built hydraulically and do not impound water.

Since the early 1970s, large surface mines have been increasing the number and size of their mine rock stockpiles. At that time numerous research organizations, agencies, and conferences began concentrating efforts and research on identifying: factors affecting stability, investigations and procedures for design and stability evaluations, and acceptable stability factors of safety.

Some of the well-known conferences and studies dealing with mine rock stockpiles include the following: Canada Centre for Mineral and Energy Technology (CANMET) Pit Slope Manual – Waste Embankments (1977); SME, AIME Workshop – Non-Impounding Waste Rock

Dumps (1985); British Columbia Mine Waste Rock Pile Research Committee (1991-1994); the U.S. Environmental Protection Agency (1995); SME Slope Stability in Surface Mining (2000); and the First International Seminar on the Management of Rock Dumps, Stockpiles, and Heap Leach Pads, Perth, Australia (2008). Relevant excerpts from these studies are attached with the Bibliography as Exhibit Scott-D.

Mine rock stockpile investigations generally include the following field and laboratory investigations: site characterization, hydrology, geology, seismicity, foundation soils/bedrock engineering properties, and mine rock engineering properties. Some of the numerous investigation guides include the following: BC Guidelines – Mined Rock and Overburden Piles Investigation and Design Manual (1991); SME – Design of Non-Impounding Mine Waste Dumps (1985); AZ BADCT Guidance Manual (2004); and MSHA – Engineering and Design Manual, Coal Refuse Disposal Facilities (2009). Relevant excerpts from these documents are attached with the Bibliography as Exhibit Scott-D.

Some site-specific factors affecting stability in mine rock stockpiles include configuration (height, volume, slope angle), foundation slope/confinement, foundation conditions, mine rock properties, construction method, piezometric/climatic conditions, and seismicity. Material strengths include empirical correlations, large scale direct shear tests, triaxial shear tests, and in situ tests (BPTs, PMTs, NALPTs, SPTs). Phreatic/Piezometric conditions include information from test holes, monitoring wells, piezometers, and observations.

Regulations and guidelines have been developed in the United States and British Columbia by various state and federal regulatory authorities to address design, management, and closure of mine rock stockpiles. The classical approach to evaluating the stability of mine rock stockpiles is to calculate a factor of safety. Guidelines and a discussion of acceptable levels of safety and regulatory requirements for mine rock stockpiles are as follows:

<u>New Mexico Mining Act (1996)</u>

19 NMAC 10.5 – Existing Mining Operations (Section 508 New Units B(7)) states that "all man-made piles such as waste dumps, topsoil stockpiles and ore piles shall be constructed and maintained to minimize mass movement." No required factor of safety is provided in B(7).

Section 508 New Units C(2) states: "All reconstructed slopes, embankments and roads shall be designed, constructed and maintained to minimize mass movement." No factor of safety is provided in C(2). It is interesting to note that in B(6)(a)(vii) impoundments having earthen embankments but not subject to the jurisdiction of MSHA or NMOSE require a minimum static safety factor of 1.3 with water impounded to the design level.

Under the Act, impoundments are to be designed and certified by a professional engineer registered in New Mexico.

New Mexico State Highway and Transportation Department (NMSHTD)

NMSHTD uses the American Association of State Highway and Transportation Officials (AASHTO) design criteria for their evaluation of overall stability of slopes along New Mexico's highways. According to AASHTO's 1997 Interim Revisions to the Standard Specifications for Highway Bridges, a minimum factor of safety of 1.3 is required for static loads, except the factor of safety shall be 1.5 in the vicinity of support abutments, buildings, critical utilities, or other installations with a low tolerance for failure. A minimum factor of safety of 1.1 is required for seismic loads. Seismic forces applied to the mass of the slope shall be based on a horizontal seismic coefficient kh equal to one-half the ground acceleration "A," with the vertical seismic coefficient kv equal to zero.

Arizona Mining BADCT Guidance Manual (1998)

The required design criteria for various types of facilities for both static and dynamic loading conditions are provided in this guidance document. For waste rock piles, the applicant is required to establish whether or not discharge can occur. If the potential for discharge exists, stability analyses should be performed and the minimum required factor of safety should meet the same criteria as dump leach piles. The required factors of safety are as follows: Static Stability (1.5 without testing and 1.3 with testing) and Dynamic Stability for final construction stages (pseudostatic factor of safety ≥ 1.1 without testing or pseudostatic factor of safety ≥ 1.0 with testing). For intermediate construction stages, the pseudostatic factor of safety ≥ 1.0 with or without testing and/or predicted deformations do not jeopardize containment integrity. Testing refers to site specific testing of material shear strengths. Pseudostatic factors of safety are applicable only when types involved (*e.g.*, clayey soils or large, coarse rock fragments) do not exhibit high potential for pore water pressure buildup and associated significant strength loss under loading.

British Columbia Mine Waste Rock Pile Research Committee (1991)

In determining the appropriate factor of safety for a given design case, several factors must be taken into consideration, including: the degree of uncertainty in the shear strength parameters; the variability of material composition (*e.g.*, proportion of fines); the variability of foundation conditions and geometry; short term (*i.e.*, during construction) vs. long term (*i.e.*, final reclamation slopes); consequences of failure; the type of analysis technique utilized, its inherent conservatism and how well the method models the physical conditions; and the importance of field control during operation of the stockpile.

Many of these factors are subjective and site specific. Consequently, it is considered unduly restrictive to establish specific factor of safety criteria which must be met in all design cases. Selection of a reasonable design factor of safety should be based on sound engineering judgment. The New Mexico Engineering and Surveying Practice Act is adequate and protective because it requires that licensed professional engineers make these judgments.

Suggested guidelines for minimum factor of safety design values for mine dumps in British Columbia are given in the following table.

INTERIM GUIDELINES FOR MINIMUM DESIGN FACTOR OF SAFETY

Stability Condition	**Suggested Minimum Design Values for Factor of Safety**	
	Case A	**Case B**
Stability of Dump Surface		
– Short Term (during construction)	1.0	1.0
– Long Term (reclamation – abandonment)	1.2	1.1
Overall Stability (Deep Seated Stability)		
– Short Term (static)	1.3 – 1.5	1.1 – 1.3
– Long Term (static)	1.5	1.3
– Pseudo-Static (earthquake)	1.1 – 1.3	1.0

The range of suggested minimum design values are given to reflect different levels of confidence in understanding site conditions, material parameters, consequences of instability and other factors.

The state-of-the-practice for non-water impounding hard rock mining stockpiles in the southwestern United States is a minimum static factor of safety of 1.3 and a minimum seismic factor of safety of 1.0.

IV. PROPOSED CHANGES TO THE COPPER RULE

In New Mexico, tailing dam stability falls under the jurisdiction of the NMOSE. To avoid duplication and/or contradictions, I recommend the stability criteria with respect to tailing impoundments in 20.6.7.33 be removed from the Proposed Rule. This section may also conflict with the mining act and the New Mexico Engineering and Surveying Practice Act. "Critical structures" is vaguely defined. All of these judgments require site specific evaluations and are best left to licensed professional engineers as appropriate under New Mexico law. Listing minimum criteria like this may or may not be protective or appropriate. This section is already adequately addressed by 20.6.7.17(A) NMAC.

V. CONCLUSION

I am pleased the Proposed Rule is not too prescriptive. The design engineer should be the one to evaluate and select specific parameters, design values, types/methods of analyses, field/laboratory investigations, storm durations, *etc*., appropriate for the site location/conditions, project requirements, material types, and project life.

Seepage discharge control methods used in copper tailing impoundments should not jeopardize stability. Consideration should be given to site specific conditions, design criteria, embankment stability, and seepage water characteristics. Factors affecting potential ground water contamination include the permeability of the tailing and foundation materials and the characteristics of the tailing effluent water. Not all effluents contain toxic constituents. Engineered seepage interceptor well systems have been an effective and proven discharge control method in capturing seepage waters.

James C. Scott

James C. Scott

Exhibit Scott-A

C.V.

Exhibit Scott-B

Technical Committee Presentations

Exhibit Scott-C

New Mexico Office of State Engineers

Rules and Regulations Governing Dam Design, Construction and Dam Safety

December 31, 2010

Exhibit Scott-D

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Exhibit Scott-E

Discharge Permit DP-484