APPENDIX D

UPDATED TAILINGS COVER DESIGN REPORT

WHITE MESA MILL

SEPTEMBER 2011

PREPARED BY

MWH AMERICAS

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Denison Mines (USA) Corp.
WHITE MESA MILL

Updated Tailings Cover Design Report

September 2011

MWH®
BUILDING A BETTER WORLD

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1.0 INTRODUCTION

This report presents the design of a monolithic evapotranspiration (ET) cover for the tailings cells at Denison Mines (USA) Corp.'s (Denison) White Mesa Uranium Mill (Mill). The Mill is located approximately 6 miles south of Blanding, in San Juan County, Utah. The millsite includes a conventional acid leach process mill, associated support facilities, and lined tailings cells. The tailings cells are located south of the Mill and comprise the following:

- Cell 1 – 55 acres, used for the evaporation of process solutions
- Cell 2 – 65 acres, used for storage of barren tailings sands
- Cell 3 – 70 acres, used for storage of barren tailings sands and evaporation of process solutions
- Cell 4A – 40 acres, used for storage of barren tailings sands and evaporation of process solutions
- Cell 4B – 40 acres, currently being used for evaporation of process solutions

1.1 Scope of Report

A previous "Tailings Cover Design" report for the White Mesa Mill was prepared by Titan Environmental Corporation (Titan, 1996), and presented design criteria for a multi-layered cover system. This design report was included as Appendix D of the Reclamation Plan, Revision 4.0 (Denison, 2009b) and previous versions of the Reclamation Plan.

This report supersedes the 1996 cover design in order to provide design criteria for a proposed monolithic ET cover system for all the tailings cells. This report provides detailed summaries of the analyses conducted to evaluate the long-term stability of the tailings reclamation cover, and the results of these analyses, including evaluations of freeze/thaw, radon attenuation, biointrusion, infiltration, slope stability, settlement, liquefaction, erosional stability, and dewatering. This report also presents plans for final cover verification, vegetation, and long-term settlement monitoring. This report replaces the Titan (1996) report as Appendix D in the Reclamation Plan, Revision 5.0 (Denison, 2011).

1.2 Updates from 1996 Cover Design

The cover system presented in Titan (1996) consisted of six feet of random fill and clay, compacted to 95 percent of maximum dry density. The cover system consisted of the following materials following materials outlined below by individual layers and thicknesses from top to bottom:

- 3 in (7.6 cm) Erosion Protection Layer (gravel)
- 2 ft (61 cm) Radon Attenuation Layer (random fill)
- 1 ft (30.5) Radon Attenuation Layer (compacted clay)
- Minimum 3 ft (91.4 cm) Radon Attenuation and Grading Layer (random fill)

This cover design was presented in the Reclamation Plan, Revision 4.0 (Denison, 2009b) for Cells 1, 2, 3, and 4A. Titan (1996) analyzed the proposed cover with respect to radon flux

attenuation, infiltration, effects of free/thaw, erosion protection, and static and pseudostatic slope stability.

An ET cover was proposed by Denison for the White Mesa Mill disposal cells in the Infiltration and Contaminant Transport Modeling (ICTM) reports (MWH 2007 and 2010) submitted to the DRC to fulfill the White Mesa Mill's Ground Water Discharge Permit No. UGW370004. A conceptual design of the ET cover was provided in these reports. It was intended that the final design of the tailings cover would be completed as part of an updated tailings cover design report.

Denison stated their intent to submit an ET cover design as part of their license renewal in a meeting with DRC on October 5, 2010 after review of the DRC Reclamation Plan, Version 4.0 Interrogatories – Round 1 (DRC, 2010). The proposed conceptual ET cover design was provided to DRC on October 7, 2010 and was essentially the same as presented in the 2010 ICTM report (MWH, 2010). The ET cover proposed and evaluated as described in this report is shown in Figure 1-1 and consists of the following materials outlined below by individual layers and thicknesses from top to bottom:

- 0.5 ft (15 cm) Erosion Protection Layer (gravel-admixture)
- 3.5 ft (107 cm) Water Storage/Biointrusion/Frost Protection/Radon Attenuation Layer (loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation Layer (highly compacted loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation and Grading Layer (loam to sandy clay)

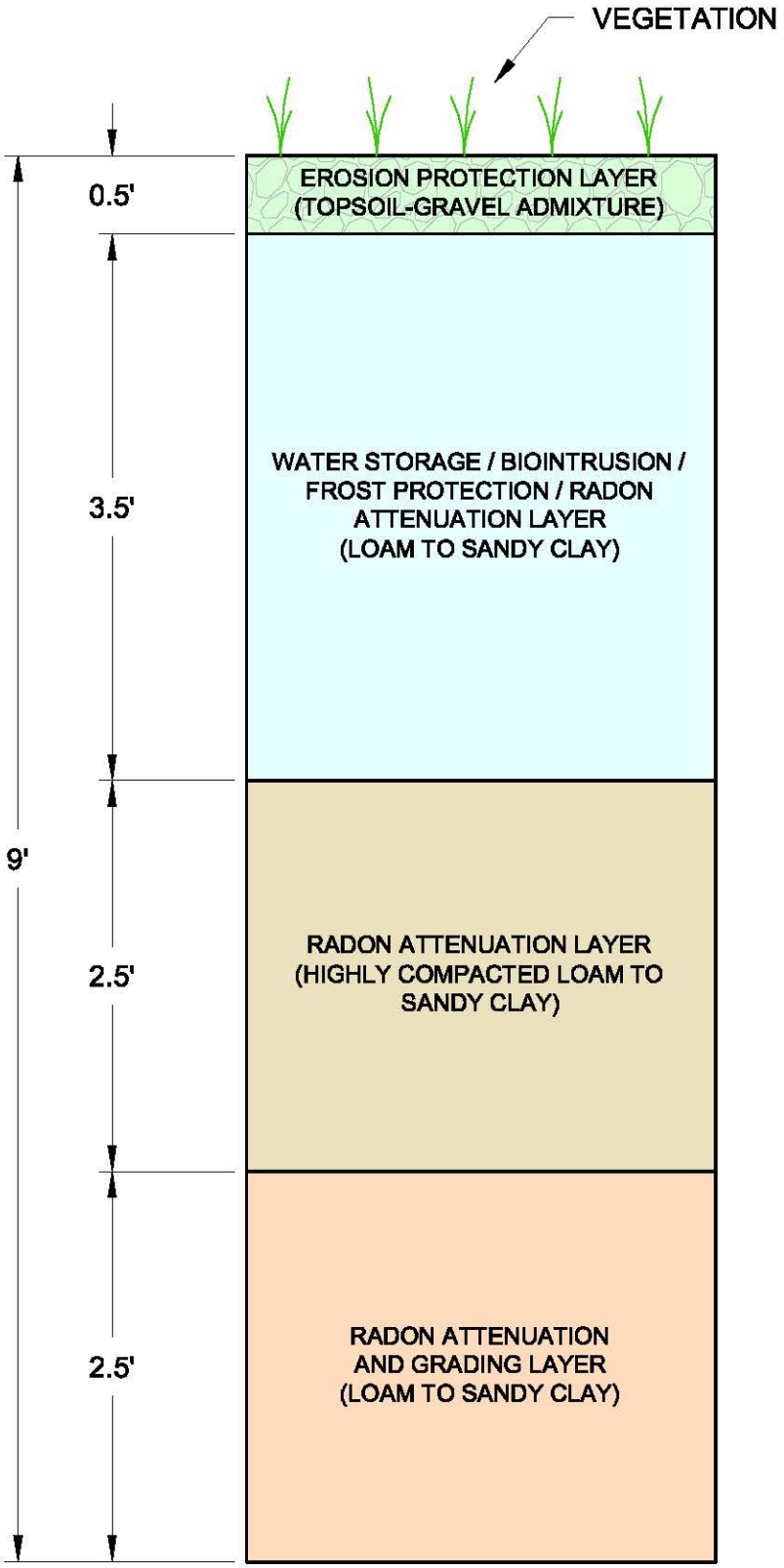
The loam to sandy clay soil is the same material referred to in Titan (1996) as random/platform fill. This material is stockpiled at the site.

This report provides the results of additional laboratory testing and analyses for the monolithic ET cover design, including radon flux attenuation, infiltration, effects of freeze/thaw, erosion protection, and static and pseudostatic slope stability; as well as analyses not previously performed for the Titan (1996) design, including biointrusion, tailings dewatering, liquefaction, and settlement.

1.3 Limitations

The analyses presented in this report use information from reports prepared by others that have been provided by Denison Mines (USA) Corp., and our experience with the White Mesa Mill site and other similar uranium mill sites. The analyses are limited by the information available but are supplemented by MWH's experience with the White Mesa Mill and other similar uranium mill sites. In the event that there are any changes in the nature, design, or characteristics of the project, or if additional data are obtained, the conclusions and recommendations contained in the report will need to be re-evaluated by MWH in light of the proposed changes or additional information obtained.

MWH warrants that services were performed within the limits prescribed by Denison with the usual thoroughness, and competence of the engineering profession. No other warranty or representation, either expressed or implied is included or intended in our technical documents.



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DENISON MINES
Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
ET COVER PROFILE

MWH

DATE AUG 2011

FIGURE 1-1

FILE NAME 1009740 WM ET COVR

2.0 SITE CONDITIONS

2.1 Location

The White Mesa Uranium Mill is located in San Juan County in southeastern Utah, approximately 6.0 miles south of Blanding, Utah. The site is located on White Mesa, a flat area bounded on the east by Corral Canyon, to the west by Westwater Creek and to the south by Cottonwood Canyon. A site location map is shown in Figure 2-1. The Mill is located at an elevation of 5,600 ft above mean sea level. The Denison facilities consist of a uranium processing mill and four lined tailings cells located within an approximately 686-acre restricted area. Total land holdings are approximately 5,415 acres (Denison, 2009b).

2.2 Climate and Vegetation

2.2.1 Climate

The regional climate of the Blanding area is semiarid with an average annual precipitation of 13.3 inches (Denison, 2009b). Most precipitation is in the form of rain, with snowfall accounting for about one quarter of the annual total precipitation. There are two separate rainfall seasons in the region, a late summer season when monsoonal moisture from the Gulf of Mexico leads to thunderstorms, and a second during the winter season related to fronts from the Pacific. The average annual Class A pan evaporation rate is 68 inches, with the largest evaporation rate typically occurring in July (Denison, 2009b). Given the annual average precipitation rate of 13.3 inches, the net evaporation rate is 34.3 inches per year (Denison, 2009b).

The mean annual temperature for Blanding, Utah is 52°F, based on the period of 1971-2000. January is typically the coldest month, with a mean monthly temperature of about 30°F. July is generally the warmest month, with a mean monthly temperature of 76°F. Daily ranges in temperatures are typically large.

As an element of the pre-construction baseline study and ongoing monitoring programs, the Mill operates an onsite meteorological station, which was initiated in early 1977 and continues to operate presently. A more thorough description of climatic conditions is presented in Denison (2009b).

2.2.2 Vegetation

As described in Denison (2009b), the natural vegetation near the site is characterized by pinyon-juniper woodland intergrading with big sagebrush (*Artemisia tridentata*) communities. The understory of this community, which is usually quite open, is composed of grasses, forbs, and shrubs that are also found in the big sagebrush communities. Based on work completed by Dames & Moore in the 1978 Environmental Report, no designated or proposed endangered plant species occur on or near the Mill site (Dames & Moore (1978). A complete discussion of flora and fauna present in the vicinity of the Mill site is provided in Denison (2009b).

2.3 Geology and Seismicity

The White Mesa Mill is located within the Blanding Basin of the Colorado Plateau physiographic province. The site is underlain by unconsolidated alluvium overlying sedimentary bedrock consisting primarily of sandstone and shale. The unconsolidated deposits are primarily eolian silt and sand and range from 1 to 30 ft thick (these deposits have been removed where the tailings cells are located). The bedrock underlying the site is relatively undeformed and

horizontal (generally dips are less than 3 degrees). Cretaceous Dakota Sandstone and Burro Canyon Formation are at or near the surface at the site; these sandstone units have a combined thickness of 100 to 140 ft at the site. Beneath the Burro Canyon Formation is the Morrison Formation, which is primarily shale. The Brushy Basin Member is the uppermost member of the Morrison Formation and is composed primarily of bentonitic mudstones, siltstones, and claystones. Beneath the Brushy Basin Member are the Westwater Canyon, Recapture, and Salt Wash members of the Morrison Formation. Beneath the Morrison Formation lies the Middle to Late Jurassic San Rafael group, and the Late Triassic to Jurassic Glen Canyon Group. For more detailed descriptions of the geologic setting, see the Reclamation Plan (Denison 2009b).

The Mill area is located within a relatively tectonically stable portion of the Colorado Plateau, characterized by a scarcity of recorded seismic events. Most of the larger seismic events in the Colorado Plateau have occurred along its margins rather than in the interior central region. Based on the region's seismic history, the probability of a major damaging earthquake occurring at or near the Mill site is very low. Additional information on the seismotectonics of the Mill site and vicinity is provided in Denison (2009b).

Several site-specific seismic studies have been performed for the Mill site (UMETCO, 1988; Tetra Tech, 2006; Tetra Tech, 2010). The most recent study (Tetra Tech, 2010) was performed to provide additional information for design of tailings Cell 4B. This study concluded that the maximum horizontal acceleration value for the Mill site is 0.15g. Based on this maximum horizontal acceleration, a pseudo-static coefficient of 0.10 g was used for seismic stability analyses of the reclaimed tailings impoundments (described in Appendix E). The Tetra Tech (2020) seismic study is provided as an attachment to Appendix E, for ease of reference.

2.4 Hydrogeology

Groundwater beneath the site is first encountered as a perched zone within the Burro Canyon Formation. The low-permeability Brushy Basin Member of the Morrison Formation acts as an aquitard and forms the base of the perched aquifer. The saturated thickness of the perched zone ranges from less than 5 ft to as much as 82 ft beneath the site, assuming the base of the Burro Canyon Formation is the base of the perched aquifer. The water table of the perched aquifer was 13 to 116 ft below ground surface (bgs) at the facility in 2007 (MWH, 2010), and is shallowest near the wildlife ponds east of the Mill and tailings cells. Groundwater within the perched zone generally flows south to southwest beneath the site. Denison (2009b) and MWH (2010) provide more detailed descriptions of the perched zone hydrogeology.

Aquifers of the Entrada sandstone and Navajo sandstone are located approximately 1,200 ft below land surface (bls), and are considered one aquifer for purposes of this report. The Navajo/Entrada Aquifer is capable of yielding significant quantities of water to wells (hundreds of gallons per minute (gpm)). Water in the Entrada/Navajo Aquifer is artesian, and rises approximately 800 ft above the base of the overlying Summerville Formation resulting in static water levels 390 to 500 ft below the ground surface (Denison, 2009b). Denison (2009b) provides more information regarding the aquifer hydrogeology.

2.5 Reclamation Materials

This section summarizes the characteristics of materials to be used in reclamation of the tailings disposal cells at the Mill site. Existing characterization data on tailings and potential cover

material are summarized in this section. In addition, durability testing of potential riprap materials (conducted by Denison) is also summarized in this section.

2.5.1 Tailings Characterization

Geotechnical and radiological data on tailings materials were previously collected and data applicable to the cover design are included in Appendix A.1. This data was previously presented in Attachments D and E of the Reclamation Plan, Version 4.0 (Denison, 2009b). Geotechnical laboratory testing was conducted by Western Colorado Testing, Inc. (1999b) on the tailings and included specific gravity, standard Proctor, Atterberg limits, and gradation (including hydrometer). Testing was conducted on four samples of tailings from Cell 2 and two samples of tailings from Cell 3. Rogers & Associates Engineering Corp. (1988) measured radium-226 activity concentration and the radon emanation coefficient on one tailings sample. The geotechnical and radiological testing results were used for the radon emanation modeling and the settlement and liquefaction analysis presented in this report.

2.5.2 Cover Borrow Material Characterization

Geotechnical and radiological data on potential cover materials were previously collected and data applicable to the cover design are included in Appendix A.1. Some of this data was previously presented in Attachment D of the Reclamation Plan, Version 4.0 (Denison, 2009b) and in Titan (1996). Geotechnical laboratory testing of potential cover material (random fill) from on-site was conducted by Chen and Associates, Inc. (1978, 1979, and 1987), Geosyntec Consultants (2006), and Western Colorado Testing, Inc. (1999a). Geotechnical testing included in-situ moisture contents, specific gravity, standard Proctor, modified Proctor, Atterberg limits, gradation, and permeability. Radon emanation coefficients of random fill samples collected from on-site stockpiles were measured by Rogers & Associates Engineering Corp. (1988). The geotechnical and radiological testing results were used for the radon emanation modeling and the settlement and liquefaction analysis presented in this report.

MWH conducted a field investigation at the Mill site on October 12, 2010 to supplement existing soils data and further evaluate the geotechnical properties of the potential cover material. Potential cover borrow material locations are shown on Figure 2-2. MWH visually evaluated all of the borrow locations and collected representative bulk samples from select locations. The bulk samples were sent to Advanced Terra Testing in Denver, Colorado for laboratory testing. Laboratory testing conducted on the collected samples included in-situ water contents, Atterberg limits, specific gravity, and gradation (including hydrometer). The laboratory testing results are summarized in Table 2-1 and provided in Appendix A.2. In addition, the volume of material available at each stockpile was estimated and is summarized in Table 2-1. The results were used for the cover design analyses presented in this report including radon attenuation, settlement and liquefaction, and erosional stability.

Table 2-1. Summary of Laboratory Test Results and Borrow Stockpile Volumes (October 2010 Field Investigation)

Borrow Stockpile ID	Stockpile ID (Field Designation)	Estimated Stockpile Volume[1] (cy)	Material Description	Sample ID	Sample Depth (ft)	Gravimetric Water Content (%)	Specific Gravity	Atterberg Limits[2] LL/PL/PI (%)	Particle Size[2]				Comments
									% Gravel	% Sand	% Silt	% Clay	
E1	--	15,900	Topsoil										not sampled
E2	1	92,000	Silty Sand/Clayey Sand Random Fill	A	5'	4.5		NP	0.5	77.1	13.5	8.9	
				B	12'	5.7	2.64	23.3/11.2/12.1	13.1	50.3	22.6	14.0	Sample from working face at south end of stockpile
E3	--	16,800	Random Fill										not sampled
E4	2	66,600	Sandy Clay Random Fill	A	5	8.6		30.3/14.4/15.9	0.0	41.2	39.1	19.7	
E5	3	68,800	Sandy Clay Random Fill	A	6	9.0		33.2/14.3/18.9	0.0	35.5	38.1	26.4	
E6	4	100,700	Clay Random Fill	A	5	14.4	2.74	40.2/15.8/24.4	0.1	17.7	49.5	32.7	
E7	5	74,900	Sandy Clay Random Fill	A	6	5.7		26.2/16.3/9.9	0.0	30.2	56.1	13.7	
E8	6	227,300	Sandy Clay Random Fill	A	2	7.4		23.0/12.0/11.0	0.0	47.0	36.9	16.1	
W1	12	85,700	Sandy Clay Random Fill	A	5	8.8		32.1/14.5/17.6	0.0	40.6	37.6	21.8	
W2	13	584,500	Sandy Clay Random Fill	A	surface	8.5		28.1/13.1/15.0	0.2	41.5	42.5	15.8	
W3	11	84,800	Topsoil (Sandy Silty Clay)	A	surface	4.3		20.9/16.2/4.7	0.2	44.2	39.2	16.4	
W4	10	90,000	Topsoil (Sandy Silt)	A	5	5.3		21.9/18.0/3.9	0.0	32.6	54.3	13.1	
W5	--	965,200	Random Fill										not sampled
W6	9	93,400	Topsoil (Sandy Silty Clay)	A	surface	3.3		23.1/16.5/6.6	0.0	34.3	51.8	13.9	
W7	8	39,500	Sandy Clay Random Fill	A	5	8.7	2.67	28.0/10.6/17.3	0.0	43.8	43.1	13.1	
W8	--	900,000	Random Fill										not sampled
W9	7	300,000	Sandy Clay Random Fill	A	surface	4.4		25.9/12.3/13.5	0.0	37.4	45.2	17.4	

Notes:

1. Volumes estimated using 2009 topography and assuming a relatively flat bottom surface, except for stockpiles W8 and W9. The volumes for stockpiles W8 and W9 were estimated based on the volume of material excavated from Cell 4B (1,360,000 cy) less the material used to construct the Cell 4B berm (83,000 cy), in addition to visual observation of the stockpiles.
2. LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index (PI = LL-PL)
3. Gravel = 4.75 mm to 75 mm, Sand = 0.075 mm to 4.75 mm, Fines: Silt = 0 .075 mm to 0.002 mm, Clay = less than 0.002 mm

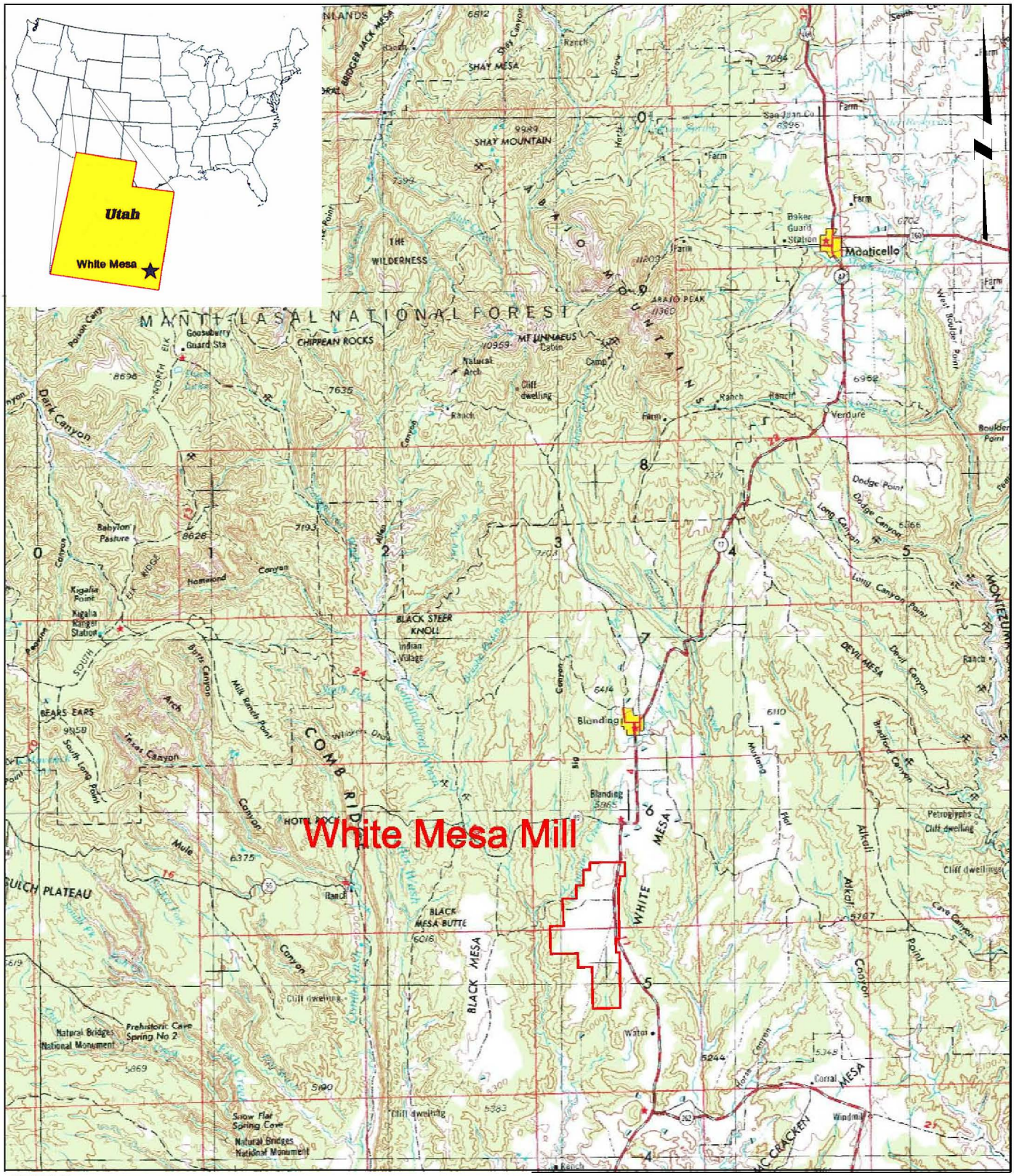
2.5.3 Erosion Protection Material Characterization

Three gravel sources were evaluated as potential sources for material for use as riprap and erosion protection at the site. Samples were tested from the Cow Canyon pit located 15 miles south of the mill, the Brown Canyon pit located four miles northeast of the mill, and the North Pit located one mile northeast of Blanding. Samples from each quarry were tested for durability in general accordance with guidelines for long-term performance outlined by the US Nuclear Regulatory Commission (NRC). These guidelines are for rock to be used for erosion protection material on exposed surfaces and utilize a rock scoring value (Johnson, 2002). In order to develop the scoring criteria the following laboratory tests were performed in accordance with U.S. Bureau of Reclamation (1987): specific gravity, absorption, sulfate soundness and L.A. Abrasion. Results of the durability testing are provided in Appendix K and were previously presented as Attachment H of the Denison Reclamation Plan, Revision 4.0 (Denison, 2009b). Table 2-2 summarizes the scoring of each potential rock source.

Table 2-2. NRC Riprap Scoring of Potential Rock Sources

Rock Source	Score (%)	Oversizing Required (%)
Cow Canyon Pit	87.61	None
Brown Canyon	60.98	19.02
North Pit	70.65	9.35

Based on information provided in Johnson (2002), areas defined as critical areas must meet a score of 65 percent or greater, and areas defined as non-critical areas must meet a score of 50 percent or higher. Critical areas include frequently-saturated areas, all channels, poorly-drained toes and aprons, control structures and energy dissipation areas. Non-critical areas include occasionally saturated areas, top slopes, side slopes, and well-drained toes and aprons. The scores calculated for each rock borrow site indicate that all three rock borrow sites would provide suitable rock for construction of the erosion protection along the embankment slopes. The Cow Canyon and North Pit sources would be used for the rock toe apron areas at the base of the toes of cell outslopes. Oversizing of both the Brown Canyon and North Pit rock would be required if used for construction. The Brown Canyon source will not be used to construct the rock toe apron areas at the base of the toes of cell outslopes.



REFERENCE:
ADAPTED FROM FIGURE 1-1 IN DENISON MINES (USA) CORPORATION, 2009. RECLAMATION PLAN WHITE MESA MILL, BLANDING, UTAH. VERSION 4.0. NOVEMBER.

DENISON MINES Denison Mines (USA) Corp	PROJECT WHITE MESA MILL TAILINGS RECLAMATION	MWH
	TITLE REGIONAL LOCATION MAP	DATE AUG 2011 — FIGURE 2-1
		FILE NAME 1009740 LOC MAP

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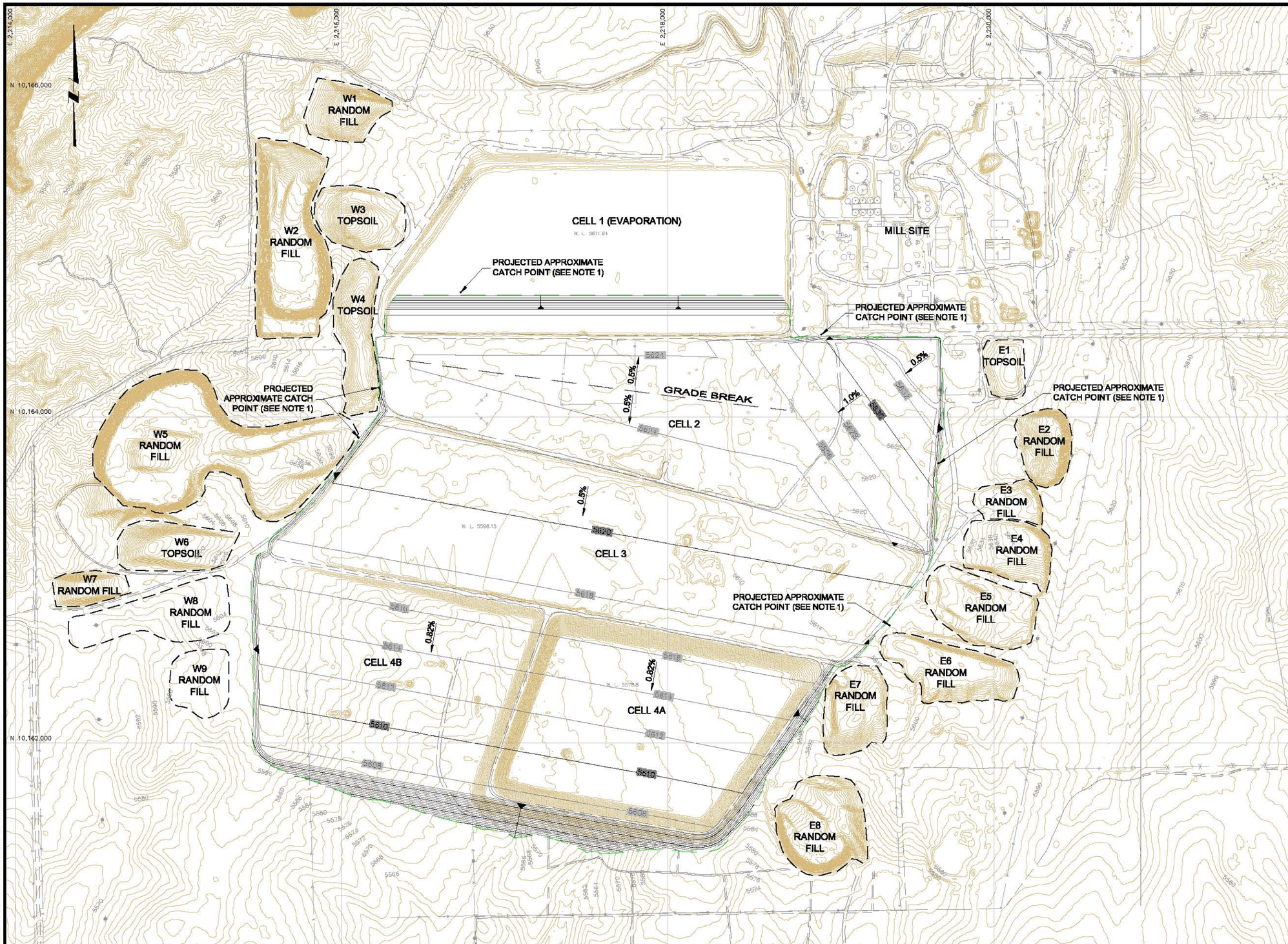

LEGEND

- EXISTING SPOT ELEVATION
- ELEVATION OF TOP OF COVER
- EXISTING GROUND CONTOUR (2007 LIDAR SURVEY)
- APPROX LIMITS OF BORROW STOCKPILE

NOTE:

1. THE COVER WILL MEET THE GROUND WITH A DOWNWARD SIDE SLOPE OF 5H:1V.

SCALE
300 0 300 600 FT

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PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
COVER MATERIAL BORROW LOCATIONS

MWH

DATE AUG 2011
FIGURE 2-2
FILE NAME 1009740 BORROW

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3.0 REGULATORY CRITERIA

Prior to the State of Utah obtaining agreement state status in 2004, the tailings at the White Mesa Mill were regulated primarily by the NRC pursuant to 10 CFR 40, Appendix A, and the U.S. Environmental Protection Agency (EPA) under 10 CFR 61, Subparts A and W which are administered by the State of Utah's Division of Air Quality. The State of Utah regulates the site according to rules and regulations presented in Title R313 – Environmental Quality, Radiation Control. These rules include, through reference, clarification, or exception, sections of 10 CRF 40 extending through Appendix A, and sections of 10 CFR Part 20. Additionally, the site is regulated under the Site's approved Groundwater Discharge Permit (Permit No.UGW370004 revised 20 January 2010) (GWDP), which is administered by the State of Utah's Department of Environmental Quality.

NRC and EPA have a Memorandum of Understanding (MOU) that covers joint expectations under what was originally Subpart T of 40 CFR 61 (uranium mill tailings closure) and a generic MOU on elimination of dual regulation. The NRC regulations also incorporate other standards by reference that were promulgated by the EPA pursuant to the Uranium Mill Tailings Radiation Control Act (UMTRCA – 1978), and Section 112 of the Clean Air Act, as amended. Compliance with these regulations under the authority of the State of Utah is provided through UAC R313-24.

The reclamation cover design has been developed in accordance with UAC R313-24, 40 CFR Part 192, and Part I.D.8 of the GWDP. In addition, the following documents have also provided design guidance:

- EPA, 1994, *The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3*, EPA/600/R-94/168b, September
- NRC, 1989, Regulatory Guide 3.64 (Task WM-503-4) *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, March
- NRC, 1984. *Radon Attenuation Handbook for Uranium Mill Tailings Cover Design*, NUREG/CR-3533
- NRC, 1990, *Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*, August
- NUREG/CR-4620, Nelson, J. D., Abt, S. R., et al., 1986, *Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments*, June
- Johnson, T.L., 2002. *Design of Erosion Protection for Long-Term Stabilization*. U.S. Nuclear Regulatory Commission (NRC), *NUREG-1623*. September
- U. S. Department of Energy, 1988, *Effect of Freezing and Thawing on UMTRA Covers*, Albuquerque, New Mexico, October
- NUREG 1620, 2003, *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*; and
- U.S. Department of Energy, 1989. *Technical Approach Document, Revision II, UMTRA-DOE/AL 050425.0002,* Uranium Mill Tailings Remedial Action Project, Albuquerque, New Mexico

The key state and federal performance criteria for tailings cover design and reclamation includes the following:

- Attenuate radon flux to a rate of 20 pCi/m^2-s, averaged over each entire cell
- Minimize infiltration into the reclaimed tailings cells
- Maintain a design life of up to 1,000 years and at least 200 years
- Provide long-term isolation of the tailings, including slope stability and geomorphic durability to withstand erosional forces of wind and runoff (up to the probable maximum precipitation event) as well as design to accommodate seismic events (up to the peak from the maximum credible earthquake) ground acceleration
- Designs are to accommodate minimum reliance on active maintenance

Following reclamation of the Mill, a designated area of the site (including the tailings cells) will be transferred to the U.S. Department of Energy (DOE) for long-term care and maintenance and institutional control. Prior to transfer, the site closure and reclamation is reviewed by the NRC for compliance with applicable design criteria and guidance (specifically Appendix A of 10 CFR 40). The guidelines of reclamation review of a Title II facility are presented in NUREG-1620 (NRC, 2003).

4.0 COVER DESIGN

4.1 Drainage and Slopes

The slopes and drainage for the new ET cover have been modified from the 2009 Reclamation Plan (Denison, 2009b) to account for the new ET cover system. The slopes and drainage provide acceptable erosional stability under long-term conditions. This includes storms up to the Probable Maximum Precipitation (PMP) event. The evaluation of acceptable erosional stability was conducted according to current NRC guidelines documented in NRC (1990) and Johnson (2002). Results of analyses conducted for drainage and slopes are presented in Appendix G of this report. The drainage and slopes are shown in the Drawings (provided in Attachment A of the Denison 2011 Reclamation Plan).

The drainage on the top surface of the ET cover at Cells 1, 2, and 3 is planned at a 0.5 percent slope, with portions of Cell 2 top surface at a one percent slope and portions of Cells 4A and 4B top surfaces at 0.8 percent slope. The slopes of the embankments are the same as those presented in Denison (2009b), with external side slopes and internal transition slopes graded to 5:1 (horizontal:vertical). The overall site drainage around the reclaimed tailings cells is also the same as presented in Denison (2009b).

4.2 Cover System

The current cover system proposed for reclamation of the tailings cells is a monolithic ET cover. This is different from the cover system proposed in Denison (2009b). A monolithic ET cover is the preferred design to minimize infiltration and meet the radon attenuation standard. The proposed cover design is sufficient to provide adequate thickness to protect against frost penetration, to attenuate radon flux, to minimize both plant root and burrowing animal intrusion, and to provide adequate water storage capacity to minimize the rate of infiltration into the underlying tailings. Furthermore, the cover is designed to be stable under both static and anticipated seismic conditions, and to provide tailings isolation under long-term wind and water erosion conditions.

The ET cover has a minimum thickness of 9 feet, and consists of the following materials listed below from top to bottom:

- 0.5 ft (15 cm) Erosion Protection Layer (gravel-admixture)
- 3.5 ft (107 cm) Water Storage/Biointrusion/Frost Protection/Radon Attenuation Layer (loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation Layer (highly compacted loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation and Grading Layer (loam to sandy clay)

The 0.5-foot thick erosion protection layer is planned to be rock mulch consisting of topsoil mixed with 25 percent gravel. The uppermost 3.5 feet of random fill will be placed at 85 percent of standard Proctor compaction in order to optimize water storage and rooting characteristics for plant growth. The middle layer (2.5 feet) of random fill will be compacted to 95 percent of standard Proctor. The lower layer of random fill consists of 2.5 feet of random fill that is assumed to be dumped and minimally compacted by construction equipment to approximately 80 percent standard Proctor. In Cell 2 and parts of Cell 3, the lower layer of random fill is already placed and is approximately 3 feet. The upper 6 inches of this fill will be compacted to

95 percent of standard Proctor compaction and will thus comprise the bottom portion of the Radon Attenuation Layer.

4.3 Freeze/Thaw

Titan (1996) included a freeze/thaw analysis for the reclamation cover design. These analyses have been updated to include the soil properties proposed for use in the monolithic ET cover. The updated calculation of frost penetration at the site was performed with the computer program ModBerg (CRREL), which uses a built-in weather database, as well as user-defined soil parameters.

In summary, the freeze/thaw calculations show the total depth of frost penetration in the area of the Mill site to be 27.1 inches (2.26 ft). This frost depth could potentially be exceeded in a given year during the long-term design life of the cover, but the characteristics of the cover materials are such that detrimental effects to the cover because of freezing and thawing are not expected. Furthermore, because the cover has a total thickness of 9 feet, the impacts of freeze and thaw will not have significant impacts to the overall integrity of the cover. A complete description of the freeze/thaw analyses conducted for the proposed cover system is presented in Appendix B.

4.4 Radon Attenuation

Titan (1996) included an analysis of radon attenuation for the reclamation cover design. Radon attenuation analyses were later conducted by MWH (2010) for the conceptual design of the proposed monolithic ET cover. The results were presented in Appendix H of the Infiltration and Contaminant Transport Modeling Report (MWH, 2010). These analyses have been updated for this report to incorporate the final design of the ET cover, changes to the final grading plan, as well as additional geotechnical testing of material properties.

The thickness of the ET cover necessary to limit radon emanation from the disposal areas was analyzed using the NRC RADON model (NRC, 1989). The model was used to calculate the cover thickness required to achieve the State of Utah's long-term radon emanation standard for uranium mill tailings (Utah Administrative Code, Rule 313-24), 20 picocuries per square meter per second (pCi/m^2-s). The analyses were conducted following the guidance presented in NRC publications NUREG/CR-3533 (NRC, 1984) and Regulatory Guide 3.64 (NRC, 1989).

The input parameters used in the model are based on engineering experience with similar projects, recent laboratory testing results for samples of random fill (included in Appendix A.2), and available data from previous work by others. Results of the RADON analyses show that the proposed cover system reduces the rate of radon-222 emanation to less than 20 pCi/m^2-s, averaged over the entire area of the tailings impoundments. A complete description of the radon attenuation analyses conducted for the ET cover system is included in Appendix C.

4.5 Vegetation and Biointrusion

4.5.1 Vegetation

The plant species proposed for the cover system consist of native perennial grasses and forbs. The use of these species in reclamation of the tailing cells should provide a permanent or sustainable plant cover because of the highly adapted nature of these species to existing site conditions, their tolerance to environmental stresses such as drought, fire, and herbivory, and their ability to effectively reproduce over time. These species can coexist and fully utilize plant

resources to keep invasive weeds and deep rooted woody species from colonizing the site. Once established, the proposed seed mixture should produce a grass-forb community of highly adapted and productive species that can effectively compete with undesirable species, including shrubs and trees native to the area.

The proposed ET cover does not contain a biobarrier (e.g. cobble layer) to minimize potential intrusion by plant roots or burrowing animals. The proposed cover system is designed to minimize both plant root and burrowing animal intrusion through the use of thick layers of soil cover in combination with a highly compacted layer placed at a depth that is below the expected rooting and burrowing depths among species that may inhabit the site. Root growth into the highly compacted radon attenuation layer that begins at a depth of 122 cm will be restricted because of the high density of this material (compaction to 95 percent Standard Proctor). In addition, both root density and the size of roots decrease at a rapid rate with rooting depth, further decreasing the potential for root growth into the compacted radon attenuation layer of the cover system. Appendix D provides a complete discussion of cover vegetation.

4.5.2 Biointrusion

Based on a review of the wildlife survey data from the 1978 Environmental Report produced for the White Mesa site (Dames & Moore, 1978), and a thorough literature review of burrowing depths and biointrusion studies, the maximum depth of on-site burrowing would be approximately one meter or slightly over three feet. Wildlife survey data for the site identify burrowing mammals as deer mice, kangaroo rats, chipmunks, desert cottontails, blacktailed jackrabbits, and prairie dogs. Other burrowing mammals, such as pocket gophers and badgers have not been observed in the area of the White Mesa site (Dames & Moore, 1978). Of the list of burrowing mammals that may occur on the site, the prairie dog is the species capable of burrowing to the greatest depth. Studies by Shuman and Whicker (1986) and Cline et al. (1982) conducted in southeast Wyoming, Grand Junction, Colorado and Hanford, Washington, document maximum burrowing depths of prairie dogs between 60 and 100 cm. Based on this empirical data and the potential species that may use the site as habitat, any burrowing activity that may occur would be limited to about one meter below ground surface. In addition, prairie dog habitat is characterized by low plant cover and vegetation that is short in vertical stature (Holechek et al. 1998). The potential for prairie dogs colonizing the tailing cells is very low because plant cover and stature will not match their habitat preferences. A complete discussion of the evaluation of Biointrusion through the ET cover is presented in Appendix D.

4.6 Infiltration

Titan (1996) included an analysis of infiltration through the reclamation cover system. Infiltration modeling for the monolithic ET cover was completed by MWH and summarized in the Infiltration and Contaminant Transport Modeling Report (MWH, 2010). These analyses included the soil properties for materials proposed for use in the monolithic ET cover. The updated evaluation of infiltration of precipitation through the cover system was evaluated with the computer program HYDRUS-1D (Simunek et al., 2009). The modeling used historic values of daily precipitation and evapotranspiration over a 57-year climate period, as well as assumptions that were either conservative or based on anticipated conditions. Given the flat nature of the cover (less than 1 percent slope), no runon- or runoff-based processes were assumed to occur. As a result, precipitation applied to the cover surface was removed through evaporation or transpiration, retained in the soil profile as storage, or transmitted downward as infiltration.

The model-predicted water flux rate varies during the 57-year period from a minimum rate of 0.17 millimeters per year (mm/yr) to a maximum rate of 1.1 mm/yr, with an average long-term flux rate through the cover system of 0.45 mm/yr. This average long-term water flux rate corresponds to approximately 0.1 percent of the average annual amount of precipitation recorded at the Blanding, Utah weather station.

The model-predicted water flux rate through the monolithic ET cover indicates that the available storage capacity of the cover should be sufficient to significantly reduce infiltration, and the ET cover should function properly as designed. A complete description of the infiltration analyses conducted for the monolithic ET cover is provided in MWH (2010).

4.7 Slope Stability Analysis

Titan (1996) included static and pseudo-static stability analyses for the tailings embankments based on the reclamation cover design. These analyses have been updated to incorporate the proposed monolithic ET cover system, updated geotechnical properties and seismic information, and an updated critical cross section. The slope stability analyses were performed for both static (long-term) and pseudo-static loading conditions, to meet NRC (2003) criteria. The analyses were performed using limit equilibrium methods with the computer program SLOPE/W (Geo-Slope, 2007).

A complete description of the input parameters and assumptions used in the analyses are included in Appendix E. The results of the stability analyses are provided in Table 4-1 below. The minimum factors of safety required in design and presented in Table 4-1 meet the criteria of NRC (2003). As shown in Table 4-1, the calculated factors of safety for both the long-term static condition and the pseudo-static condition exceed the required values.

Table 4-1. Results of Slope Stability Analyses

Loading Condition	Required Factor of Safety	Calculated Factor of Safety
Static Long-Term	1.5	4.30
Pseudo-static	1.1	2.82

4.8 Settlement and Liquefaction Analyses

4.8.1 Settlement Analyses

Settlement analyses were performed to evaluate the amount of tailings settlement expected to occur due to placement of the interim cover, dewatering, and subsequent construction of the final cover. Settlement analyses were not previously conducted for the tailings. Settlement of the tailings was modeled by applying loads corresponding to these loading conditions. Historic monitoring data from monitoring points in Cells 2 and 3 were used to estimate settlement parameters for calculation of future settlement. Material properties used in the analyses were obtained from laboratory test results or estimated based on historic monitoring data.

Settlement due to dewatering and placement of the interim cover is estimated to be approximately 2 inches in Cell 2, and approximately 10 inches in Cells 3, 4A and 4B. After placement of the interim cover, settlement monuments will be installed within Cells 3, 4A, and 4B. Monuments will be monitored on a regular basis in order to verify that most (90 percent) of the settlement due to dewatering and interim cover placement has occurred prior to construction

of the final cover. The time required to reach 90 percent of total anticipated settlement ranges from approximately 2.5 to 4 years. Additional settlement due to placement of the final cover is estimated to be approximately 5 to 6 inches. The results of the analyses are summarized in Table 4-2. A detailed discussion of the settlement analyses performed for the ET cover is provided in Appendix F.

Table 4-2. Estimate of Future Settlement in Tailings Cells

Description	Cell 2	Cell 3	Cells 4A/4B
Total Settlement due to Interim Cover Placement and Dewatering	0.14 ft	0.83 ft	0.87 ft
Total Settlement due to Final Cover Placement	0.42 ft	0.38 ft	0.38 ft
Time to Reach 90% Consolidation	2.6 yrs	3.8 yrs	4.1 yrs

Note: Values presented in table are based on average consolidation parameters (C_c and c_v)

4.8.2 Liquefaction Analyses

Liquefaction analyses were performed to evaluate the risk of earthquake-induced liquefaction of the tailings. The analyses summarized herein are an update to modeling presented in Attachment E of Denison (2009b). These analyses have been updated to incorporate the proposed monolithic ET cover system and a more recent reference for liquefaction analyses (Youd et al., 2001). Material properties used in the analyses were obtained from results of laboratory tests on tailings samples, or were estimated where site-specific data was not available. Site-specific seismic hazard information from Tetra Tech (2010) was used in the analysis and includes a peak ground acceleration of 0.15g for an approximate 10,000 year return period, with the mean seismic source being a magnitude (Mw) 5.81 event occurring 51.5 km from the site. The Tetra Tech (2020) seismic study is provided as an attachment to Appendix E (Slope Stability Analyses).

Based on the results of the liquefaction analysis, including assumed geotechnical material properties and site-specific estimations of ground acceleration, the tailings are not susceptible to earthquake-induced liquefaction. Computed factors of safety for an approximate 10,000 year return period range from 1.3 to 1.9. A detailed discussion of the liquefaction analyses performed is included in Appendix F.

4.9 Erosion Protection

The erosional stability of the reclaimed tailings cells was evaluated in terms of long-term water erosion under extreme storm conditions. Titan (1996) provided an erosion protection design for the reclamation cover system described in their 1996 report. An updated evaluation of erosional stability of the cover surface and reclaimed embankment slopes has been performed to incorporate the proposed ET cover system, the new final grading design, and the updated Probable Maximum Precipitation (PMP) event (Denison, 2009a). The updated analyses also include an evaluation of sheet erosion of the top slope of the cells, a rock apron at the toe of the embankment slopes, and the need for filter material between riprap and the underlying soil. In addition, hydraulic and erosional analyses were updated for the drainage channel and sedimentation basin. The previous analyses were provided in the Denison 2009 Reclamation Plan. The analyses have been conducted in general accordance with NRC guidelines (NRC, 1990; Johnson, 2002). A detailed description of the analyses performed is presented in

Appendix G. The erosion protection required for reclamation is presented in the Drawings (provided in Attachment A of Denison's 2011 Reclamation Plan).

The components of erosion protection for the reclaimed tailings cells consist of the following:

- The cover on the top surface of Cells 1, 2, and 3, with slopes of 0.5 percent, should be constructed as a vegetated slope, with 6 inches of topsoil vegetated with a grass mixture.
- The portions of Cell 2 with a top surface of 1 percent slope, and the portions of Cells 4A and 4B with 0.8 percent slope, should be constructed with 6 inches of topsoil mixed with 25 percent (by weight) gravel (maximum diameter of 1-inch).
- External side slopes or internal transition slopes graded to 5:1 (horizontal: vertical) should be constructed with 12 inches of angular riprap with a median rock size of 7.4 inches.
- A rock apron is recommended for the south side slopes of the reclaimed surfaces of Cells 4A and 4B and the east side of Cell 4A. The rock apron should be constructed with 3.75 feet of angular riprap with a median rock size of 15 inches.
- A rock apron is recommended for the transition areas of the toes of the north and west side slope and the east side slope of Cells 2 and 3. The rock apron should be constructed with 2 feet of angular riprap with a median rock size of 7.4 inches.
- A filter is recommended between the soil and rock protection, due to the size of riprap required for the embankment slopes and the fine-grained nature of the underlying topsoil.

The components of erosion protection for the drainage channel and sedimentation basin consist of the following:

- The surface of sedimentation basin, with a slope of 0.1 percent, should be constructed as a vegetated slope, with 6 inches of topsoil vegetated with a grass mixture.
- The remaining surface of the sedimentation basin will be excavated into bedrock. A rock apron will be placed at the transition from the vegetated surface to the portion excavated into bedrock.
- The channel will be excavated into bedrock. The channel has a bottom slope of 0.1 percent, a 150-foot bottom width and 3:1 (H:V) side slopes. The plan view of the channel is shown in the Drawings.

4.10 Tailings Dewatering

An evaluation of the effects of dewatering in tailings Cells 2, 3, 4A and 4B was conducted to estimate the time required to dewater the tailings, as well as to calculate the residual saturated thickness of tailings after dewatering operations cease. Dewatering analyses for Cells 2 and 3 were conducted by MWH and are presented in Appendix J of MWH (2010). Dewatering analyses for Cells 4A and 4B were conducted by Geosyntec (2007a, 2007b). The pertinent excerpts from MWH (2010), Geosyntec (2007a, 2007b), and DRC (2008) are included in Appendix H.

4.10.1 Tailings Cells 2 and 3

Dewatering of Cells 2 and 3 will be performed via the drain network consisting of perforated PVC pipe located across the base of the cells. The pipes drain to an extraction sump on the southern side of each cell. Tailings water gravity drains to the sump and is then pumped to Cell 1 for evaporation. The design for the drains is the same for both cells, and each drain system covers an approximate area of 400-feet by 600-feet in each cell. The drain pipes are covered by an envelope of sand over the drains, in contrast to a continuous layer of sand across the bottom of the tailing cells.

The analyses of dewatering of Cells 2 and 3 were performed with the computer code MODFLOW (McDonald and Harbaugh, 1988; Harbaugh et al., 2000) with the Department of Defense Groundwater Modeling System (GMS) pre- and post-processor. The slimes drains were simulated with the Drain package in MODFLOW, and values of hydraulic conductivity were based on measured values reported for uranium mill tailings at a similar facility (MWH, 2010).

The MODFLOW dewatering model completed for Cells 2 and 3 predicted that the tailings would draindown nonlinearly through time reaching an average saturated thickness of 3.5 feet (1.07 m) after 10 years of dewatering (MWH, 2010). The model also predicted that dewatering rates would decline to approximately 2 gallons per minute (gpm) after 10 years of pumping. A complete description of the dewatering modeling conducted for tailings Cells 2 and 3 is provided in Appendix J of MWH (2010), and is attached herein as Appendix H.1.

4.10.2 Tailings Cells 4-A and 4-B

The drain network design in Cells 4A and 4B is the same for each cell, and is different from that constructed in Cells 2 and 3. The drain network in Cells 4A and 4B consists of a series of 12-inch wide HDPE strip drains wrapped in geotextile, and covered by sand bags. The drain spacing is 50 feet across the entirety of both cells. The HDPE drains are connected to a perforated 4-inch diameter PVC pipe bedded in drain aggregate and wrapped in geotextile. The PVC pipe gravity drains the tailings water to the sump for extraction.

A tailings cell dewatering model was not constructed for Cells 4A and 4B because analytical solutions presented by Geosyntec Consultants (2007a, 2007b) were deemed adequate given the uniform distribution of the drain system in those cells. Material properties for tailings in Cells 4A and 4B were estimated based on results of laboratory tests. Results of the analyses indicated the areas of Cells 4A and 4B with the maximum thickness of tailings will be drained within approximately 5.5 years (Geosyntec Consultants, 2007a; 2007b). Cells 4A and 4B are estimated to be dewatered significantly faster than Cells 2 and 3 due to the more extensive drain network.

4.11 Material Quantities

The volume of materials required for construction of the interim cover, final cover, and erosion protection are provided in Table 4-3. The quantities of materials available for construction of the cover are also provided in Table 4-3. A summary of the volumes of borrow stockpiles was provided in Section 2.5. Sufficient quantities are available from on-site sources for the topsoil and random fill materials. The bedding and gravel materials would be obtained from off-site commercial sources. Three commercial sources have been identified as potential sources for the bedding and gravel materials. The potential off-site sources were listed in Section 2.5. Sufficient quantities of material are available from the off-site sources identified.

Table 4-3. Reclamation Cover Material Quantity Summary

Material	Quantity Required for Reclamation (cy)	Quantity Available (Identified Sources) (cy)
Topsoil (for Erosion Protection Layer)	226,000	284,100 (on-site stockpiles)
Gravel (1-inch minus for Erosion Protection Layer)	25,000	Sufficient quantity available (off-site commercial source)
Random Fill (total for water storage and radon attenuation cover layers)	3,398,000	3,522,000 (on-site stockpiles)
Riprap (D_{50} = 7.4 and 15 inch for side slopes and rock aprons)	54,000	Sufficient quantity available (off-site commercial source)
Riprap Bedding/Filter Layer	21,000[1]	Sufficient quantity available (off-site commercial source)

Note:
1. Based on 6-inch thick medium sand bedding/filter layer beneath riprap.

5.0 ADDITIONAL PLANS AND MONITORING PROGRAMS

5.1 Settlement Monitoring Plan

There are two objectives for monitoring settlement associated with the tailings cells: (1) assurance that the materials in the tailings cells have stabilized prior to construction of the final cover system, and (2) after final cover construction, verification that the final cover surface is not experiencing significant settlement. Monitoring of tailings surface settlement will be conducted at the end of operations to measure rates and locations of settlement prior to construction of the cover system. After construction of the cover system, settlement monitoring will be conducted as part of post-closure performance monitoring. A detailed settlement monitoring plan will be prepared to outline the procedures and measurement frequency for monitoring and will be submitted for agency review at least one year prior to decommissioning of Cells 2, 3, 4A and 4B. A preliminary settlement monitoring plan is presented in Appendix I.

5.2 Revegetation Plan

Revegetation of the tailing cells at the Mill site will be completed following construction of the cover system. The revegetation process will establish a grass-forb community consisting primarily of native, perennial grasses and forbs that are highly adapted to the climatic and edaphic conditions of the site. Revegetation methods will follow state-of-the-art techniques for soil amendments, seedbed preparation, seeding and mulching. In addition, quality assurance and quality control procedures will be followed to ensure that revegetation methods are implemented correctly and the results of the process meet expectations. A revegetation plan presenting seedbed preparation, soil amendments, species types, seeding rates, and quality assurance is presented in Appendix J.

5.3 Final Cover Verification

Following construction of the final tailings reclamation cover, but prior to placement of erosion protection, testing will be performed to verify that the cover meets the requirements of long-term radon-222 emanation (less than 20 pCi/m^2-s averaged over the entire area of the tailings cells). The components of the verification program are summarized below.

Following final design of the reclamation cover, Denison will submit an Emissions Measurement Plan to the DRC for review. The Emissions Measurement Plan will provide a map showing the extent of the tailings disposal cells and reclamation cover, as well as the measurement locations for the radon emissions testing. This Emissions Measurement Plan will be developed in general accordance with procedures outlined in 40 CFR Part 61, Appendix B, Method 115.

Following construction of the final tailings reclamation cover, but prior to placement of erosion protection, verification testing will be performed to measure radon-222 emanation. Verification testing will be performed in accordance with procedures described in 40 CFR Part 61, Appendix B, Method 115, or another method of verification approved by the Executive Secretary as being at least as effective in demonstrating the effectiveness of the final radon barrier. The schedule for construction of the final cover is unknown at this time, and may either be performed in a phased manner, or may be performed as continuous placement of the cover over all of the tailings cells. If the final cover is constructed in phases, verification testing will be performed for each portion of the reclaimed tailings after each phase of construction. However, if construction of the final cover is performed as a continuous placement of the cover over all of the tailings cells, verification testing will be conducted for the entire reclaimed tailings area at once. In

either scenario, verification testing will be performed as soon as reasonably achievable after placement of the final cover. Results of the verification testing will be reported within ninety days of the completion of all testing and analysis relevant to the verification.

Measurement, calculation of radon flux, and reporting will all be performed in accordance with procedures described in 40 CFR Part 61, Appendix B, Method 115. The documentation will include the results of all measurements, the calculations and/or analytical methods used to derive radon flux, and the procedure used to determine compliance. These records will be maintained on site or at an off-site storage facility until the time of site transfer to the DOE.

5.4 Closure and Post-Closure Monitoring

The performance monitoring and verification tasks for the reclaimed tailings cells are consistent with plans for overall site reclamation and review guidelines in NRC (2003). Key tasks outlined below will be performed from the time of site reclamation until property transfer to the DOE.

- **Settlement.** Settlement will be monitored with survey monuments, as discussed in Section 5.1 and Appendix I.
- **Vegetative Cover.** The Revegetation Plan discussed in Section 5.2 and Appendix J will be followed. The vegetation performance will be monitored on a semi-annual basis for comparison with goals outlined in the Revegetation Plan. The vegetation performance will be monitored by Denison until that responsibility is changed with property transfer to the U.S. Department of Energy.
- **Erosional Stability.** The erosional stability of the cover surface will be monitored on a semi-annual basis, most likely at the same time as the vegetation monitoring. Elements of the erosional stability monitoring are degree of vegetation cover (in terms of surface coverage), identification of settled or ponded areas (such as on the top surface), and identification of rills, gullies, or other areas of runoff concentration. Areas that are identified will be monitored to determine if corrective action is necessary. Corrective action would include fill placement with topsoil or placement of erosion-resistant materials on the surface, such as rock mulch. The erosional stability of the cover surface will be monitored by Denison until that responsibility is changed with property transfer to the DOE.

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APPENDIX A

MATERIALS CHARACTERIZATION

ATTACHMENT A.1

HISTORICAL LABORATORY TESTING

ATTACHMENT A.1.1

CHEN AND ASSOCIATES, INC.

1978

chen and associates, inc.
CONSULTING ENGINEERS

SOIL & FOUNDATION ENGINEERING
96 S. ZUNI • DENVER, COLORADO 80223 • 303/744-7105
1924 EAST FIRST STREET • CASPER, WYOMING 82601 • 307/234-2126

SECTION 2

Extracted Data From

SOIL PROPERTY STUDY
EARTH LINED TAILINGS RETENTION CELLS
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

Prepared for:

ENERGY FUELS NUCLEAR, INC.

PARK CENTRAL
1515 ARAPAHOE STREET
DENVER, COLORADO 80202

Job No. 16,406

July 18, 1978

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Test Hole	Depth (Ft.)	NATURAL		Maximum Dry Density	Optimum Moisture Content	ATTERBERG LIMITS		GRADATION ANALYSIS			REMOLDED		PERMEABILITY		Specific Gravity	Soil Type
		Moisture Content (%)	Dry Density (pcf)	(pcf)	(%)	Liquid Limit (%)	Plasticity Index (%)	Maximum Size	Passing #200 (%)	Less than 2 μ (%)	Dry Density (pcf)	Moisture Content (%)	ft./yr.	cm./sec.		
2	0-5			117.5	10.8	20	3	#16	58	19	111.6	16.4	0.57	5.5×10^{-7}		Sandy Silt
3	7-8	7.2				21	6	#16	62							Sandy Clayey Silt
5	7½-10			104.1	18.5	33 ✓	8	3/4 In.	56	12	102.1	22.0	0.085	8.2×10^{-8}	2.65	Calcareous Silty Clay
6	1-2	10.3				25	7	#16	77							Sandy Clayey Silt
6	8½-9	6.1				27 ✓	8	#4	70							Sandy Clay
8	5-5½	13.1					NP	3/4 In.	62							Calcareous Sandy Silt
9	0-1	8.1					NP	#16	53							Sand - Silt
10	4-6½					24	10	#4	73							Sandy Clay
11	5½-6½	14.0				26	6	#16	65							Siltstone-Claystone
12	2-5			101.0	20.6	53 ✓	35	#16	88	59	95.0	18.3	0.068	6.6×10^{-8}	2.67	Weathered Claystone
13	7-8	13.1				39 ✓	13	#8	84							Calcareous Silt Clay
14	1-2	19.3				40 ✓	21	#4	89							Weathered Claystone
15	1½-4½			106.8	19.0	26 ✓	8	3/8 In.	65	27	103.4	18.0	0.012	1.2×10^{-8}	2.64	Mod. Calcareous Sandy Clay
17	2-3	11.4				19	4	#8	59							Sandy Silt
19	0-3			117.5	12.8	23	6	#16	70		109.9	12.4	0.035	3.4×10^{-8}		Sandy Clayey Silt
22	1-2	13.2				26 ✓	10	#4	73							Sandy Clay
23	1-3					48 ✓	24	#30	87							Weathered Claystone
23	6-8					61 ✓	30	#30	96							Claystone
25	1-3½	13.3				26 ✓	9	#4	57							Sandy Clay
26	4½-5	15.3				41 ✓	20	#4	91							Weathered Claystone
28	0-2	12.7				28 ✓	10	3/8 In.	72							Sandy Clay
29	2-3	8.5				19	2	#16	59							Sandy Silt
32	8-8½	5.6				23	6	#30	73							Sandy Clayey Silt
37	0-4			118.8	11.5	23	5	#8	72		110.5	11.5	0.63	6.1×10^{-7}		Sandy Clayey Silt
38	5-7			111.0	16.7	29 ✓	14	3/8 In.	69		102.4	17.9	0.041	4.0×10^{-8}		Sandy Clay
40	4-5½			110.0	16.2	26 ✓	9	#8	64	27	106.4	16.4	0.017	1.6×10^{-8}	2.65	Sandy Clay

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Test Hole	Depth (Ft.)	NATURAL		Maximum Dry Density	Optimum Moisture Content	ATTERBERG LIMITS		GRADATION ANALYSIS			REMOLDED		PERMEABILITY		Specific Gravity	Soil Type
		Moisture Content (%)	Dry Density (pcf)	(pcf)	(%)	Liquid Limit (%)	Plasticity Index (%)	Maximum Size	Passing #200 (%)	Less than 2 μ (%)	Dry Density (pcf)	Moisture Content (%)	ft./yr.	cm./sec.		
40	9-9½	6.8				22	8	3/8 In.	60							Sandy Clay
42	13½-14½	7.6				26 ✓	10	3/8 In.	73							Sandy Clay
43	11-12	12.1				41 ✓	22	#4	86							Claystone
43	13½-16½			110.0	16.9	40 ✓	24	3/8 In.	85	44	104.1	15.8	0.024	2.3×10^{-8}	2.62	Claystone
44	6½-7	7.5				30 ✓	11	3/8 In.	79							Calcareous Sandy Clay
46	0-2	12.3				22	6	#16	76							Sandy Clayey Silt
✓48	5-5½					30 ✓	9	3/8 In.	65							Sandy Clay
✓49	5-7			110.7	15.6	25 ✓	9	#16	71		105.2	13.9	0.33	3.2×10^{-8}		Sandy Clay
✓49	14-15					28 ✓	5	#8	55							Calcareous Sandy Silt
54	0-2	12.1				23	9	#8	64							Sandy Clay
55	5-5½	7.8				28 ✓	14	#30	71							Sandy Clay
55	9½-10½					28 ✓	13	#4	71							Sandy Clay
✓58	5½-6	12.5				35 ✓	11	#4	75							Sandy, Silty Clay
61	0-1	11.5				21	4	#16	75							Sandy Silt
62	11-11½	8.1					NP	1 In.	34							Calcareous Sand & Silt
63	4-6					30 ✓	14	#8	68							Sandy Clay
65	1-2	9.0					NP	#16	44							Silty Sand
68	7½-8	8.6				28 ✓	13	#8	67							Sandy Clay
70	3½-4½	16.4				27	4	1½ In.	46							Calcareous Sand & Silt
72	0-2	12.2				22	8	#16	59							Sandy Clay
75	10-11	12.4				41 ✓	25	#4	75							Weathered Claystone
75	12-14					45 ✓	22	#16	93							Claystone

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TABLE II

LABORATORY PERMEABILITY TEST RESULTS

Sample	Soil Type	Compaction			Surcharge Pressure (psf)	Permeability	
		Dry Density (pcf)	Moisture Content (%)	% of ASTM D698		(Ft/Yr)	(Cm/
TH 2 @ 0'-5'	Sandy Silt	111.6	16.4	95	500	0.57	5.5x1
TH 5 @ 7½'-10'	Calcareous Silty Clay	102.1	22.0	101	500	0.085	8.2x1(
TH 12 @ 2'-5'	Weathered Claystone	95.0	18.3	94	500	0.068	6.6x1(
TH 15 @ 1½'-4½'	Calcareous Sandy Clay	103.4	18.0	97	500	0.012	1.2x1(
TH 19 @ 0'-3'	Sandy, Clayey Silt	109.9	12.4	94	500	0.035	3.4x1(
TH 37 @ 0'-4'	Sandy, Clayey Silt	110.5	11.5	93	500	0.63	6.1x1(
TH 38 @ 5'-7'	Sandy Clay	102.4	17.9	92	500	0.041	4.0x1(
TH 40 @ 4'-5½'	Sandy Clay	106.4	16.4	97	500	0.017	1.6x1(
TH 43 @ 13½-16½'	Claystone	104.1	15.8	95	500	0.024	2.3x1(
TH 49 @ 5'-7'	Sandy Clay	105.2	13.9	95	500	0.33	3.2x1(

ft / year	cm / sec
0.57	5.5E-07
0.085	8.2E-08
0.068	6.6E-08
0.012	1.2E-08
0.035	3.4E-08
0.63	6.1E-07
0.041	4.0E-08
0.017	1.6E-08
0.024	2.3E-08
0.33	3.2E-07

TABLE III

RESULTS OF ATTERBERG LIMITS

SAMPLE	SOIL TYPE	PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS			SHRINKAGE RATIO
			Liquid Limit (%)	Plastic Limit (%)	Shrinkage Limit (%)	
2 @ 0 - 5'	Sandy Silt	58	20	17	17	1.81
5 @ 7½ - 10'	Calcareous Silty Clay	56	33	25	25	1.62
15 @ 1½-4½'	Calcareous Sandy Clay	65	26	18	17.5	1.76
19 @ 0-3'	Sandy, Clayey Silt	70	23	17	18	1.80
26 @ 4½-5'	Weathered Claystone	91	41	21	12	1.90
38 @ 5 - 7'	Sandy Clay	69	29	15	14	1.89

ATTACHMENT A.1.2

CHEN AND ASSOCIATES, INC.

1979

chen and associates, inc.
CONSULTING ENGINEERS

SOIL & FOUNDATION ENGINEERING

96 S. ZUNI • DENVER, COLORADO 80223 • 303/744-7105

SECTION 3

Extracted Data From

SOIL PROPERTY STUDY
PROPOSED TAILINGS RETENTION CELLS
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

Prepared for:

ENERGY FUELS NUCLEAR, INC.
1515 ARAPAHOE STREET
DENVER, COLORADO 80202

Job No. 17,130

January 23, 1979

CHEN AND ASSOCIATES

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
76	0 - 1	4.5		21	5				78	Sandy silt
	9.5 - 10	4.4			NP				26	Silty, gravelly sand
77	7.5 - 8	8.6		30	15				71	Sandy clay
79	0 - 1	4.1		20	5				83	Sandy silt
	5 - 5.5	5.5			NP				41	Calcareous sandy clay
80	4.5 - 7			39	20				78	Calcareous sandy clay
	8 - 8.5	10.1		40	20				86	Weathered claystone
81	3 - 4	6.3		26	8				64	Silty, sandy clay
83	4 - 6			24	7				64	Sandy, clayey silt
84	0 - 2			18	2				65	Sandy silt
	9 - 9.5	2.7			NP				27	Silty sand
86	8 - 8.5	2.6			NP				12	Sandstone
87	0 - 1	3.1		16	1				61	Sandy silt
89	0 - 3			21	5				66	Sandy silt
90	8 - 8.5	12.9		35	15				61	Weathered claystone
92	0 - 1	5.9		21	5				80	Sandy silt
94	5 - 5.5	13.7		27	10				68	Sandy clay
95	6 - 7			23	5				62	Sandy silt
96	0 - 2	5.2		21	4				79	Sandy silt
	8.5 - 9.5			32	6				66	Calcareous sandy clay
98	0 - 1	3.8		20	5				74	Sandy silt
	4 - 4.5	17.8		49	25				76	Weathered claystone
99	8 - 9.5			40	20				89	Weathered claystone

CHEN AND ASSOCIATES

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
99	11 - 12	13.5		26	10				73	Claystone
100	0 - 1			17	NP				44	Silty sand
	5.5 - 6	12.0			NP				61	Sandstone-siltstone
102	6.5 - 7	16.7		30	8				79	Calcareous sandy clay
	13.5 - 14	9.5		23	6				87	Claystone-siltstone
103	10 - 10.5	7.0		28	12				57	Sandy clay
104	8 - 8.5	9.2		33	9				70	Calcareous sandy clay
105	0 - 1	5.4		22	6				77	Sandy silt
	6.5 - 7	4.5			NP				86	Sandy silt
106	5 - 5.5	10.4		28	6				59	Claystone-sandstone
107	7.5 - 9				NP				23	Sandstone
108	0 - 1	4.0		18	3				69	Sandy silt
	9.5 - 10	9.9		38	16				93	Claystone
109	4 - 5			25	7				75	Sandy, clayey silt
111	9 - 9.5	5.8		25	10				53	Claystone
113	5 - 8			40	20				84	Weathered claystone
	10.5 - 11			24	10				54	Claystone-sandstone
114	0 - 2			22	6				58	Sandy, clayey silt
115	4.5 - 6				NP				58	Calcareous
116	0 - 3			22	5				72	Sandy silt
	7 - 8			24	10				42	Claystone-sandstone
117	1 - 2	10.6		25	5				77	Sandy silt
118	0 - 2			25	6				77	Sandy silt

CHEN AND ASSOCIATES

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
118	6.5 - 8.5			40	20				89	Weathered claystone
119	4.5 - 5	10.0		26	12				68	Sandy clay
120	1 - 2			25	8				69	Sandy, clayey silt
	5 - 5.5	15.5		29	10				78	Sandy clay
	11 - 11.5	11.6		42	24				90	Claystone
122	4 - 6			25	8				66	Sandy, silty clay
	14.5 - 15	6.4		26	8				66	Sandy clay
123	1 - 3			23	7				71	Sandy, clayey silt
124	4.5 - 5	6.0		23	7				69	Sandy, clayey silt
125	0 - 1	3.8		22	6				67	Sandy silt
127	5 - 6			54	34				89	Claystone
128	6 - 8			41	24				90	Claystone

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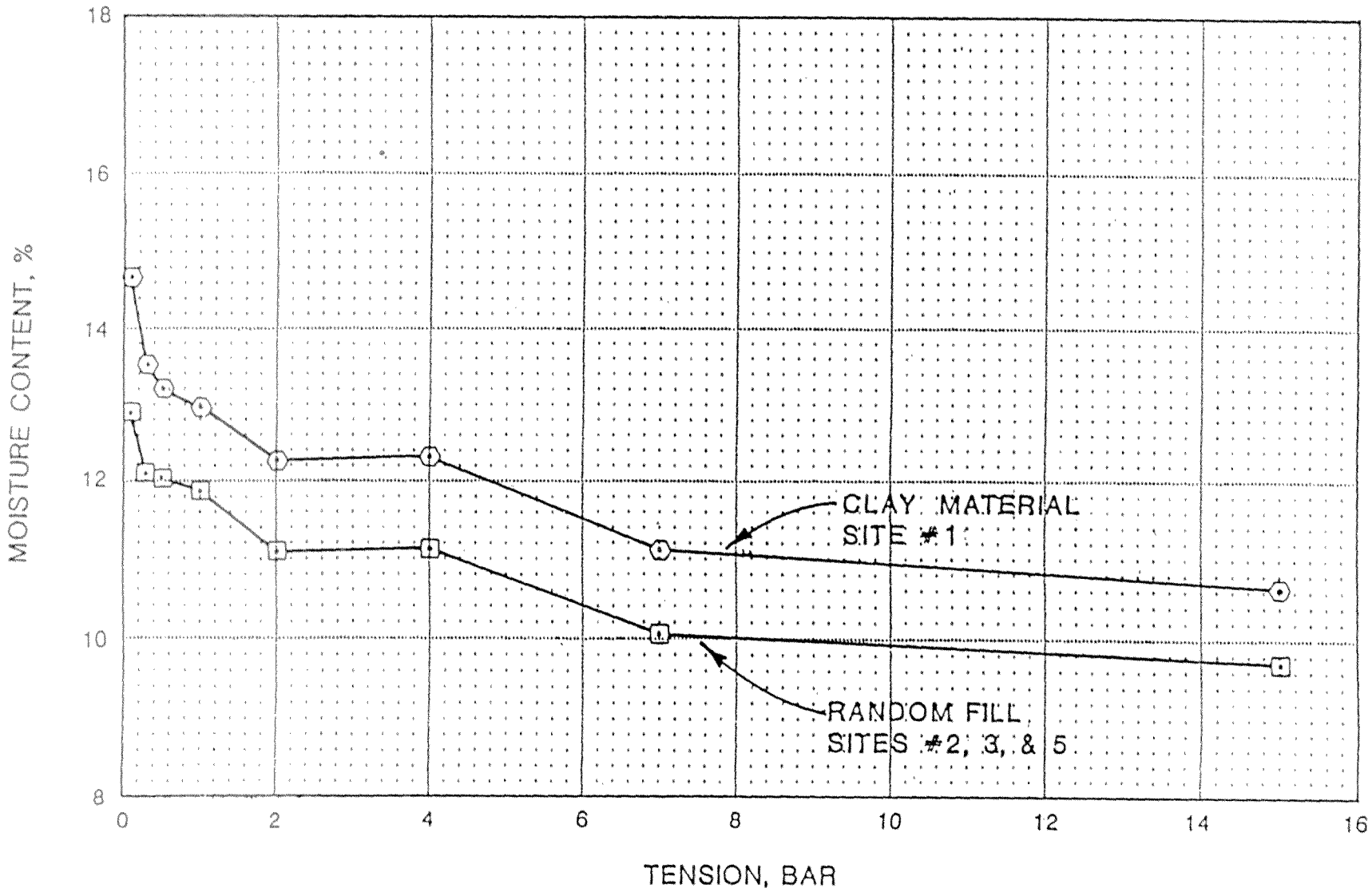
LABORATORY PERMEABILITY TEST RESULTS

Sample	Classification	Compaction Dry Density (pcf)	Compaction Moisture Content (%)	Compaction % of ASTM D698	Surcharge Pressure (psf)	Permeability Ft./Yr.	Permeability Cm/Sec
TH 80 @ 4½-7'	Calcareous sandy clay -200=78; LL=39; PI=20	100.2	19.4	96	500	0.81	7.8×10^{-7}
TH 84 @ 0-2'	Sandy silt -200=65; LL=18; PI=2	113.8	11.7	96	500	4.45	4.3×10^{-6}
TH 96 @ 8½-9½'	Calcareous sandy clay -200=66; LL=32; PI=6	96.9	20.7	97	500	1.55	1.5×10^{-6}
TH 96 @ 8½-9½'	Calcareous sandy clay	95.7	20.3	96	500	26.90*	2.6×10^{-5}
TH 99 @ 8-9½'	Weathered claystone -200=89; LL=40; PI=20	99.8	18.5	95	500	0.22	2.1×10^{-7}
TH 100 @ 0-1'	Very silty sand -200=44; PI=NP	117.5	9.7	98	500	0.38	3.7×10^{-7}
TH 114 @ 0-2'	Sandy, clayey silt -200=58; LL=22; PI=6	112.4	12.9	95	500	0.60	5.8×10^{-7}
TH 120 @ 1-2'	Sandy, clayey silt -200=69; LL=24; PI=6	108.2	14.7	95	500	0.11	1.1×10^{-7}
TH 122 @ 4-6'	Sandy, silty clay -200=66; LL=25; PI=8	108.8	15.5	96	500	0.43	4.2×10^{-7}
TH 123 @ 1-3'	Sandy, clayey silt -200=71; LL=23; PI=7	110.9	12.6	95	500	0.56	5.4×10^{-7}
TH 128 @ 6-7'	Claystone -200=89; LL=41; PI=24	92.4	23.9	93	500	0.12	1.2×10^{-7}
TH 128 @ 6-7'	Claystone -200=89; LL=41; PI=4	93.1	22.1	94	500	0.52*	5.0×10^{-7}*

* 1.5 pH sulfuric acid liquor used during percolation test interval.

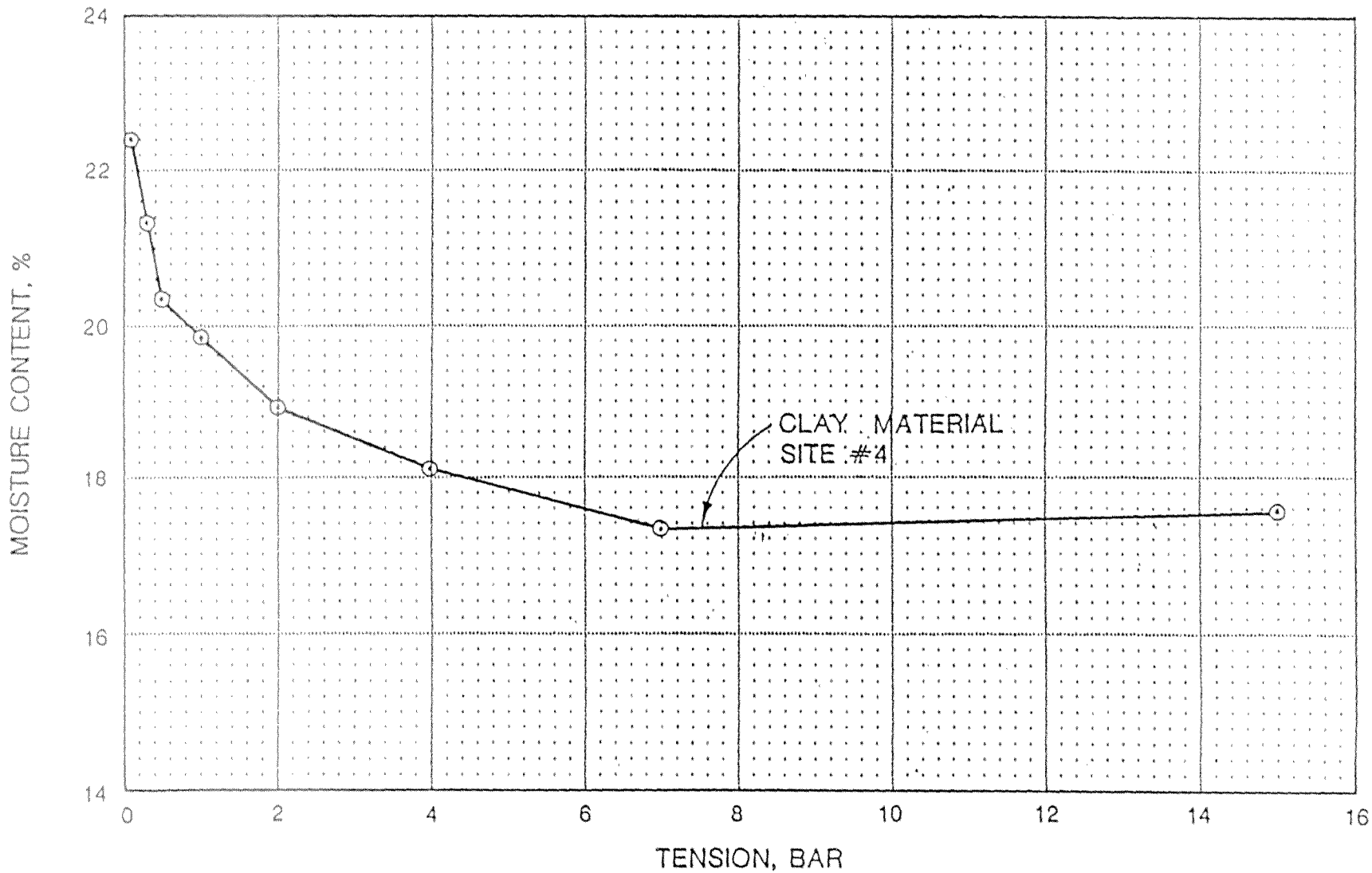


SUMMARY OF CAPILLARY MOISTURE RELATIONSHIP TEST RESULTS

WHITE MESA PROJECT

FIGURE 3.5-1

DATA FROM CHEN & ASSOCIATES



SUMMARY OF CAPILLARY MOISTURE RELATIONSHIP TEST RESULTS
WHITE MESA PROJECT
FIGURE 3.5-2

DATA FROM CHEN & ASSOCIATES

ATTACHMENT A.1.3

CHEN AND ASSOCIATES, INC.

1987

Table 3.4-1

Physical Properties of Tailings

and

Proposed Cover Material

Material Type	Atterberg Limits LL	Atterberg Limits PI	Specific Gravity	% Passing No. 200 Sieve	Maximum Dry Density (pcf)	Optimum Moisture Content
Tailings	28	6	2.85	46	104.0	18.1
Random Fill	22	7	2.67	48	120.2	11.8

Note: Physical Soil Data from Chen and Associates (1987).

ATTACHMENT A.1.4

GEOSYNTEC CONSULTANTS

2006

GEOSYNTEC CONSULTANTS

11305 Rancho Bernardo Rd., Suite 101
San Diego, CA 92127 USA
Tel (858) 674-6559 Fax (858) 674-6586

23 January 2006

Mr. Harold R. Roberts
Vice President, Corporate Development
International Uranium (USA) Corporation
Independence Plaza, Suite 950
1050 Seventeen Street
Denver, Colorado 80265

Subject: Stockpile Evaluation
Tailings Cell 4A, White Mesa Mill
Blanding, Utah

Dear Mr. Roberts:

GeoSyntec Consultants (GeoSyntec) is pleased to provide this letter report to International Uranium (USA) Corporation (IUC) presenting the results of the GeoSyntec soil stockpile evaluation at the White Mesa Mill facility (site) in Blanding, Utah. This stockpile evaluation was performed in accordance with an authorized proposal dated 5 October 2005.

INTRODUCTION

The site is located at 6425 S. Highway 191, approximately 6 miles south of the City of Blanding, San Juan County, Utah (Figure 1). The 5,415-acre site is bordered on all sides by undeveloped land that is sparsely vegetated. The mill is utilized to process ores and alternate feed streams for the extraction and enrichment of uranium and other approved materials.

BACKGROUND

In addition to marketable product produced during the milling process, ore spoils (tailings) and highly acidic wastewaters are also generated as process by-products. The tailings and wastewater are stored on site within constructed surface cells that are lined with low-permeability soil (clay) and geosynthetic materials to mitigate potential impacts to underlying soils and groundwater. Cell 4A was a previously constructed surface impound at the south end of the site (Figure 2) and contained a compacted clay liner and a geosynthetic liner.

PURPOSE

A new geosynthetic lining system may be installed in future cell base liner systems. In addition to the potential need for clay material for the construction of future base liner systems, clay material will be needed for final cover system installation overlying closed cells. Although many soil stockpiles exist on site, the material in many of these stockpiles would not meet specific permeability requirements and are not considered available for use.

Based on discussions between IUC and GeoSyntec during a 29 September 2005 meeting at the site, it was understood that clay soil may be available in two on-site stockpiles. Clay liner materials are typically required to have an in-situ hydraulic conductivity of $1x10^{-7}$ cm/sec or less. In order to prepare design drawings, appropriately budget and plan for the future liner system construction, and evaluate final cover system soil materials, the two existing soil stockpiles with potentially-suitable clay soil were characterized to evaluate quality and consistency of the material. In addition, a third on-site stockpile was sampled and evaluated at the request of IUC.

FIELD INVESTIGATION

As part of this investigation, soil from three existing on site soil stockpiles was sampled. Before field work began, GeoSyntec reviewed and discussed documentation for previous sampling events performed by others on many of the soil stockpiles on site. In agreement with IUC, stockpiles C1, C2, and RF5 were identified as potential stockpiles of clay material and were the focus of the GeoSyntec field evaluation and sampling event (Figure 2). Prior to mobilizing to site, GeoSyntec field personnel prepared a project-specific health and safety plan (HASP) for the field work to be performed.

The field investigation was performed for the three stockpiles on 10 and 11 November 2005. Soil stockpile evaluation was assisted by an IUC employee operating a Caterpillar 426B backhoe on 10 November 2005 and a Caterpillar front-end loader on 11 November 2005. Stockpile evaluation included the visual evaluation of stockpile surface and excavated test-pits and the collection and transport of soil samples for off-site laboratory geotechnical testing. General observations made during the stockpile evaluation by GeoSyntec field personnel, including surficial conditions of the three stockpiles, were recorded on Daily Field Reports (Appendix A).

On 10 November 2005 nine test-pits were excavated in soil stockpile C1, and seven test pits were excavated in soil stockpile C2. One test pit in stockpile C2 and two test pits in stockpile RF5 were excavated on 11 November 2005. The approximate test pit locations are shown on Figures 3 through 5. Test pits were excavated to depths ranging from approximately 2 to 10 feet below ground surface (bgs) and from approximately 10 to 15 feet long. Test pits excavated with the backhoe were

approximately 2 feet wide and those excavated with the loader were approximately 6 feet wide. General visual observations were made of the materials excavated for each test pit and the soils were logged in general accordance with the American Society for Testing and Materials (ASTM) soil classification system, as outlined in ASTM standard D2488. Logs of the test pits are presented in Appendix A.

Representative soil samples were obtained from the soil cuttings in 5-gallon buckets and shipped, via courier, to the off-site geotechnical laboratory for further testing and classification.

LABORATORY TESTING

Geotechnical laboratory testing was performed on selected soil samples to evaluate the suitability of the soil within the stockpiles for use as clay liner. Laboratory testing was performed by a GeoSyntec subcontractor, Excel Geotechnical Testing. The following laboratory tests were performed in general accordance with ASTM test methods on selected soil samples or on a composite of two or more like samples, as selected by the GeoSyntec project manager:

- Grain size analyses (ASTM D422)
- Atterberg Limits (ASTM D4318)
- Laboratory Compaction by Modified Effort (ASTM D1557)
- Permeability (ASTM D5084)

The laboratory test results are presented in Appendix B and summarized in Table 1.

CONCLUSIONS AND RECOMMENDATIONS

Based on observations made during the field investigation and review of the results of the laboratory testing performed for this evaluation, the soil within each of the three on-site stockpiles (C1, C2, and RF5) is suitable for construction of the clay liner or soil cover. The soil encountered within the test pits performed for the three stockpiles was generally consistent (e.g. the soils encountered in the test pits performed in stockpile C1 were generally consistent throughout stockpile C1). The samples tested from all three stockpiles, although different, are generally suitable for use as clay liner.

Based on the results of laboratory testing, the on-site stockpile soils, compacted to a minimum relative compaction of 90 percent using modified effort and a moisture content of at least 4 percent above optimum, should have a hydraulic conductivity of less than 1×10^{-7} cm/s when subjected to a consolidation pressure of 30 pounds per square inch (consistent with anticipated bottom liner system normal stresses).

GeoSyntec recommends that the soil to be used from the three sampled stockpiles (C1, C2, and RF5) as clay liner be compacted to a minimum relative compaction of 90 percent of the maximum laboratory dry density, as determined in accordance with ASTM D1557 – Laboratory Compaction using Modified Effort. Soil compacted for the clay liner should be compacted at least 4 percent wet of the optimum moisture content as determined in accordance with ASTM D1557.

Should you have questions or require additional information regarding this letter report, please contact us at (858) 674-6559.

Sincerely,

Chad Bird, E.I.T. 020454
Environmental Engineer

REGISTERED PROFESSIONAL ENGINEER
No. 6020077-2202
GREGORY T. CORCORAN
STATE OF UTAH

Gregory T. Corcoran, R.C.E. 6020077-2202
Associate

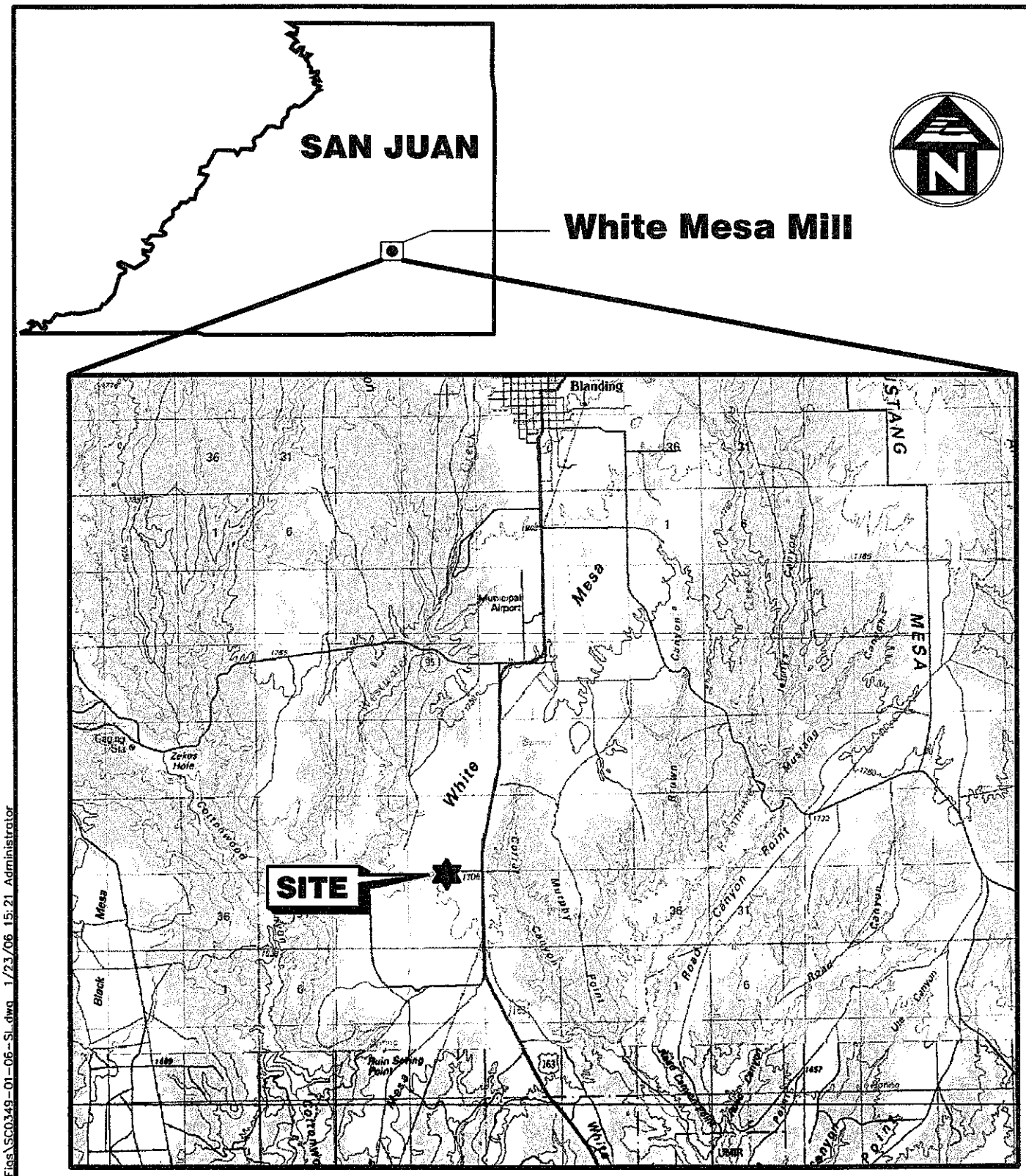
Attachments:

Table 1 – Summary of Laboratory Testing
Figure 1 – Site Location Map
Figure 2 – Site Plan
Figure 3 – Location of Stockpile Samples (C1)
Figure 4 – Location of Stockpile Samples (C2)
Figure 5 – Location of Stockpile Samples (RF5)
Appendix A – Field Investigation
Appendix B – Laboratory Testing

Table 1
Summary of Laboratory Testing
Stockpile Evaluation - Tailings Cell 4A

		Permeability	Lab. Compaction		Atterberg Limits			Gradation Analyses		
Sample ID	**Stockpile**	**Permeability (cm/s)**	**Max. Dry Unit Wt. (pcf)**	**Optimum Moisture Content (%)**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Percent Passing #200 Sieve**	**Classification**	**Description**
C1S1-C					34	15	19	67.6	CL	Sandy lean clay
C1S1-E					33	15	18	75.9	CL	Lean clay with sand
C1S1-G	C1				31	14	17	66.2	CL	Sandy lean clay
Mix 1[1]		4.7E-07	125.4	10.4						
Mix 1[2]		2.1E-08								
C2S1-C					32	15	17	47.3	SC	Clayey fine sand
C2S1-F					32	14	18	60.2	CL	Sandy lean clay
C2S1-G	C2				35	17	18	50.7	CL	Sandy lean clay
Mix 2[1]		5.7E-07	128.7	9.5						
Mix 2[2]		3.2E-08								
RF5-S1-A					53	16	37	81.2	CH	Fat clay with sand
RF5-S1-B	RF5				40	14	26	73.9	CL	Lean clay with sand
Mix 3[1]		4.6E-08	126.8	11.2						
Mix 3[2]		3.3E-08								

Notes:
Mix 1 - a mixture of equal volumes of C1S1-C, C1S1-E, and C1S1-G
Mix 2 - a mixture of equal volumes of C2S1-C, C2S1-F, and C2S1-G
Mix 3 - a mixture of equal volumes of RF5-S1-A and RF5-S1-B
[1] - Sample compacted to approximately 90 percent relative compaction at a moisture content 2% above optimum
[2] - Sample compacted to approximately 90 percent relative compaction at a moisture content 5% above optimum



SOURCE:
TerraServer-USA;
USGS 7.5 MINUTE
TOPOGRAPHIC MAP
1 JULY 1982

3,000 1,500 0 3,000 6,000

SCALE IN FEET

GEOSYNTEC CONSULTANTS

SITE LOCATION WHITE MESA MILL BLANDING, UTAH	FIGURE NO. 1 PROJECT NO. SC0349-01-06 DATE: JANUARY 2006

P:\PRJ\SDCadd\CADD\SC0349\01-06-Figs\SC0349-01-06-SL.dwg 1/23/06 15:21 Administrator

LEGEND

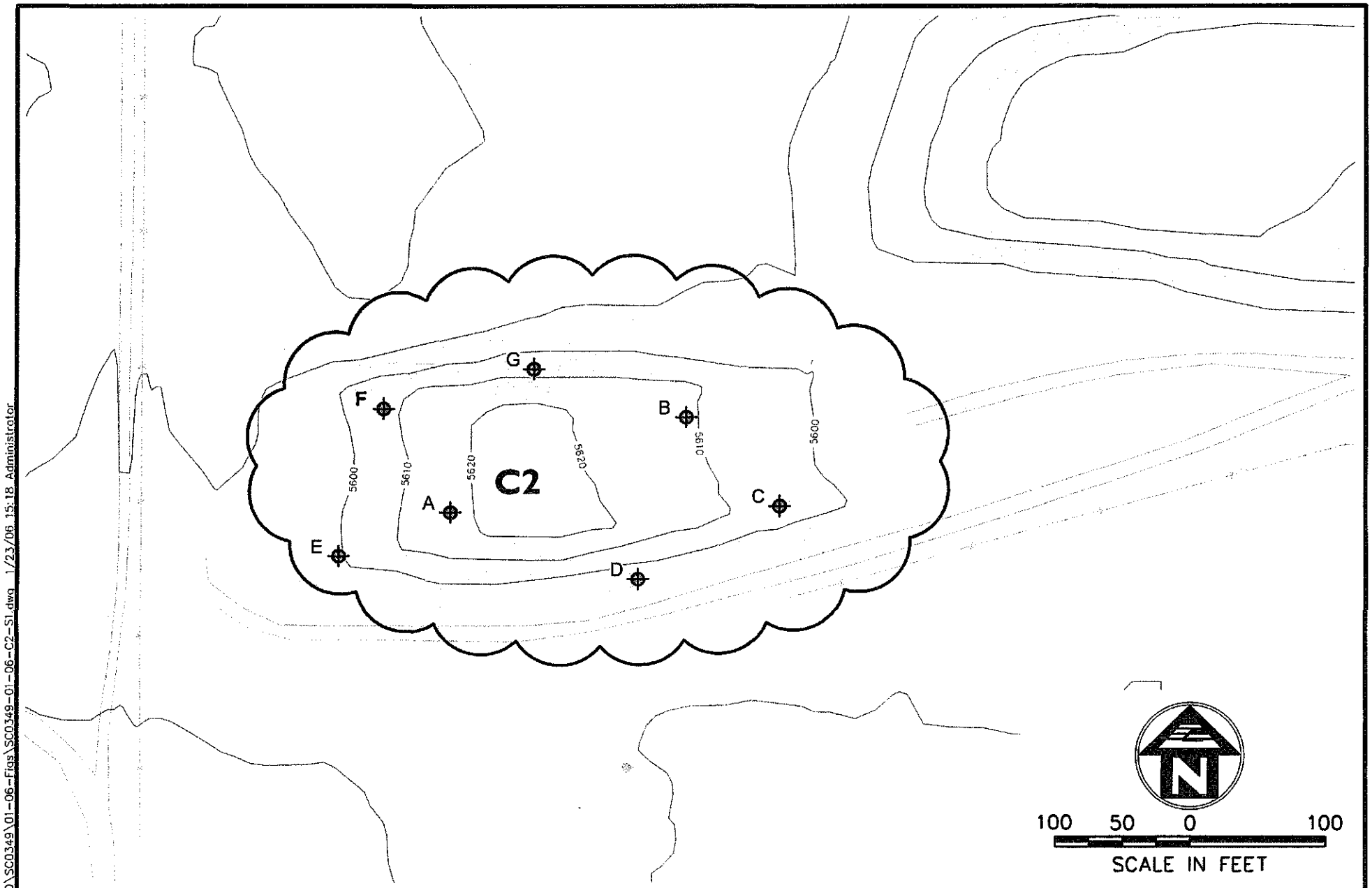
G ⊕ SOIL SAMPLE LOCATION AND ID

GEOSYNTEC CONSULTANTS

LOCATION OF STOCKPILE SAMPLES
WHITE MESA MILL
BLANDING, UTAH

FIGURE NO.	3
PROJECT NO.	SC0349-01-06
DATE:	JANUARY 2006

P:\PRJ\SPCadd\CADD\SC0349\01-06-Figs\SC0349-01-06-C1-S1.dwg 1/23/06 17:05 Administrator



LEGEND

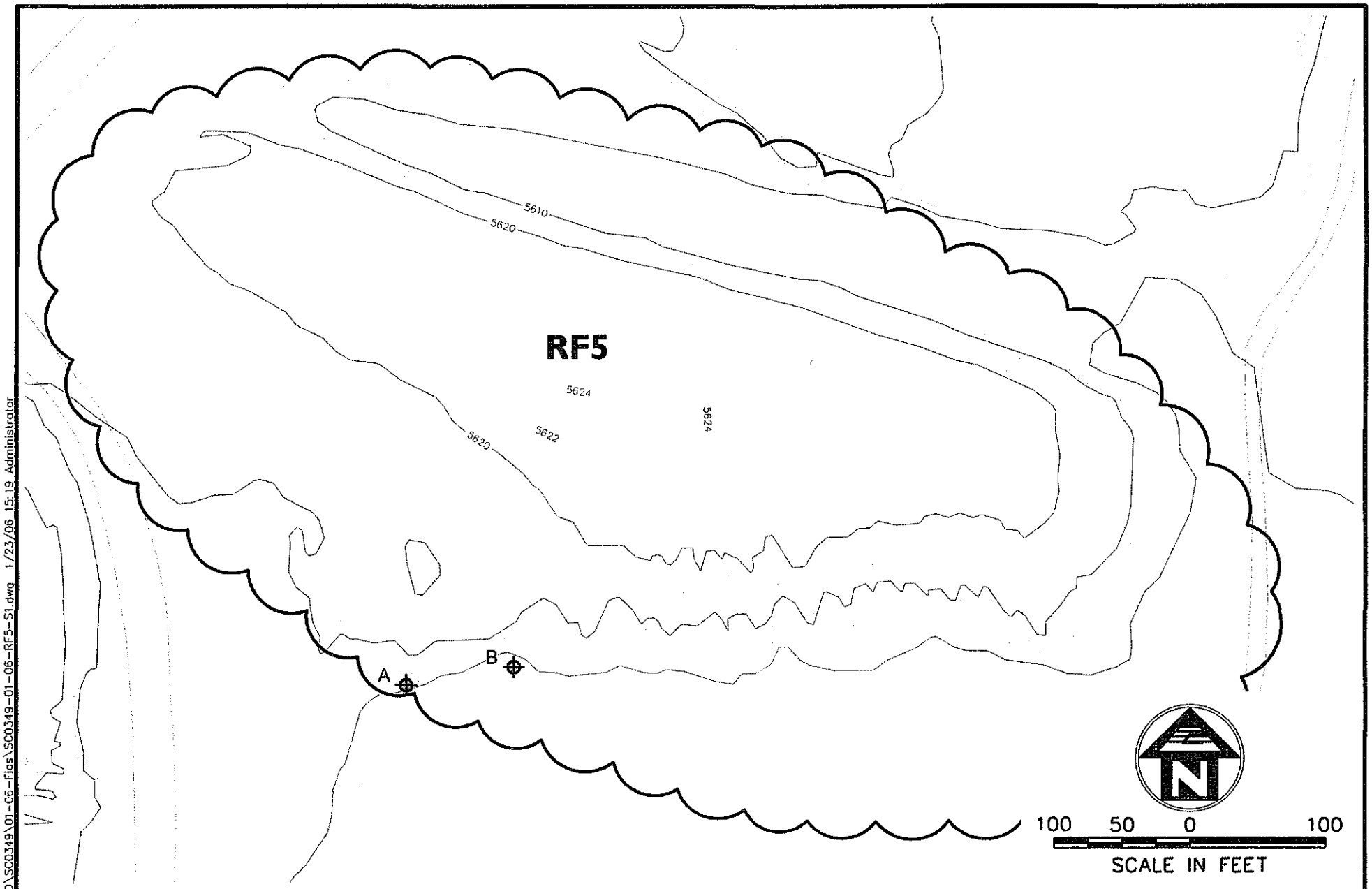
G ⊕ SOIL SAMPLE LOCATION AND ID

GEOSYNTEC CONSULTANTS

LOCATION OF STOCKPILE SAMPLES
WHITE MESA MILL
BLANDING, UTAH

FIGURE NO.	4
PROJECT NO.	SC0349-01-06
DATE:	JANUARY 2006

P:\PRJ\SDCadd\CADD\SC0349\01-06-Figs\SC0349-01-06-C2-S1.dwg 1/23/06 15:18 Administrator



LEGEND

G ⊕ SOIL SAMPLE LOCATION AND ID

GEOSYNTEC CONSULTANTS

LOCATION OF STOCKPILE SAMPLES
WHITE MESA MILL
BLANDING, UTAH

FIGURE NO.	5
PROJECT NO.	SC0349-01-06
DATE:	JANUARY 2006

P:\PRJ\SDCadd\CADD\SC0349\01-06-Figs\SC0349-01-06-RF5-S1.dwg 1/23/06 15:19 Administrator

GEOSYNTEC CONSULTANTS

DAILY FIELD REPORT

PROJECT: IUC WHITE MESA MILL

LOCATION: BLANDING, UTAH PROJECT NO.: SC0349 TASK NO.: 01-06

DESCRIPTION: CLAY STOCKPILE SAMPLING DATE: 10 day NOV month 05 year

CONTRACTOR: NA CLIENT: INTERNATIONAL URANIUM CORP. THURSDAY

WEATHER: MOSTLY SUNNY, H ~ 70°, L ~ 45°

0745 - ARRIVE ON SITE. MEET KEN MAYOSHI OF INTENATIONAL URANIUM ~~(USC)~~ (USA) CORPORATION (IUC).

~0815 - MEET RICH BARTLETT OF IUC. VISIT C1-S1 SOIL STOCKPILE AREA. ~~KEN~~ R. BARTLETT ARRANGES FOR BACKHOE AND OPERATOR FOR WRITER.

- THE C1-S1 STOCKPILE BOUNDS ARE MANIFEST. PILE IS COVERED WITH LOW VEGETATION (~2-3 FT TALL). THERE ARE MANY LENGTHS OF APPARENTLY USED PREVIOUSLY POLYETHYLENE PIPES OF VARYING DIAMETER ON PILE AND OTHER DEBRIS. AN ACCESS ROAD ASCENDS FROM WEST TO EAST ALONG NORTH SIDE OF STOCKPILE.

0900 - OPERATOR W/ BACKHOE ASSIGNED (WAYLAN). PROCEED BACK TO C1-S1 (FIGURE 1)

0915 - TEST PIT C1S1-A AS SHOWN ON ATTACHED FIGURE. SOIL SAMPLE STICKY WHEN WETTED. MAKES BALL. STICKS TO SIDE OF PE PIPE. (SEE TEST PIT LOGS.)

~0950 - TEST PIT C1S1-B (SEE FIGURE). SOIL BELOW ~1.5' DIFFICULT TO DIG. DRY SURFACE (TOP ~1.5') SOIL SLOUGHS INTO TEST PIT (T.P.). DEEP SOIL IS STIFFER, HARD TO EXCAVATE.

~1010 - T.P. C1S1-C (SEE FIGURE). SOIL COMES OUT ~~IN~~ MAINLY IN ~6" CLODS OR LARGER. DIFFICULT TO EXCAVATE W/ DEPTH. SIDEWALLS ARE STIFF AND MODERATELY SMOOTH. OBTAIN 5-GAL. BUCKET SAMPLE

1150 - T.P. C1S1-D (SEE FIGURE). NOT TOO DIFFICULT TO EXCAVATE.

~~1100~~ - 1105 - WAYLAN BREAKS FOR LUNCH.

~~1110~~ 1115 - CALL NADER RAD AT SOILS LAB AND DESCRIBE SOIL OBSERVATIONS. NADER REQUESTS ~½ - ¾ FULL 5-GALLON BUCKET SOIL SAMPLE VOLUME FOR LABORATORY TESTING.

1135 - RETURN TO C1S1. FINISH LOGGING C1S1-D.

~~14~~ 1150 - C1S1-E (SEE FIGURE). SEMI-MOIST RED CLAY. COMES UP IN ~4" TO 6" CLODS; EASILY CRUMBLED. OBTAIN OFF-SITE LAB SAMPLE.

COPY TO: FILE PER: CHAD BIRD HRS: 8.5

GEOSYNTEC CONSULTANTS

DAILY FIELD REPORT DATE: 10 day NOV month 05 year

~1210 - TP C1S1-F (SEE FIG). REDDISH BROWN ~~CLAY~~ SAND W/ FINES AND BROWN SAND W/ FINES. SMALL (~1" ϕ) CLODS. ROUGH SIDEWALLS THAT EASILY SLOUGH. ~~SAND ROUGH SIDEWALLS. CLAY SMOOTH.~~

~1230 - TP C1S1-G (SEE FIG). REDDISH TAN SAND W/ FINES (SHALLOW) AND TANNISH RED CLAY (~1.5'+). SAND - DRY; ROUGH SIDEWALLS. CLAY - WETTER; SMOOTH SIDEWALLS; HARD TO EXCAVATE. OBTAIN SAMPLE FOR OFF-SITE LAB TESTING.

~1250 - TP C1S1-H (SEE FIG). REDDISH BROWN CLAY. DRY SHALLOW; ROUGH SIDEWALLS. WETTER DEEPER; SMOOTH SIDEWALLS. SOME BROWN CLAY CLODS, EASILY CRUMBLED. DIFFICULT TO EXCAVATE DEEP.

~1310 - TP C1S1-I (SEE FIG). REDDISH TAN CLAY SHALLOW. ROUGH SIDEWALLS. DRY.

1325 - EXCAVATOR IS LEAKING HYDRAULIC FLUID AND NEEDS REPAIR. TP C1S1-I EXCAVATION DISCONTINUED.

1350 - TP C1S1-I EXCAVATION RESUMES BEFORE REPAIR COMPLETE. REDDISH BROWN CLAY (~1.0' - ~2.0'). HARD CLODS: ~4" - 6" ϕ. DIFFICULT EXCAVATION DEEPER. CONCLUDES C1S1 SAMPLING.

~1410 - ARRIVE AT C2S1 STOCKPILE. PILE IS DOTTED WITH A FEW SMALL BUSHES, BUT IS MOSTLY UNVEGETATED.

~~THE~~ 1415 - TP C2S1-A (SEE FIGURE 2). SOIL IS BROWN SAND W/ SOME FINES AND FRAGMENTS OF SANDSTONE. SOIL IS EASILY EXCAVATED. SANDSTONE: COMBINATION OF EASY + DIFFICULT TO CRUMBLE.

- WITH END OF WORK DAY APPROACHING, THE WRITER REQUESTS HOE OPERATOR TO EXCAVATE SEVERAL TEST PITS IN ADVANCE OF LOGGING. ~~EXCA~~ WRITER DIRECTS LOCATIONS. TP C2S1 - ~~B~~ C THROUGH F. EXCAVATED BEFORE END OF DAY. THIS PITS NOT LOGGED.

1530 - RETURN TO COMPLEX AREA. CHECK PERSONS FOR RADIOACTIVITY W/ GEIGER COUNTER. NONE DETECTED.

1545 - DEPART SITE.

0.25 HR OFF-SITE PHONE MEETING W/ GREG CORCORAN (GEOSYNTEC) REGARDING FIELD ACTIVITIES.

COPY TO: FILE PER: [signature]

GEOSYNTEC CONSULTANTS

DAILY FIELD REPORT

PROJECT: IUC WHITE MESA MILL

LOCATION: BLANDING, UTAH PROJECT NO.: SC0349 TASK NO.: 01-06

DESCRIPTION: CLAY STOCKPILE SAMPLING DATE: 11 day NOV month 05 year

CONTRACTOR: NA CLIENT: INTENATIONAL URANIUM (USA) CORPORATION (IUC) FRIDAY

WEATHER: OVERCAST, T-STORMS, H ~ 55°?, L ~ 35°?

0700 - ARRIVE ON SITE. MEET ~~HAROLD~~ CB RICH BARTLETT (IUC). DISCUSS OBTAINING SAMPLES FROM ~~CL~~ CB SOIL STOCKPILE RFS-S1 FOR OFF-SITE LAB TESTING. PER PHONE CONVERSATION W/ GREG CORCORAN (GEOSYNTEC) ON 10 NOV 05, THIS HAS BEEN AGREED TO AND DIRECTED BY HAROLD ROBERTS OF IUC.

0710 - MEET WAYLON (EQUIPMENT OPERATOR). CAT 426 B HOE UTILIZED YESTERDAY IS BEING USED FOR OTHER PLANT ACTIVITIES. A LOADER WILL ALTERNATELY BE USED. (REMAINING EXCAVATIONS ARE INTO STOCKPILE SIDESLOPES.) CB (SEE FIGURE 2)

0715 - ARRIVE AT C2S1 STOCKPILE. BEGIN LOGGING TEST PITS.

0720 - ~~C2S1~~ CB TP C2S1-B - EASILY EXCAVATED (ON 10 NOV 05). MAINLY BROWN SAND W/ SOME CLAY ~~+ SAND~~ CB CLODS (EASILY BROKEN).

0735 - TP C2S1-C - EASILY EXCAVATED (ON 10 NOV 05). MOSTLY SAND W/ FINES, BUT POSSIBLY CLAY AT BOTTOM - MAY BE COMPACTED, WETTER SAND. CONTAINS SOFT AND HARD PIECES OF SANDSTONE. OBTAIN SAMPLE FOR OFF-SITE LAB TESTING.

0750 - TP C2S1-D - EASILY EXCAVATED (ON 10 NOV 05). DUG INTO SIDESLOPE OF PILE. MAINLY BROWN TAN SAND. CONTAINS SANDSTONE/CLAYSTONE PARTICLES - EASY AND DIFFICULT TO CRUMBLE.

0805 - TP C2S1-E - TANNISH BROWN SAND. NOTABLY VERY ROUGH SIDEWALLS. COMES OUT MAINLY IN LARGE HARD PIECES OF SANDSTONE.

0820 - TP C2S1-F - TANNISH BROWN SAND W/FINES AND SANDSTONE PIECES. SOME SANDSTONE PIECES ARE GRAY. OBTAIN SAMPLE FOR OFF-SITE LABORATORY TESTING.

0840 - TP C2S1-G - EXCAVATED TODAY W/ LOADER INTO SIDESLOPE OF STOCKPILE. COMPARATIVELY FEWER FINES AND SANDSTONE. OBTAIN SAMPLE FOR OFF-SITE LAB TESTING. RAIN AND T-STORMS IN AREA: EVACUATE.

(SEE FIGURE 2 FOR C2S1 TEST PIT LOCATIONS)

COPY TO: FILE PER: [signature] HRS: 5.0

CHAD BIRD

GEOSYNTEC CONSULTANTS

DAILY FIELD REPORT

DATE: 11 day NOV month 05 year

~0900 - ARRIVE AT RFS-S1 STOCKPILE. PILE HAS BEEN EXCAVATED ~~RECENTLY~~ RECENTLY. SPARSE VEGETATION ON TOP OF PILE. RAIN ARRIVES (LIGHT).

~0905 - ~~TP RFS-S1-A~~ LOADER SPREADS EXISTING SOIL MOUND TO ALLOW WRITER TO OBTAIN SAMPLE FROM UNEXPOSED (RECENTLY) SOIL. OBTAIN SOIL SAMPLE RFS-S1-A FOR OFF-SITE TESTING.

~0910 - LOADER DIGS INTO SIDE OF STOCKPILE. WRITER OBTAINS SOIL SAMPLE FOR OFF-SITE TESTING. ~~SOIL~~ (RFS-S1-B).

- BOTH RFS-S1 A+B ARE MAINLY CLAY AND CLAY STONE, NOT EASILY BROKEN BY HAND. PARTICLE SIZES RANGE FROM SMALL (~1/4"?) TO ~8" IN DIAMETER. SEE FIG. 3 FOR SAMPLE LOCATIONS

~0915 - CONCLUDE SOIL SAMPLING AS RAIN FALLS HARDER. RETURN TO COMPLEX.

- ARRANGE WITH ADMIN. STAFF TO SHIP SOIL SAMPLES. IUC SHIPS SAMPLES (WITH IUC ACCOUNT) VIA UPS COURIER. UPS GROUND UTILIZED.

- WORK ON PROJECT DOCUMENTATION.

1130 - UPS PICKS UP SAMPLES.

- MAKE COPIES OF SAMPLING MAPS (FIGURES) FOR KEN MAYOSHI (IUC).

1200 - END OF WORK DAY.

COPY TO: FILE PER: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

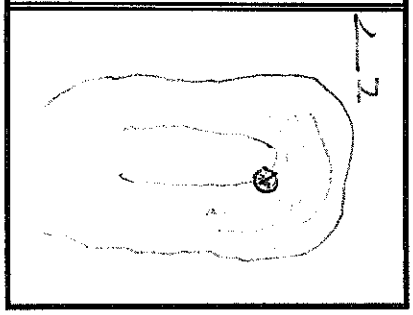
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(A)
Test Pit Width: ~12'
Test Pit Depth: ~4'
Equipment Used: CAT 426B HOE
Subcontractor: —

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

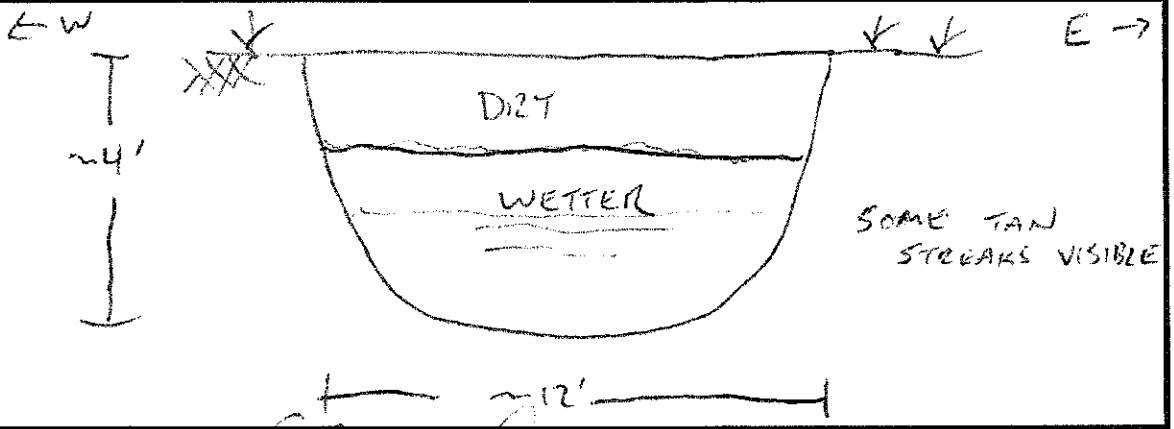
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time: ~9:19/

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~1.5	DRY, LIGHT BROWNISH RED CLAY. CRUMBLES. NO PARTICLES.	NA	
~1.5 - ~4	WETTER, BROWNISH RED CLAY w/ SOME THIN STREAKS OF TAN MATERIAL.		

Cross Section View



Samplers Signature: CBS

GEOSYNTEC CONSULTANTS

TEST PIT LOG

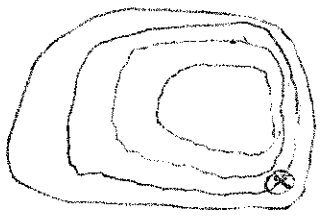
Project Name: IVC NMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(B)
Test Pit Width: ~12'
Test Pit Depth: ~3'
Equipment Used: CAT 426 B HOE
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

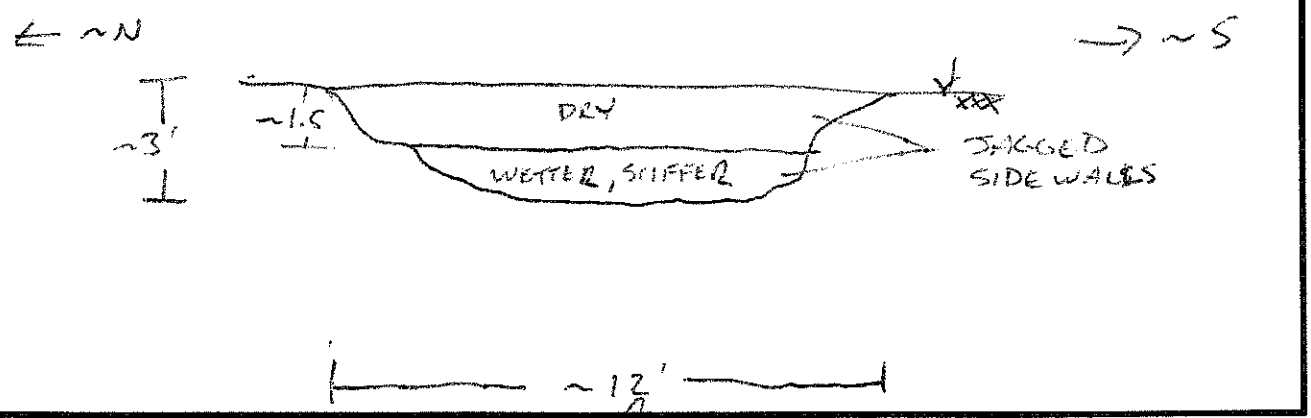
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0-~1.5	REDDISH TAN SAND w/ FINES. DRY. SOME CLODS. NO ROCKS.		
~1.5-~3	REDDISH TAN SAND w/ FINES. SLIGHTLY WETTER. SIDEWALLS NOT SMOOTH, BUT ARE STIFF. DIFFICULT TO EXCAVATE.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

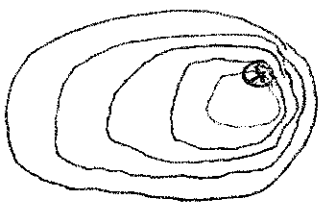
Project Name: IOC WMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(C)
Test Pit Width: ~12
Test Pit Depth: ~3.5
Equipment Used: CAT 426 B HOE
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

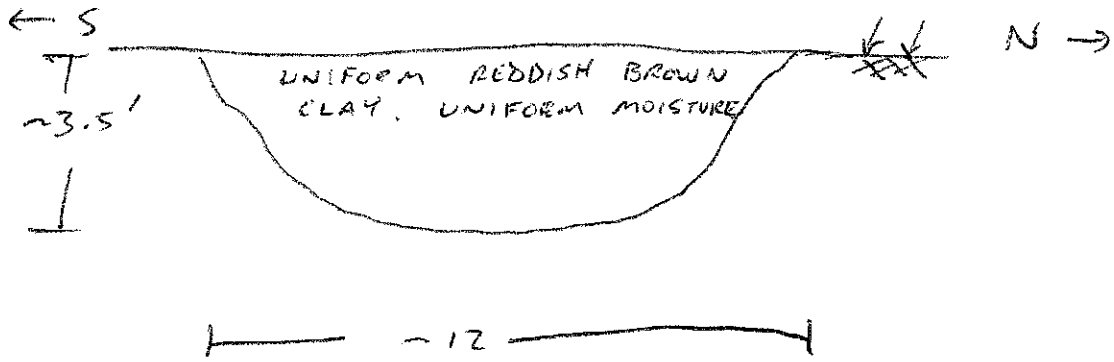
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 ~ 3.5'	REDDISH BROWN CLAY. DIFFICULT TO EXCAVATE JAGGED STIFF SIDE WALLS. MOISTURE NEARLY UNIFORM W/ DEPTH.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

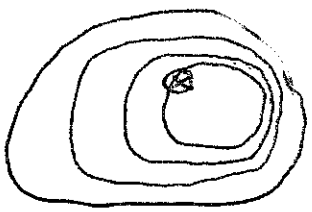
Project Name: ~~SC0349-01-06~~ FUL WMM (CB)
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(D)
Test Pit Width: ~70
Test Pit Depth: ~3.5
Equipment Used: CAT 426 B HOE
Subcontractor: NA

Date: 10 NOV 05
Weather: M.SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

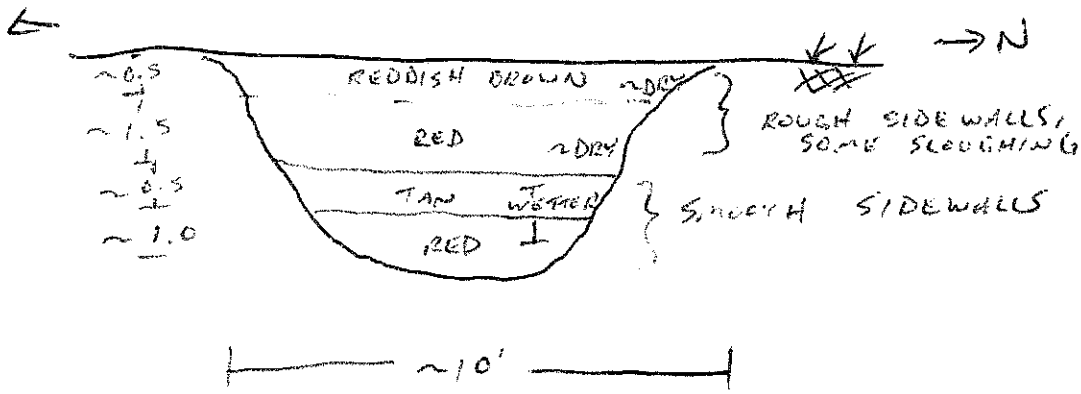
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~0.5	DRY, REDDISH BROWN CLAY	N/A	
0.5 - ~2.5	DRY RED CLAY		
(CB) ~~1.5~~ 2.0			
2.0 - 2.5	WETTER, TAN CLAY		
2.5 - ~3.5	WETTER, RED CLAY		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

JUC WMM (B)

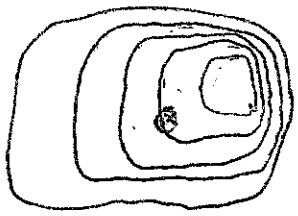
Project Name: SC0349-01-06
Project Number: ↓
Site: C151

Test Pit ID: C151-(E)
Test Pit Width: ~15'
Test Pit Depth: ~ 3
Equipment Used: CAT 426B Hoe
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

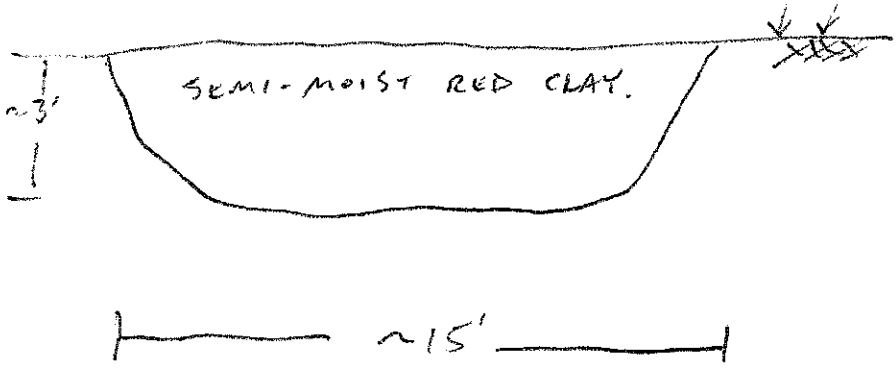
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~3'	SEMI-MOIST RED CLAY. EXCAVATES MAINLY IN 4" - 6" EASILY CRUMBLED CLODS.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

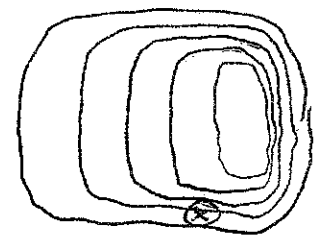
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-F
Test Pit Width: ~10'
Test Pit Depth: ~5
Equipment Used: CAT 426B HOE
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

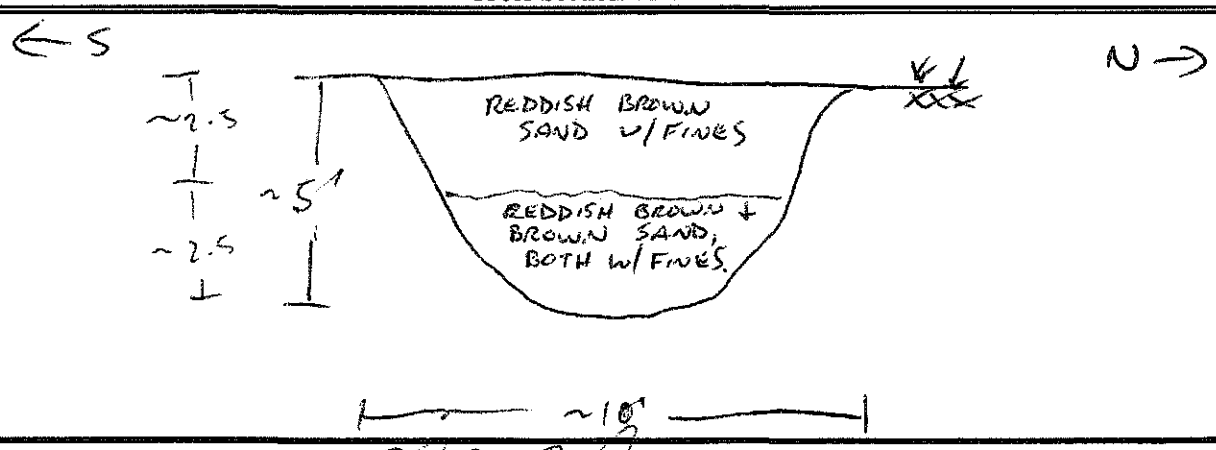
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~2.5	REDDISH BROWN SAND W/ FINES. MOSTLY DRY. SOME SMALL (~1" ϕ) EASILY CRUMBLED CLODS. ROUGH SIDEWALLS.		
2.5 - 5	REDDISH BROWN SAND AND BROWN SAND, BOTH WITH FINES. SMALL CLODS. ROUGH SIDEWALLS. MOSTLY DRY.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

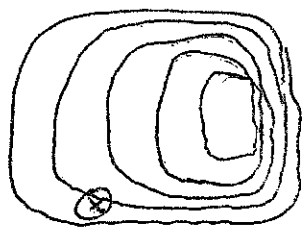
Project Name: CB JUC WMM
Project Number: SC0349-01-06
Site:

Test Pit ID: C151-(B)
Test Pit Width: ~12
Test Pit Depth: ~3
Equipment Used: CAT 426 B HOE
Subcontractor: NA

Date: CB ~~OT~~, 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

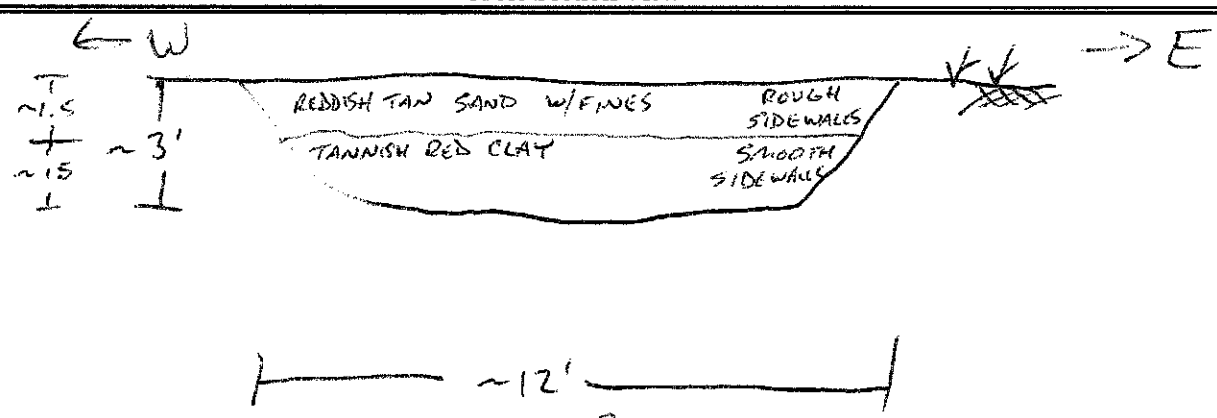
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~~2~~			
0 - ~1.5	REDDISH TAN SAND W/FINES. MOSTLY DRY, ROUGH SIDEWALLS.		
~1.5 - ~3.0	TANNISH RED CLAY. ~~COM~~ CB ~4" ϕ HARD CLODS. MOSTLY DRY. SMOOTH SIDEWALLS. HARD TO EXCAVATE.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

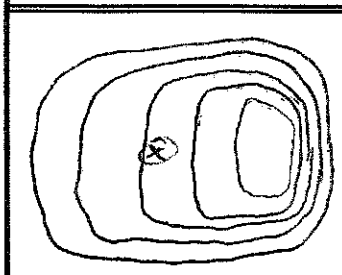
Project Name: ~~SE~~ (CB) IUC WMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(H)
Test Pit Width: ~10'
Test Pit Depth: ~3'
Equipment Used: CAT 426B HOE
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CD
Samples Collected by: CD

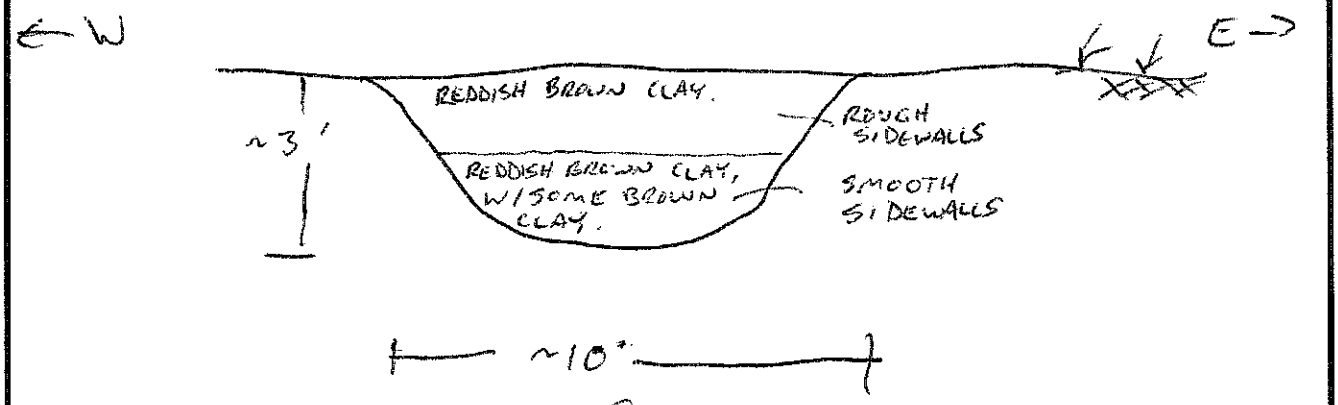
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~1.5	REDDISH BROWN CLAY. SEMI-MOIST. ~2" - 6" EASILY CRUMBLED CLODS. ROUGH SIDEWALLS.		
~1.5 - 3	REDDISH BROWN CLAY, SOME BROWN CLAY CLODS. DIFFICULT TO EXCAVATE. SMOOTH SIDEWALLS. SEMI-MOIST.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

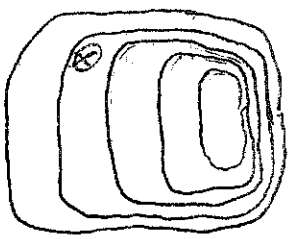
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C151

Test Pit ID: C151-(I)
Test Pit Width: ~10'
Test Pit Depth: ~2'
Equipment Used: CAT 426B Hoe
Subcontractor: NA

Date: 10 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

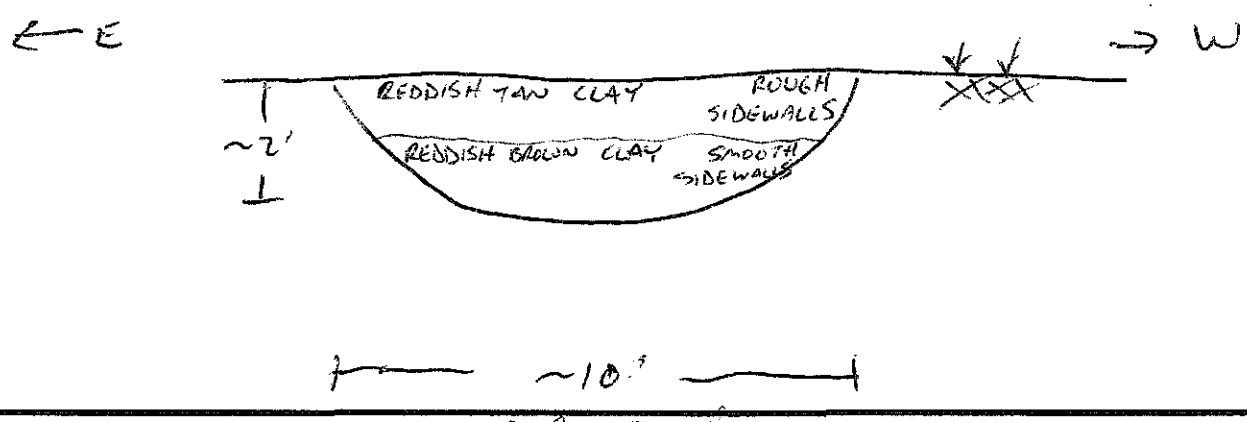
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~1.0	REDDISH TAN CLAY. DRY & CRUMBLY. ~4" ϕ CLODS. ROUGH SIDEWALLS THAT SLOUGH.		
~1.0 - ~2.0	REDDISH BROWN CLAY. SLIGHTLY WETTER ~4" - 6" ϕ CLODS, NOT EASILY CRUMBLED. HARD TO EXCAVATE.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

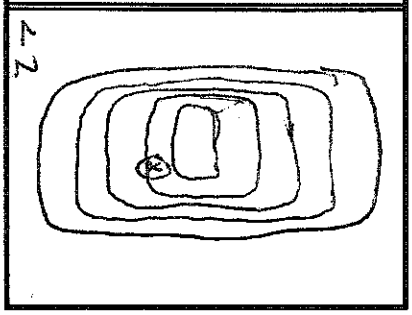
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C251-B

Test Pit ID: C251-A
Test Pit Width: ~10'
Test Pit Depth: ~5'
Equipment Used: CAT 426 B
Subcontractor: NA

Date: 10 NOV 05
Weather: M-SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

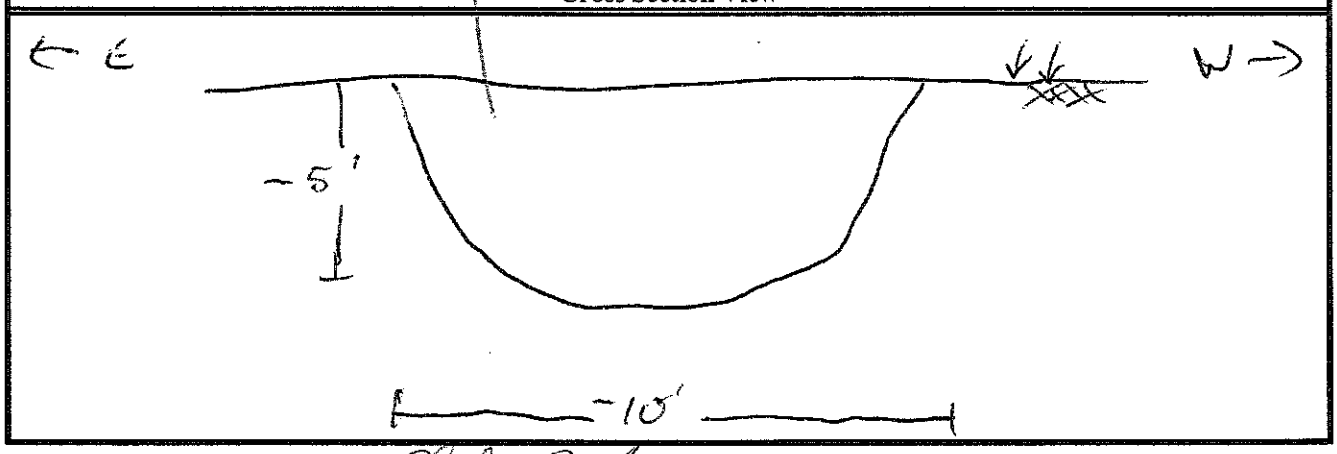
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~5'	BROWN SAND W/ SOME FINES. CONTAINS SAND STONE FRAGMENTS. SEMI-MOIST. ROUGH SIDEWALLS THAT SLOUGH EASILY.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

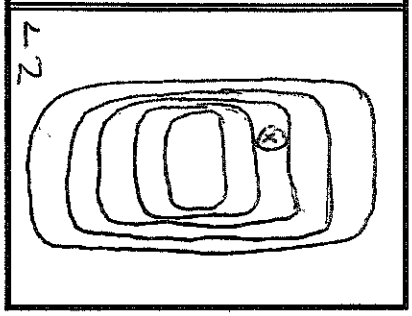
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C251

Test Pit ID: C251-(B)
Test Pit Width: ~10'
Test Pit Depth: ~4'
Equipment Used: CAT 426B Hoe
Subcontractor: NA

Date: EXC: 10 NOV 05 (CB); LOGGED 11 NOV 05
Weather: M. SUNNY
Test Pit Logged By: CB
Samples Collected by: CB

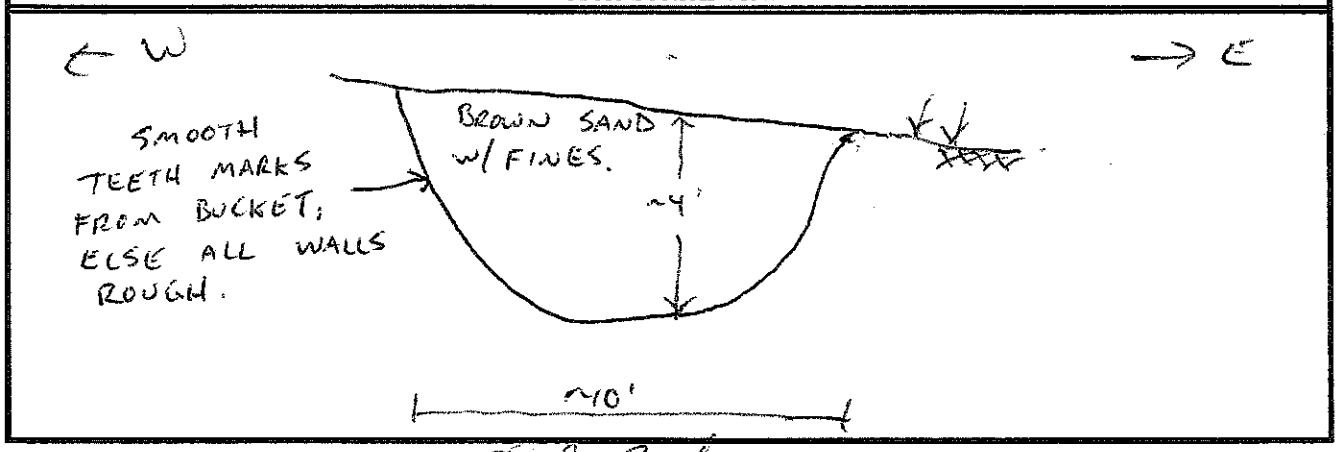
Depth to Water (ft): NA
~~Immiscible Layer: Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0-~4'	BROWN SAND w/ FINES. SOME CLAY CLODS (~2"-4" ϕ), BROKEN W/ MODERATE EFFORT. SEMI-MOIST. ROUGH SIDEWALLS w/ SLOUGHING.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

EXC: 10 NOV 05, LOGGED..

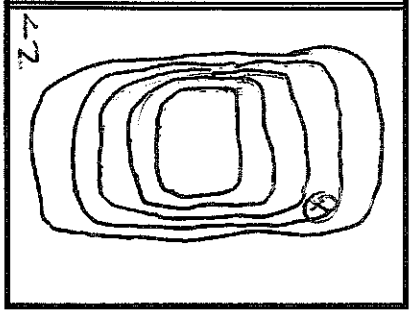
Project Name: IUC WMM
Project Number: SK0349-01-06
Site: C251

Test Pit ID: ~~C1~~ CB C251-C
Test Pit Width: ~15
Test Pit Depth: ~4.5
Equipment Used: CAT 426B HOE
Subcontractor: NA

Date: 11 NOV 05 (CB)
Weather: 10 NOV: M.S., 11 NOV: CC, TS
Test Pit Logged By: CB
Samples Collected by: CB

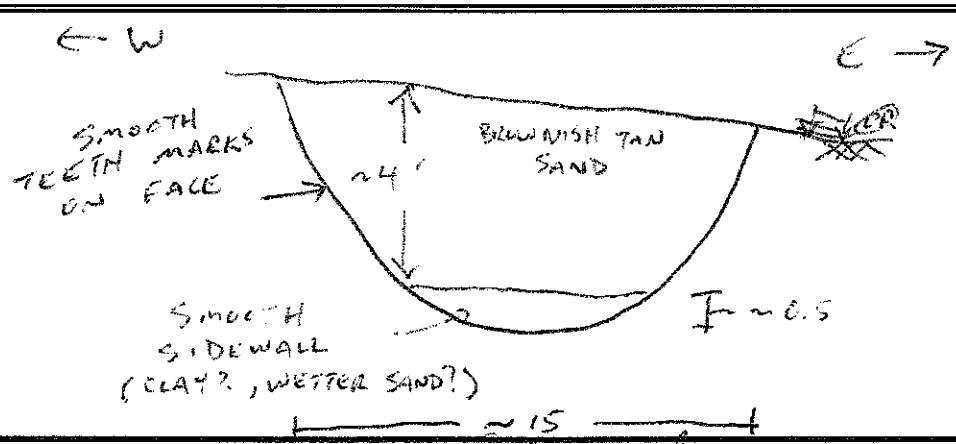
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0. ~4'	BROWNISH TAN SAND W/ FINES. SEMI-MOIST. ROUGH SIDEWALLS.		
~4'-~4.5'	APPEARS TO BE ~~CA~~ CB POSSIBLY CLAY, BUT MAY BE SAME MATERIAL AS ABOVE, ONLY WETTER. SMOOTH SIDEWALLS.		
	EXCAVATED SOIL CONTAINS SOME SOFT AND HARD PIECES OF SANDSTONE.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

EXC: 10 NOV 05, LOGGED

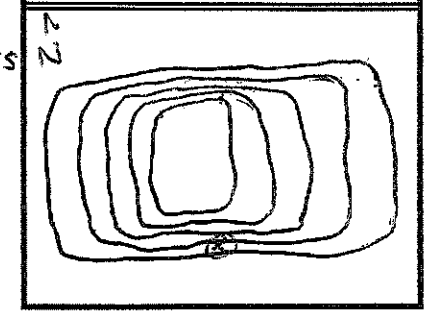
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C251

Test Pit ID: C251-(D)
Test Pit Width: ~12'
Test Pit Depth: ~8'
Equipment Used: 426B HOE (CAT)
Subcontractor: NA

Date: 11 NOV 05
Weather: 10 NOV: M.S., 11 NOV: OC, TS
Test Pit Logged By: CB
Samples Collected by: CB

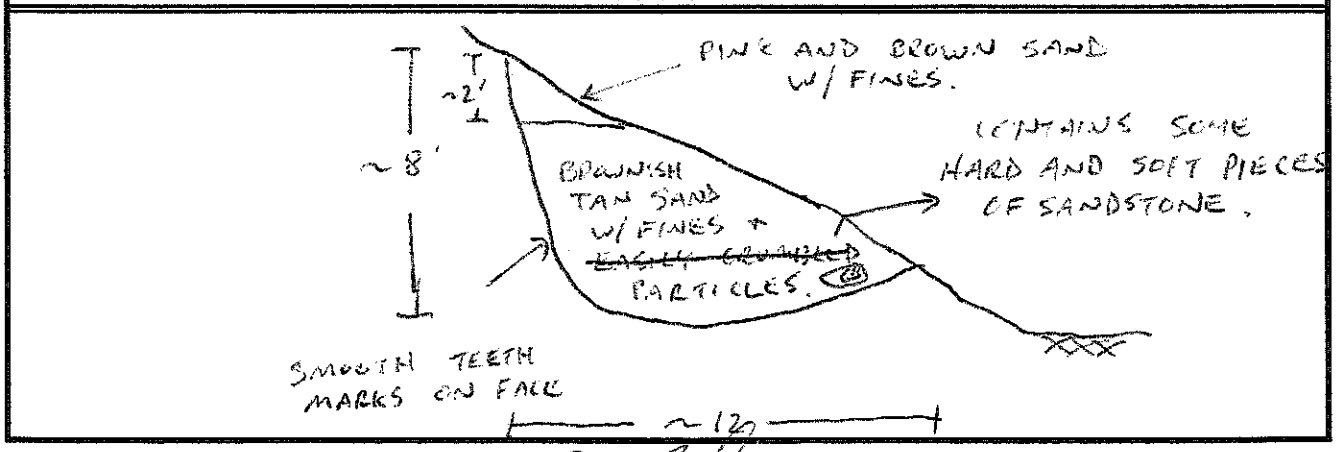
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~2'	PINK AND BROWN SAND ~~LAYER~~ (CB) W/ FINES. COLORS LAYERED. MOSTLY DRY. EASILY EXCAVATED. ~~DRY~~ (CB) MOSTLY DRY.		
~2' - ~8'	BROWNISH TAN SAND W/ FINES AND CLAYSTONE PARTICLES → EASILY CRUMBLED AND DIFFICULT TO CRUMBLE. SEMI-MOIST.		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

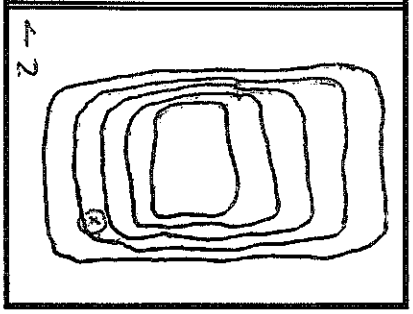
Project Name: JUC WMM
Project Number: SC0349-01-06
Site: C251

Test Pit ID: C251-(E)
Test Pit Width: ~12'
Test Pit Depth: ~6'
Equipment Used: CAT 426B HOE
Subcontractor: NA

Date: EX: 10 NOV 05, LOGGED 11 NOV 05
Weather: 10 NOV: MS, 11 NOV: CC, TS
Test Pit Logged By: CB
Samples Collected by: CB

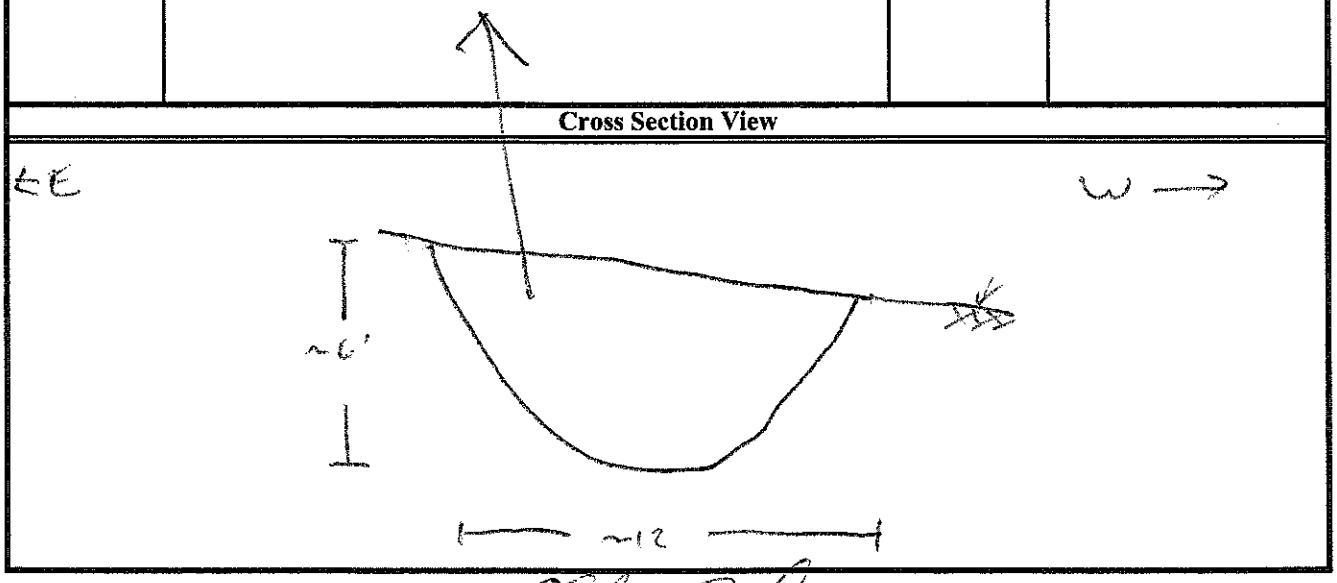
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~6'	TANNISH BROWN SAND W/ FINES, SEMI-MOIST, VERY ROUGH SIDEWALLS, LARGE PIECES OF SANDSTONE (HARD). LARGE QUANTITY OF SANDSTONE PIECES ~ (2" ~ 8" ϕ).		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

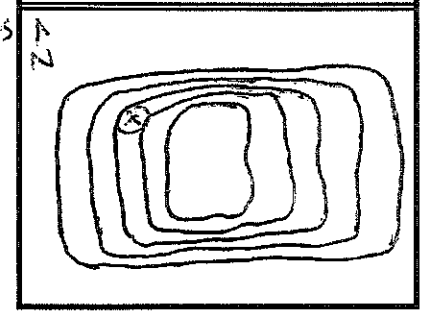
Project Name: IUC WMM
Project Number: SC0349-01-06
Site: C251

Test Pit ID: C251-(F)
Test Pit Width: ~15'
Test Pit Depth: ~10'
Equipment Used: CAT 426B HOE
Subcontractor: NA

Date: EXC: 10 NOV 05, LOGGED 11 NOV 05
Weather: 10 NOV: MS, 11 NOV: OC, TS
Test Pit Logged By: CB
Samples Collected by: CB

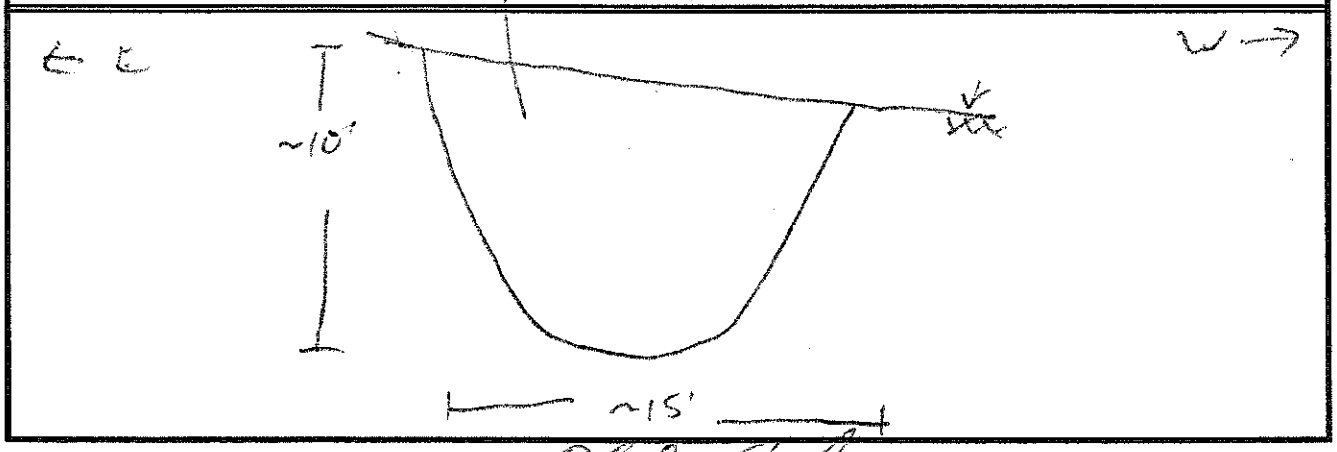
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description ~~CLAY~~ SAND (CB)	PID (ppm)	Sample ID/Comments
0 - ~10'	TANNISH BROWN ~~CLAY~~ W/ FINES AND SANDSTONE. SEMI-MOIST. ROUGH SIDEWALLS. EASILY EXCAVATED. SOME GRAY PIECES OF SANDSTONE		

Cross Section View



Samplers Signature: [signature]

GEOSYNTEC CONSULTANTS

TEST PIT LOG

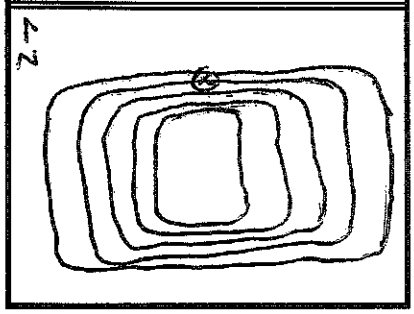
Project Name: ~~SCE~~ IVC WMM
Project Number: SL0347-01-06
Site:

Test Pit ID: C251-G
Test Pit Width: ~10'
Test Pit Depth: ~10'
Equipment Used: ~~CAT 426 HOE~~ LOADER
Subcontractor: NA

Date: 11 NOV 05
Weather: OVRCST, T-STORM
Test Pit Logged By: CB
Samples Collected by: CB

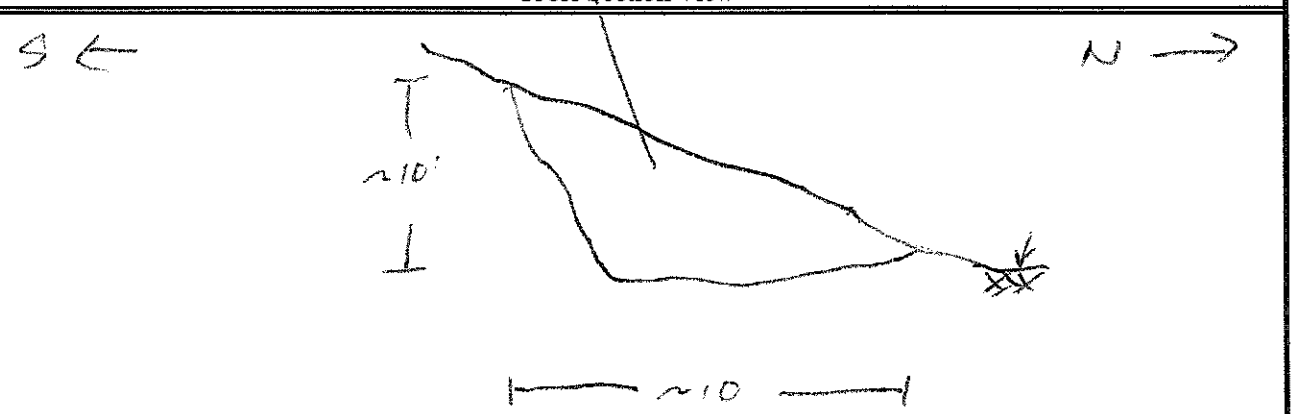
Depth to Water (ft): NA
Immiscible Layer: ~~Y/N~~
Start/Stop Time:

Sketch of Test Pit Location



Depth (ft)	Description	PID (ppm)	Sample ID/Comments
0 - ~10'	TANNISH BROWN SAND W/ FINES. ~~NO~~ SANDSTONE OBSERVED. LITTLE (FEW) ~~SAN~~ SEMI-MOIST. SOME LENSES OF ~~BR~~ PINK CLAY. EASILY EXCAVATED. ~~A~~ WAS EXCAVATED W/ LOADER.		

Cross Section View



Samplers Signature: CB

GEOSYNTEC CONSULTANTS

SOIL SAMPLE LOG

PROJECT: IUC WHITE MESA MILL

LOCATION: BLANDING, UTAH PROJECT NO.: SC0349 TASK NO.: 01-06

DESCRIPTION: CLAY STOCKPILE SAMPLING YEAR: 2005

MATERIAL TYPE: CLAY/SAND

SITE SAMPLE NO.	OFF-SITE LAB SAMPLE NO.	VISUAL DESCRIPTION	SOURCE (LOCATION/DEPTH)	DATE SAMPLED (day/mo)	TEST METHODS	QA ID
C1S1-A		BROWNISH RED, CLAY REDDISH, TAN (B)		10 NOV		CB
B		~~BROWNISH RED~~ SAND W/FINES				CB
C		REDDISH BROWN CLAY BROWN AND REDDISH	OBTAINED FROM SEV. PLACES IN EXCAVATED PILE FOR OFF-SITE LAB TESTING			CB
D		BROWN CLAY.				CB
E		RED CLAY	OBTAINED SAMPLE C1S1 PER METHOD FOR (C) (B)			CB
F		REDDISH BROWN SAND, BROWN SAND				CB
G		REDDISH TAN SAND, TANNISH RED CLAY	OBTAINED SAMPLE C1S2 PER METHOD FOR (C)			CB
H		REDDISH BROWN CLAY				CB
I		REDDISH TAN CLAY, REDDISH BROWN CLAY				CB
(B) ~~C1S2~~						CB
C2S1-A		BROWN SAND, FINES, SANDSTONE FRAGMENTS				CB
B		BROWN SAND W/FINES		11 NOV		CB
C		BROWNISH TAN SAND (B) W/FINES. SOME CLAY?	OBTAIN SAMPLE PER SAME METHOD AS C1S1-(C)			CB
D		PINK SAND, BROWN SAND, BROWNISH TAN SAND				CB

COMMENTS:

GEOSYNTEC CONSULTANTS

SOIL SAMPLE LOG

PROJECT: IUC WHITE MESA MILL

LOCATION: BLANDING, UTAH PROJECT NO.: SC0349 TASK NO.: 01-06

DESCRIPTION: CLAY STOCKPILE SAMPLING YEAR: 2005

MATERIAL TYPE: CLAY / SAND

SITE SAMPLE NO.	OFF-SITE LAB SAMPLE NO.	VISUAL DESCRIPTION	SOURCE (LOCATION/DEPTH)	DATE SAMPLED (day/mo)	TEST METHODS	QA ID
C2S1-E		TANNISH BROWN SAND		11 NOV		CB
F		TANNISH BROWN SAND	OBTAIN SAMPLE PER SAME METHOD AS C1S1-C			CB
G		TANNISH BROWN SAND				CB
RFSS1-A		TANNISH BROWN CLAY				CB
RFSS1-B		TANNISH BROWN CLAY				CB

COMMENTS:

GEOSYNTEC CONSULTANTS

LABORATORY TEST REQUEST

PROJECT: IUC WHITE MESA MILL PROJECT NO.: SC0349 TASK NO. 01-06

SOURCE: ON-SITE CLAY STOCKPILES APPLICATION: _____ LAB SAMPLE NO.: _____

SHIPPER: UPS REQUESTED BY: CHAD BIRD DATE: _____ SITE SAMPLE ID.: C251-~~A → I~~ C, E, G; C251-C, F, G; RF5-S1-A, B

TASK	AS RECEIVED MOISTURE CONTEST ASTM D 2216 (%)	PERCENT PASSING NO. 200 ASTM D 1140 (%)	GRAIN SIZE ASTM D 422 SIEVE	GRAIN SIZE ASTM D 422 HYDROMETER	ATTEBERG LIMITS ASTM D 4318 LL (%)	ATTEBERG LIMITS ASTM D 4318 PL (%)	ATTEBERG LIMITS ASTM D 4318 PI ( )	SOIL CLASSIFICATION ASTM D 2487	LOI ASTM C 311 (%)	CARBO CONT. ASTM D3042 (%)	COMPACTION ASTM D 698 ☐ ASTM D 1557 ☒ A B C D ASTM D 4710 MAX DRY UNIT WT. (pcf)	COMPACTION OPT. MOIST. CONT. (%)	HYDRAULIC CONDUCTIVITY ASTM D 5084 ☒ ASTM D 2434 ☐ TUBE SAMPLE ☐ REMOLDED SAMPLE ☒ REL.COMP.= ___% γ_d= ___ (pcf); W=W_{opt} ___(%) W= ___(%) DRY UNIT WT. (pcf)	HYDRAULIC CONDUCTIVITY MOIST. CONT. (%)	HYDRAULIC CONDUCTIVITY K (cm/sec) at σ'_c = ___(psi) i= ___	
			✓		✓	—	✓				✓		✓			

DEADLINE													

REMARKS: PERFORMANCE TEST ☐ CONFORMANCE TEST ☐

PLEASE HOLD C251-C, F, + G UNTIL/UNLESS DIRECTED TO TEST.

DISTRIBUTE RESULTS TO: GEOSYNTEC (GTC) CLIENT _____ SITE _____ OFFICE

 FILE NO. 2-23-LTR

Excel Geotechnical Testing

"Excellence in Testing"

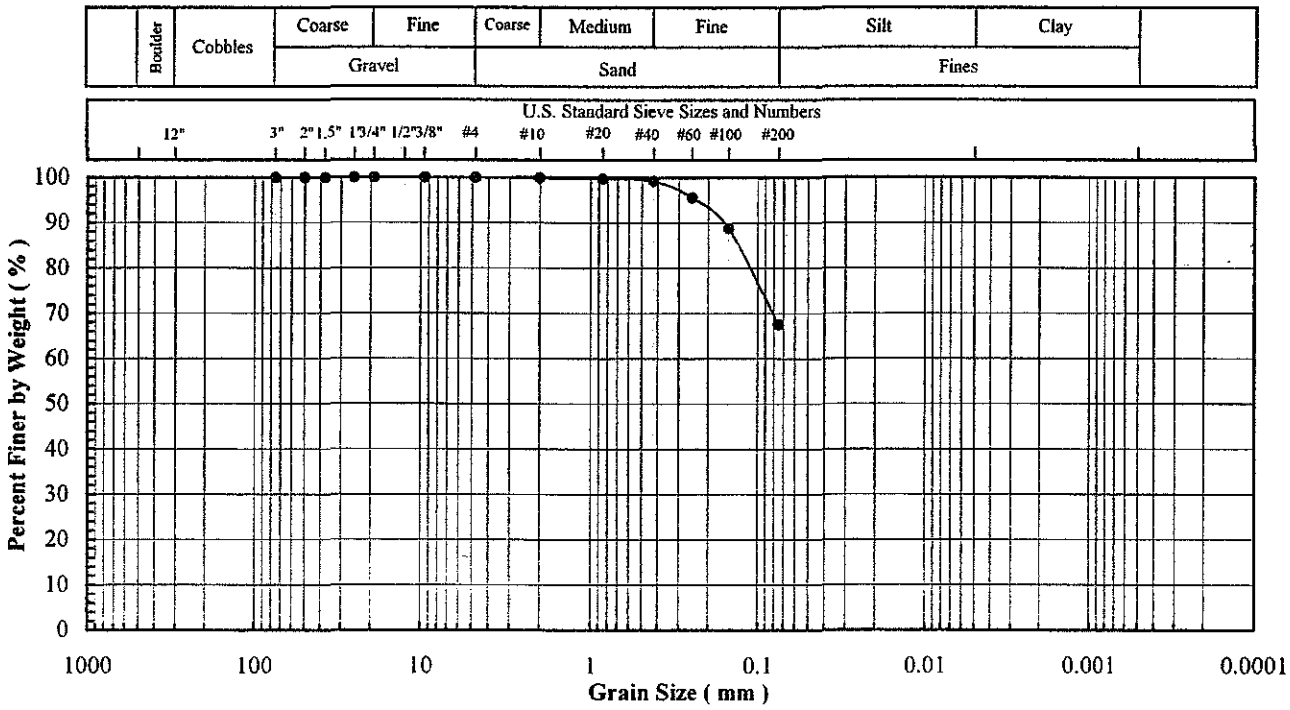
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C1S1-C
Lab Sample No: K236

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



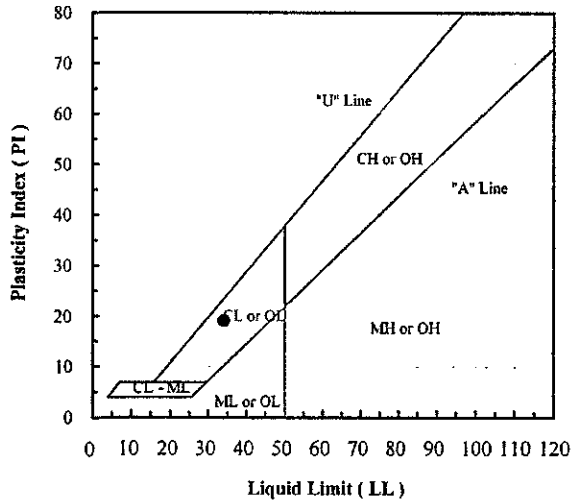
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.7
#40	0.425	99.2
#60	0.250	95.6
#100	0.150	88.8
#200	0.075	67.6

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	32.4
Fines (%):	67.6
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C1S1-C	K236	9.6	67.6	34	15	19	CL - Sandy lean clay

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

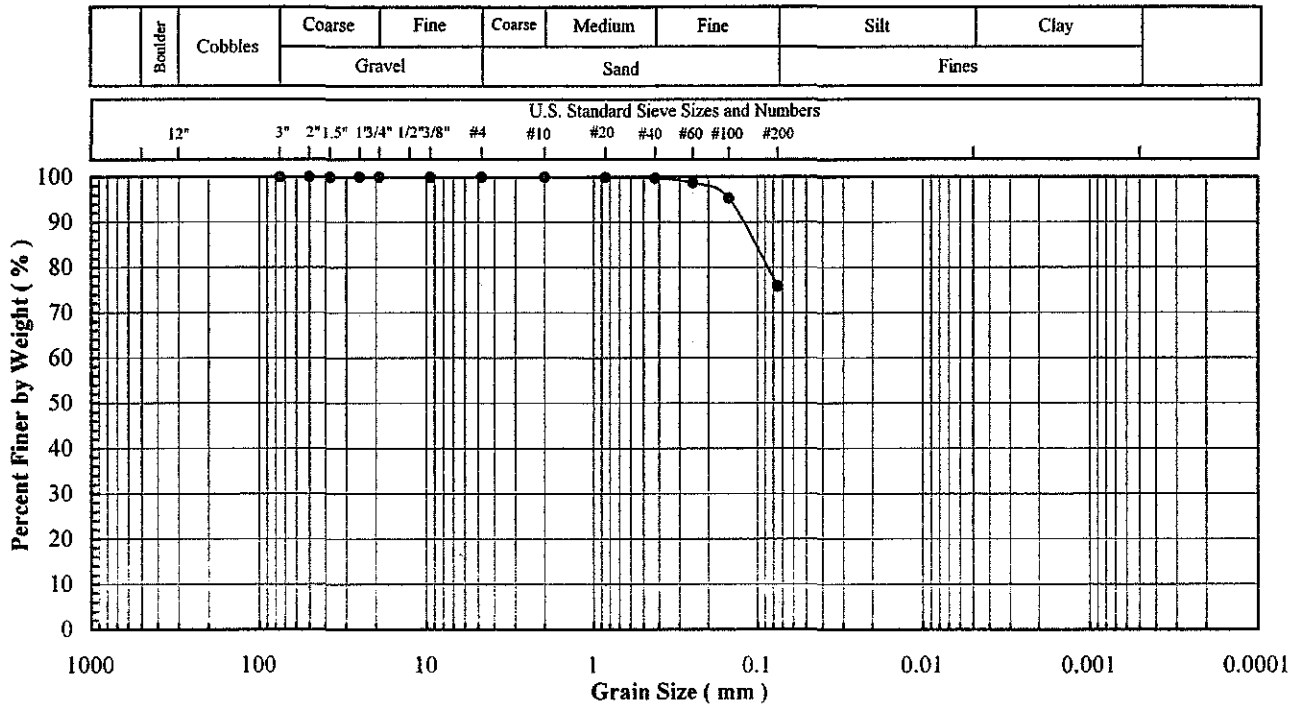
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C1S1-E
Lab Sample No: K237

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



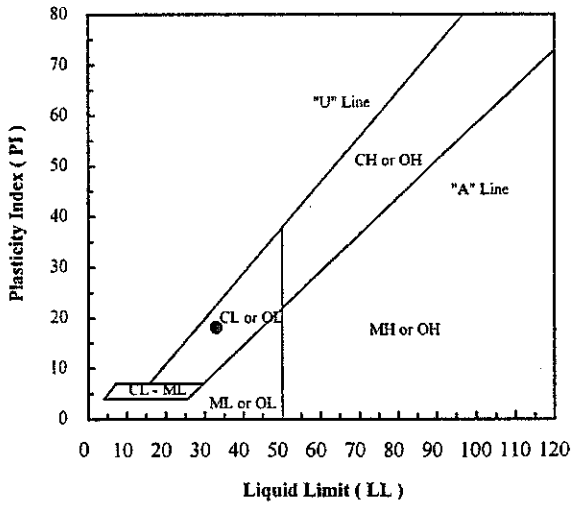
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	99.7
#60	0.250	98.7
#100	0.150	95.3
#200	0.075	75.9

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	24.1
Fines (%):	75.9
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C1S1-E	K237	10.3	75.9	33	15	18	CL - Lean clay with sand

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

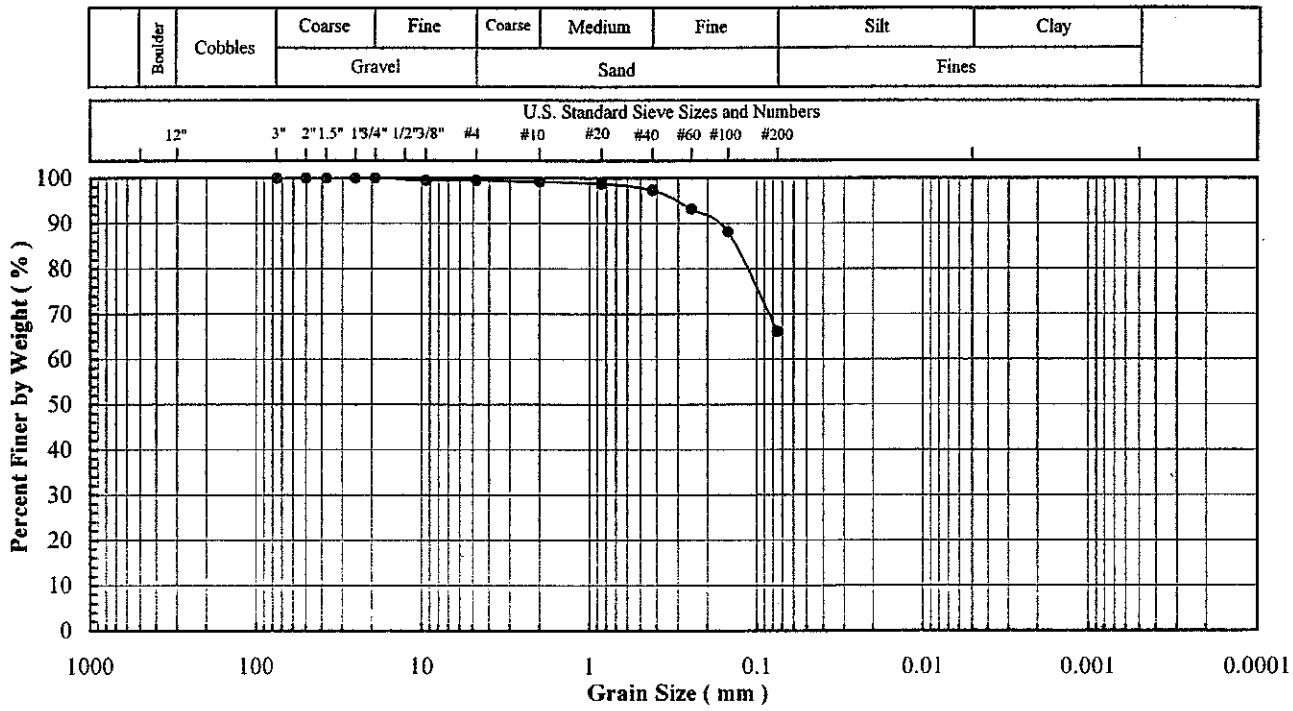
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C1S1-G
Lab Sample No: K238

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



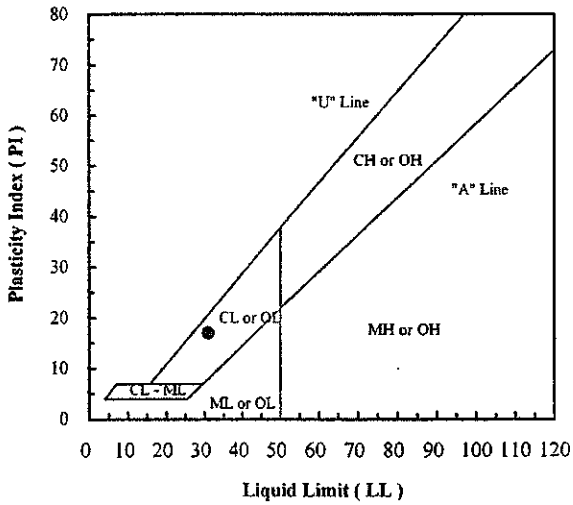
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	99.5
#4	4.75	99.5
#10	2.00	99.2
#20	0.850	98.8
#40	0.425	97.4
#60	0.250	93.2
#100	0.150	88.2
#200	0.075	66.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.5
Sand (%):	33.3
Fines (%):	66.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C1S1-G	K238	8.0	66.2	31	14	17	CL - Sandy lean clay

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

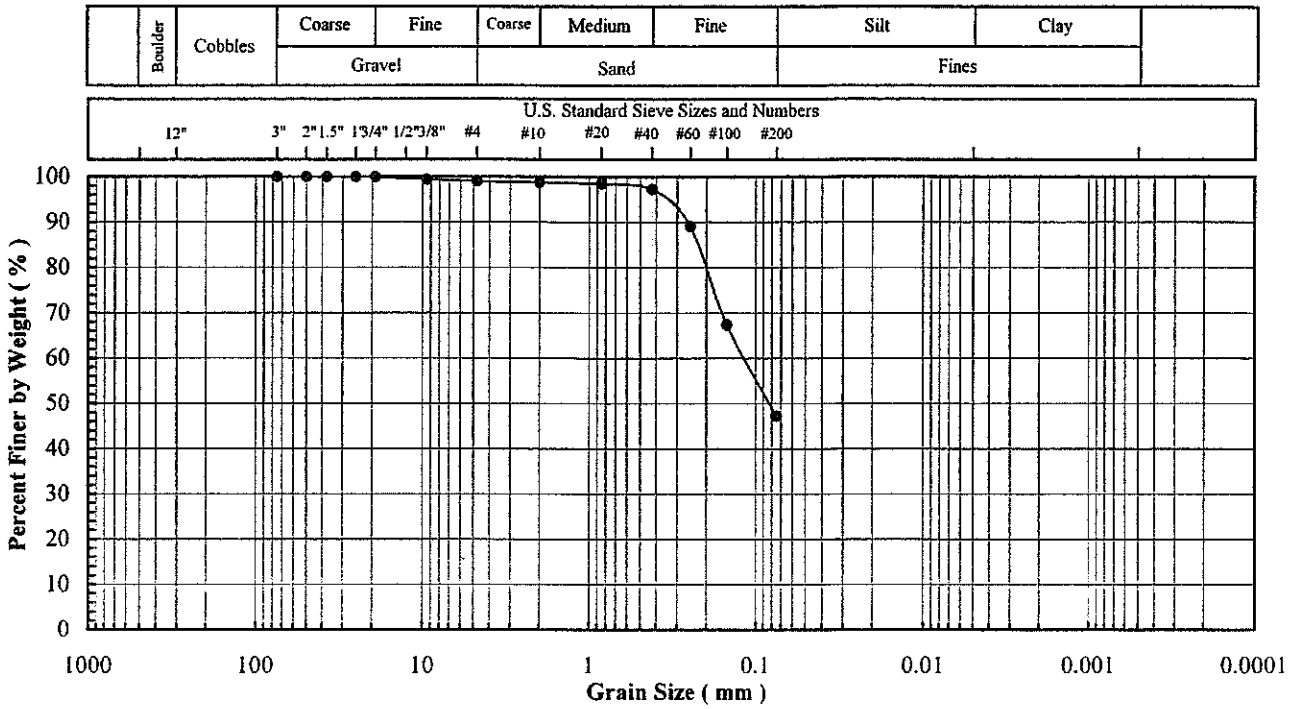
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C2S1-C
Lab Sample No: K239

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



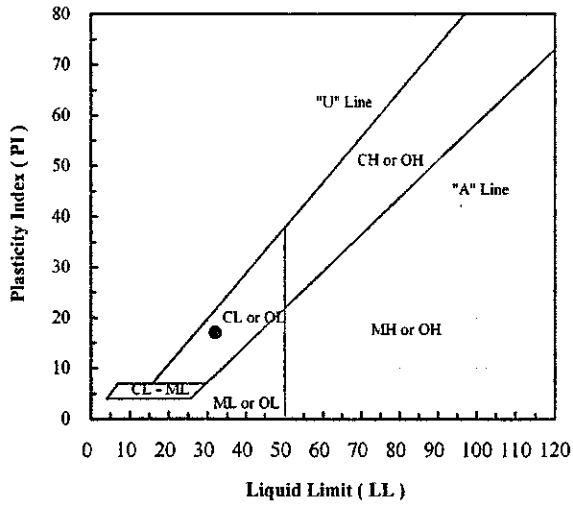
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	99.4
#4	4.75	99.1
#10	2.00	98.8
#20	0.850	98.5
#40	0.425	97.3
#60	0.250	89.1
#100	0.150	67.4
#200	0.075	47.3

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.9
Sand (%):	51.8
Fines (%):	47.3
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C2S1-C	K239	8.5	47.3	32	15	17	CL - Sandy lean clay

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

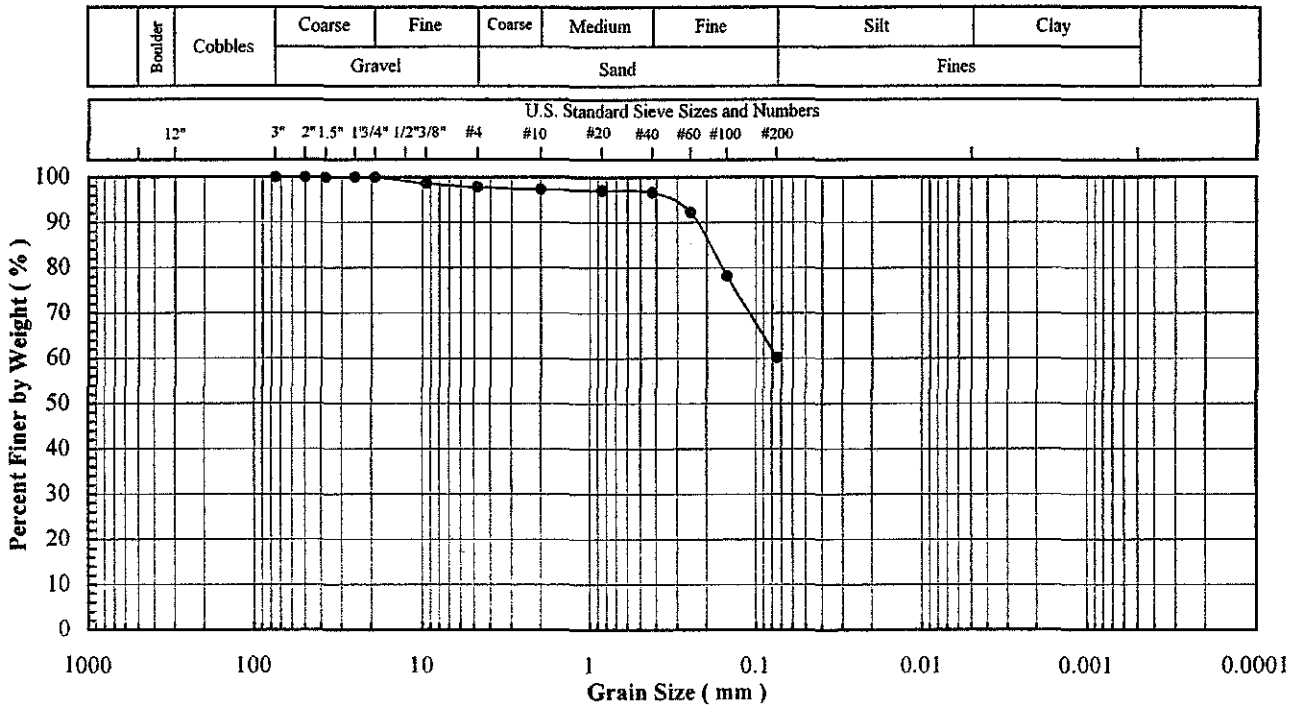
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C2S1-F
Lab Sample No: K240

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



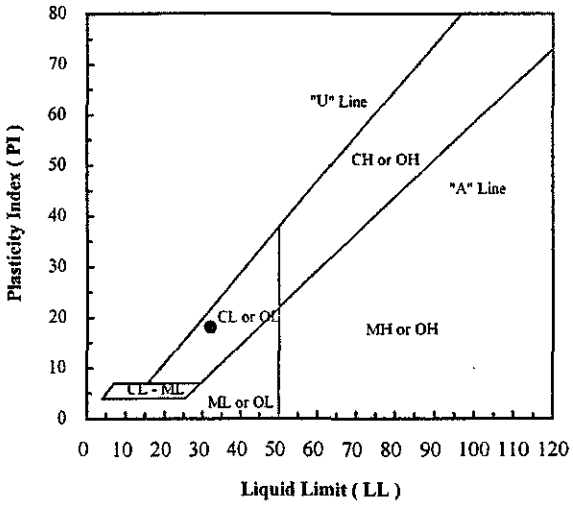
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.6
#4	4.75	97.8
#10	2.00	97.3
#20	0.850	97.1
#40	0.425	96.7
#60	0.250	92.3
#100	0.150	78.2
#200	0.075	60.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	2.2
Sand (%):	37.6
Fines (%):	60.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C2S1-F	K240	8.4	60.2	32	14	18	CL - Sandy lean clay

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

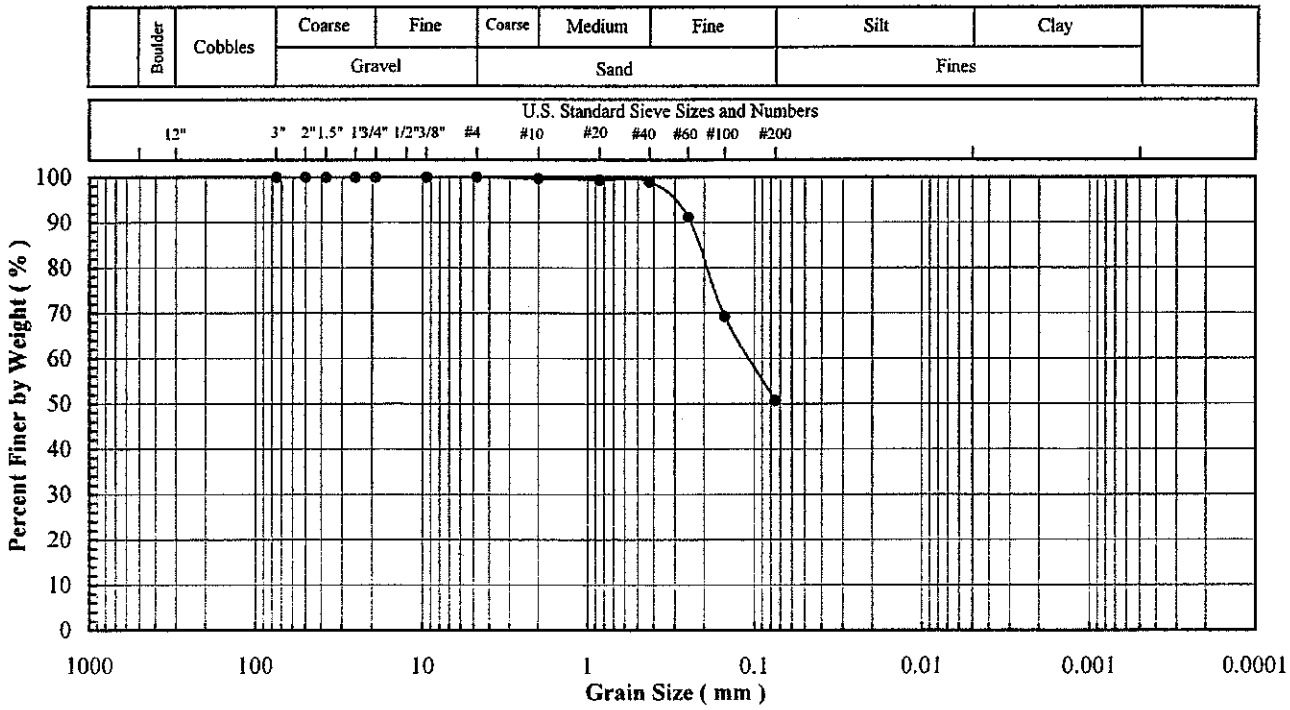
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: C2S1-G
Lab Sample No: K241

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



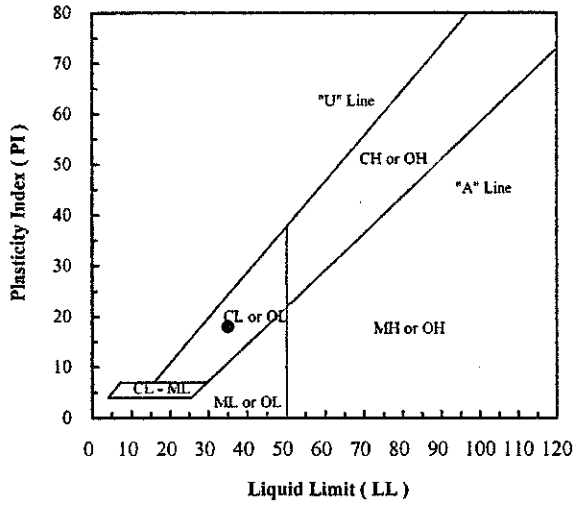
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.7
#20	0.850	99.4
#40	0.425	99.0
#60	0.250	91.2
#100	0.150	69.3
#200	0.075	50.7

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	49.3
Fines (%):	50.7
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
C2S1-G	K241	9.9	50.7	35	17	18	CL - Sandy lean clay

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

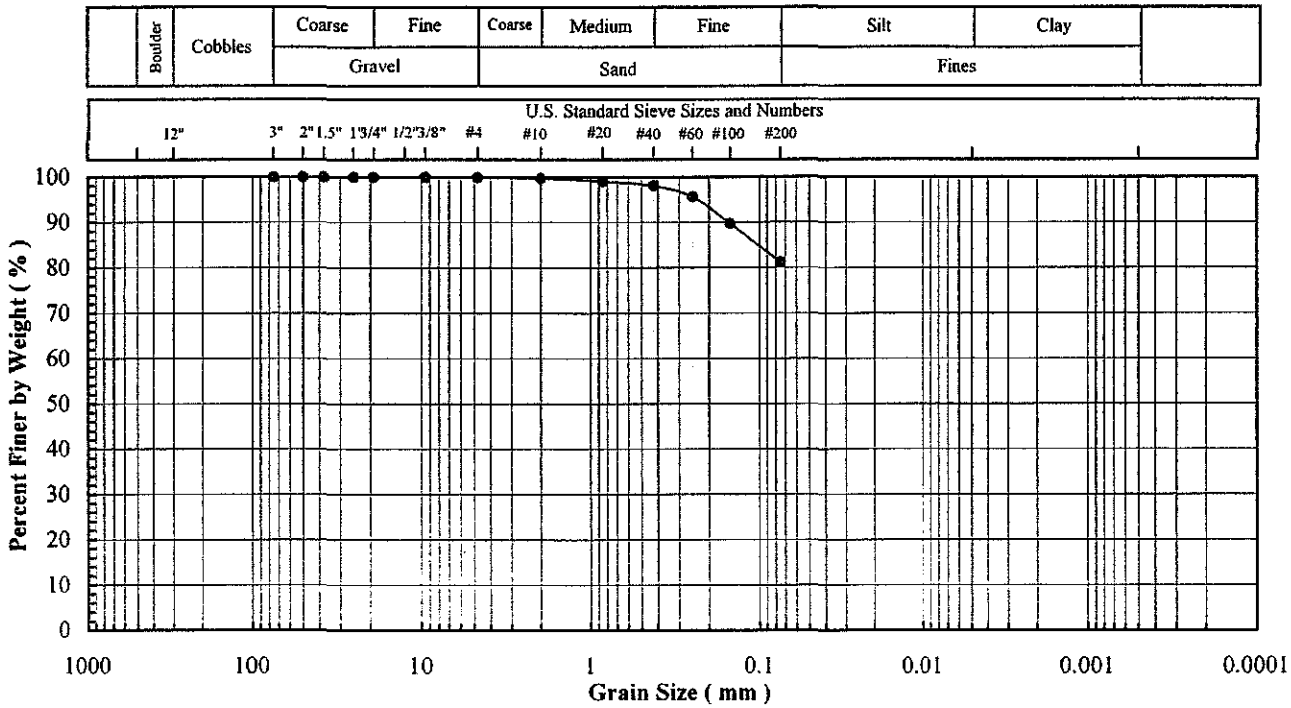
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: RF5-S1-A
Lab Sample No: K242

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



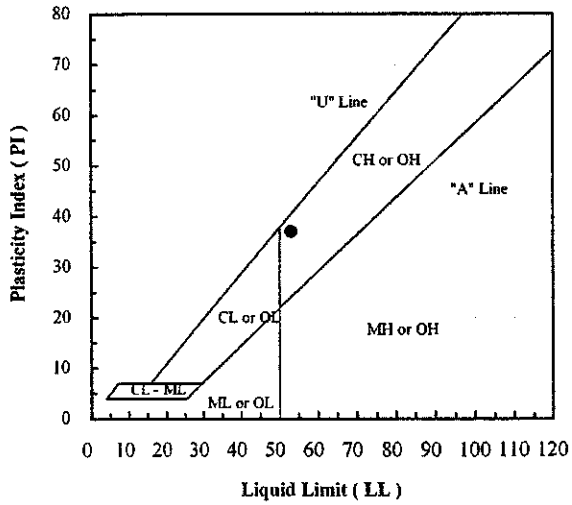
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.9
#10	2.00	99.7
#20	0.850	99.1
#40	0.425	98.1
#60	0.250	95.7
#100	0.150	89.7
#200	0.075	81.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.1
Sand (%):	18.7
Fines (%):	81.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
RF5-S1-A	K242	9.9	81.2	53	16	37	CH - Fat clay with sand

Note(s):

Excel Geotechnical Testing

"Excellence in Testing"

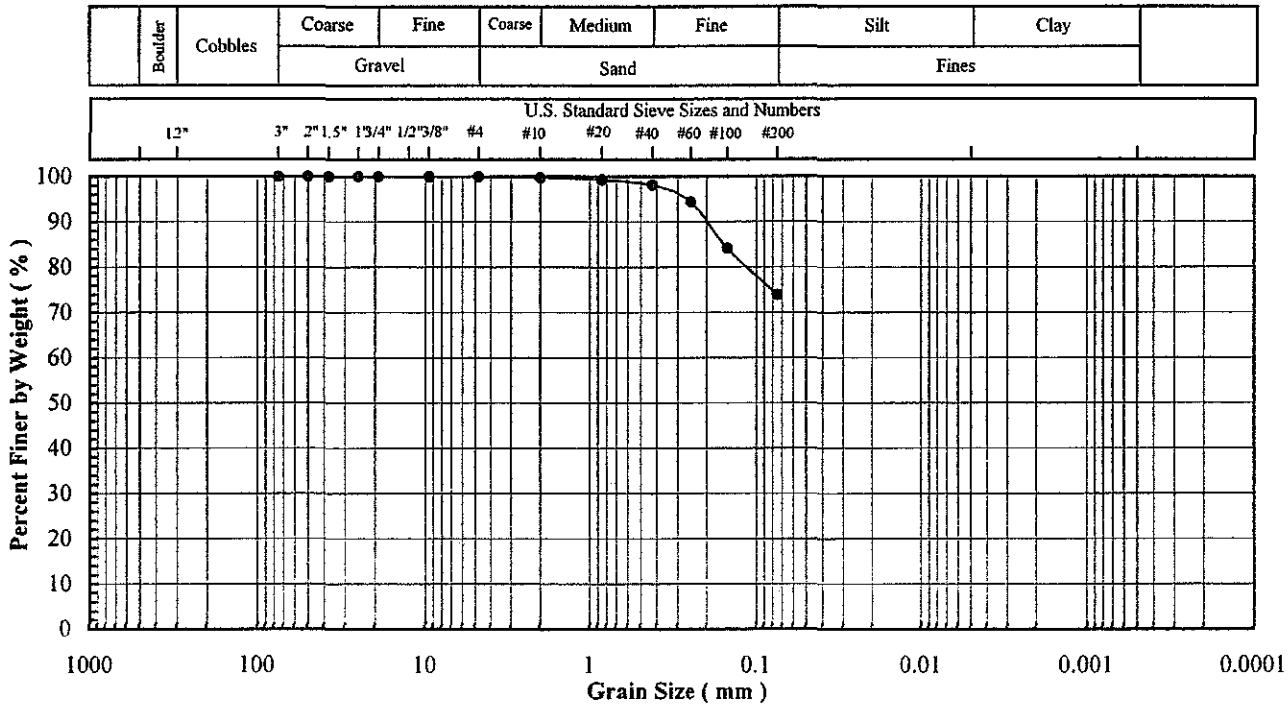
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Site Sample ID: RF5-S1-B
Lab Sample No: K243

ASTM D 2216, D 1140, D 422, D 854, C136

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



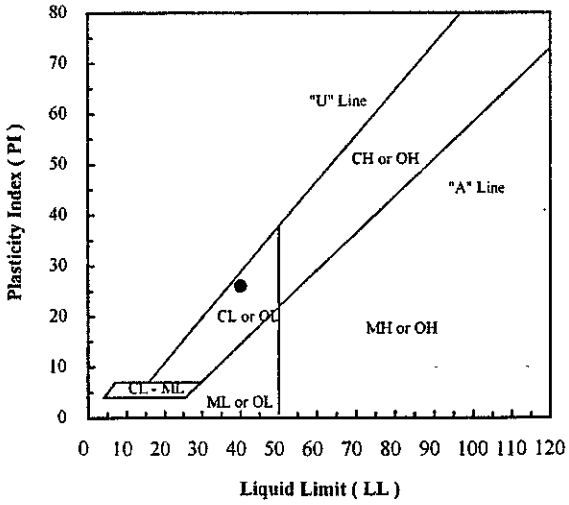
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.7
#20	0.850	99.3
#40	0.425	98.1
#60	0.250	94.4
#100	0.150	84.2
#200	0.075	73.9

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	26.1
Fines (%):	73.9
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



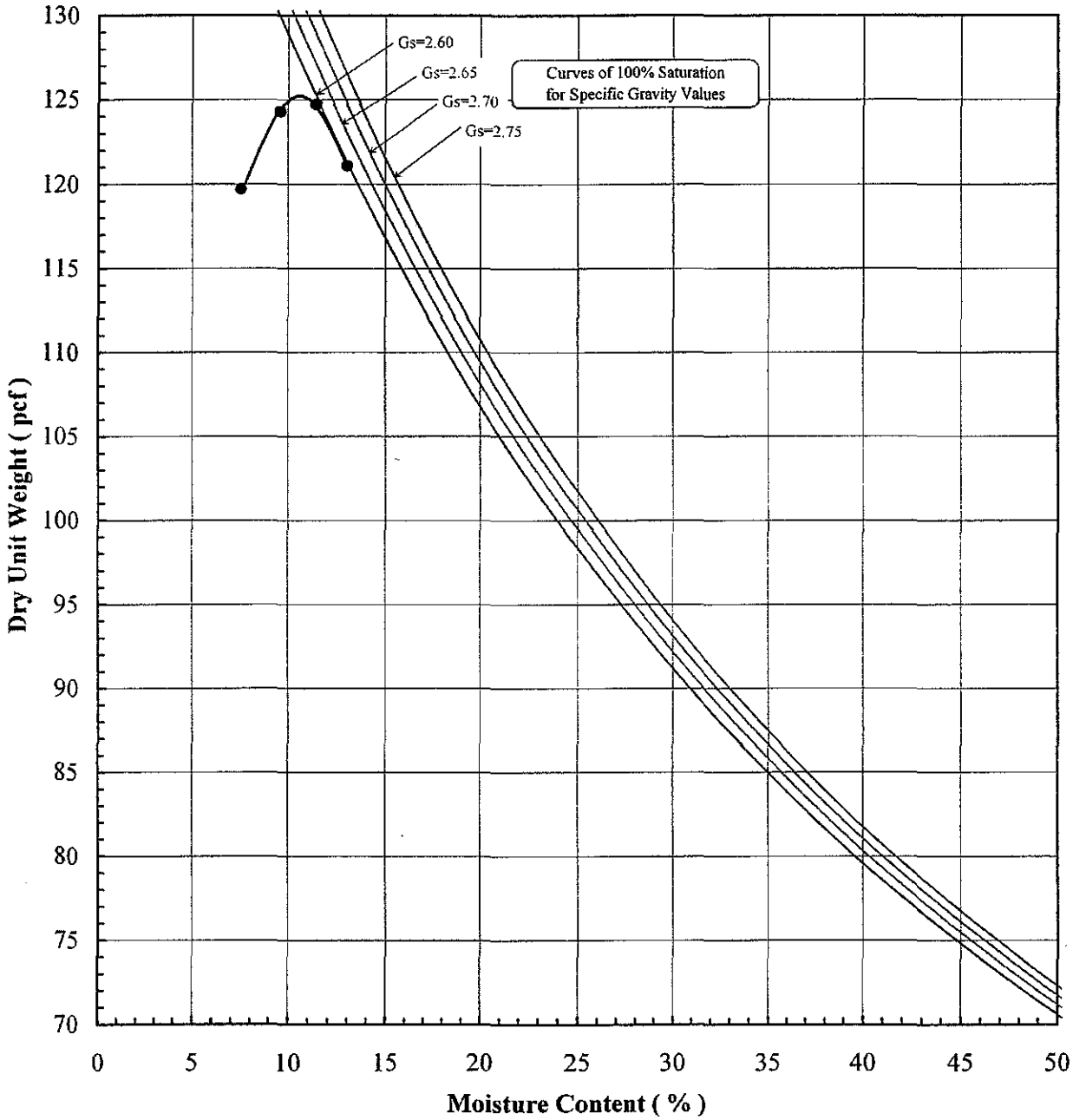
Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
RF5-S1-B	K243	9.6	73.9	40	14	26	CL - Lean clay with sand

Note(s):

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Client Sample ID: Mix 1*
Lab Sample No: K265

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
Mix 1*	K265	125.4	10.4	

Note(s):

* A mixture of equal volumes of C1S1-C, C1S1-E and C1S1-G.

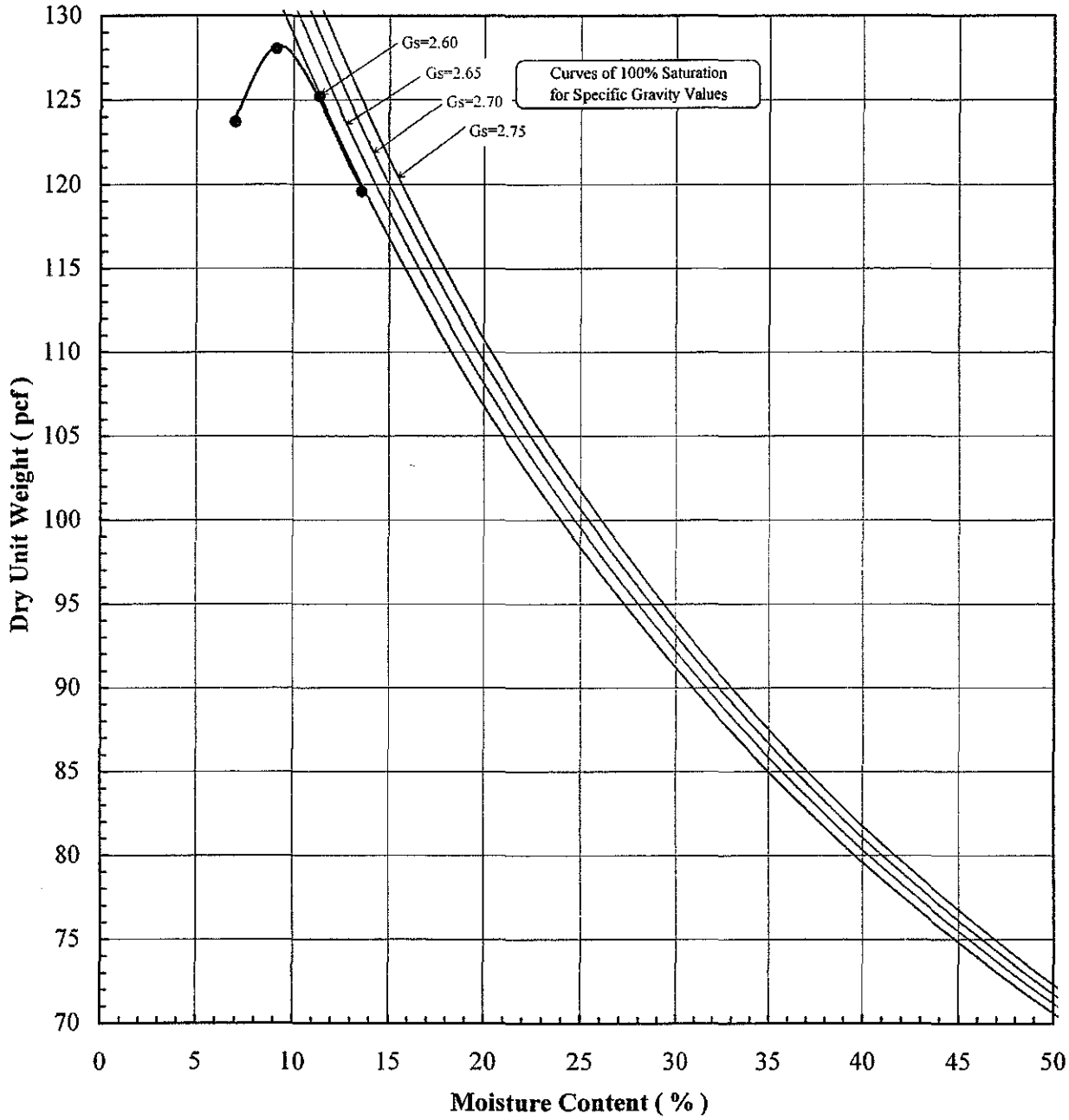
Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: IUC White Mesa Mill
Project No: 165
Client Sample ID: Mix 2*
Lab Sample No: K266

ASTM D 1557

COMPACTION MOISTURE-DENSITY RELATIONSHIP

Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
Mix 2*	K266	128.7	9.5	

Note(s):

* A mixture of equal volumes of C2S1-C, C2S1-F and C2S1-G.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUC White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 2* (See Note 2)
Lab Sample Number:	K266
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.99	7.21	118.4	14.6	90.0	60.0	30.0	DTW	23	3.2E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of C2S1-C, C2S1-F and C2S1-G.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUC White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 1* (See Note 2)
Lab Sample Number:	K265
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.95	7.24	115.8	12.7	90.0	60.0	30.0	DTW	15	4.7E-7

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of C1S1-C, C1S1-E and C1S1-G.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUCW White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 1* (See Note 2)
Lab Sample Number:	K265
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.91	7.24	114.6	15.6	90.0	60.0	30.0	DTW	23	2.1E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of C1S1-C, C1S1-E and C1S1-G.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUC White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 2* (See Note 2)
Lab Sample Number:	K266
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.97	7.23	118.6	11.7	90.0	60.0	30.0	DTW	22	5.7E-7

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of C2S1-C, C2S1-F and C2S1-G.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUC White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 3* (See Note 2)
Lab Sample Number:	K267
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.97	7.25	116.9	13.1	90.0	60.0	30.0	DTW	23	4.6E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of RF5-S1-A and RF5-S1-B.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	IUC White Mesa Mill
Project Number:	165
Client Name:	GeoSyntec Consultants
Site Sample ID:	Mix 3* (See Note 2)
Lab Sample Number:	K267
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	11/27/2005

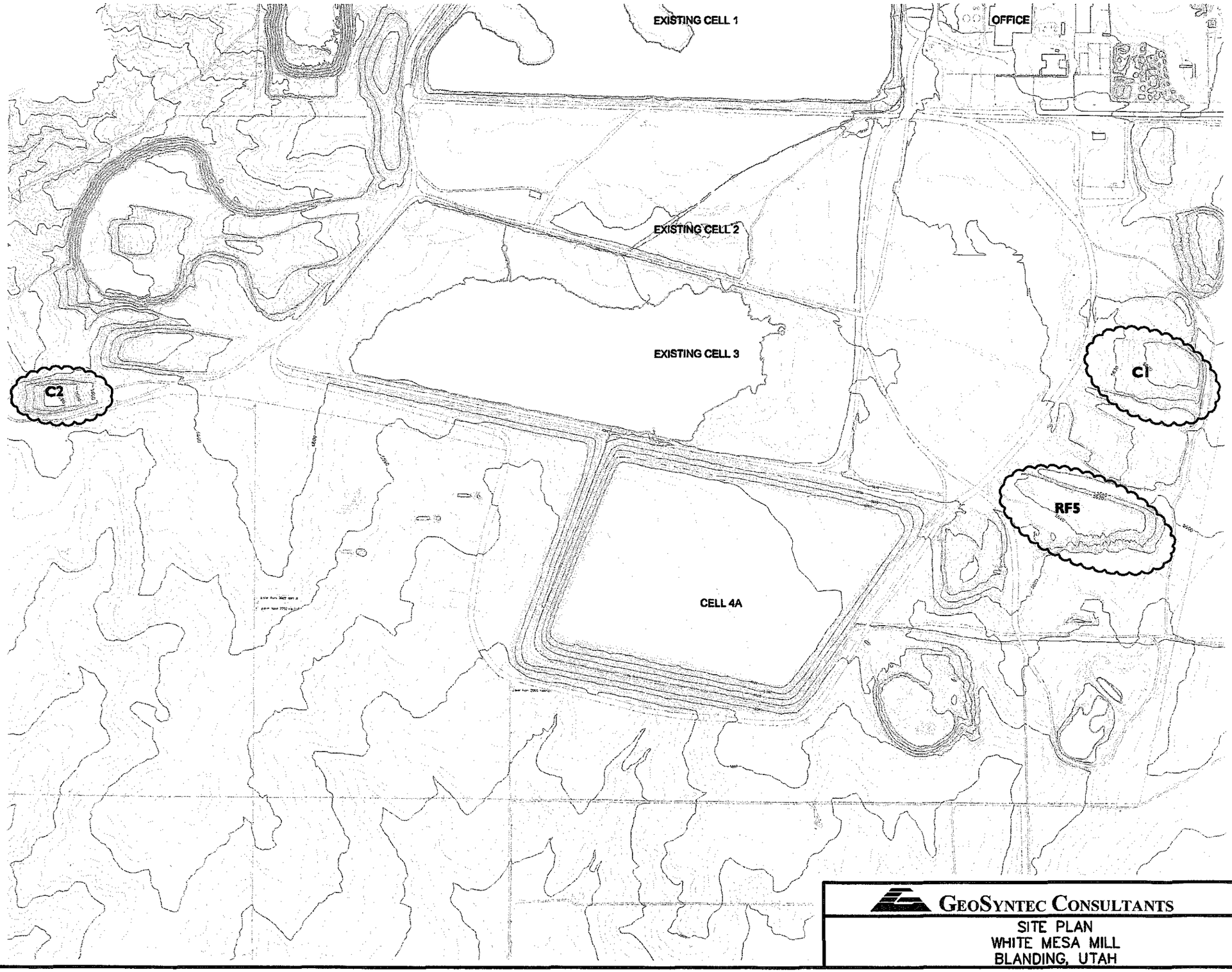
Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [3] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [4] (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.93	7.23	115.5	17.3	90.0	60.0	30.0	DTW	23	3.3E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. * A mixture of equal volumes of RF5-S1-A and RF5-S1-B.
3. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
4. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.



LEGEND

EXISTING MAJOR TOPOGRAPHIC CONTROUR

EXISTING MINOR TOPOGRAPHIC CONTOUR

STOCKPILE LOCATION

N

500 250 0 500

SCALE IN FEET

GEOSYNTEC CONSULTANTS

SITE PLAN
WHITE MESA MILL
BLANDING, UTAH

BASE MAP REFERENCE:
EXISTING TOPOGRAPHY OBTAINED FROM INTERNATIONAL URANIUM (USA) CORPORATION.

FIGURE NO. 2
PROJECT NO. SC0349-01-06
DATE: JANUARY 2006

P:\PRJ\SDCadd\CADD\SC0349\01-06-Figs\SC0349-01-06-SP.dwg 1/23/06 14:19 Administrator

ATTACHMENT A.1.5

ROGERS AND ASSOCIATES ENGINEERING CORP

1988

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

March 4, 1988

Mr. C.O.Sealy
Umetco Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

C8700/22

Dear Mr. Sealy:

We have completed the tests ordered on the four samples shipped to us. The results are as follows:

Sample	Radium pCi/gm	Emanation Fraction	Diffusion Coeffic.	(g/cm^3) Density	Moisture	Saturation
Tailings	981±4	0.19±0.01	2.0E-02	1.45	13.2	0.39
			8.4E-03	1.44	19.1	0.56
Composite (2,3,&5)			1.6E-02	1.85	6.5	0.40
			4.5E-04	1.84	12.5	0.75
Site #1			1.6E-02	1.85	8.1	0.48
			1.4E-03	1.84	12.6	0.76
Site #4			1.1E-02	1.65	15.4	0.63
			4.2E-04	1.65	19.3	0.80

The samples will be shipped back to you in the next few weeks. If you have any questions regarding the results on the samples please feel free to call.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB/b

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

MAY 12 1988

May 9, 1988

Mr. C.O. Sealy
UMETCO Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

C8700/22

Dear Mr. Sealy:

The tests for radium content and radon emanation coefficient in the following samples have been completed and the results are as follows:

Sample	Radium (pCi/g)	Radon Emanation Coefficient
Random (2,3 & 5)	1.9 ± 0.1	0.19 ± 0.04
Site 1	2.2 ± 0.1	0.20 ± 0.03
Site 4	2.0 ± 0.1	0.11 ± 0.04

If you have any questions regarding these results please feel free to call Dr. Kirk Nielson or me.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB:ms

515 East 4500 South • Salt Lake City, Utah 84107

ATTACHMENT A.1.6

WESTERN COLORADO TESTING, INC.

1999a

The onsite random fill and clay stockpiles were sampled in characterized in a program detailed in the April 15, 1999, submittal to the NRC, "Additional Clarifications to the White Mesa Mill Reclamation Plan". A copy of this sampling and testing program are included in this Attachment as well as the results of the characterization work. The samples wee characterized for:

-- Classification
- Grain size and sieve
- Atterberg limits

-- Standard Proctor

The results of these tests for the onsite stockpiled material are included in this Attachment.

Soil Sampling and Testing Program – White Mesa Mill

The purpose of this Soil Sampling and Testing Program is to verify the soil classification, gradation and compaction characteristics (standard proctor) of the stockpiled random fill and clay materials that will be used for cover materials on the tailings cells at the White Mesa Mill. Additionally this program will verify the compaction characteristics and gradation of the random fill materials utilized in the platform fill previously placed on Cells 2 and 3.

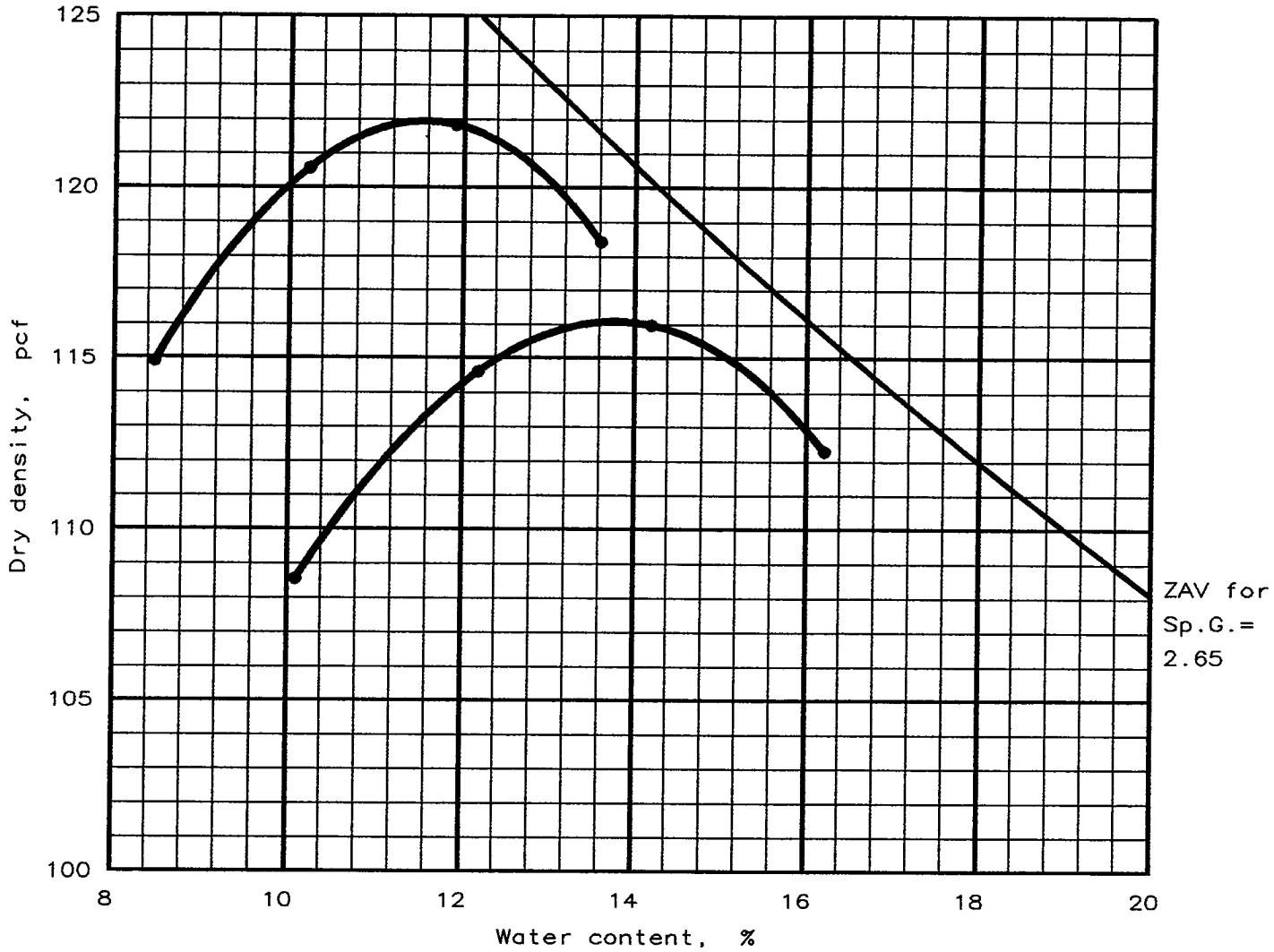
Sampling

Sampling will take place on each of six stockpiles of random fill (designated RF-1 through RF-6 on Exhibit A), two clay material stockpiles (C-1 and C-2 on Exhibit A), and on platform fill areas in Cells 2 & 3. A total of 9 samples will be taken from the random fill stockpiles. Two (2) samples will be taken from the clay stockpiles and three (3) samples will be taken from the covered areas of the cells. Samples will be taken from test pits excavated by a backhoe. Samples will be taken from a depth of 8 feet in stockpiles and from 2 foot depth in cells. One backhoe bucket full of material will be taken from the test pit at the specified depth and dumped separately. This sample will be quartered and one quarter will be screened to minus 2" (rocks over 8" will be removed prior to screening). Two five gallon sample buckets will be filled with sample randomly selected from the screened fraction. Oversized material remaining after the screening of the sample will be visually classified and then weighed. Sample locations will be indicated on a site map and sample descriptions will recorded and maintained in the facility's records. A total of fourteen samples will be submitted for testing during this program.

Testing

Samples will be packaged and shipped to a certified commercial testing laboratory for testing. Tests will be run on each sample for standard proctor (ASTM D698), particle size analysis (ASTM C117 and ASTM C136), soil classification (ASTM D2487) and plasticity index (Atterberg limits ASTM D4318).

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			16.1 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 122.0 pcf	116.1 pcf	2-1-W
Optimum moisture = 11.6 %	13.8 %	Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

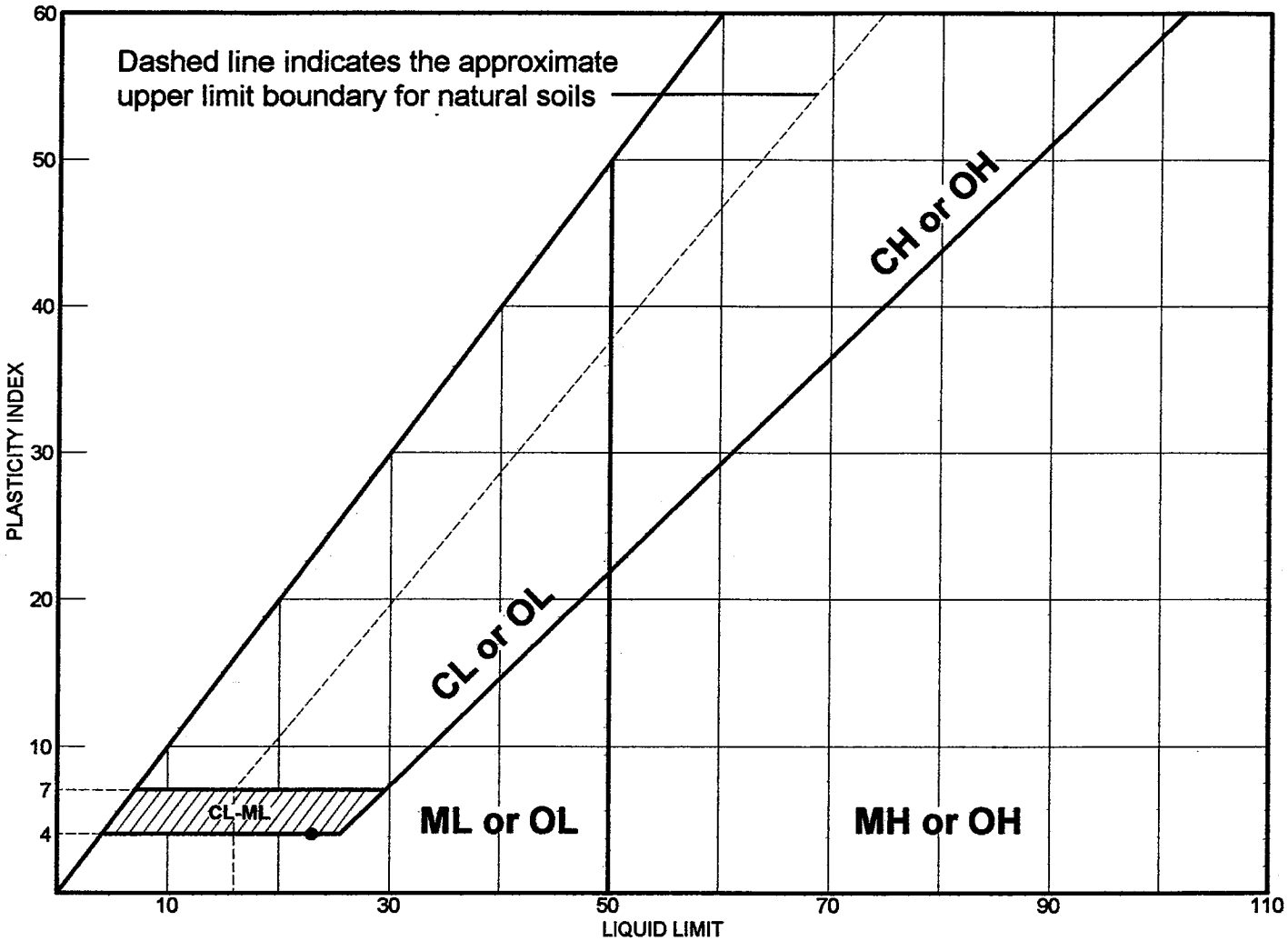
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 7

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, very clayey, sl silty, red	23	19	4	56.9	25.1	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** 2-1-W

Remarks:

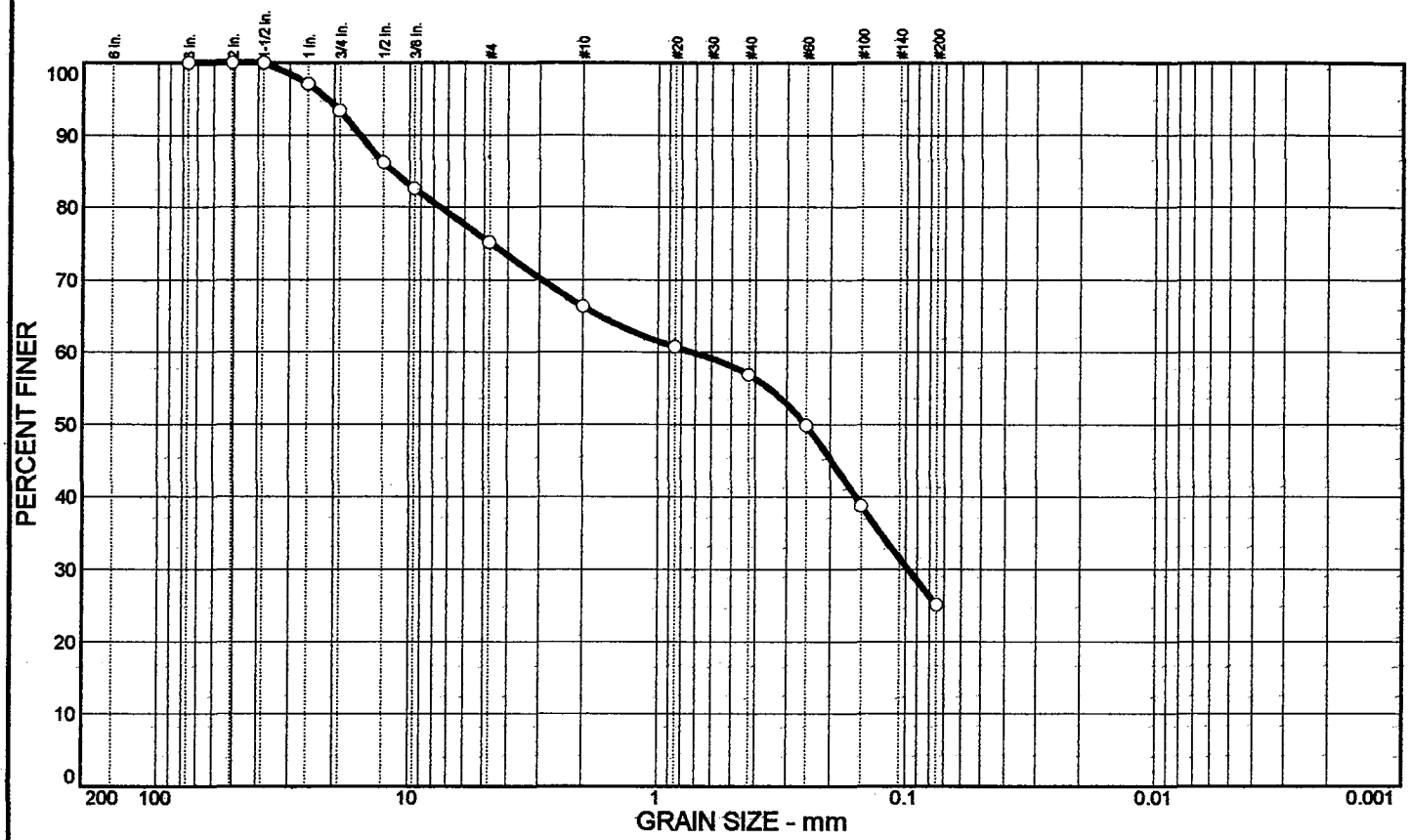
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 22

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		24.8	50.1			SM	A-2-4(0)	19	23

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	97.1		
3/4	93.4		
1/2	86.3		
3/8	82.6		
	GRAIN SIZE		
D_{60}	0.726		
D_{30}	0.0973		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	75.2		
#10	66.3		
#20	60.7		
#40	56.9		
#60	49.9		
#100	38.8		
#200	25.1		

SOIL DESCRIPTION

○ Sand, very clayey, sl silty, red

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: 2-1-W

WESTERN COLORADO TESTING, INC.

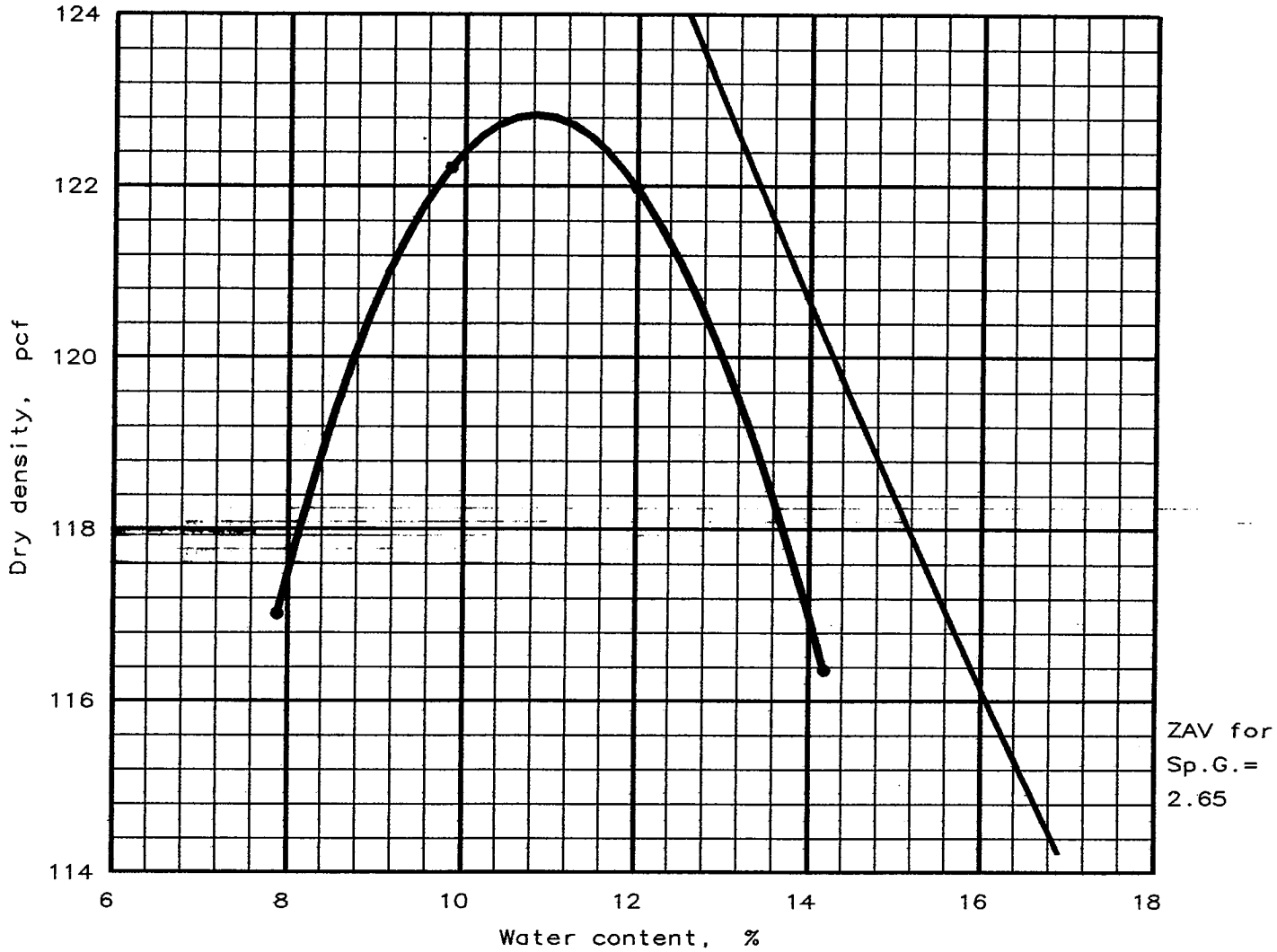
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 38

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			13.4 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 122.8 pcf Optimum moisture = 10.8 %	122.8 pcf 10.8 %	2W-7C Sand, silty, gravely, br

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

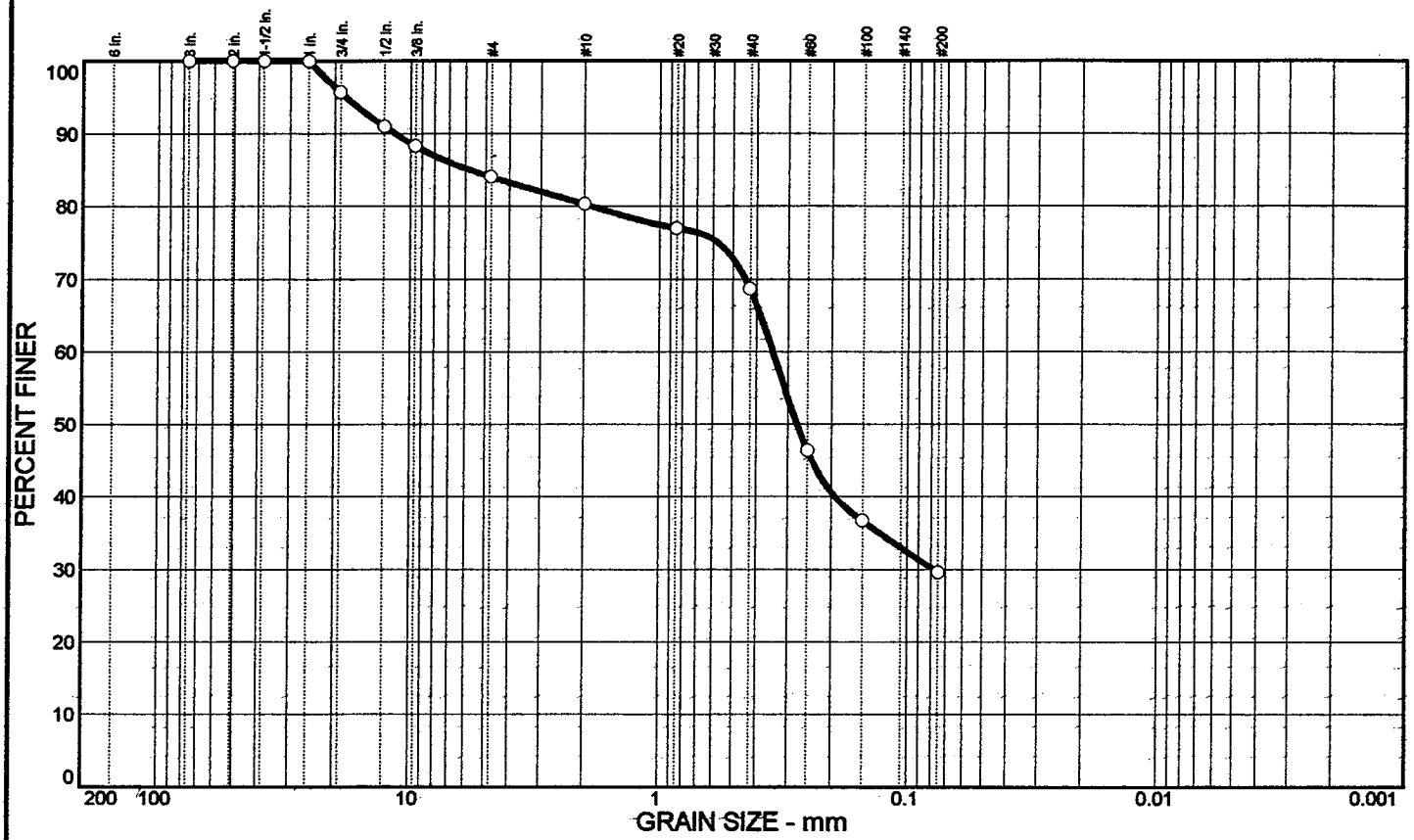
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 8

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		15.9	54.5			SM	A-2-4(0)	NP	

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	95.7		
1/2	91.0		
3/8	88.3		
	GRAIN SIZE		
D_{60}	0.344		
D_{30}	0.0781		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	84.1		
#10	80.3		
#20	77.0		
#40	68.6		
#60	46.4		
#100	36.7		
#200	29.6		

SOIL DESCRIPTION

○ Sand, silty, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: 2W-7C

WESTERN COLORADO TESTING, INC.

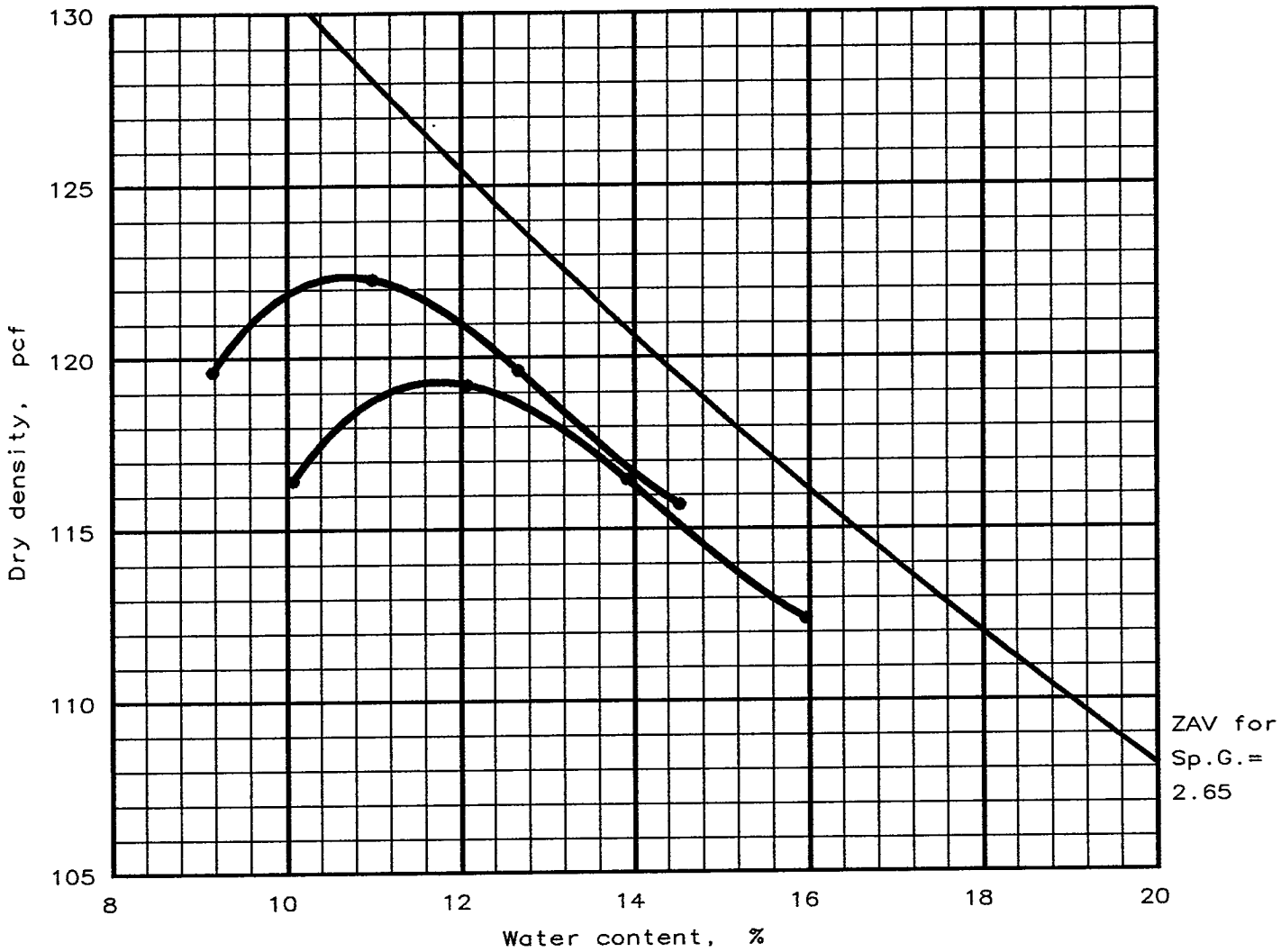
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 39

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			9.0 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 122.4 pcf Optimum moisture = 10.7 %	119.3 pcf 11.8 %	3-1C Sand, clayey, grvly, brn

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

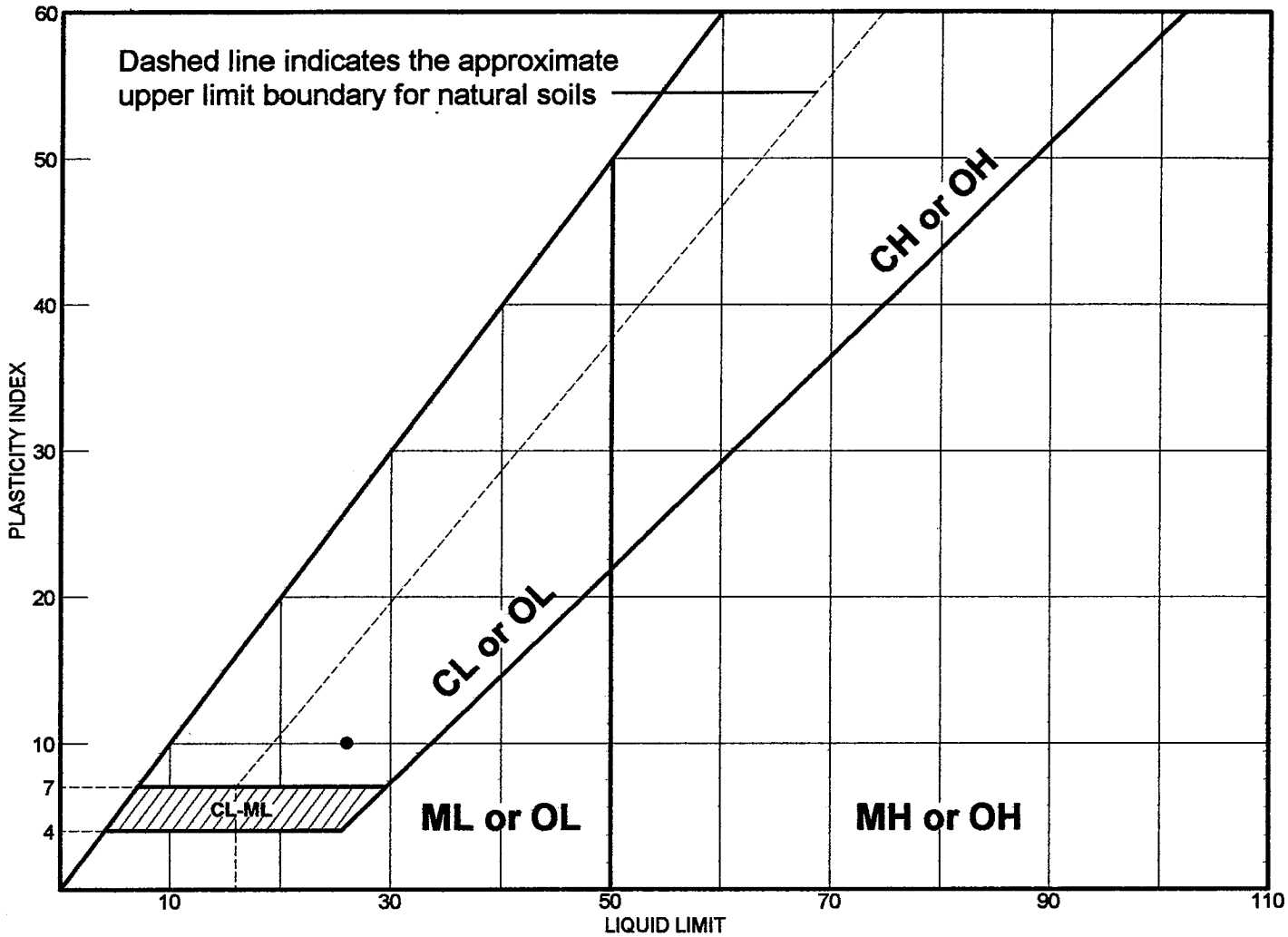
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 9

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, clayey, gravely, brown	26	16	10	69.5	36.9	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** 3-1C

Remarks:

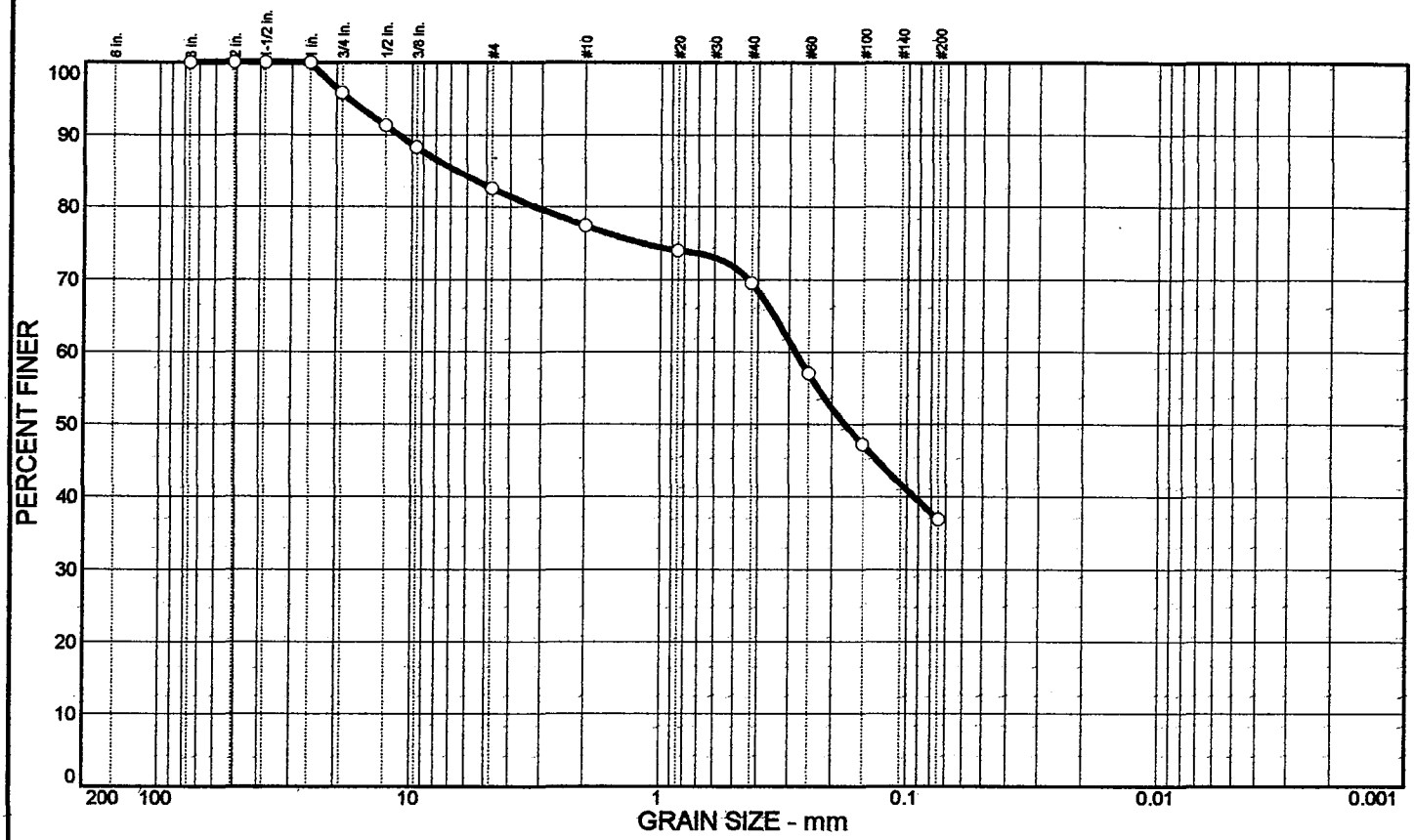
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 23

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		17.4	45.7			SM	A-4(0)	16	26

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	95.8		
1/2	91.3		
3/8	88.3		
GRAIN SIZE			
D_{60}	0.282		
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	82.6		
#10	77.4		
#20	74.0		
#40	69.5		
#60	57.0		
#100	47.2		
#200	36.9		

SOIL DESCRIPTION

○ Sand, clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: 3-1C

WESTERN COLORADO TESTING, INC.

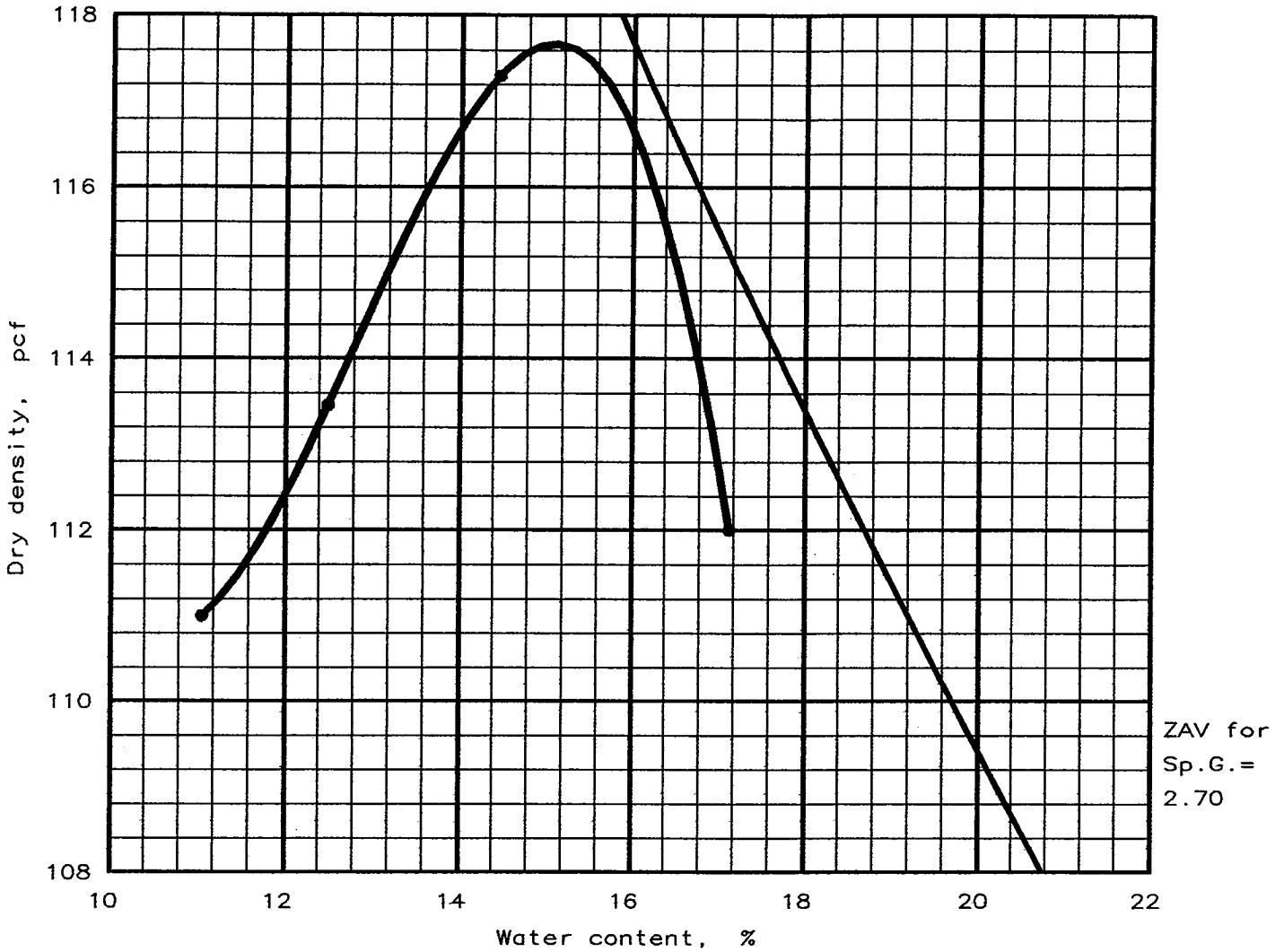
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 40

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
			N/A %	2.70				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 117.7 pcf Optimum moisture = 15.1 %	117.7 pcf 15.1 %	C1-S1 Clay, v sandy, silty, rd

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

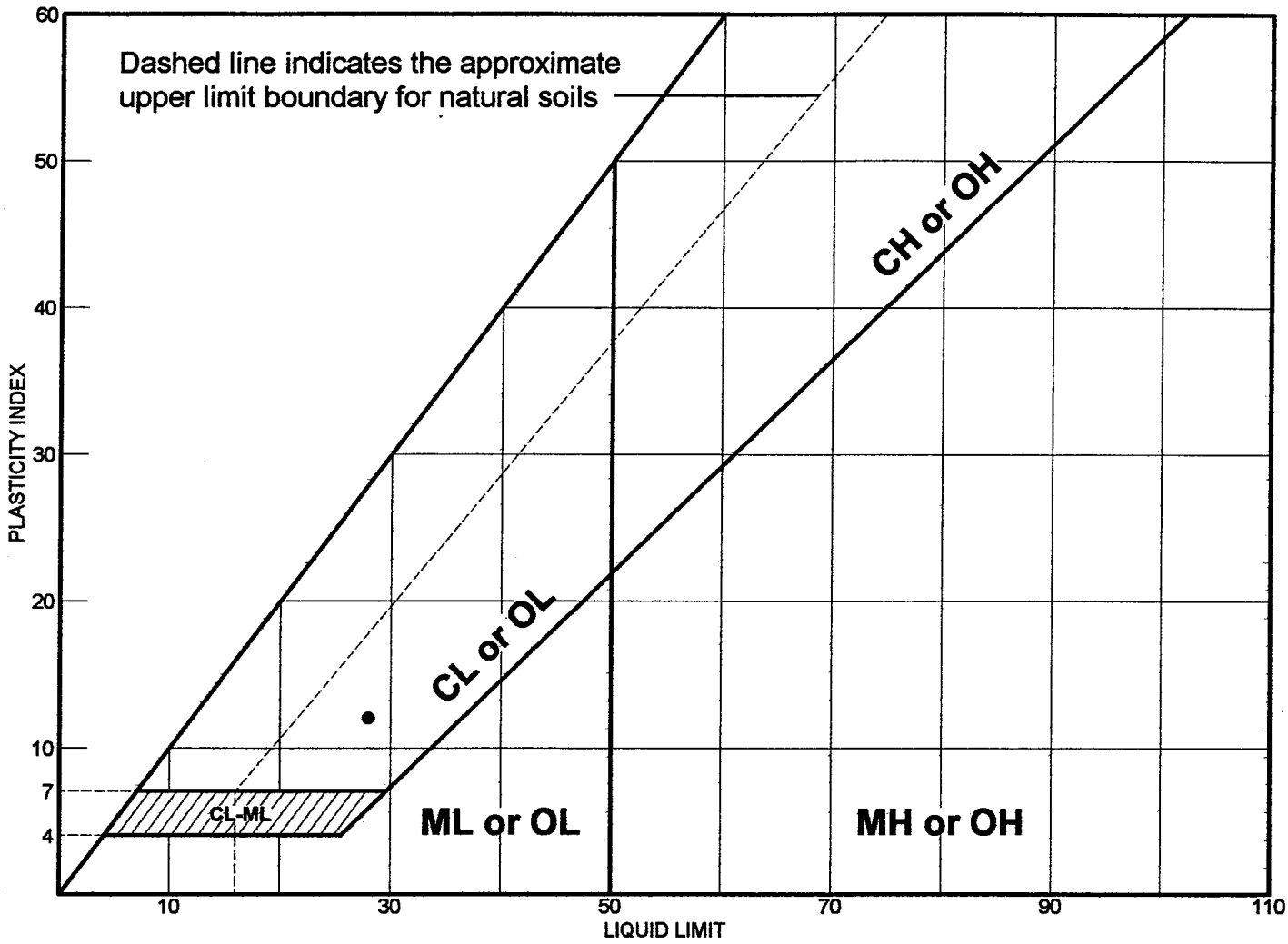
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 10

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clay, very sandy, silty, red	28	16	12	98.3	64.8	CL

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** C1-S1

Remarks:

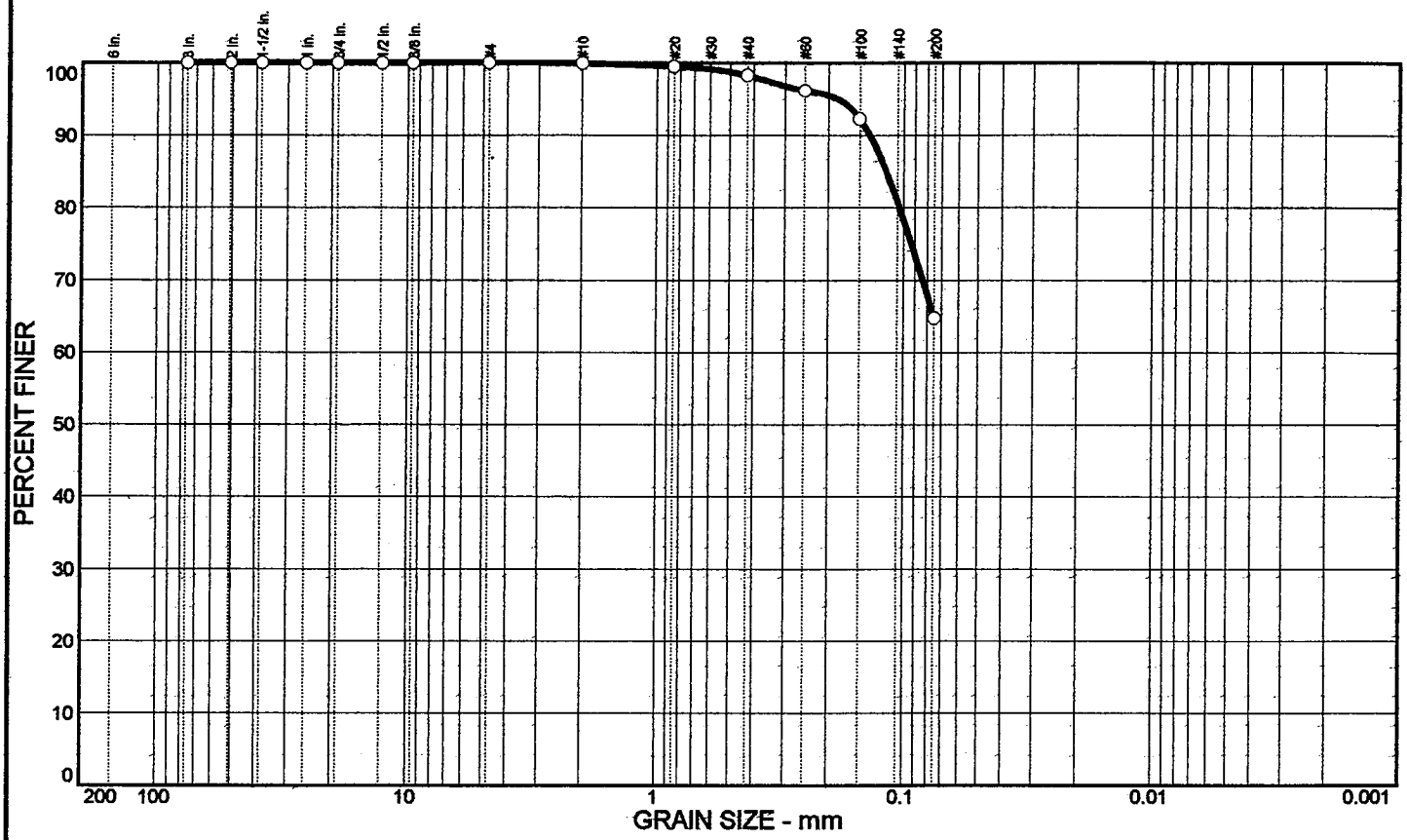
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 24

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	35.2			CL	A-6(5)	16	28

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.9		
#20	99.5		
#40	98.3		
#60	96.2		
#100	92.3		
#200	64.8		

SOIL DESCRIPTION

○ Clay, very sandy, silty, red

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: C1-S1

WESTERN COLORADO TESTING, INC.

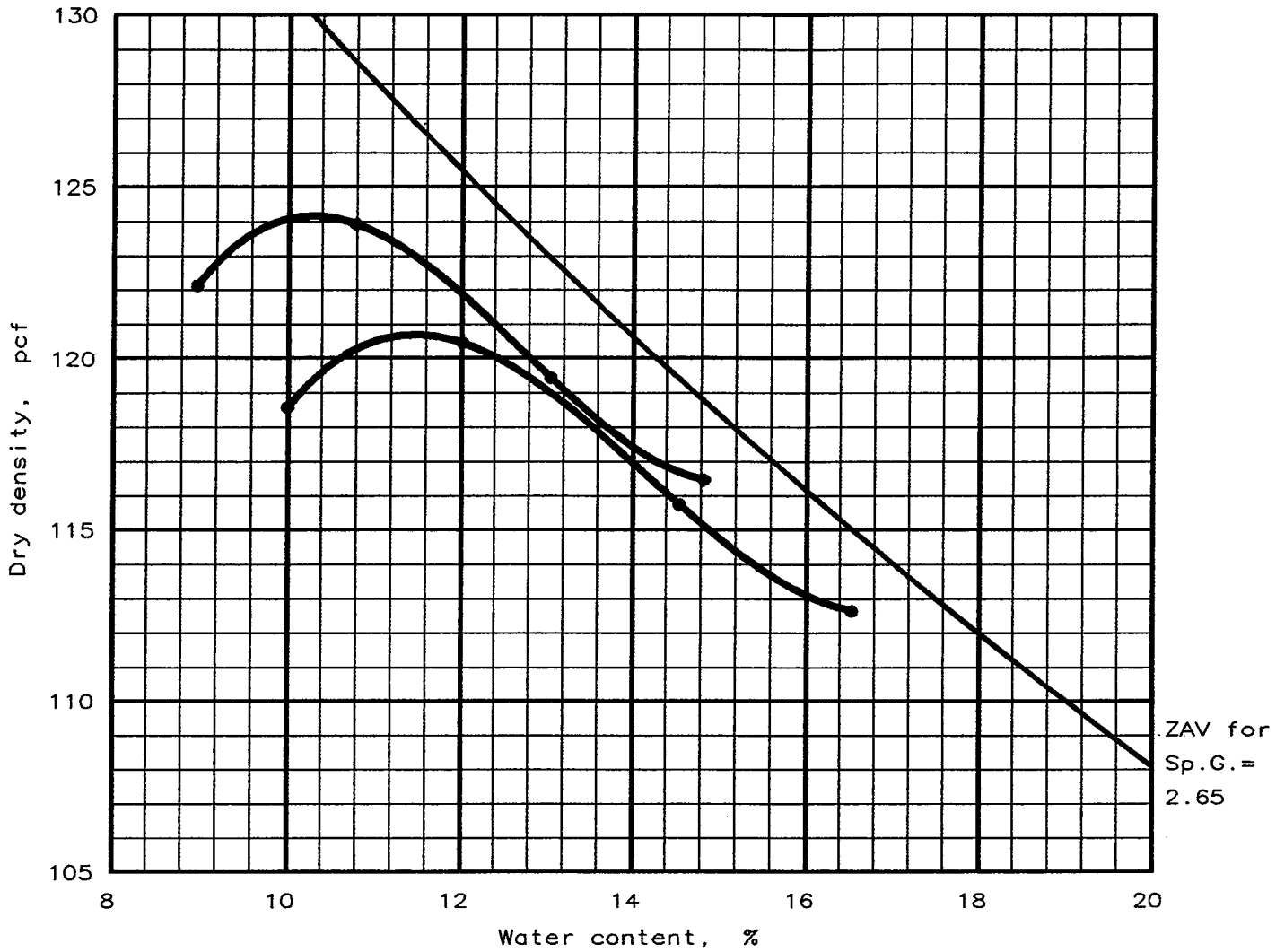
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 41

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			10.3 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 124.2 pcf Optimum moisture = 10.3 %	120.7 pcf 11.5 %	C2-S1 Sand, clayey, grvly, brn

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

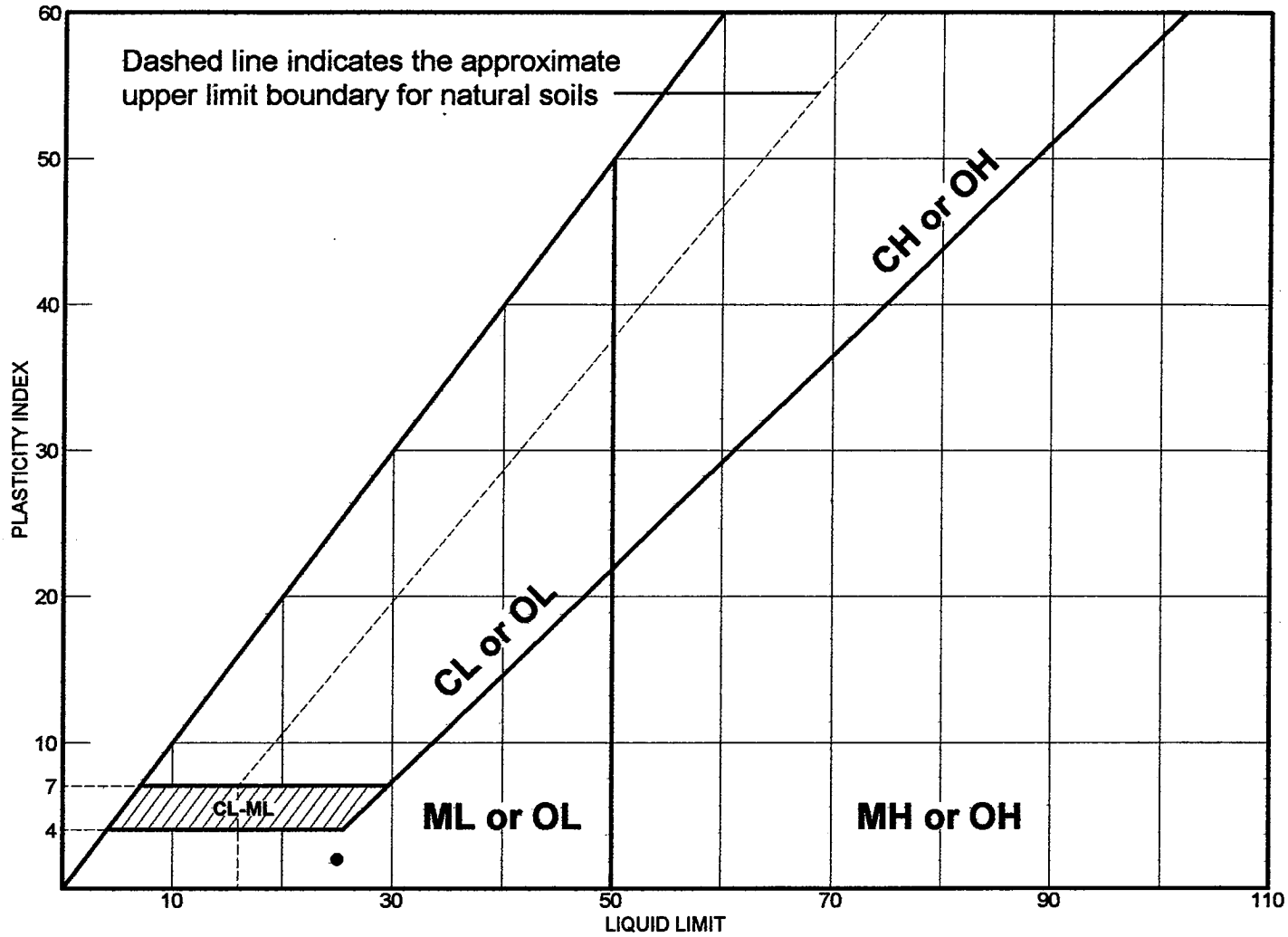
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 11

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, clayey, gravely, brown	25	23	2	48.2	26.7	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** C2-S1

Remarks:

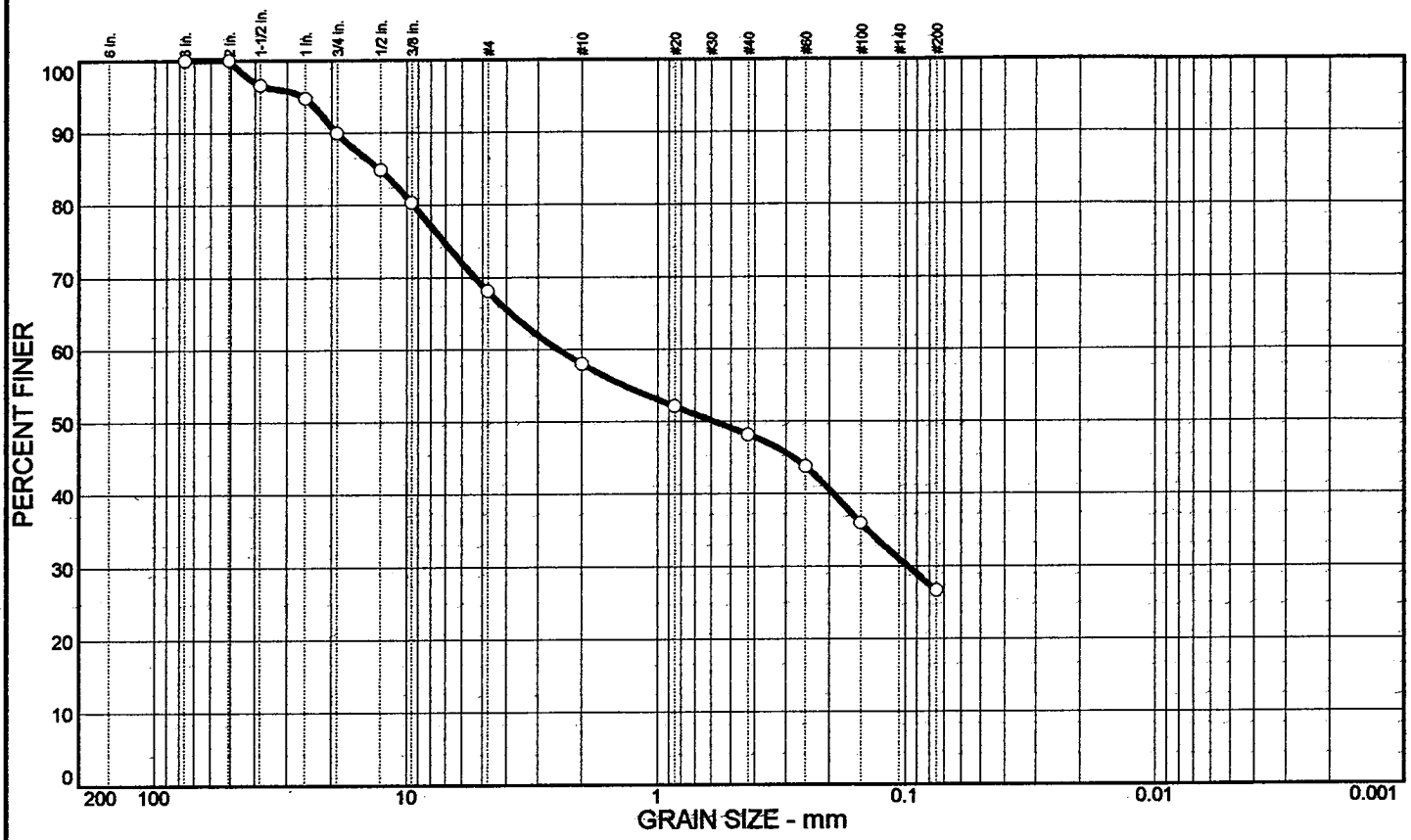
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 25

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		31.9	41.4			SM	A-2-4(0)	23	25

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	96.6		
1	94.8		
3/4	90.0		
1/2	84.9		
3/8	80.3		
	GRAIN SIZE		
D_{60}	2.48		
D_{30}	0.0977		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	68.1		
#10	58.0		
#20	52.1		
#40	48.2		
#60	43.8		
#100	36.0		
#200	26.7		

SOIL DESCRIPTION

○ Sand, clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: C2-S1

WESTERN COLORADO TESTING, INC.

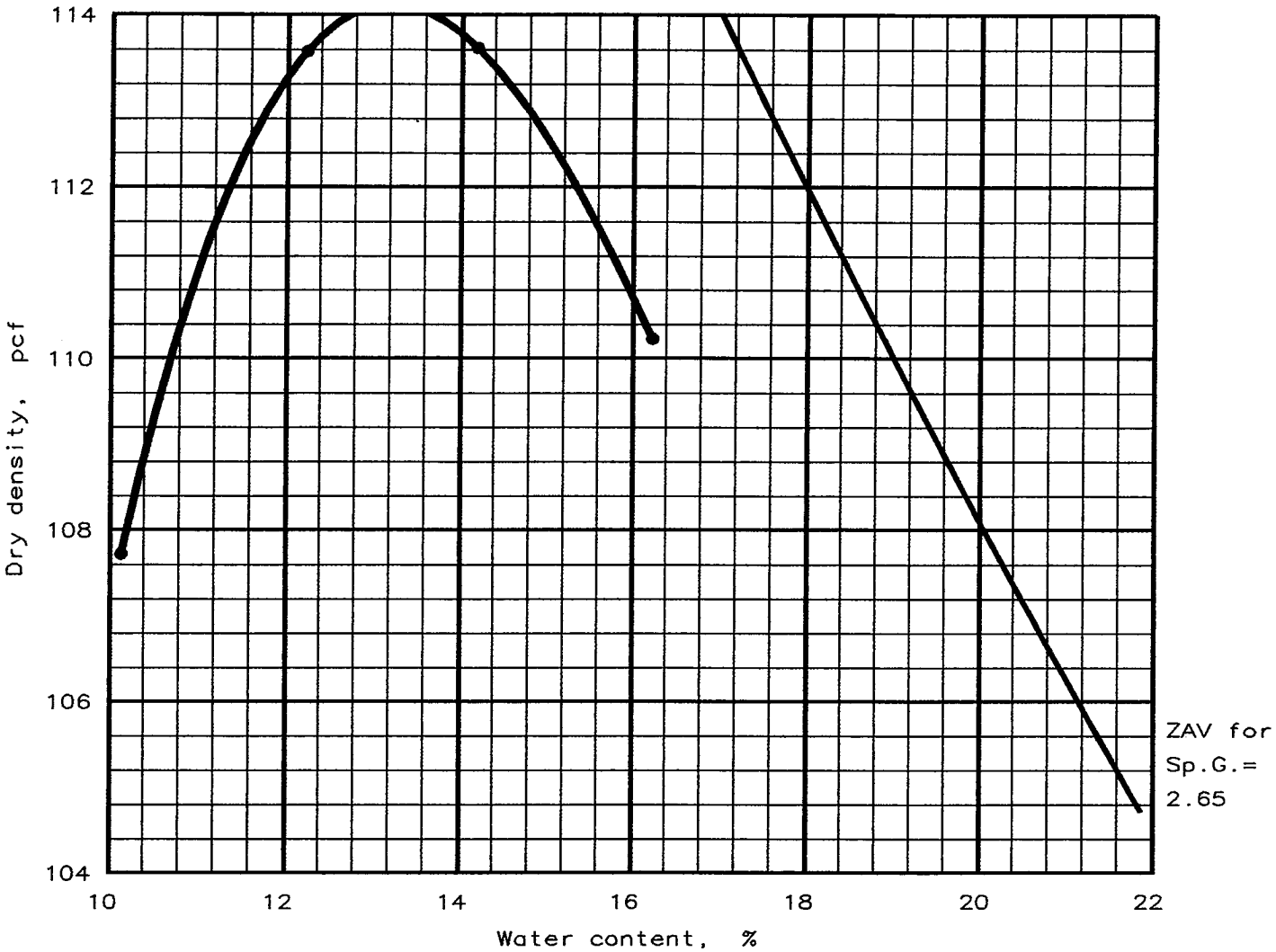
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 42

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 114.1 pcf Optimum moisture = 13.2 %	114.1 pcf 13.2 %	RF1-S1 Clay, silty, sandy, red

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

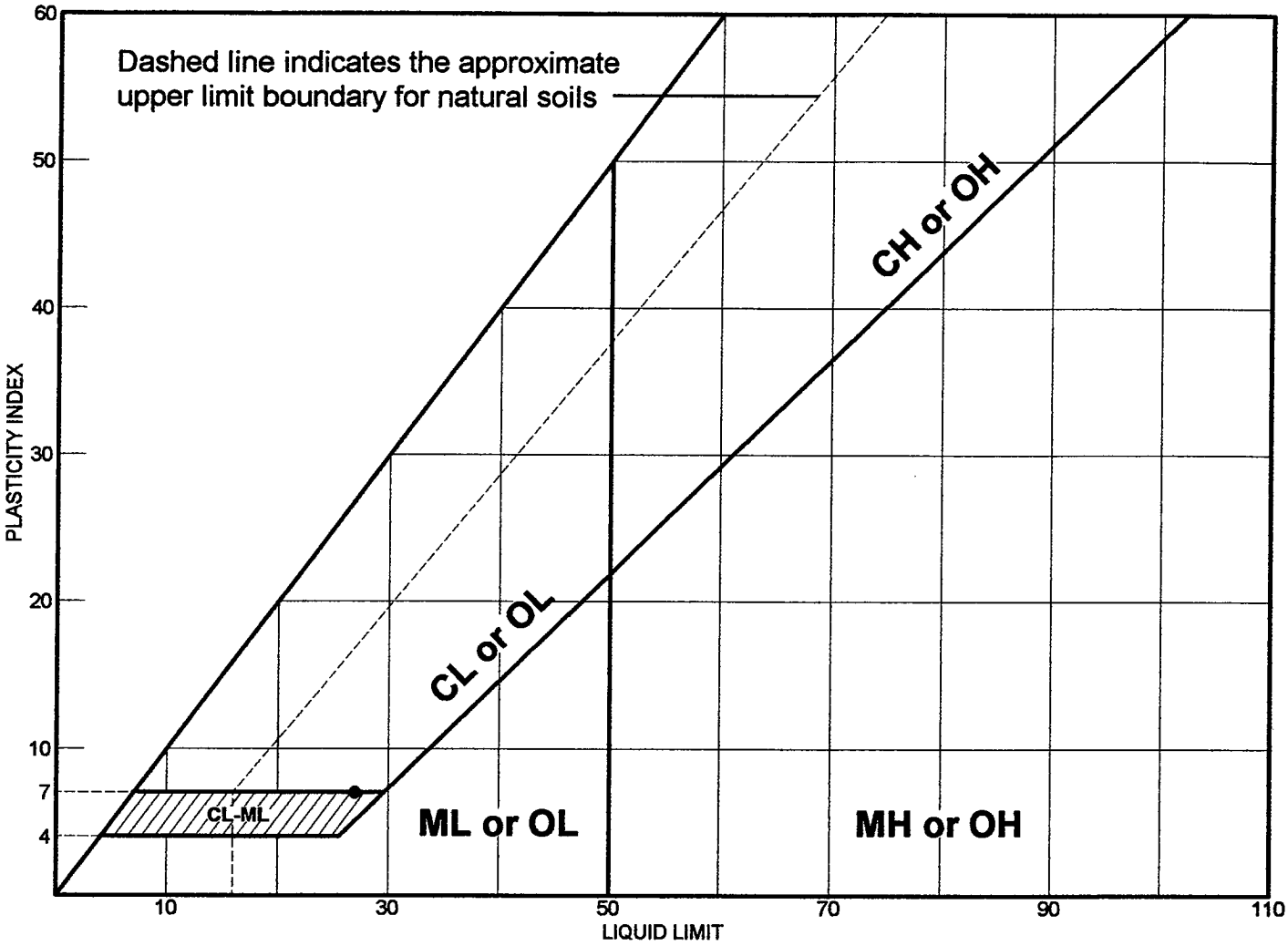
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 12

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clay, silty, sandy, red	27	20	7	99.1	63.1	ML

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF1-S1

Remarks:

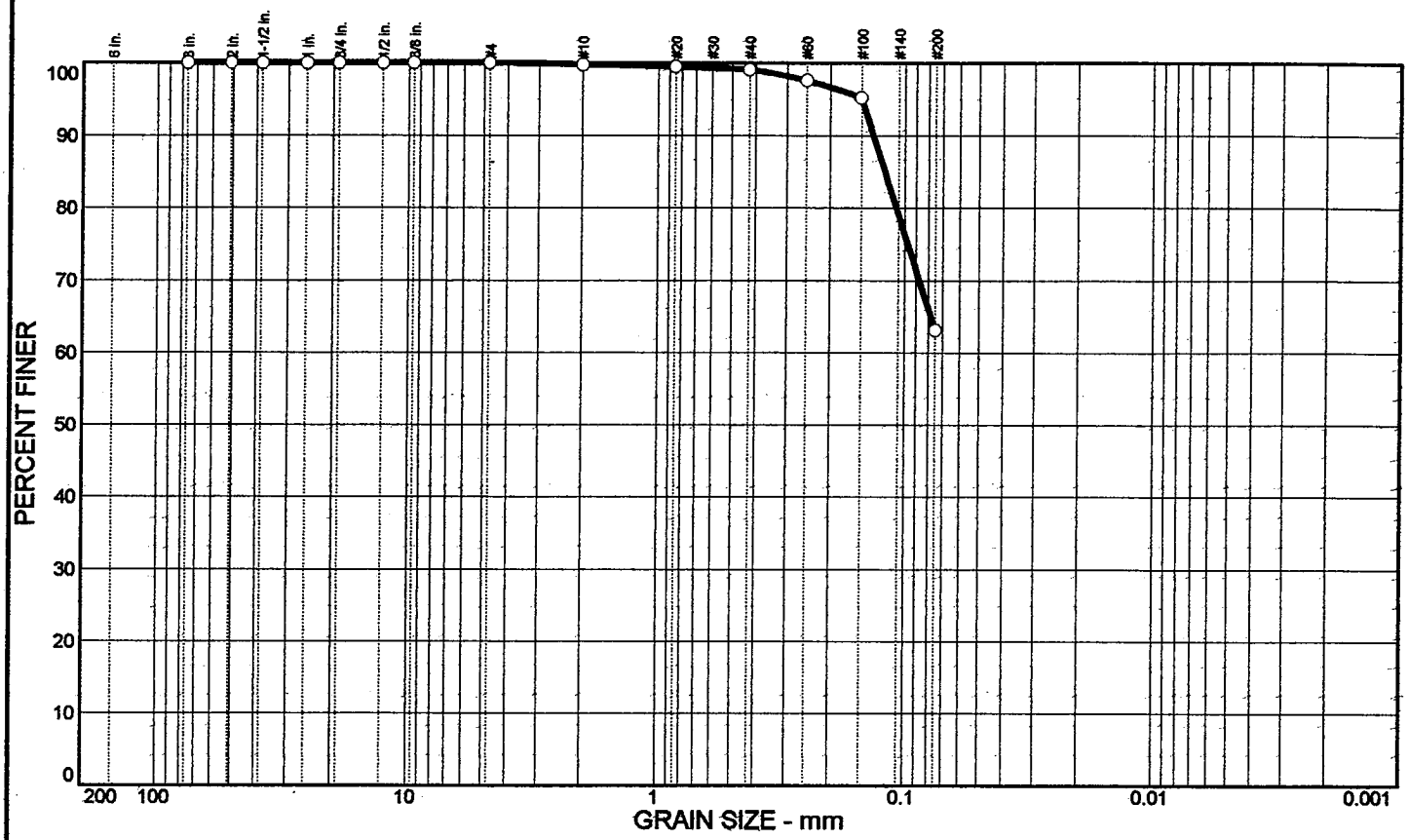
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 26

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	36.9			ML	A-4(0)		

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.8		
#20	99.5		
#40	99.1		
#60	97.6		
#100	95.2		
#200	63.1		

SOIL DESCRIPTION

○ Clay, silty, sandy, red

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF1-S1

WESTERN COLORADO TESTING, INC.

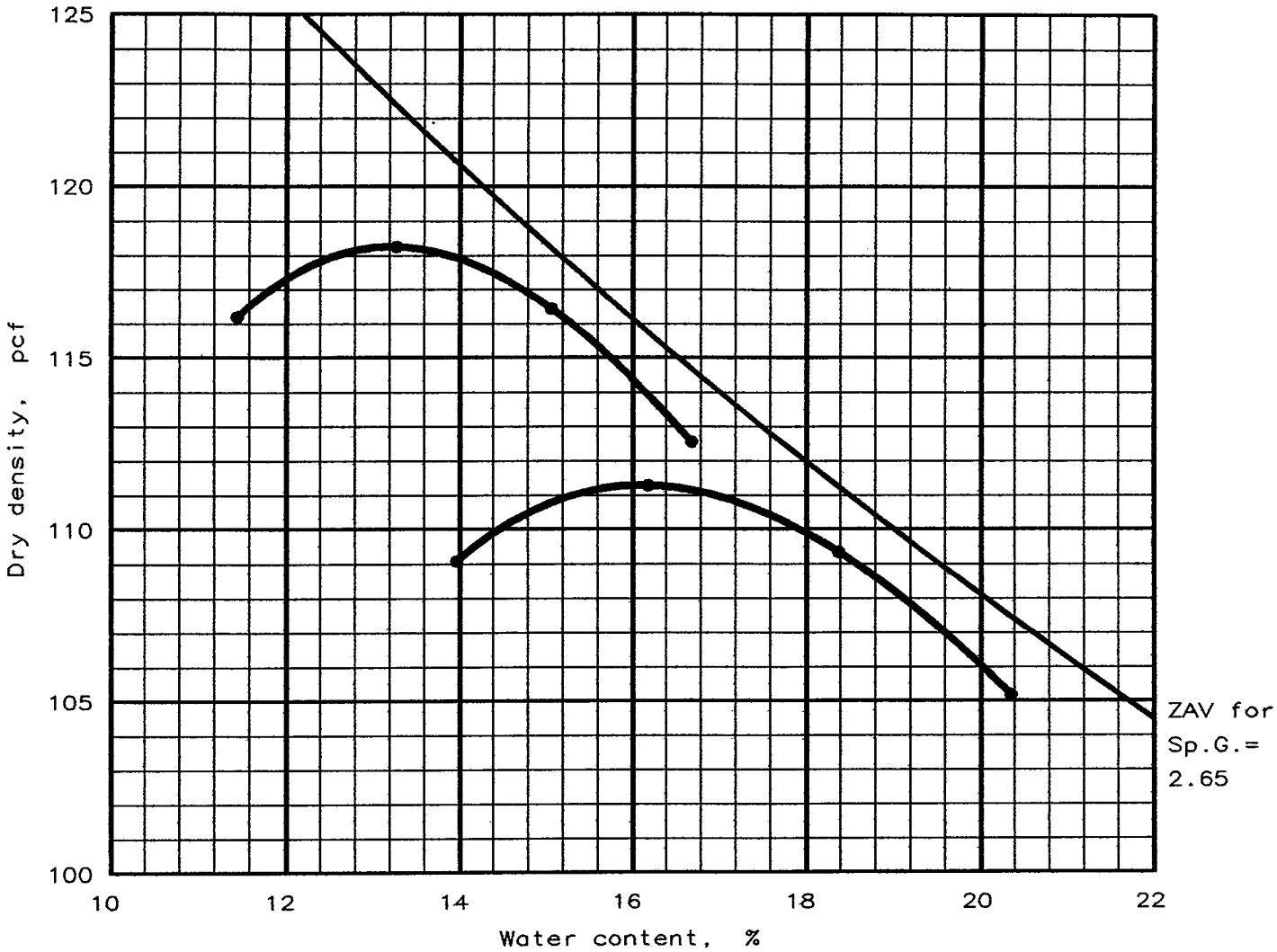
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 43

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			18.0 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 118.3 pcf Optimum moisture = 13.2 %	111.3 pcf 16.1 %	RF2-S1 Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

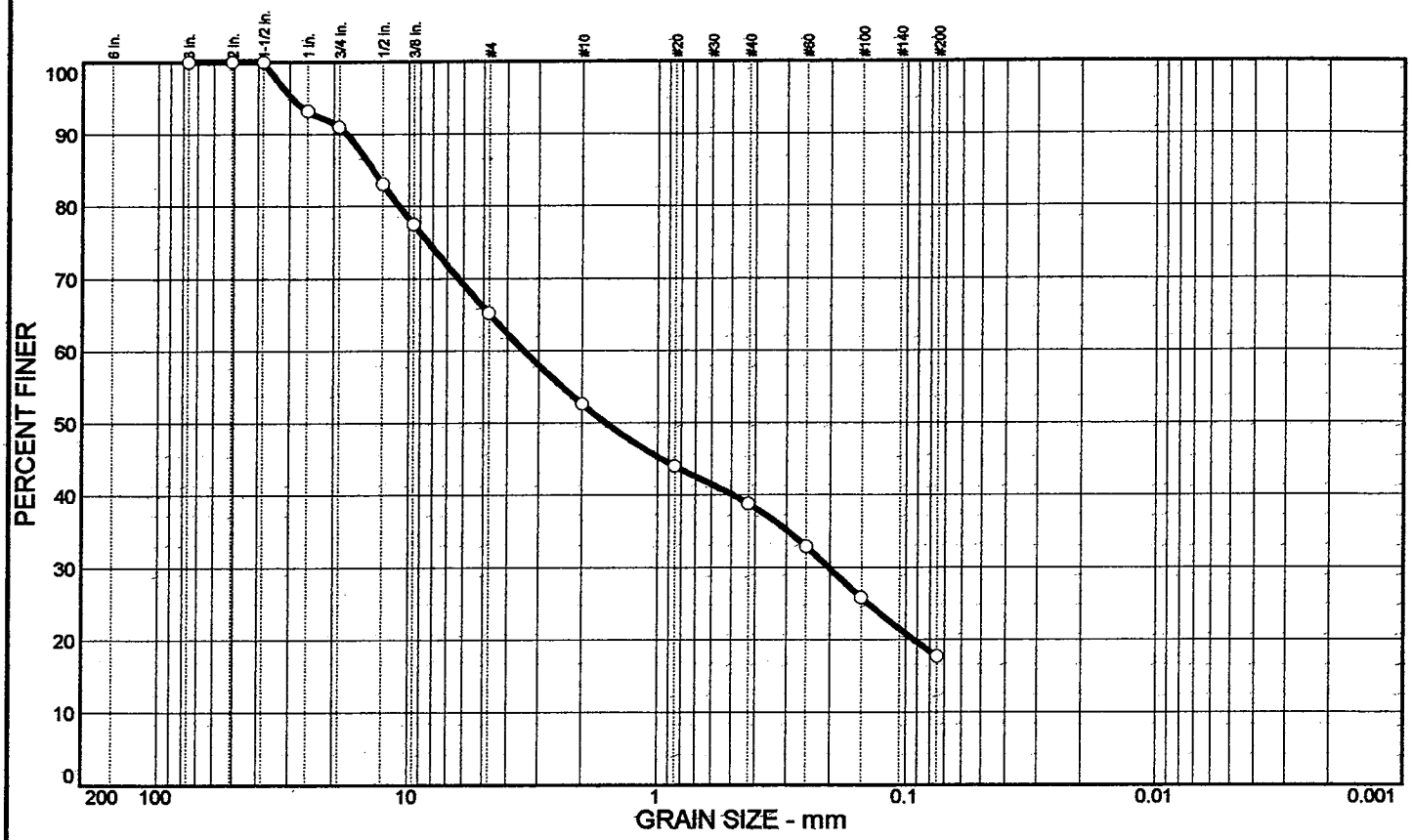
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 13

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		34.8	47.5			SM	A-1-b	NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	93.2		
3/4	91.0		
1/2	83.1		
3/8	77.5		
	GRAIN SIZE		
D_{60}	3.42		
D_{30}	0.203		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	65.2		
#10	52.6		
#20	44.0		
#40	38.8		
#60	32.9		
#100	25.8		
#200	17.7		

SOIL DESCRIPTION

○ Sand, sl clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF2-S1

WESTERN COLORADO TESTING, INC.

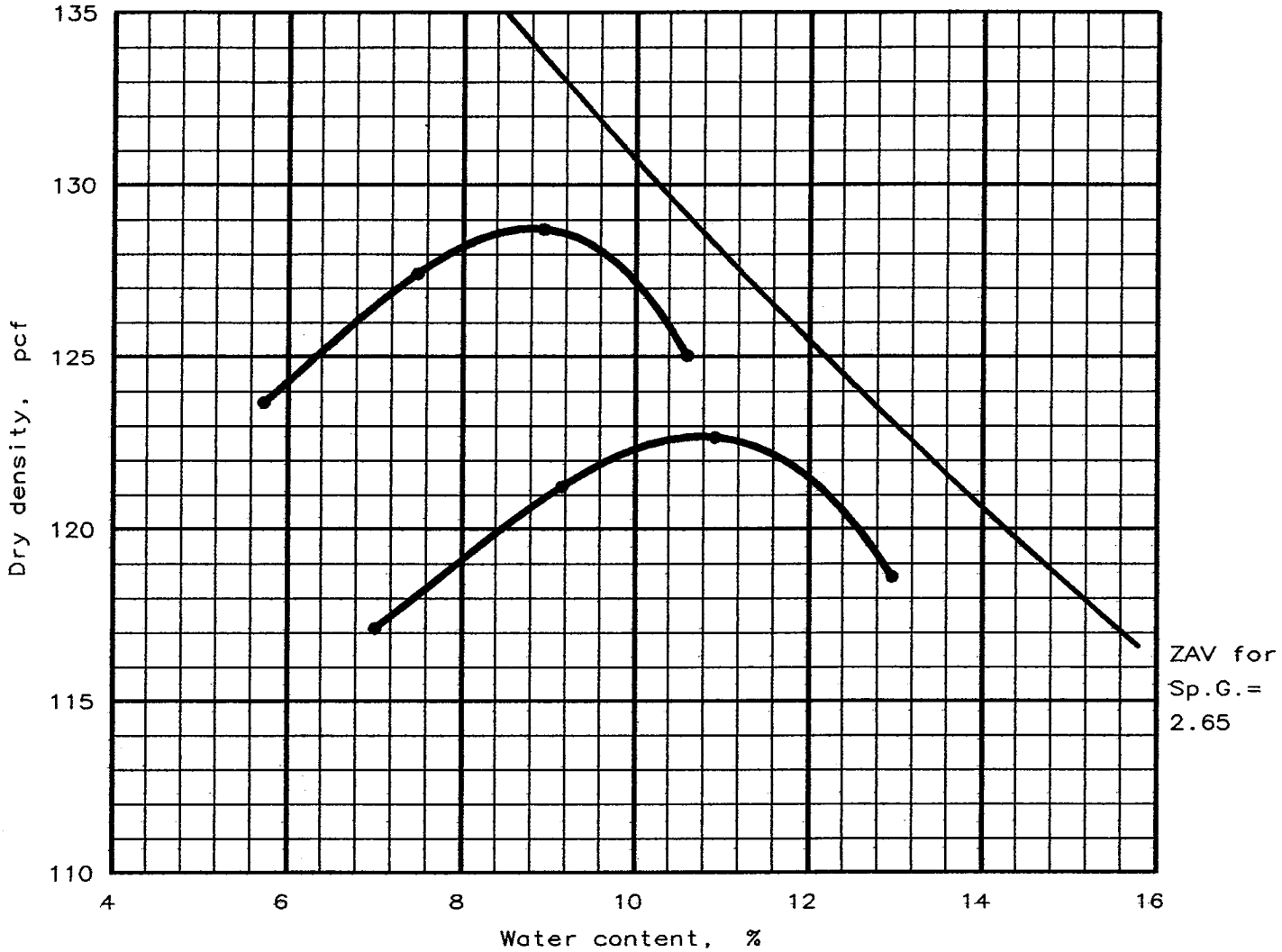
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 44

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			18.2 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 128.7 pcf Optimum moisture = 8.8 %	122.7 pcf 10.8 %	RF2-S2 Sand, gravely, brown

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

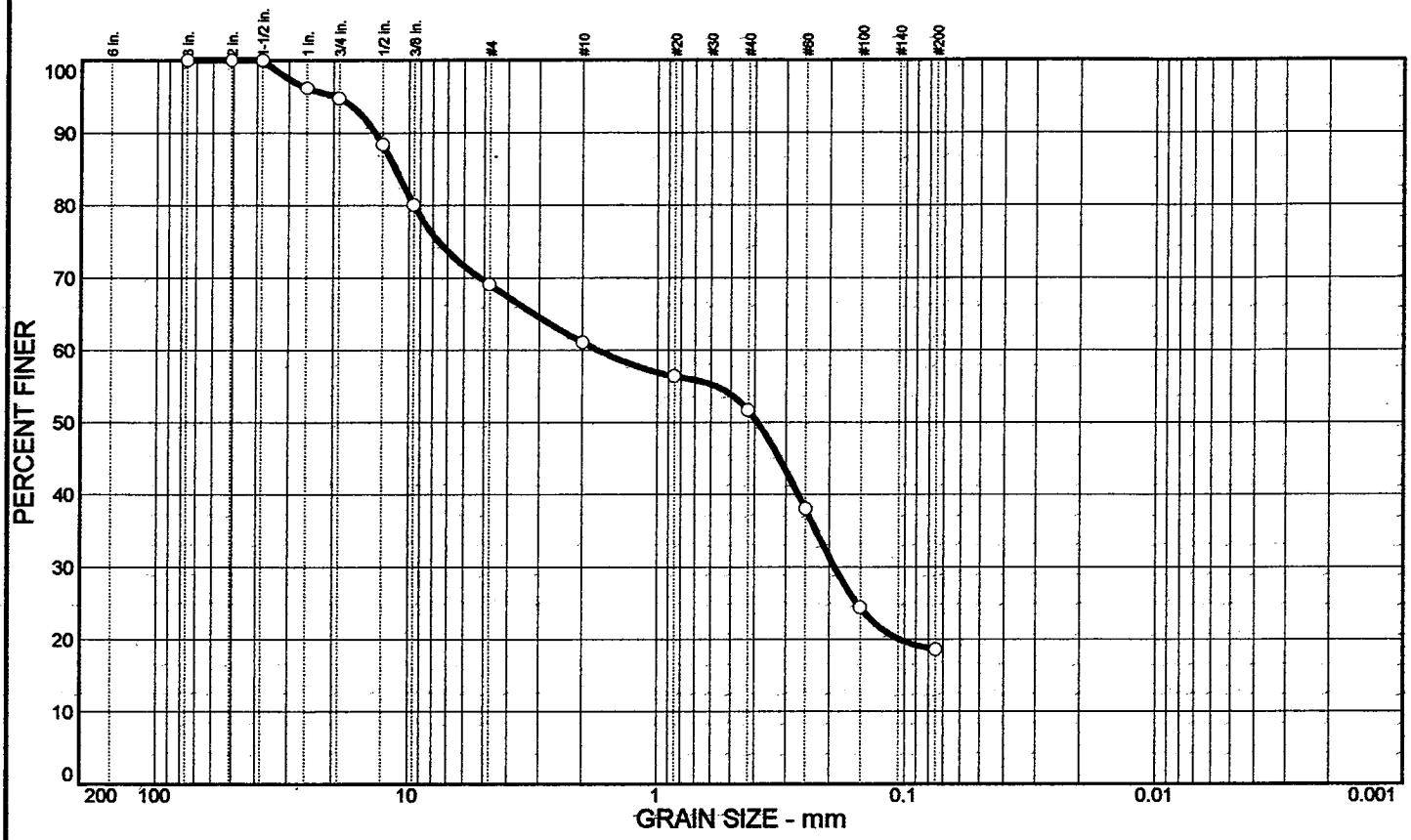
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 14

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		30.9	50.5			SM	A-2-4(0)	NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	96.2		
3/4	94.8		
1/2	88.4		
3/8	80.1		
	GRAIN SIZE		
D_{60}	1.73		
D_{30}	0.190		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	69.1		
#10	61.1		
#20	56.4		
#40	51.7		
#60	38.0		
#100	24.4		
#200	18.6		

SOIL DESCRIPTION

○ Sand, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF2-S2

WESTERN COLORADO TESTING, INC.

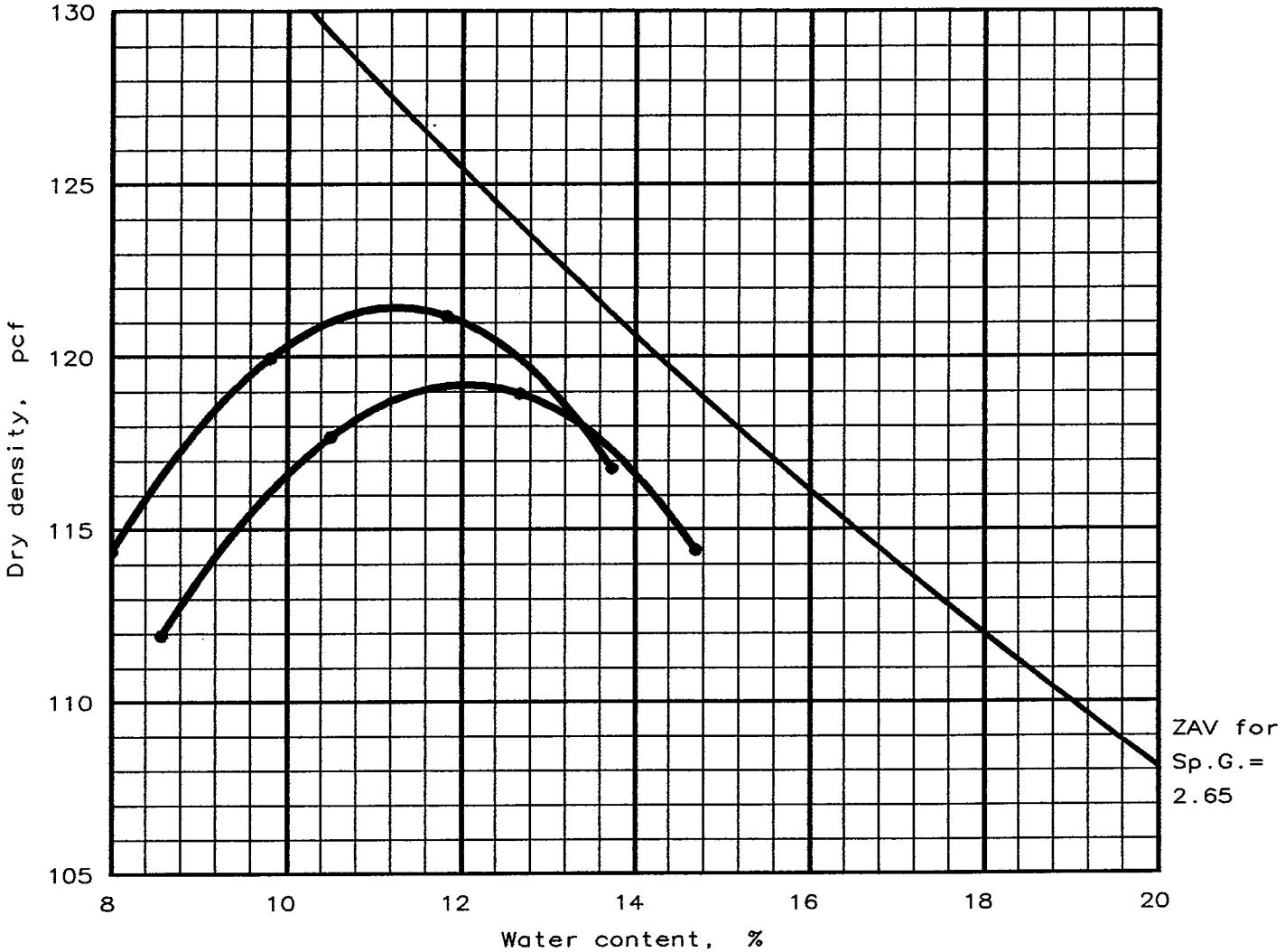
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 45

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			6.6 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 121.4 pcf Optimum moisture = 11.3 %	119.2 pcf 12.1 %	RF3-S1 Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

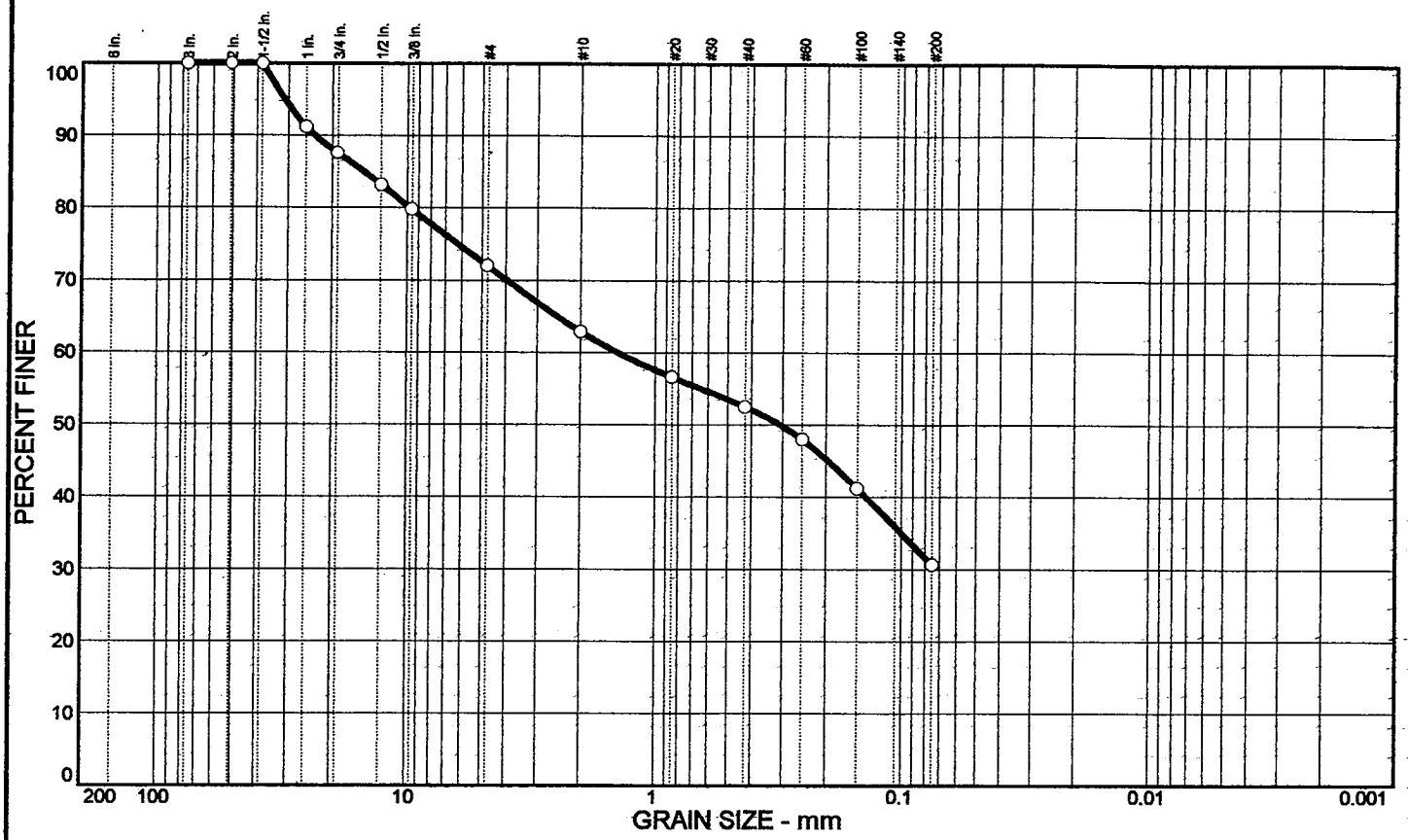
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 15

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		28.0	41.4			SM	A-2-4(0)	NP	

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	91.2		
3/4	87.6		
1/2	83.2		
3/8	79.8		
	GRAIN SIZE		
D_{60}	1.41		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	72.0		
#10	62.9		
#20	56.6		
#40	52.5		
#60	48.0		
#100	41.2		
#200	30.6		

SOIL DESCRIPTION

○ Sand, sl clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF3-S1

WESTERN COLORADO TESTING, INC.

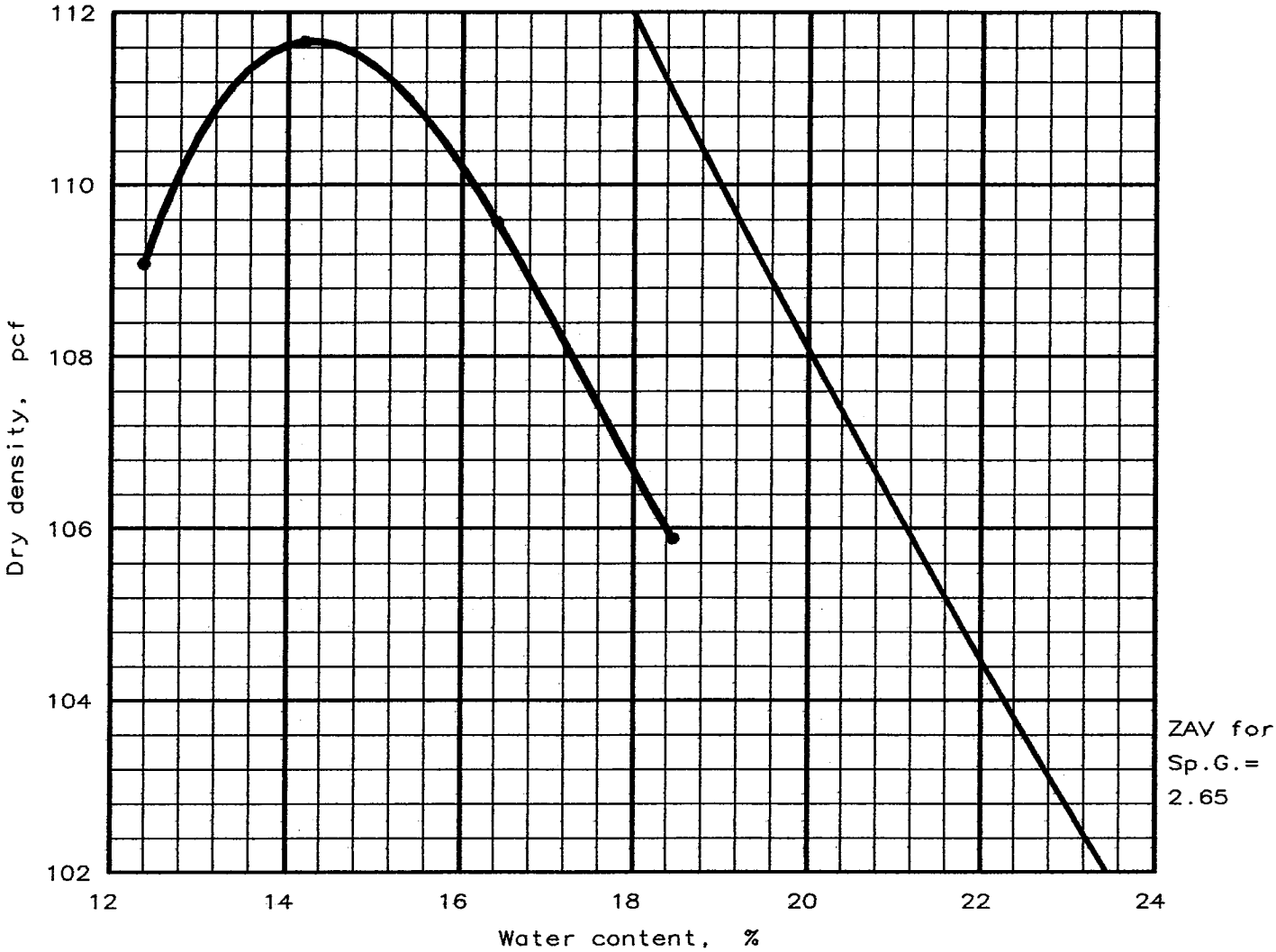
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 46

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 111.7 pcf Optimum moisture = 14.3 %	111.7 pcf 14.3 %	RF3-S2 Clay, v sandy, red

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

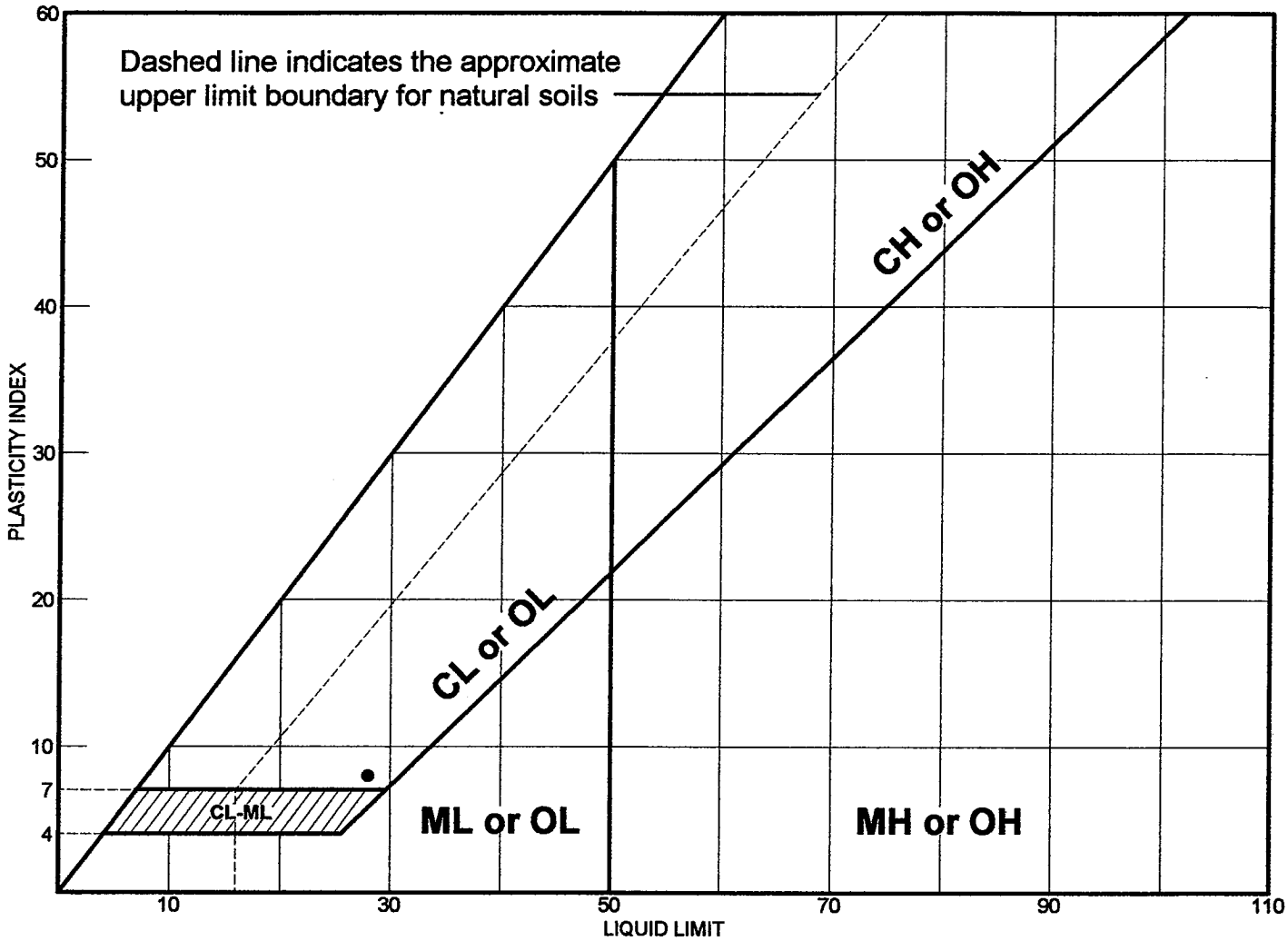
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 16

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clay, very sandy, red	28	20	8	69.0	39.0	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF3-S2

Remarks:

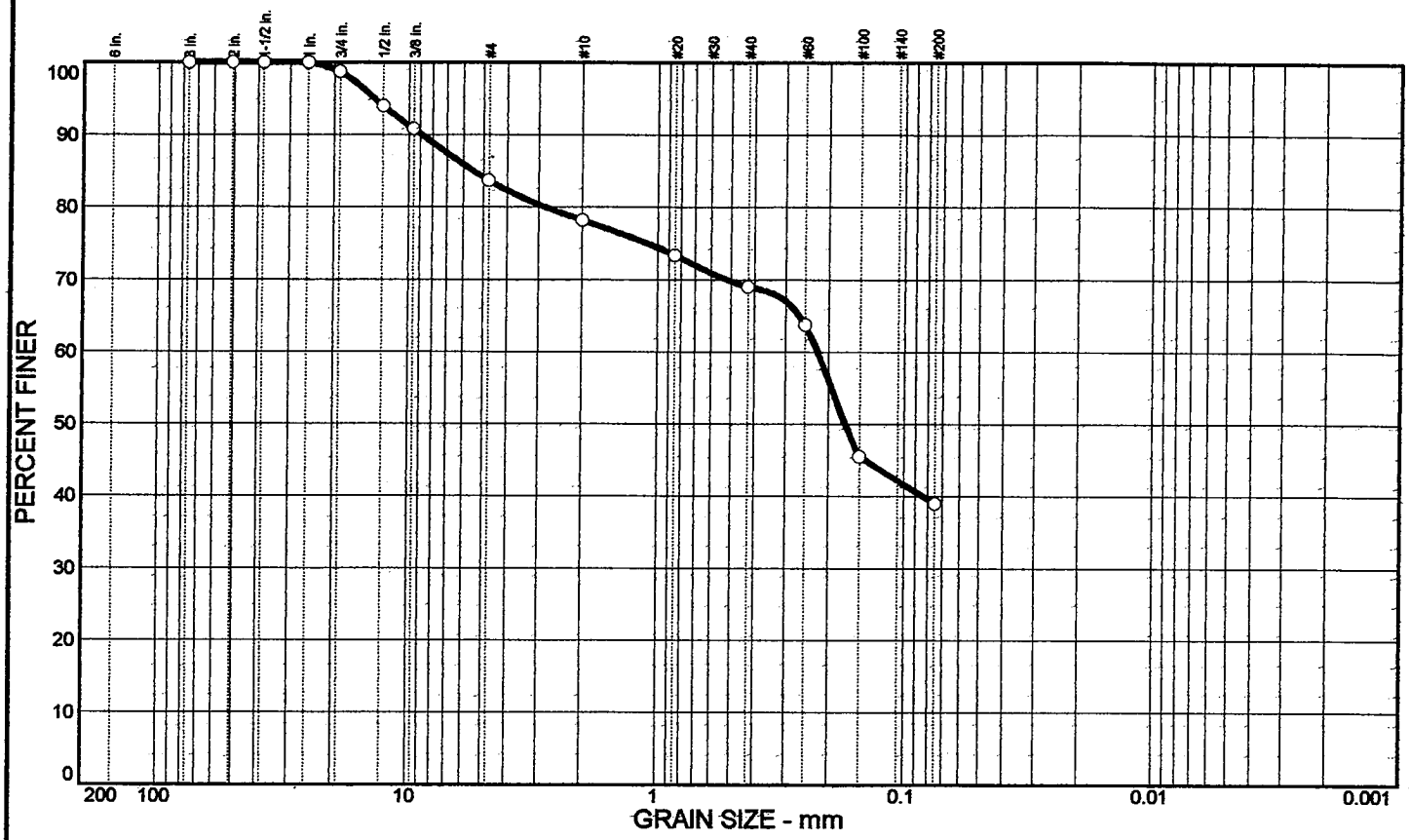
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 27

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		16.3	44.7			SM	A-4(0)		

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	98.7		
1/2	94.0		
3/8	90.8		
	GRAIN SIZE		
D_{60}	0.222		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	83.7		
#10	78.2		
#20	73.4		
#40	69.0		
#60	63.7		
#100	45.5		
#200	39.0		

SOIL DESCRIPTION

○ Clay, very sandy, red

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF3-S2

WESTERN COLORADO TESTING, INC.

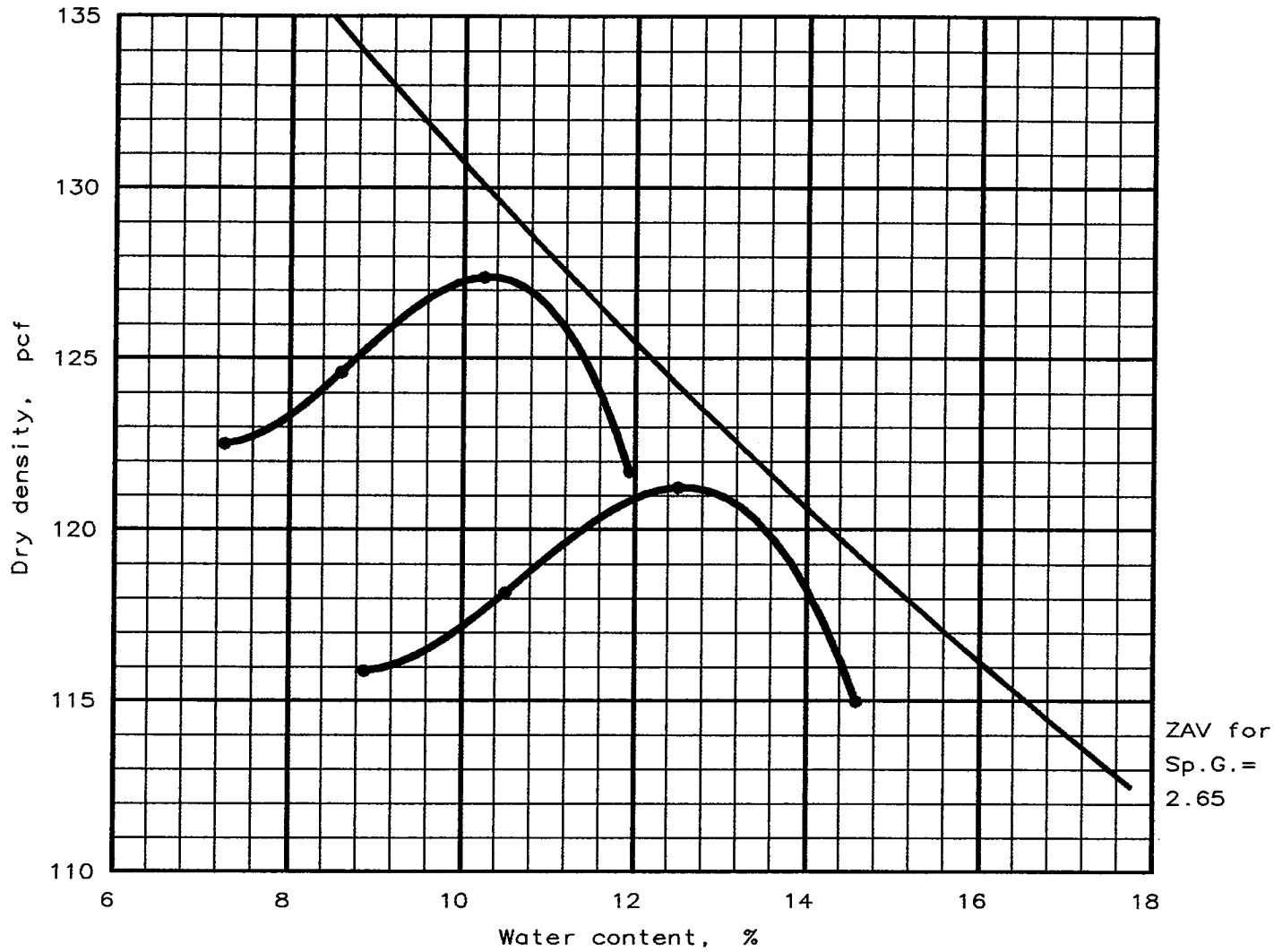
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 47

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			18.1 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 127.4 pcf Optimum moisture = 10.3 %	121.3 pcf 12.6 %	RF3-S3 Sand, clayey, grvly, brn

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

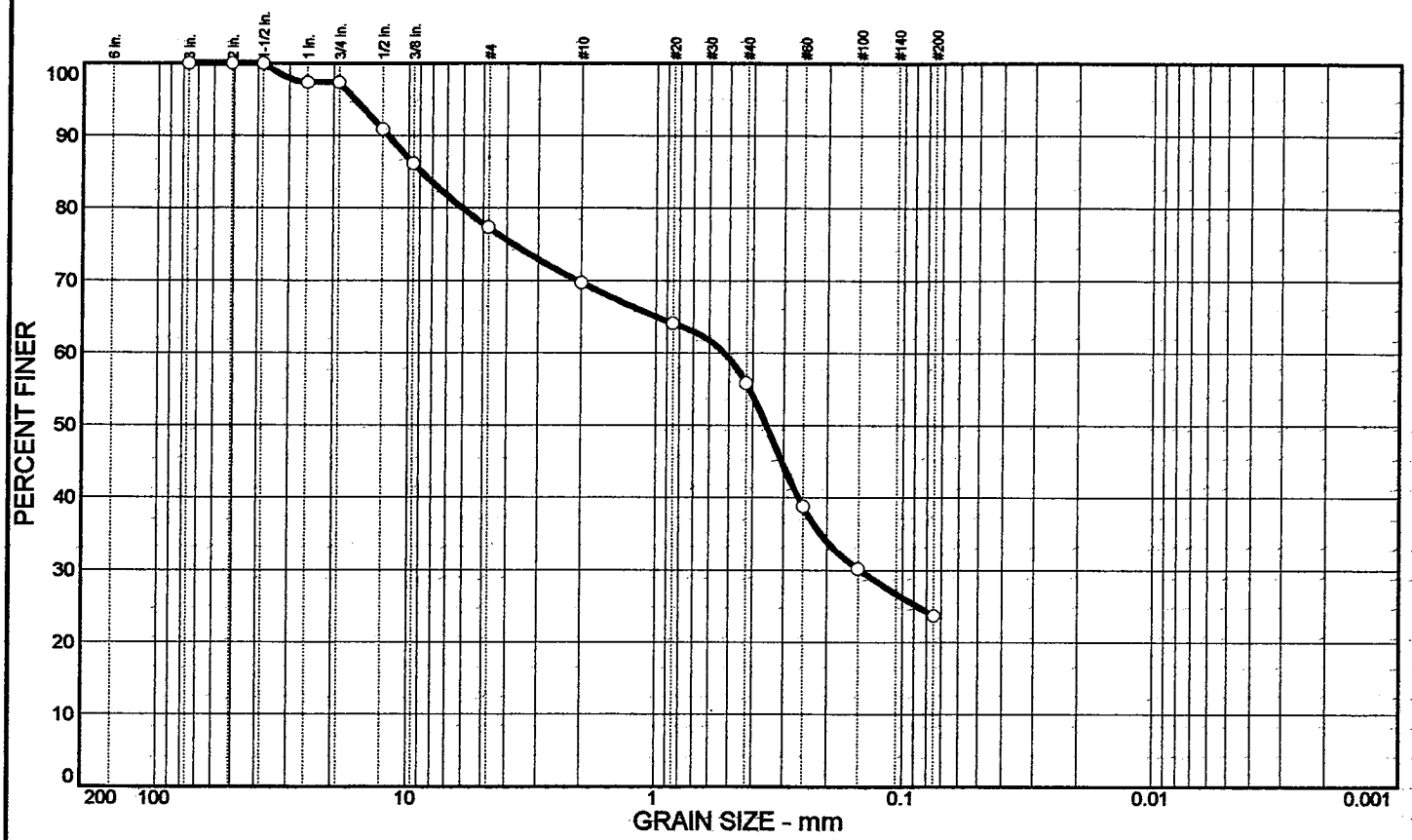
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 17

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		22.7	53.6			SM	A-2-4(0)	NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	97.4		
3/4	97.4		
1/2	90.9		
3/8	86.2		
	GRAIN SIZE		
D_{60}	0.523		
D_{30}	0.147		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	77.3		
#10	69.7		
#20	64.1		
#40	55.8		
#60	38.8		
#100	30.2		
#200	23.7		

SOIL DESCRIPTION

○ Sand, sl clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF3-S3

WESTERN COLORADO TESTING, INC.

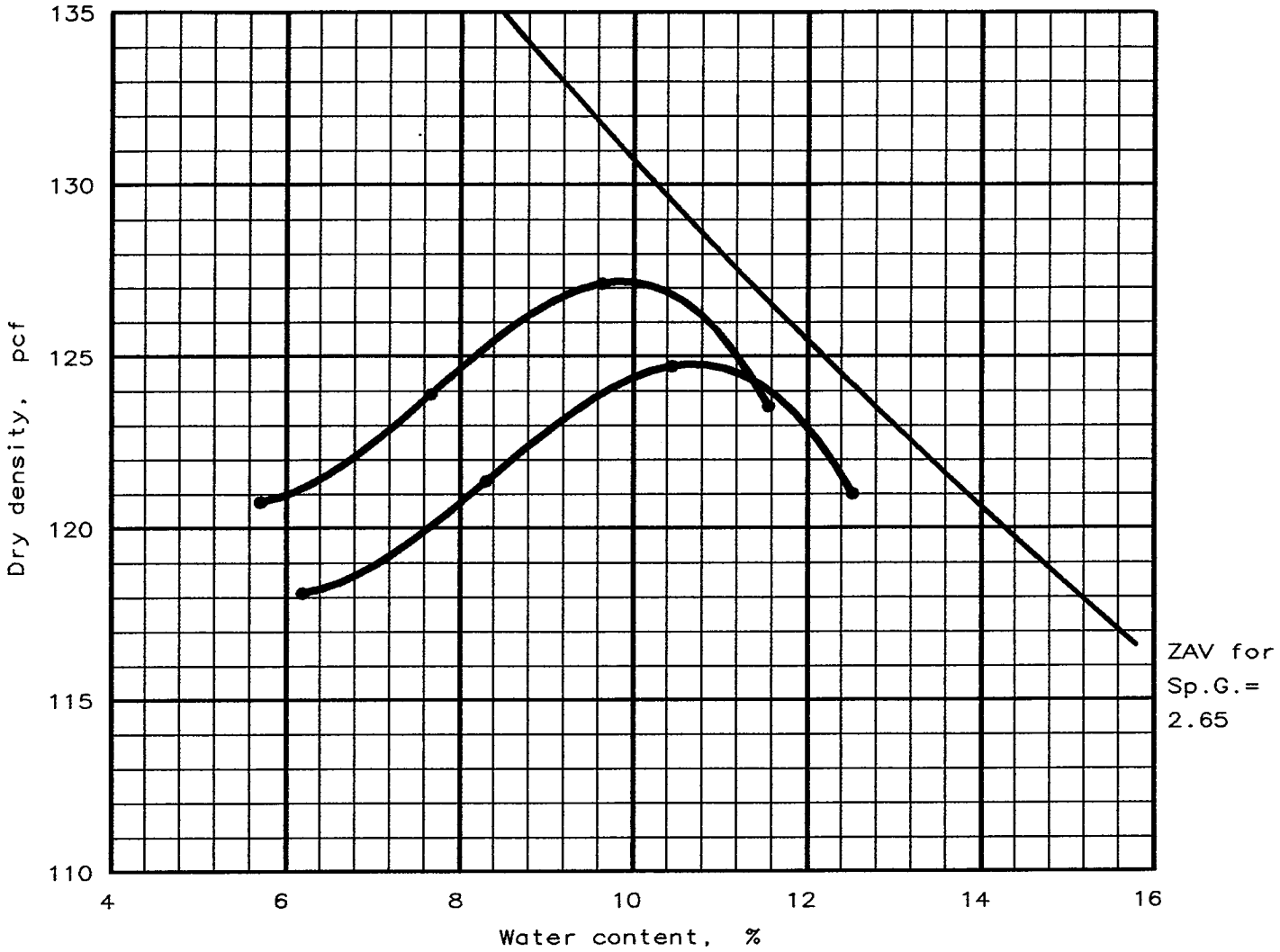
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 48

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			7.7 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 127.2 pcf Optimum moisture = 9.9 %	124.8 pcf 10.7 %	RF4-S1 Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

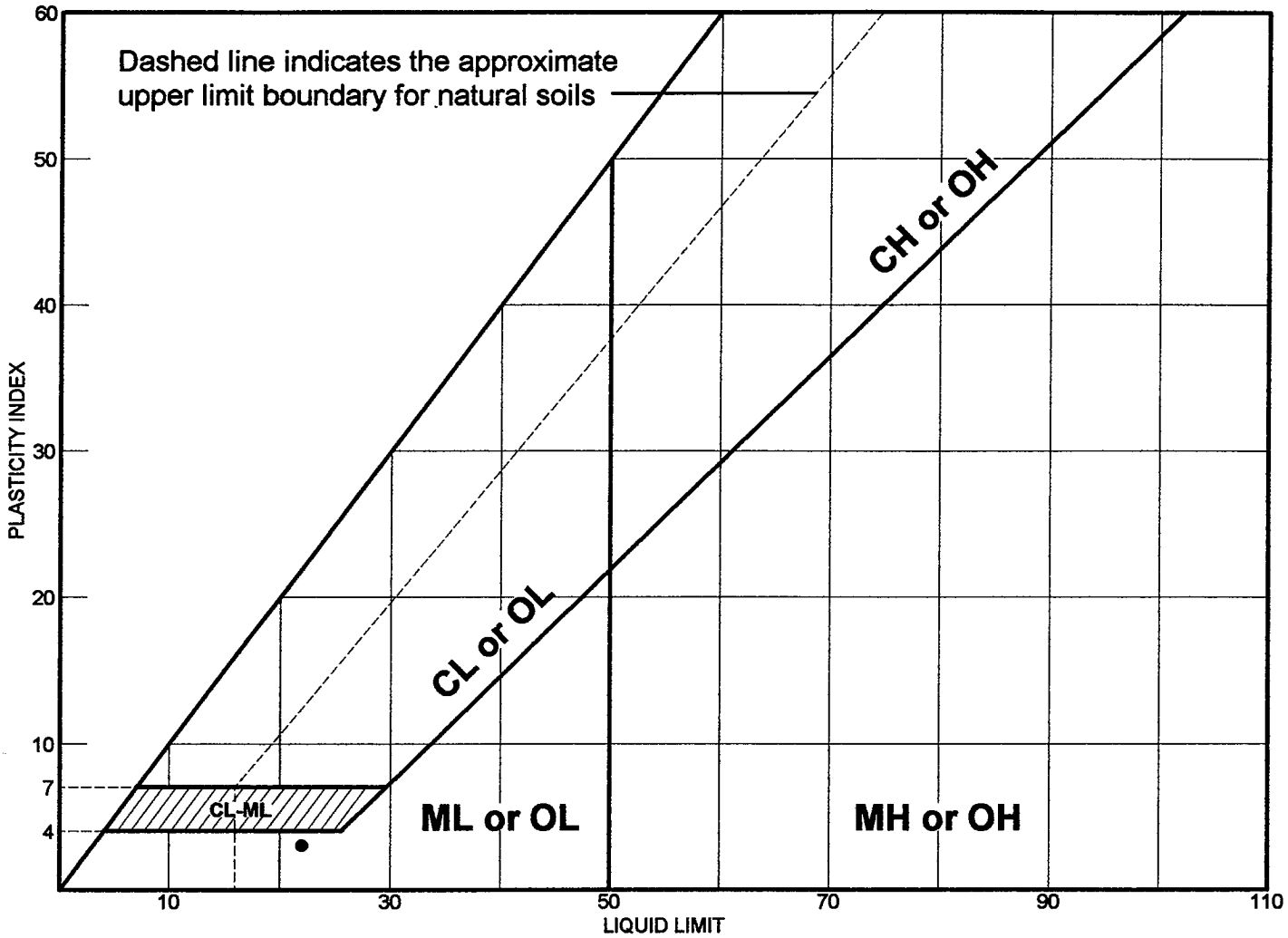
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 18

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, clayey, gravely, brown	22	19	3	51.1	25.5	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF4-S1

Remarks:

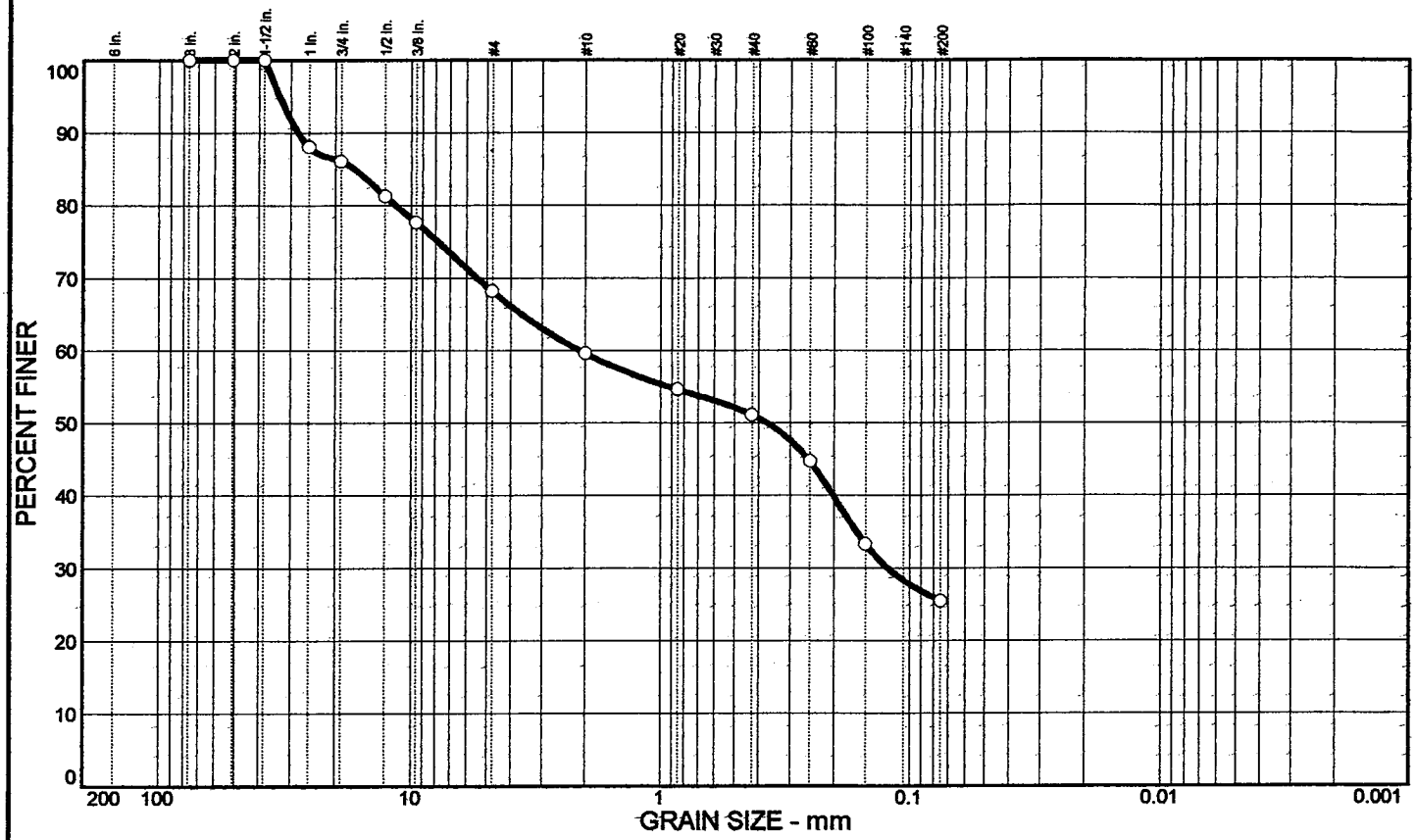
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 28

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		31.8	42.7			SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	88.1		
3/4	86.1		
1/2	81.3		
3/8	77.7		
	GRAIN SIZE		
D_{60}	2.11		
D_{30}	0.122		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	68.2		
#10	59.6		
#20	54.6		
#40	51.1		
#60	44.7		
#100	33.3		
#200	25.5		

SOIL DESCRIPTION

○ Sand, clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF4-S1

WESTERN COLORADO TESTING, INC.

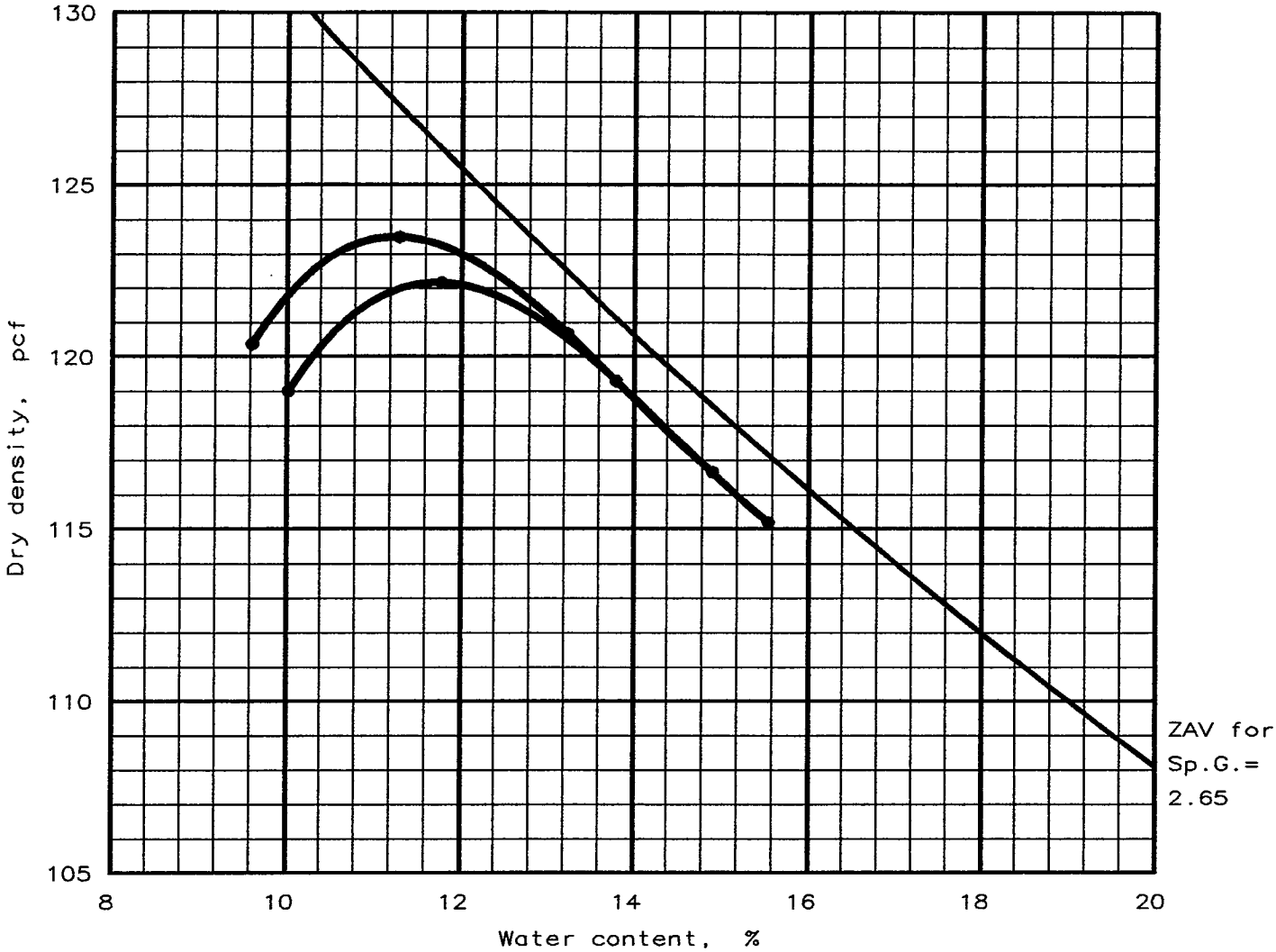
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 49

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			4.1 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 123.5 pcf Optimum moisture = 11.3 %	122.2 pcf 11.7 %	RF5-S1 Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

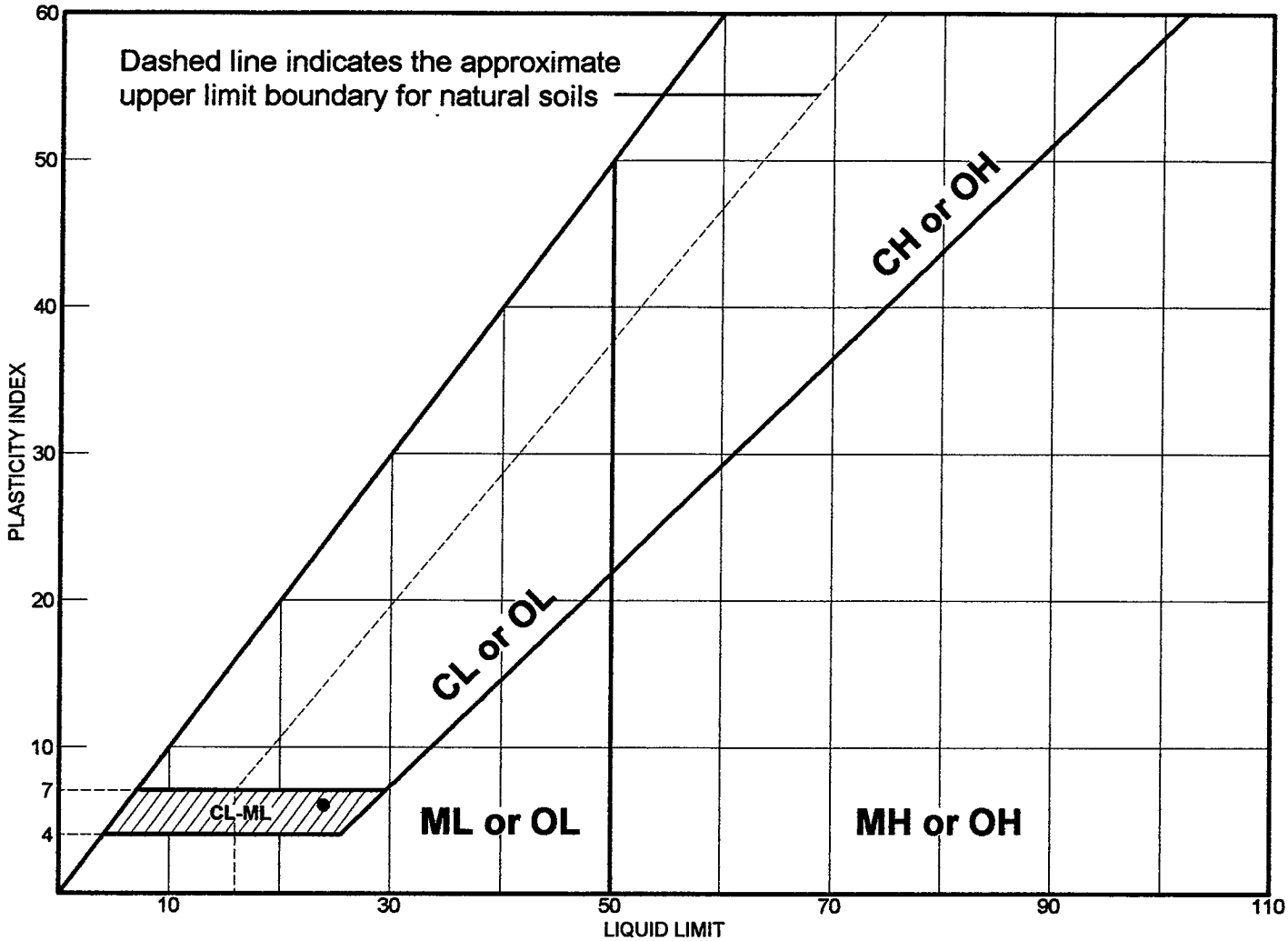
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 19

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, clayey, gravely, brown	24	18	6	74.3	41.6	SM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF5-S1

Remarks:

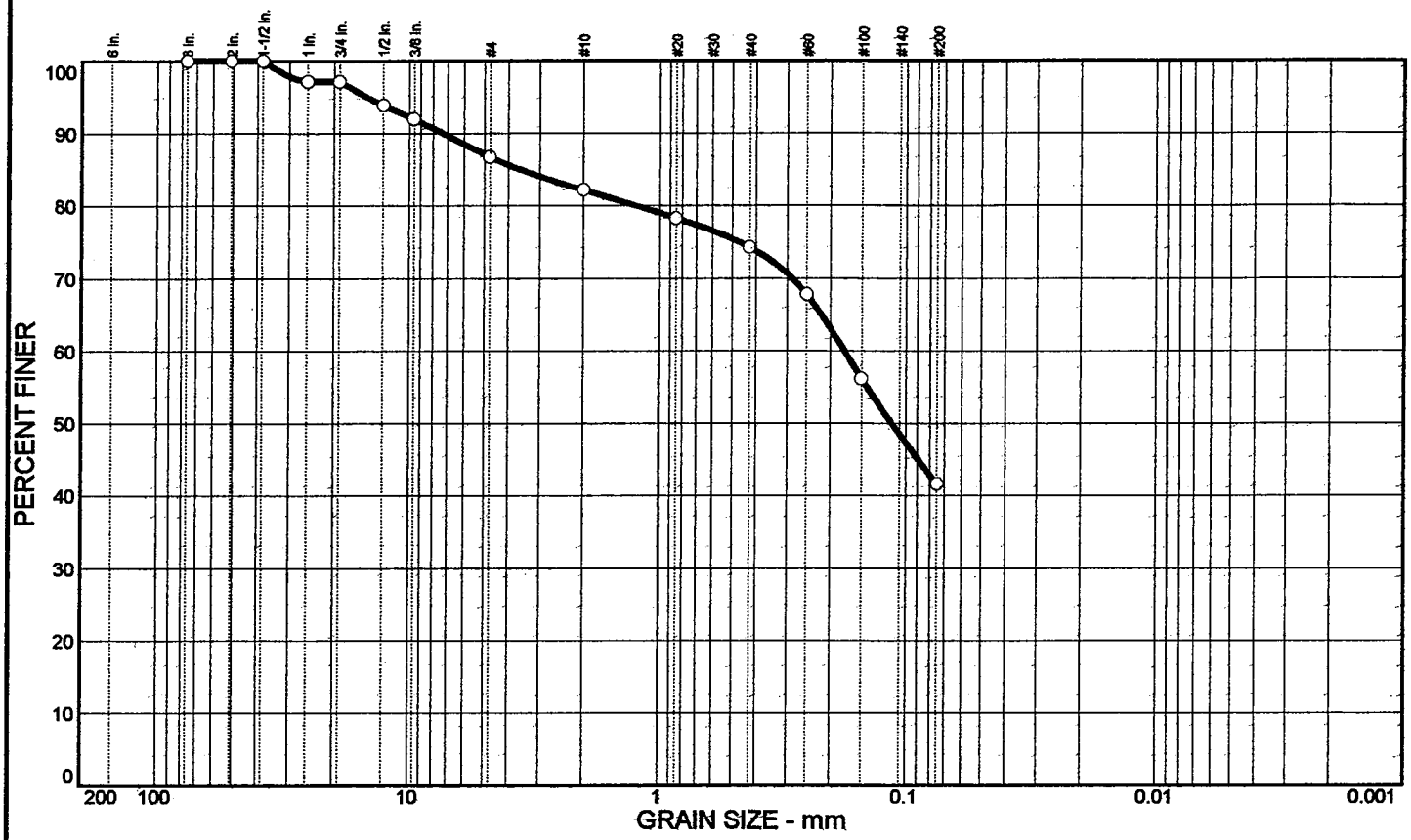
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 29

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		13.2	45.2			SM	A-4(0)		

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	97.2		
3/4	97.2		
1/2	93.9		
3/8	92.0		
	GRAIN SIZE		
D_{60}	0.176		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	86.8		
#10	82.2		
#20	78.3		
#40	74.3		
#60	67.8		
#100	56.2		
#200	41.6		

SOIL DESCRIPTION

○ Sand, clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF5-S1

WESTERN COLORADO TESTING, INC.

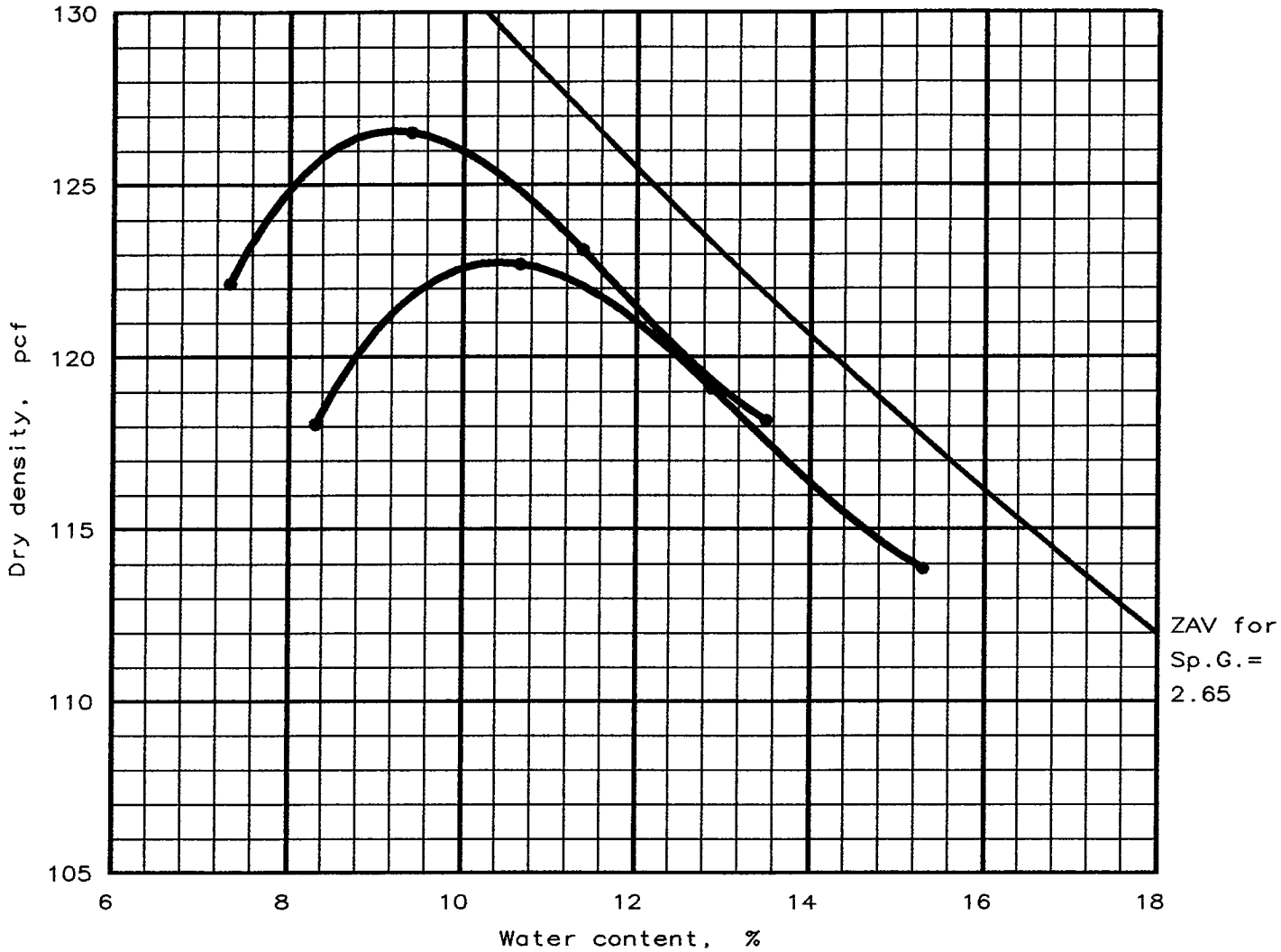
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 50

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
			N/A %	2.65			11.7 %	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 126.6 pcf Optimum moisture = 9.2 %	122.8 pcf 10.4 %	RF6-S1 Sand, clayey, grvly, brn

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 5/3/99

Remarks:

SUBMITTED BY: Client

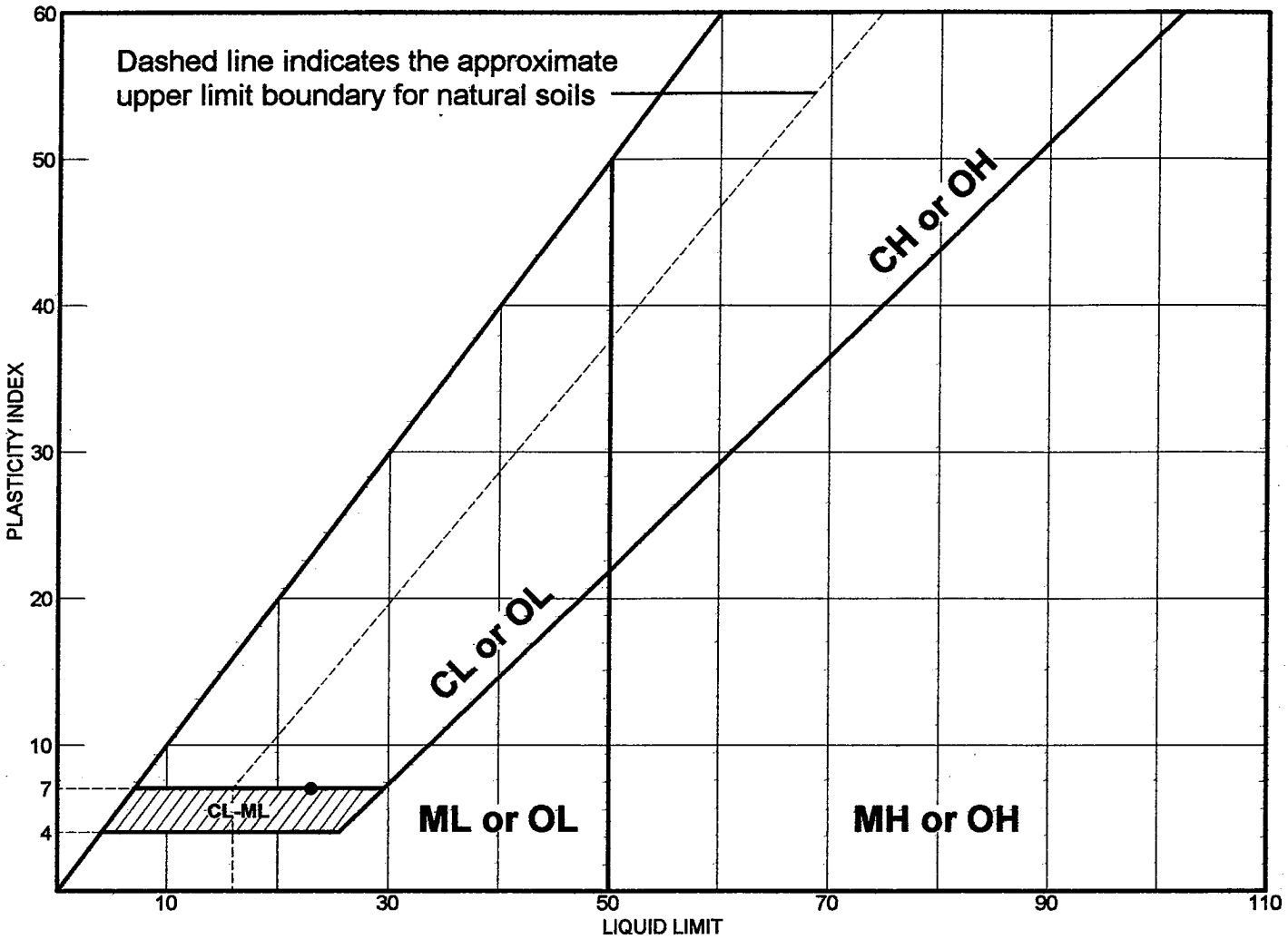
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 20

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sand, clayey, gravely, brown	23	16	7	53.0	30.6	GC-GM

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF6-S1

Remarks:

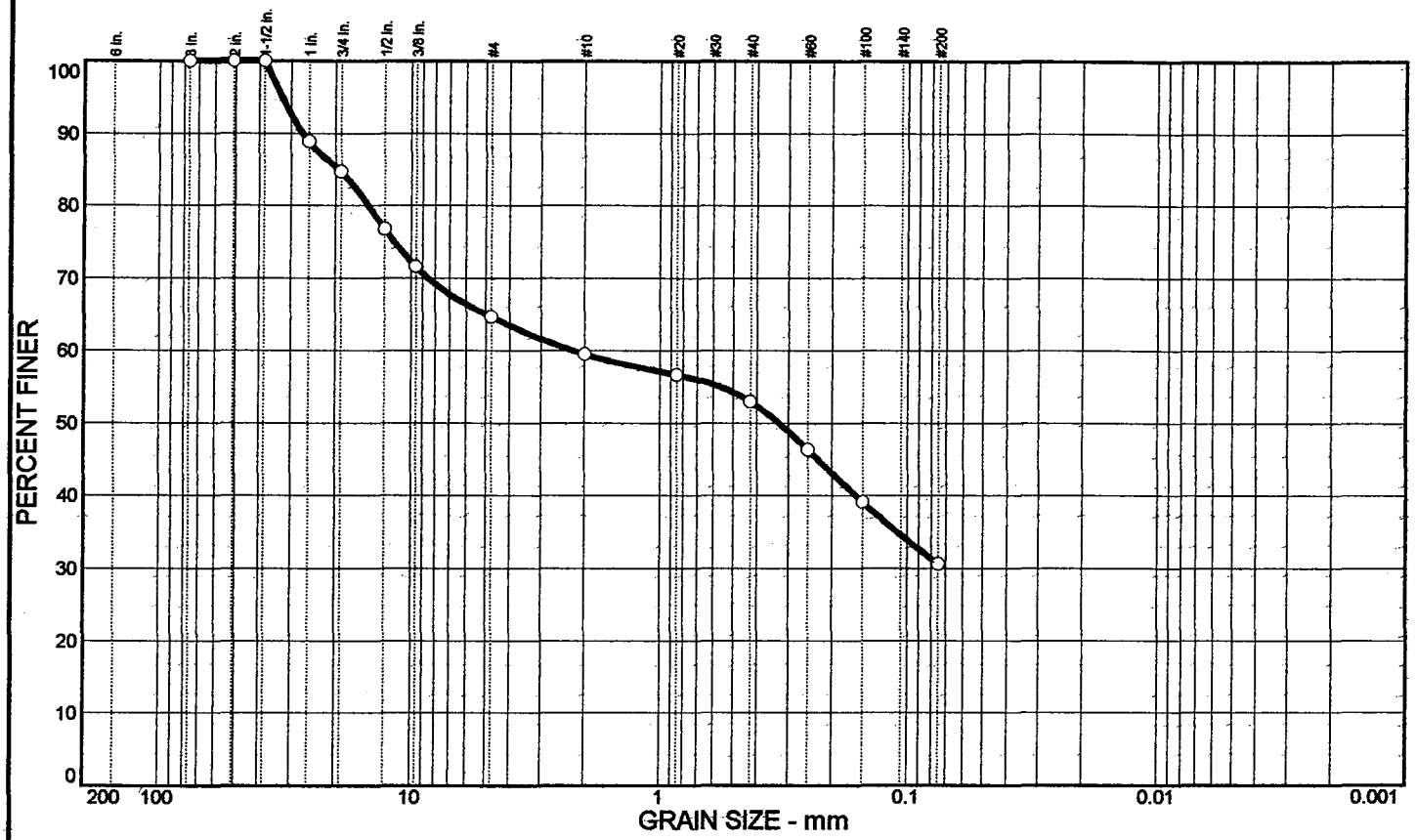
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 30

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		35.3	34.1			GC-GM	A-2-4(0)	16	23

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	88.9		
3/4	84.7		
1/2	76.8		
3/8	71.6		
	GRAIN SIZE		
D_{60}	2.23		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	64.7		
#10	59.5		
#20	56.7		
#40	53.0		
#60	46.4		
#100	39.1		
#200	30.6		

SOIL DESCRIPTION

○ Sand, clayey, gravely, brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF6-S1

WESTERN COLORADO TESTING, INC.

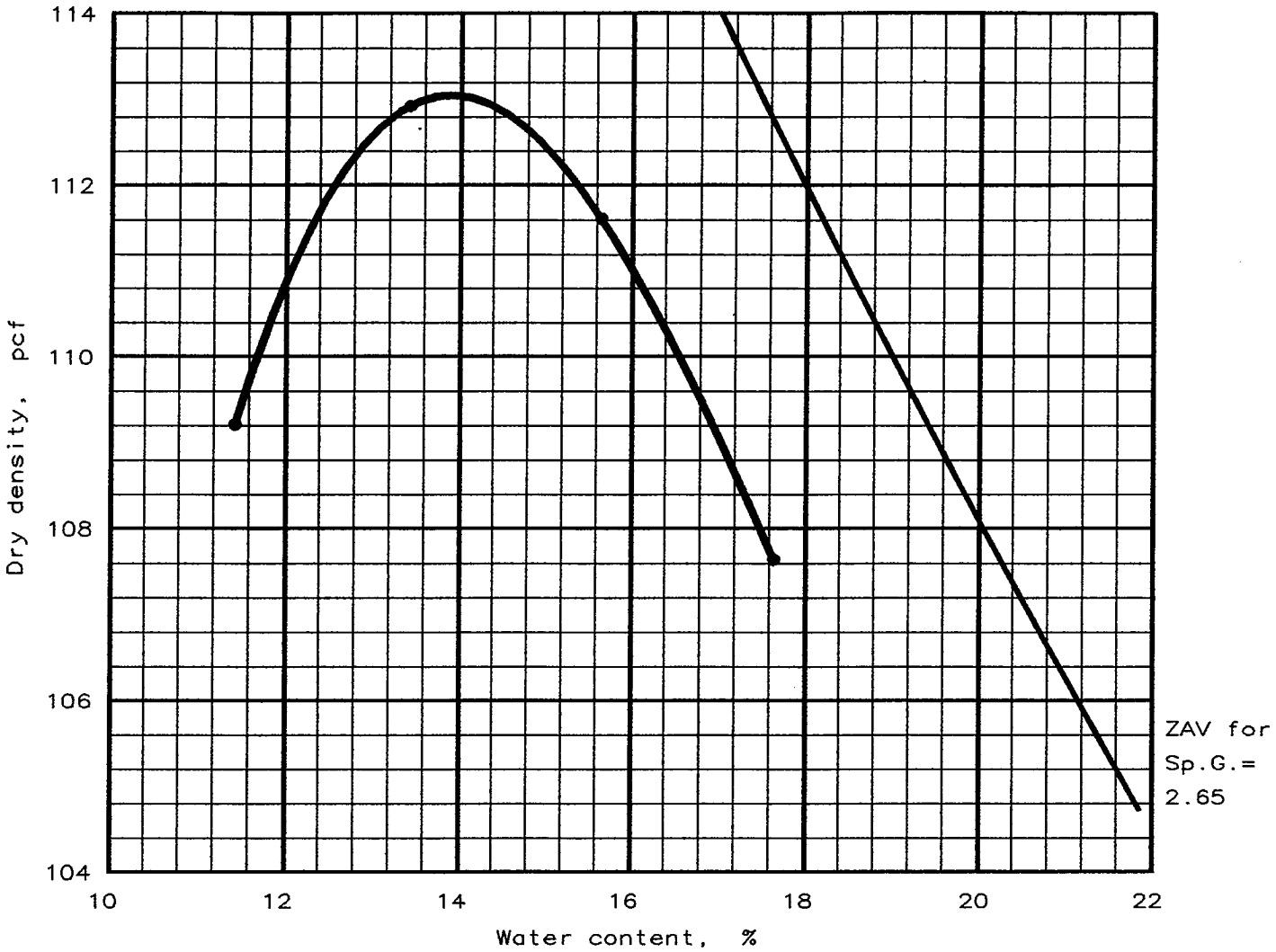
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 51

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 113.1 pcf Optimum moisture = 13.9 %	113.1 pcf 13.9 %	RF7-S1 Clay, v sandy, silty, rd

Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

Date: 5/3/99

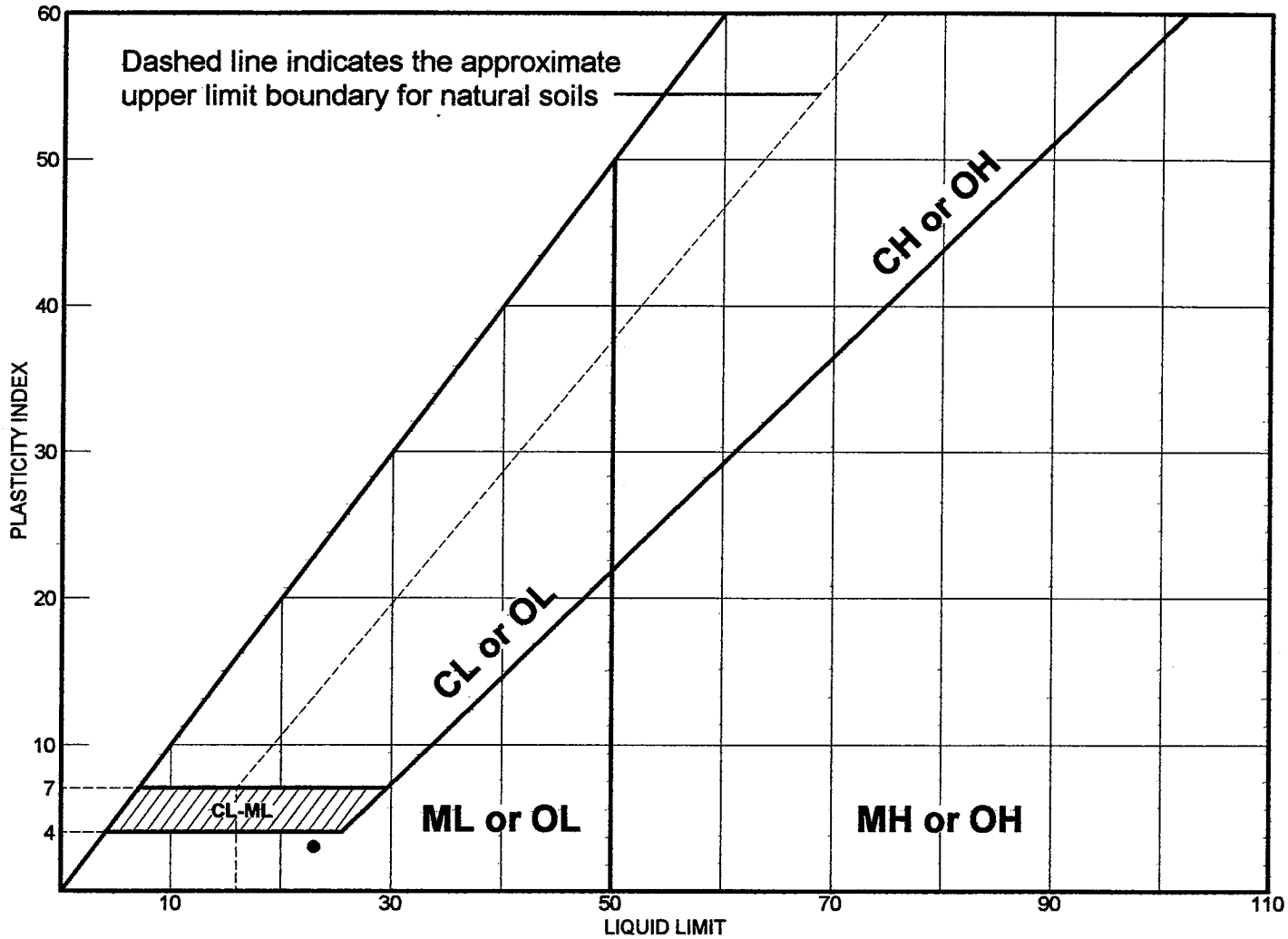
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 21

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clay, very sandy, silty, red	23	20	3	88.6	56.8	ML

Project No. 804899 **Client:** International Uranium Corporation

Project: Soil Sample Testing

● **Source:** **Sample No.:** RF7-S1

Remarks:

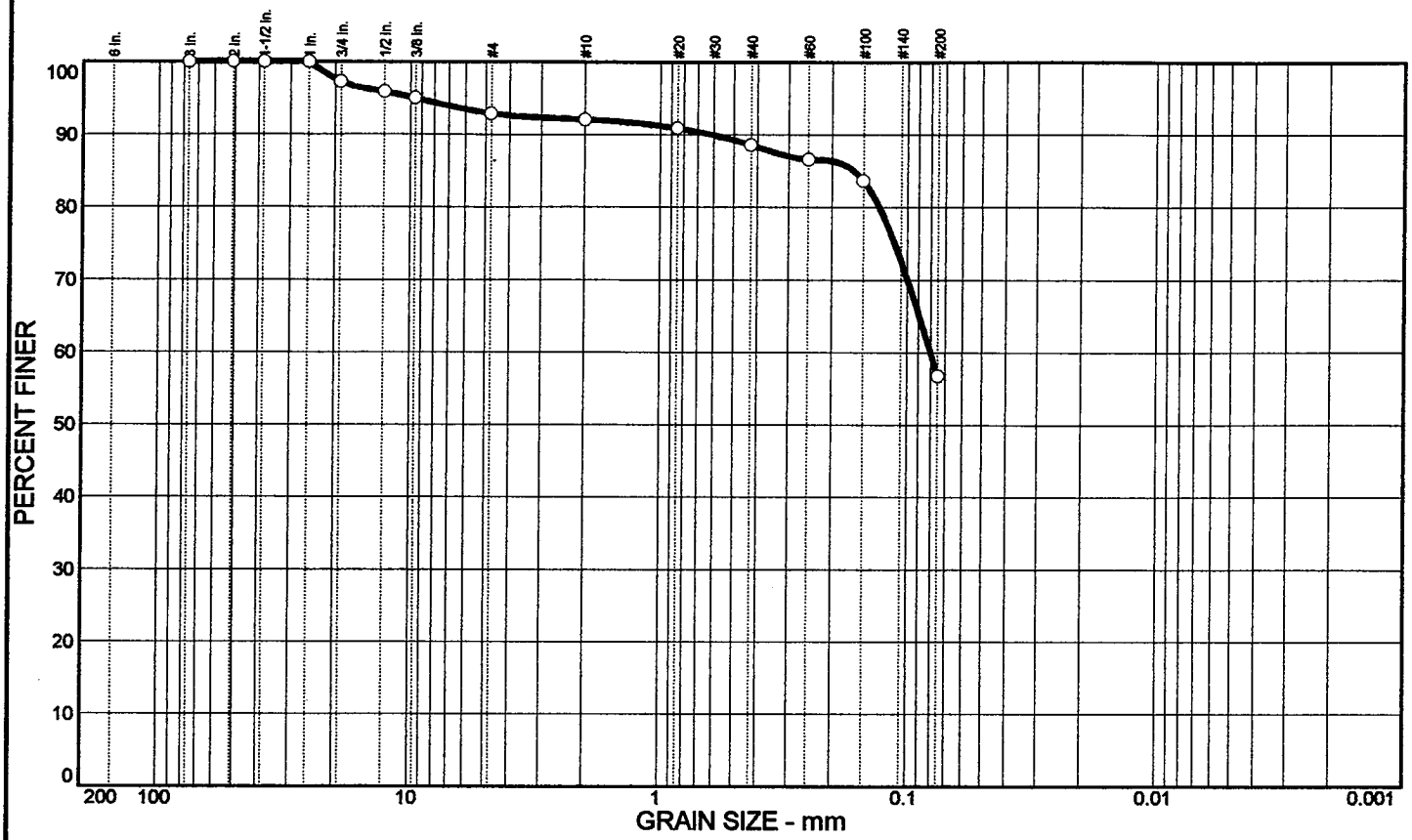
● Tested By: JH

LIQUID AND PLASTIC LIMITS TEST REPORT

WESTERN COLORADO TESTING, INC.

Figure 31

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		7.1	36.1			ML	A-4(0)	20	23

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	97.3		
1/2	95.9		
3/8	95.0		
	GRAIN SIZE		
D_{60}	0.0801		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	92.9		
#10	92.1		
#20	90.9		
#40	88.6		
#60	86.6		
#100	83.7		
#200	56.8		

SOIL DESCRIPTION

○ Clay, very sandy, silty, red

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: RF7-S1

WESTERN COLORADO TESTING, INC.

Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 52

ATTACHMENT A.1.7

WESTERN COLORADO TESTING, INC.

1999b

WESTERN COLORADO TESTING, INC.

529 25 1/2 Road, Suite B-101
Grand Junction, Colorado 81505
(970) 241-7900 • Fax (970) 241-7783

May 4, 1999
WCT #804899

International Uranium USA Corporation
Independence Plaza, Suite 950
1050 17th Street
Denver, Colorado 80265

Subject: Soil Sample Testing

As requested, we have completed the soil laboratory work for International Uranium USA Corporation. The testing performed included the following:

21 Sieve Analyses
21 Atterberg Limit Tests
21 Standard Proctor Tests (ASTM D698)
6 Hydrometer Tests
6 Specific Gravity Tests

Data sheets are included for each test except for the specific gravities. The results of these are shown below:

Sample	Avg. Bulk Specific Gravity	Avg. Bulk Specific Gravity (SSD)	Apparent Specific Gravity	Absorption Percent
C2 - TS1	2.337	2.468	2.673	5.372
C2 - TS2	2.137	2.392	2.868	11.926
C2 - TS3	2.157	2.359	2.705	9.396
C2 - TS4	2.265	2.432	2.721	7.402
C3 - TS1	2.456	2.562	2.746	4.294
C3 - TS2	2.349	2.464	2.655	4.900

We have been happy to be of service. If you have any questions or we may be of further assistance, please call.

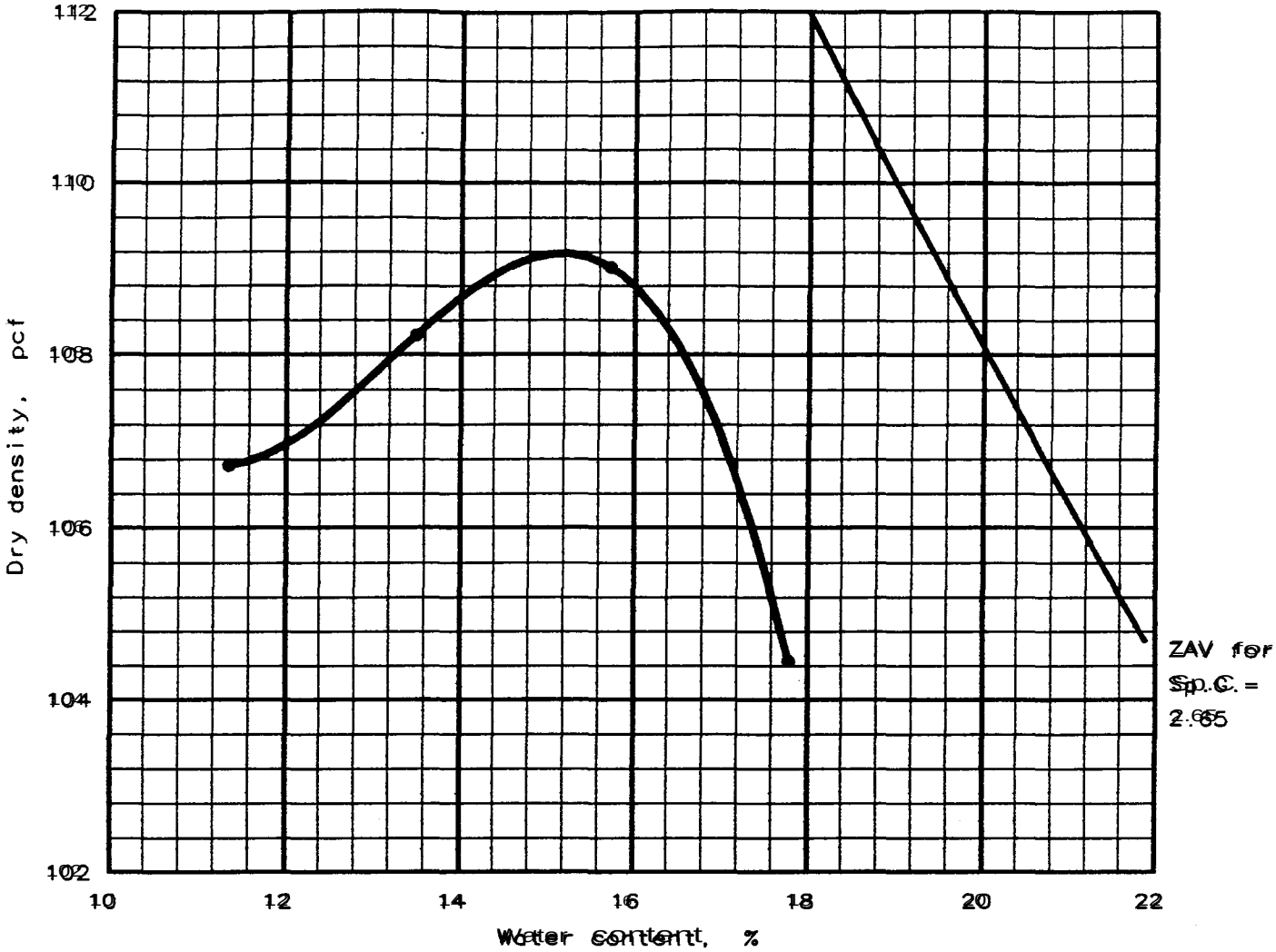
Respectfully Submitted:
WESTERN COLORADO TESTING, INC.

Wm. Daniel Smith

Wm. Daniel Smith, P.E.
Senior Geotechnical Engineer

WDS/mh
Mab:jobs\8048b0504

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 109.2 pcf Optimum moisture = 15.2 %	109.2 pcf 15.2 %	C2-S-1

Project No: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing

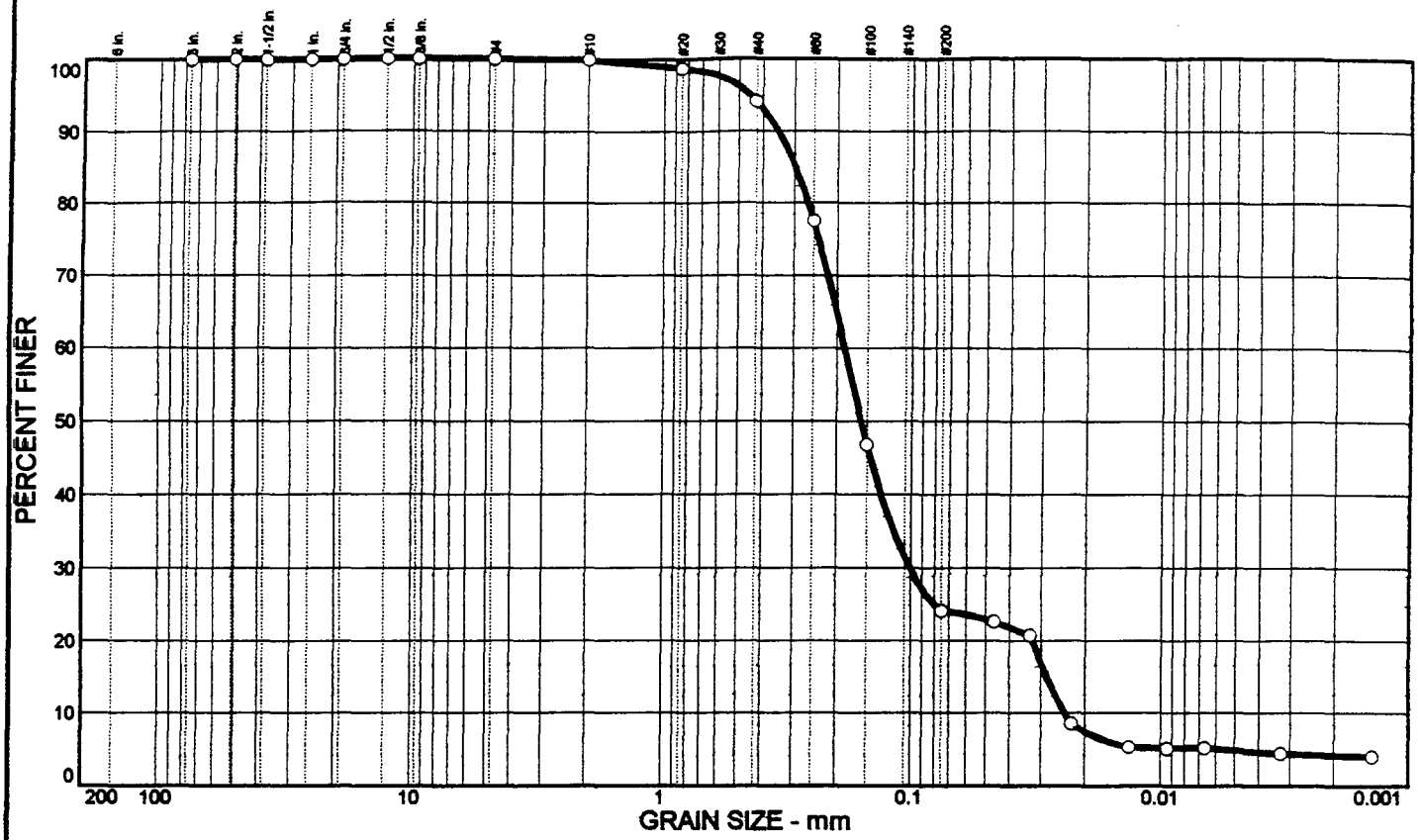
Date: 4/27/99

Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST
WESTERN COLORADO TESTING, INC.

Fig No. 1

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	75.9	19.3	4.8	SM	A-2-4(0)	NP	NP
							A-2-40	NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.186		
D_{30}	0.100		
D_{10}	0.0241		
	COEFFICIENTS		
C_c	2.25		
C_u	7.74		

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	100.0		
#20	98.7		
#40	94.1		
#60	77.5		
#100	46.8		
#200	24.1		

SOIL DESCRIPTION

○ Sandl, silty, gray/brown

REMARKS:

Tested by: JH

○ Source:

Sample No.: C2-ST1

WESTERN COLORADO TESTING, INC.

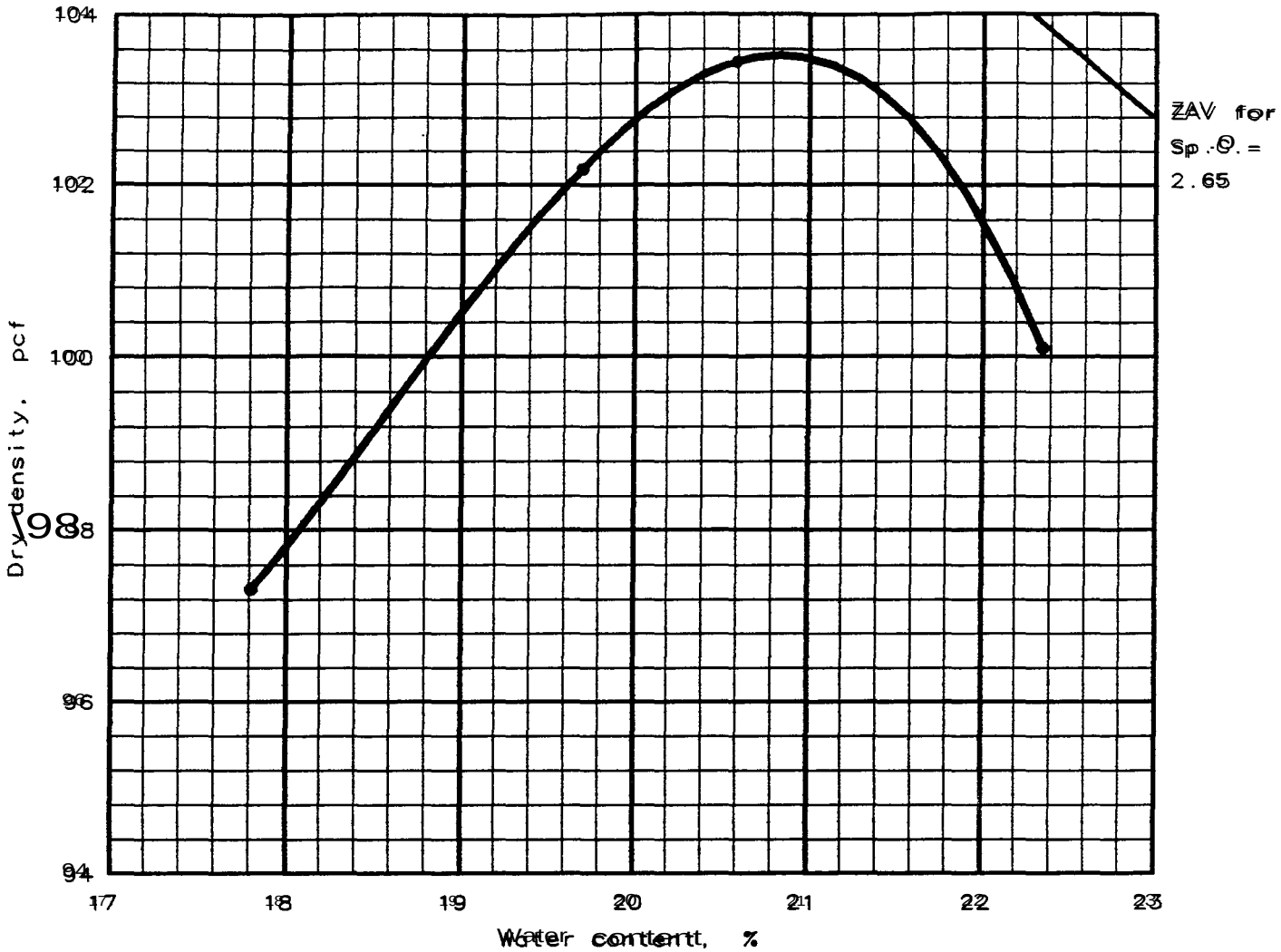
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 32

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 103.5 pcf Optimum moisture = 20.8 %	103.5 pcf 20.8 %	C2TS82

Project No: 80899
Project: International Uranium Corporation
Location: Soil Sample Testing
Date: 4/27/99

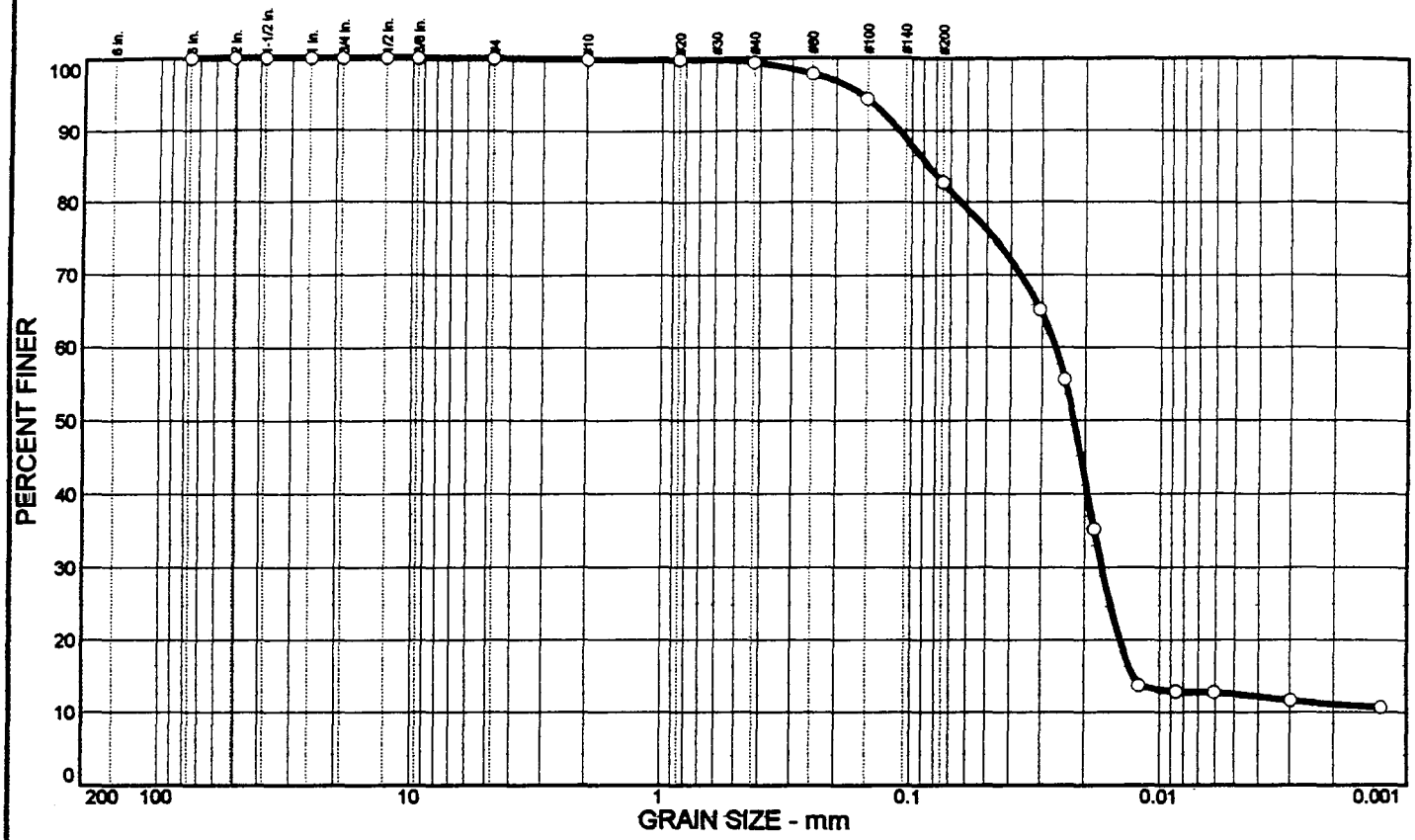
Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 2

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% 03	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	17.3	70.2	12.5	ML	A-4(0)	29	29

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.0264		
D_{30}	0.0170		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	100.0		
#20	99.9		
#40	99.4		
#60	97.8		
#100	94.3		
#200	82.7		

SOIL DESCRIPTION

○ Silt, clayey, sandy, gray

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: C2-TS2

WESTERN COLORADO TESTING, INC.

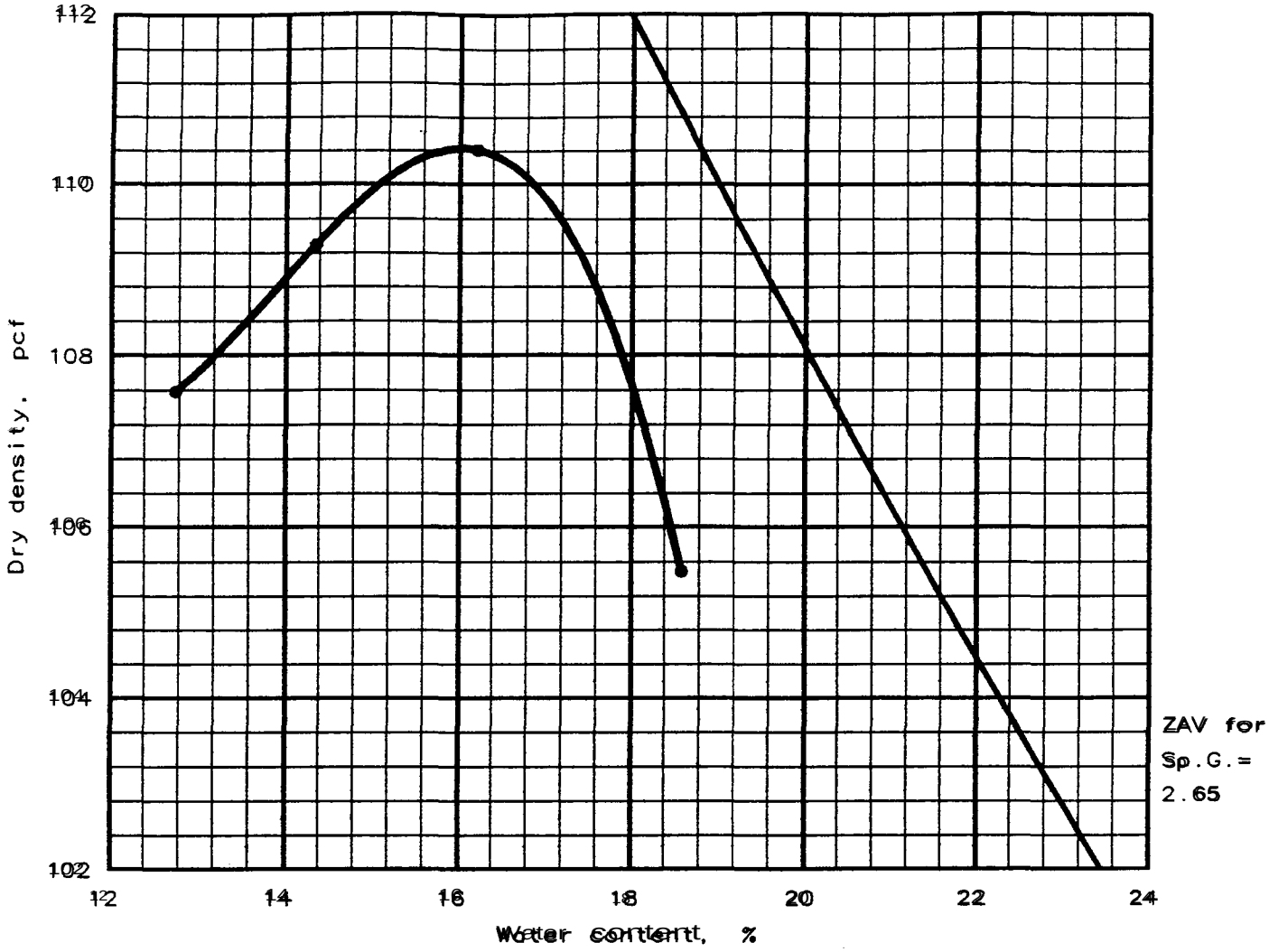
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 33

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard
Oversize correction applied to each point

Elev// Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 110.4 pcf Optimum moisture = 16.0 %	110.4 pcf 16.0 %	C2FSS3

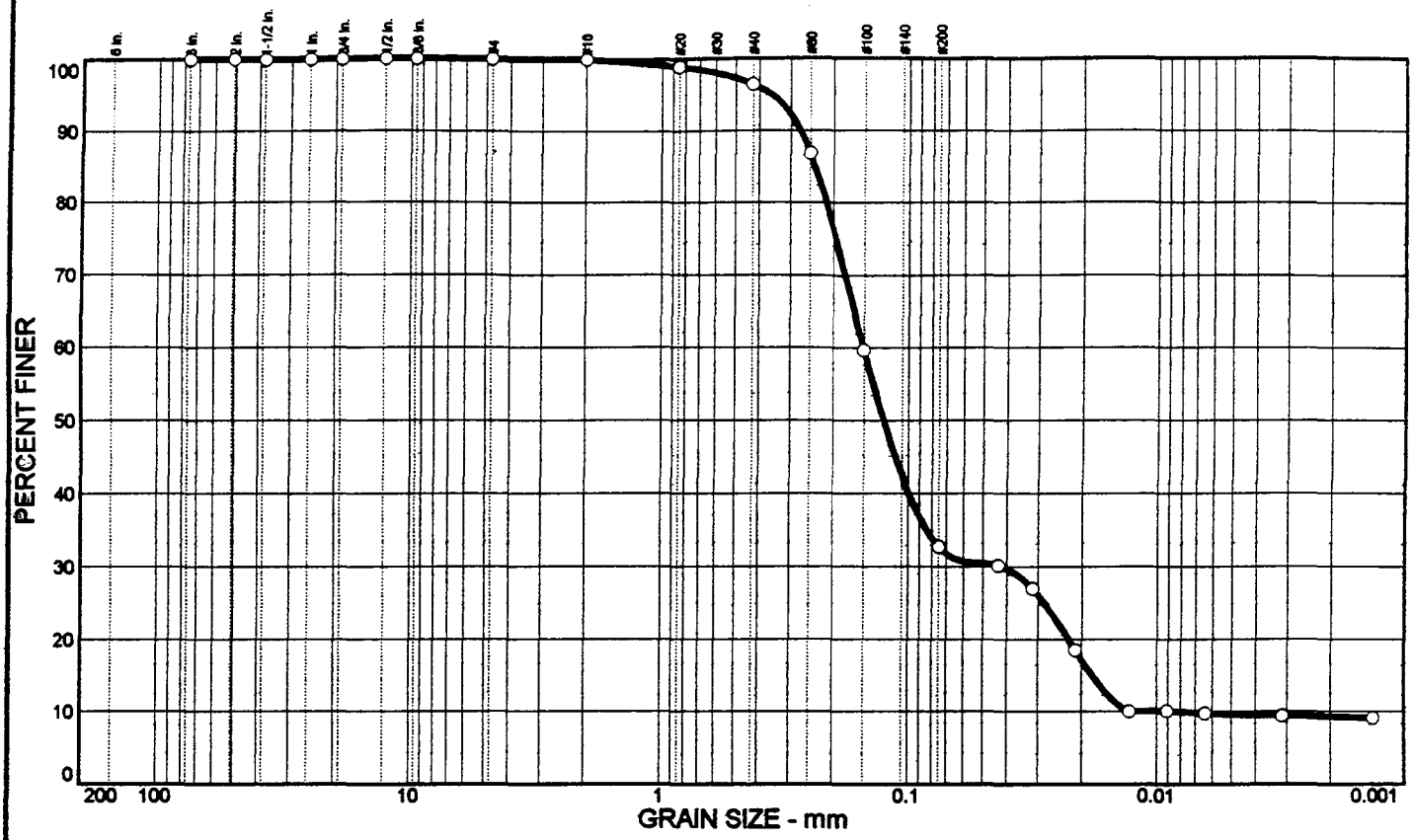
Project No.: 804899
Project: International Uranium Corporation
Location: Soil Sample Testing
Date: 4/27/99

Remarks:
SUBMITTED BY: Client
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST
WESTERN COLORADO TESTING, INC.

Fig. No. 3

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	67.3	23.2	9.5	SM	A-2-4(0)	NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.151		
D_{30}	0.0425		
D_{10}	0.0084		
	COEFFICIENTS		
C_c	1.42		
C_u	18.03		

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	100.0		
#20	98.9		
#40	92.4		
#60	86.9		
#100	59.6		
#200	32.7		

SOIL DESCRIPTION

○ Sand, silty, gray/brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: C2-TS3

WESTERN COLORADO TESTING, INC.

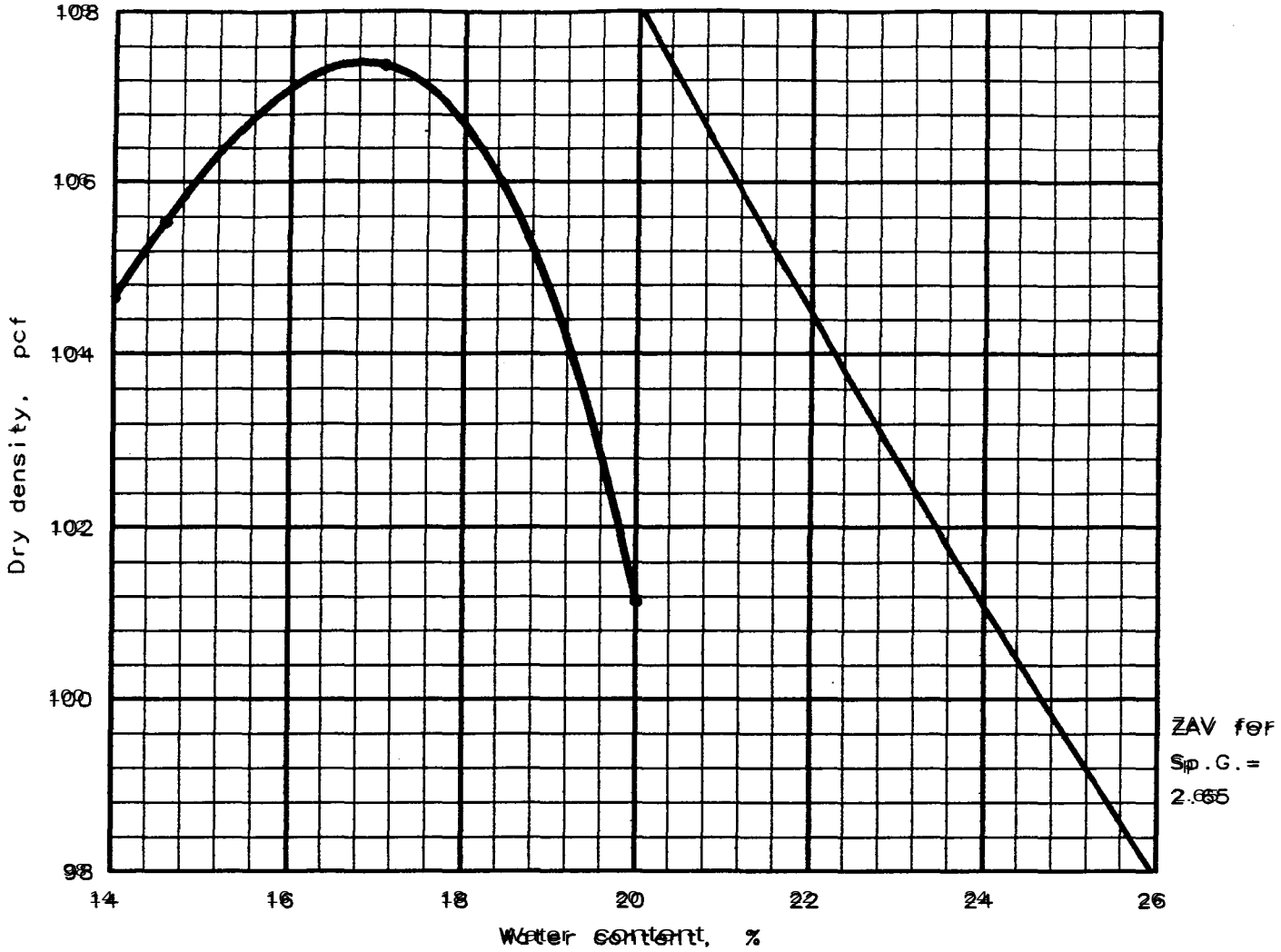
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 34

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard

Oversize correction applied to each point

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 107.4 pcf Optimum moisture = 16.8 %	107.4 pcf 16.8 %	C2-TS4

Project No: 8048399

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 4/27/99

Remarks:

SUBMITTED BY: Client

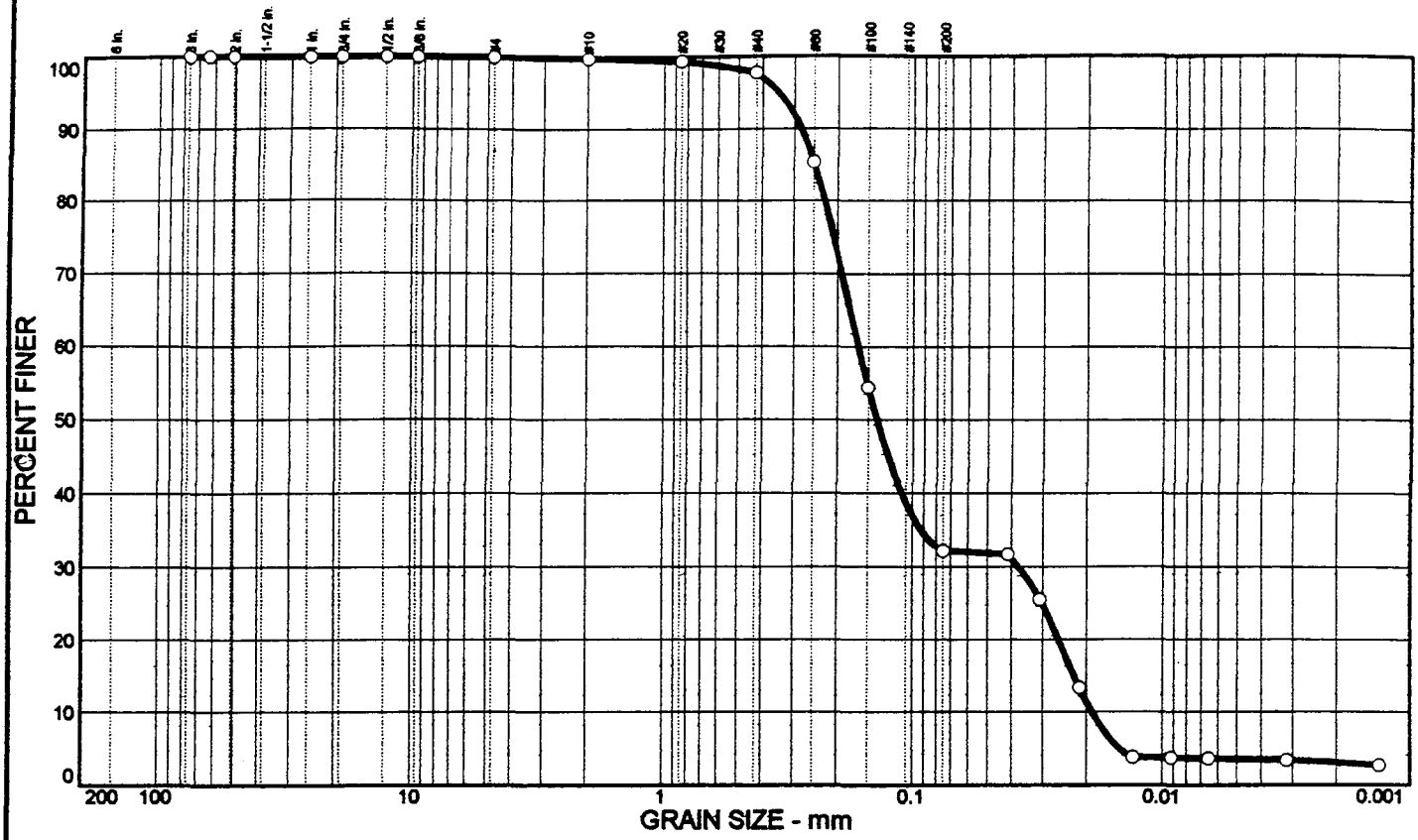
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig No. 4

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	67.8	28.7	3.5	SM	A-2-4(0)	NP	NP
							A-2-4(0)	ThP	NIJ

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2.5	100.0		
2	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
GRAIN SIZE			
D_{60}	0.164		
D_{30}	0.0376		
D_{10}	0.0189		
COEFFICIENTS			
C_c	0.45		
C_u	8.69		

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.8		
#20	99.4		
#40	97.8		
#60	85.4		
#100	54.4		
#200	32.2		

SOIL DESCRIPTION

○ Sand, silty, gray/brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No: C2-TS4

WESTERN COLORADO TESTING, INC.

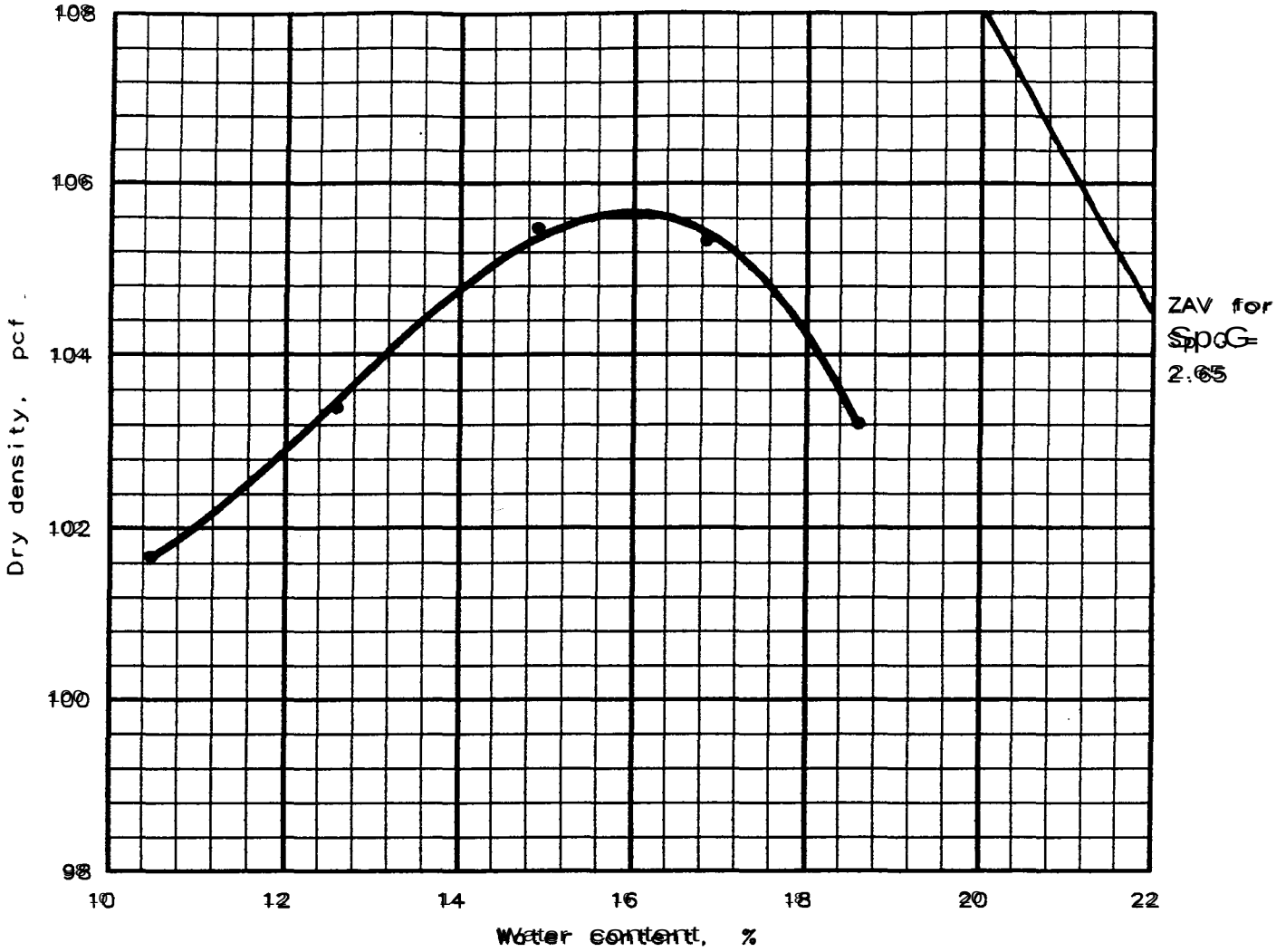
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No: 804899

Figure 35

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard

Oversize correction applied to each point

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 105.7 pcf Optimum moisture = 16.0 %	105.77 pcf 16.0 %	C3-TS1

Project No.: 8048999

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 4/27/99

Remarks:

SUBMITTED BY: Client

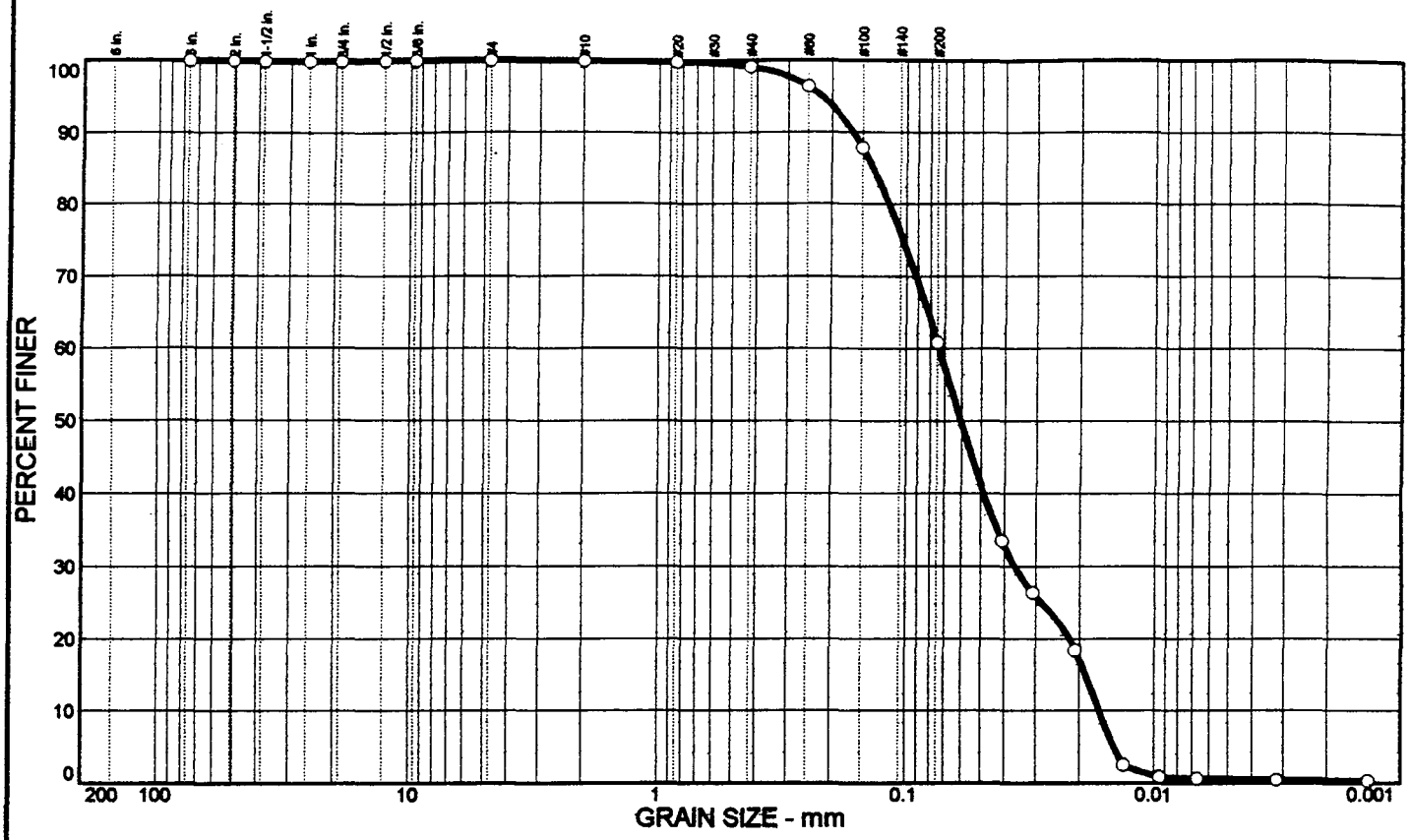
TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig. No. 5

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	LL	PI
○		0.0	39.2	60.3	0.5	ML	A-4(0)	NP	NP

SIEVE inches Size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.0738		
D_{30}	0.0364		
D_{10}	0.0166		
	COEFFICIENTS		
C_c	1.08		
C_u	4.45		

SIEVE number Size	PERCENT FINER ○		
#4	100.0		
#10	100.0		
#20	99.9		
#40	99.1		
#60	96.3		
#100	87.8		
#200	60.8		

SOIL DESCRIPTION

○ Silt, sandy, brown

REMARKS:

○ Tested by: JH

○ Source:

Sample No.: C3-TS1

Location:

WESTERN COLORADO TESTING, INC.

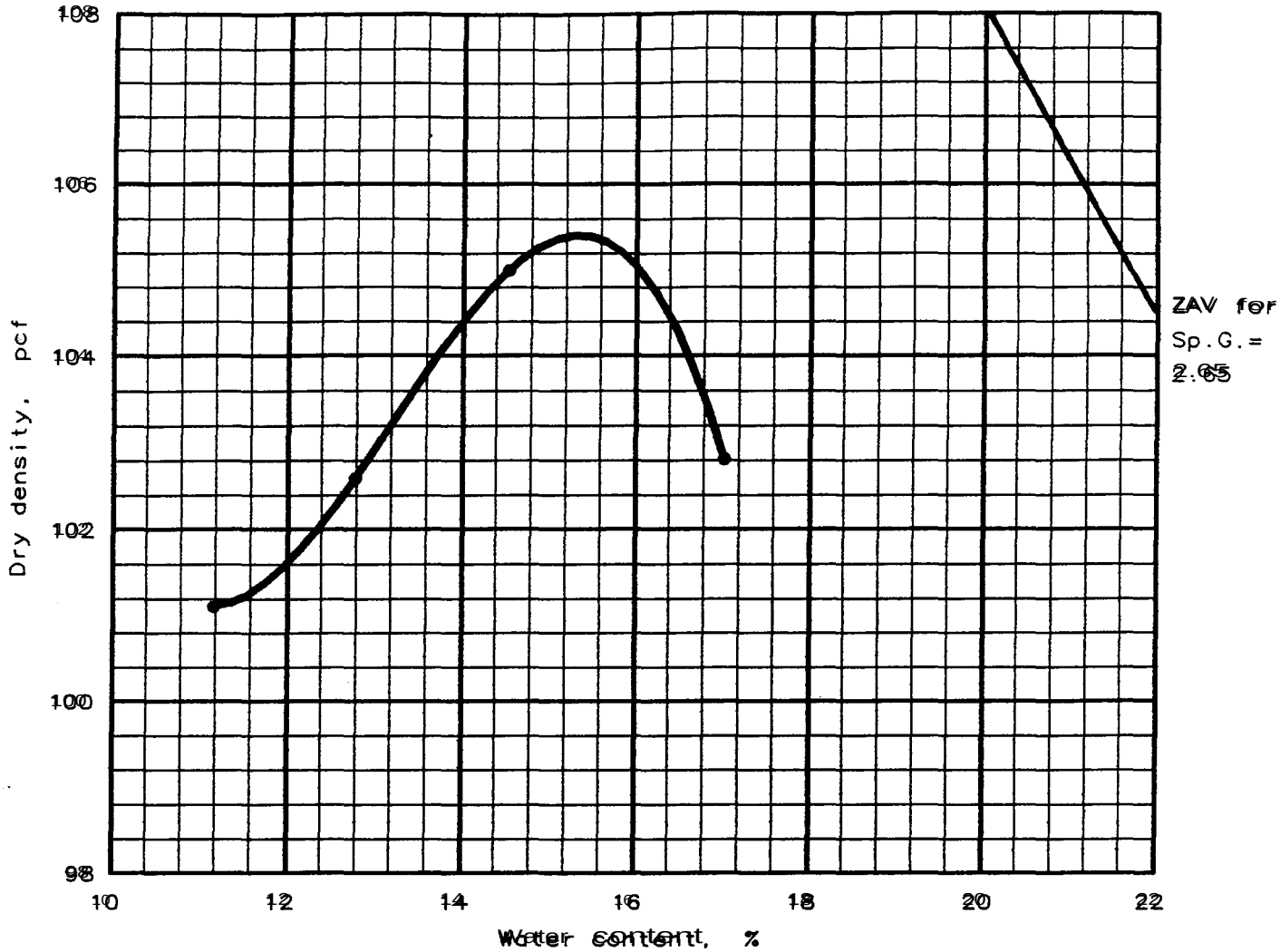
Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 36

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure A, Standard

Oversize correction applied to each point

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
			N/A %	2.65				

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 105.4 pcf Optimum moisture = 15.3 %	105.4 pcf 15.3 %	C3-TS2

Project No.: 804899

Project: International Uranium Corporation

Location: Soil Sample Testing

Date: 4/27/99

Remarks:

SUBMITTED BY: Client

TESTED BY: JH

MOISTURE-DENSITY RELATIONSHIP TEST

WESTERN COLORADO TESTING, INC.

Fig No. 6

PARTICLE SIZE DISTRIBUTION TEST REPORT

	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.0	77.0	16.9	6.1	SM	A-2-4(0)	NP	NP
								NP	NP

SIEVE inches size	PERCENT FINER ○		
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.185		
D_{30}	0.102		
D_{10}	0.0260		
	COEFFICIENTS		
C_c	2.16		
C_u	7.12		

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.9		
#20	99.0		
#40	94.6		
#60	78.1		
#100	46.9		
#200	23.0		

SOIL DESCRIPTION

○ Sand, silty, gray/brown

REMARKS:

○ Tested By: JH

○ Source:

Sample No.: C3-TS2

WESTERN COLORADO TESTING, INC.

Client: International Uranium Corporation

Project: Soil Sample Testing

Project No.: 804899

Figure 37

ATTACHMENT A.2

ADVANCED TERRA TESTING, INC.

2010

ADVANCED TERRA TESTING, Inc.
ATT
833 Parfet Street • Lakewood, Colorado 80215 • (303) 232-8308 • Fax: (303) 232-1579

MOISTURE CONTENT
ASTM D 2216

Moisture Content Determinations
ASTM D 2216

CLIENT: MWH JOB NO.: 2521-53

LOCATION: Denison White Mesa Project

BORING	Stockpile 1	Stockpile 1	Stockpile 2	Stockpile 3
SAMPLE DEPTH	5.0'	12.0'	5.0'	6.0'
SAMPLE NO.	A South	B South	A	A
DATE SAMPLED	10/12/10	10/12/10	10/12/10	10/12/10
DATE TESTED	10/23/10 LB	10/23/10 LB	10/23/10 LB	10/23/10 LB
SOIL DESCRIPTION	1009740	1009740	1009740	1009740
MOISTURE DETERMINATIONS				
Wt. of Wet Soil & Dish (gms)	168.75	189.58	140.80	159.75
Wt. of Dry Soil & Dish (gms)	161.67	179.59	129.88	146.78
Net Loss of Moisture (gms)	7.08	9.99	10.92	12.97
Wt. of Dish (gms)	3.04	3.16	3.08	3.02
Wt. of Dry Soil (gms)	158.63	176.43	126.80	143.76
Moisture Content (%)	4.5	5.7	8.6	9.0

BORING	Stockpile 4	Stockpile 5	Stockpile 6	Stockpile 7
SAMPLE DEPTH	5.0'	6.0'	2.0'	0
SAMPLE NO.	A	A	A	A
DATE SAMPLED	10/12/10	10/12/10	10/12/10	10/12/10
DATE TESTED	10/23/10 LB	10/23/10 LB	10/23/10 LB	10/23/10 LB
SOIL DESCRIPTION	1009740	1009740	1009740	1009740
MOISTURE DETERMINATIONS				
Wt. of Wet Soil & Dish (gms)	124.09	129.19	176.52	135.98
Wt. of Dry Soil & Dish (gms)	108.90	122.37	164.58	130.35
Net Loss of Moisture (gms)	15.19	6.82	11.94	5.63
Wt. of Dish (gms)	3.14	3.07	3.30	3.04
Wt. of Dry Soil (gms)	105.76	119.30	161.28	127.31
Moisture Content (%)	14.4	5.7	7.4	4.4

Data entered by: BKL Date: 10/26/2010
Data checked by: DPM Date: 10/26/10
FileName: MHN053AA

ADVANCED TERRA TESTING, INC. ATT

Moisture Content Determinations
ASTM D 2216

CLIENT: MWH JOB NO.: 2512-53

LOCATION: Denison White Mesa Project

BORING	Stockpile 8	Stockpile 9	Stockpile 10	Stockpile 11
SAMPLE DEPTH	5.0'	0'	5.0'	0'
SAMPLE NO.	A	A	A	A
DATE SAMPLED	10/12/10	10/12/10	10/12/10	10/12/10
DATE TESTED	10/23/10 LB	10/23/10 LB	10/23/10 LB	10/23/10 LB
SOIL DESCRIPTION	1009740	1009740	1009740	1009740
MOISTURE DETERMINATIONS				
Wt. of Wet Soil & Dish (gms)	151.72	156.77	120.43	161.56
Wt. of Dry Soil & Dish (gms)	139.81	151.93	114.57	154.98
Net Loss of Moisture (gms)	11.91	4.84	5.86	6.58
Wt. of Dish (gms)	3.04	3.04	3.11	3.29
Wt. of Dry Soil (gms)	136.77	148.89	111.46	151.69
Moisture Content (%)	8.7	3.3	5.3	4.3

BORING	Stockpile 12	Stockpile 13
SAMPLE DEPTH	5.0'	0'
SAMPLE NO.	A	A
DATE SAMPLED	10/12/10	10/12/10
DATE TESTED	10/23/10 LB	10/23/10 LB
SOIL DESCRIPTION	1009740	1009740
MOISTURE DETERMINATIONS		
Wt. of Wet Soil & Dish (gms)	138.36	155.25
Wt. of Dry Soil & Dish (gms)	127.42	143.36
Net Loss of Moisture (gms)	10.94	11.89
Wt. of Dish (gms)	3.11	3.28
Wt. of Dry Soil (gms)	124.31	140.08
Moisture Content (%)	8.8	8.5

Data entered by: BKL Date: 10/26/2010
Data checked by: DM Date: 10/26/10
FileName: MHN053AB

ADVANCED TERRA TESTING, INC. ATT

SPECIFIC GRAVITY TEST
ASTM D 854

SPECIFIC GRAVITY TESTS ASTM D 854

CLIENT:	MWH	JOB NO.	2512-53
SOIL DESCR.	1009740	LOCATION	Denison White Mesa Mill Project

BORING NO.	Stockpile 8	Stockpile 1	Stockpile 4
DEPTH	5.0'	5.0'	5.0'
SAMPLE NO.	A	A-South	A
DATE SAMPLED			
DATE TESTED	11/17/10 MLM	11/17/10 MLM	11/17/10 MLM

Pycnometer #	Big 1	Big 9	Big 10
Weight of oven dry soil (g) (Wo)	108.770	105.460	91.720
Weight of flask, soil, and water. (g) (Wb)	739.740	740.170	730.080
Temperature (deg. C) (Tx)	25.3	25.3	25.4
Weight of water & flask at Tx (from cal. curve)(Wa)	671.632	674.591	671.815
Specific Gravity*	2.67	2.64	2.74

*Specific Gravity = Wo/[Wo+(Wa-Wb)]

Data entry by: MLM Date: 11/18/2010
Data checked by: BKC Date: 11/8/10
FileName: MHE0S814

ADVANCED TERRA TESTING, INC. ATT

ATTERBERG LIMITS
ASTM D 4318

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	DATE SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	11/08/10 MLM
SAMPLE NO.	A South		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit
Determination

Wt Dish & Wet Soil	
Wt Dish & Dry Soil	
Wt of Moisture	
Wt of Dish	NON-PLASTIC
Wt of Dry Soil	
Moisture Content	

Liquid Limit Device Number 1075
Determination

Number of Blows

Wt Dish & Wet Soil	
Wt Dish & Dry Soil	
Wt of Moisture	
Wt of Dish	NON-PLASTIC
Wt of Dry Soil	
Moisture Content	

Liquid Limit	NP
Plastic Limit	NP
Plasticity Index	NP

Atterberg Classification NP

Data entry by: MLM Date: 11/08/2010
Checked by: LB Date: 10-09-10
FileName: MHG0S15A

ADVANCED TERRA TESTING, INC. ATT

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	DATE SAMPLED	10/12/10
DEPTH	12.0'	DATE TESTED	11/08/10 MLM
SAMPLE NO.	B South		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	12.25	12.02	11.89
Wt Dish & Dry Soil	11.15	10.92	10.80
Wt of Moisture	1.10	1.10	1.09
Wt of Dish	1.14	1.14	1.14
Wt of Dry Soil	10.01	9.78	9.66
Moisture Content	10.99	11.25	11.28

Liquid Limit Determination — Device Number 1075

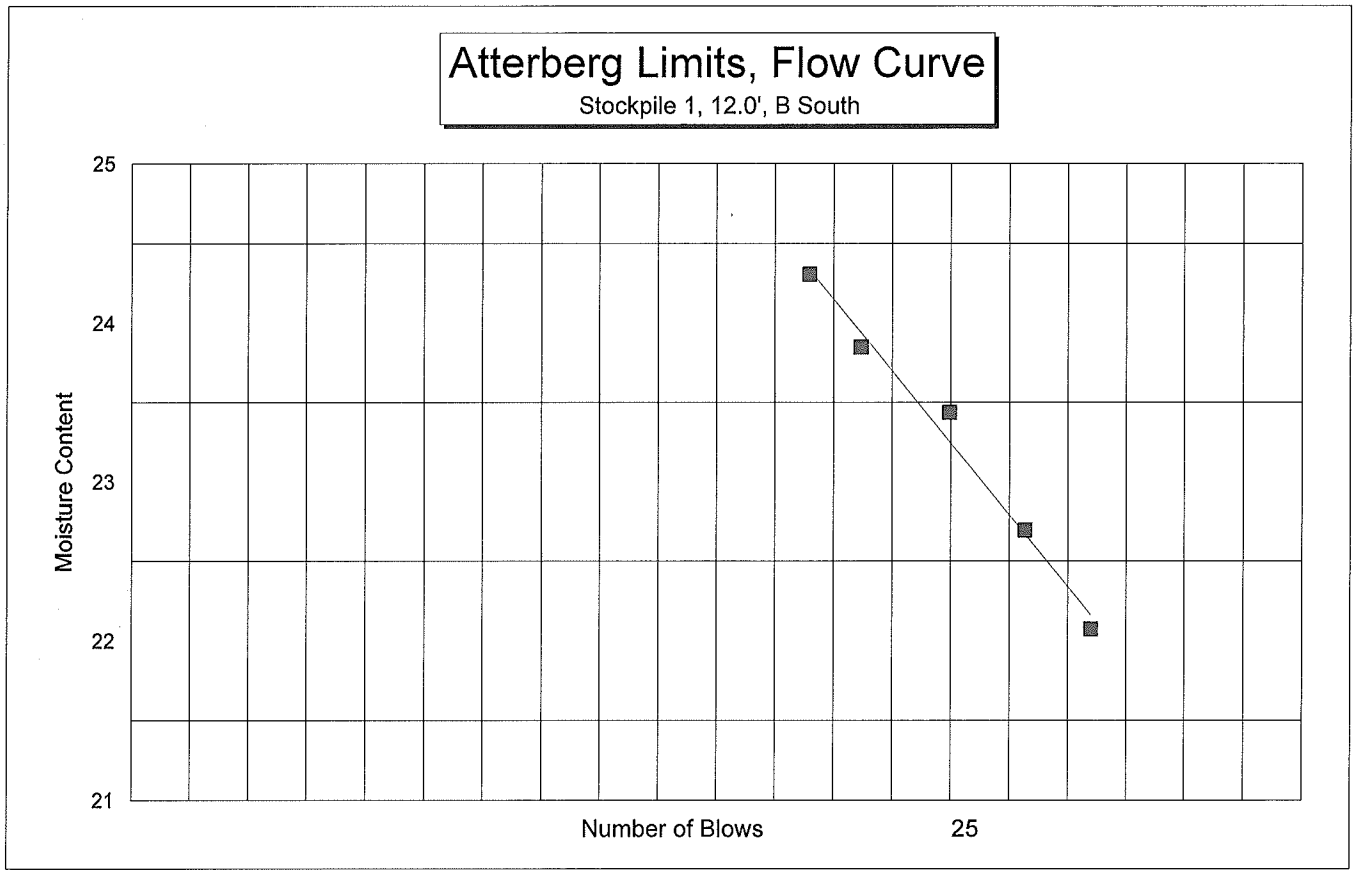
	1	2	3	4	5
Number of Blows	33	29	25	21	19
Wt Dish & Wet Soil	12.90	11.80	12.19	11.65	12.34
Wt Dish & Dry Soil	10.77	9.83	10.09	9.63	10.15
Wt of Moisture	2.13	1.97	2.10	2.02	2.19
Wt of Dish	1.12	1.15	1.13	1.16	1.14
Wt of Dry Soil	9.65	8.68	8.96	8.47	9.01
Moisture Content	22.07	22.70	23.44	23.85	24.31

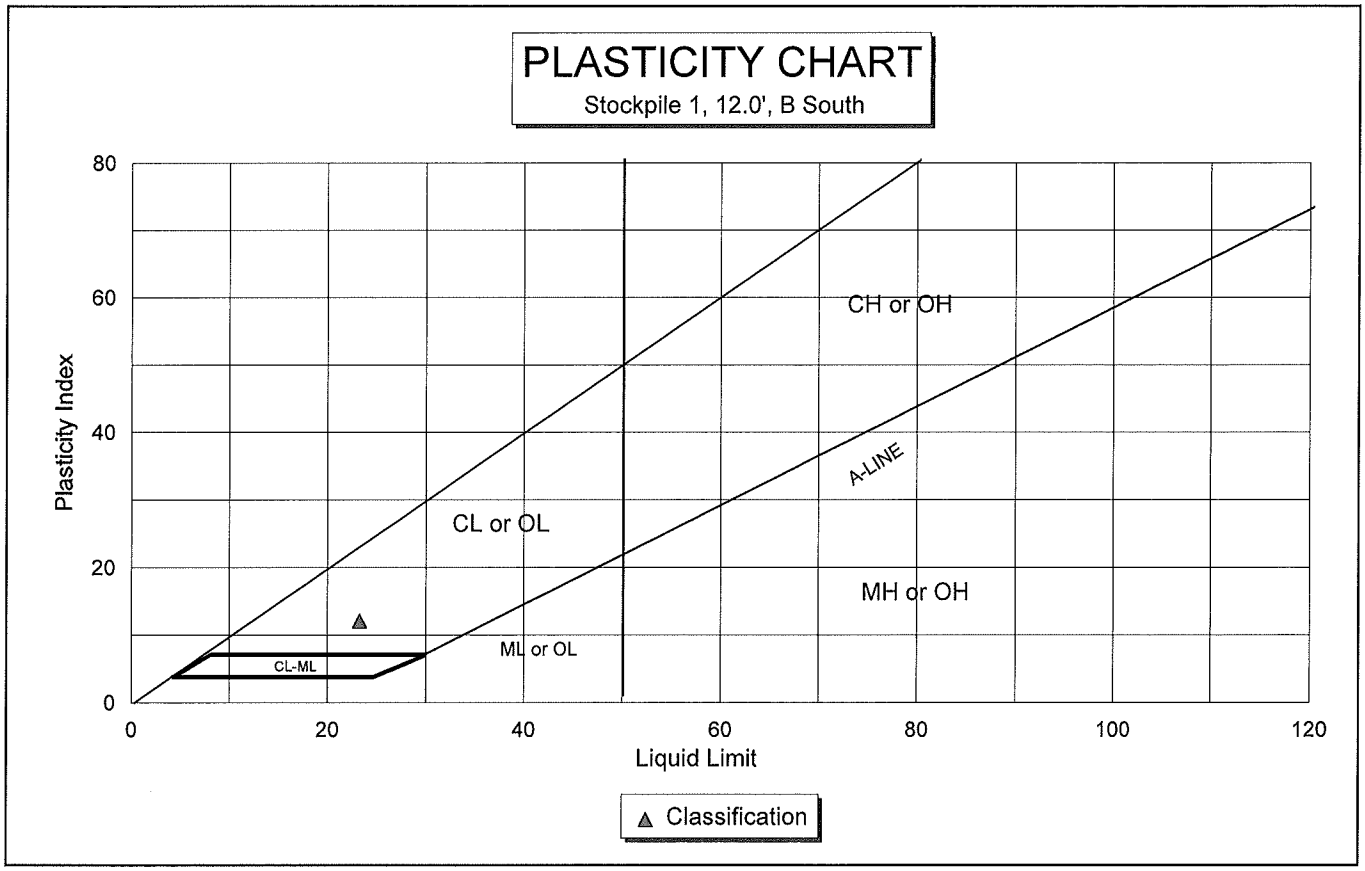
Liquid Limit	23.3
Plastic Limit	11.2
Plasticity Index	12.1

Atterberg Classification CL

Data entry by: MLM Date: 11/09/2010
Checked by: BKL Date: 11/9/10
FileName: MHG0S1BS

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 1, 12.0', B South
Moisture Content
25
24
23
22
21
Number of Blows
25


PLASTICITY CHART
Stockpile 1, 12.0', B South
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 2	DATE SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	10/27/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.04	11.59	11.84
Wt Dish & Dry Soil	8.91	10.25	10.53
Wt of Moisture	1.13	1.34	1.31
Wt of Dish	1.14	1.15	1.15
Wt of Dry Soil	7.77	9.10	9.38
Moisture Content	14.54	14.73	13.97

Liquid Limit Determination — Device Number 1080

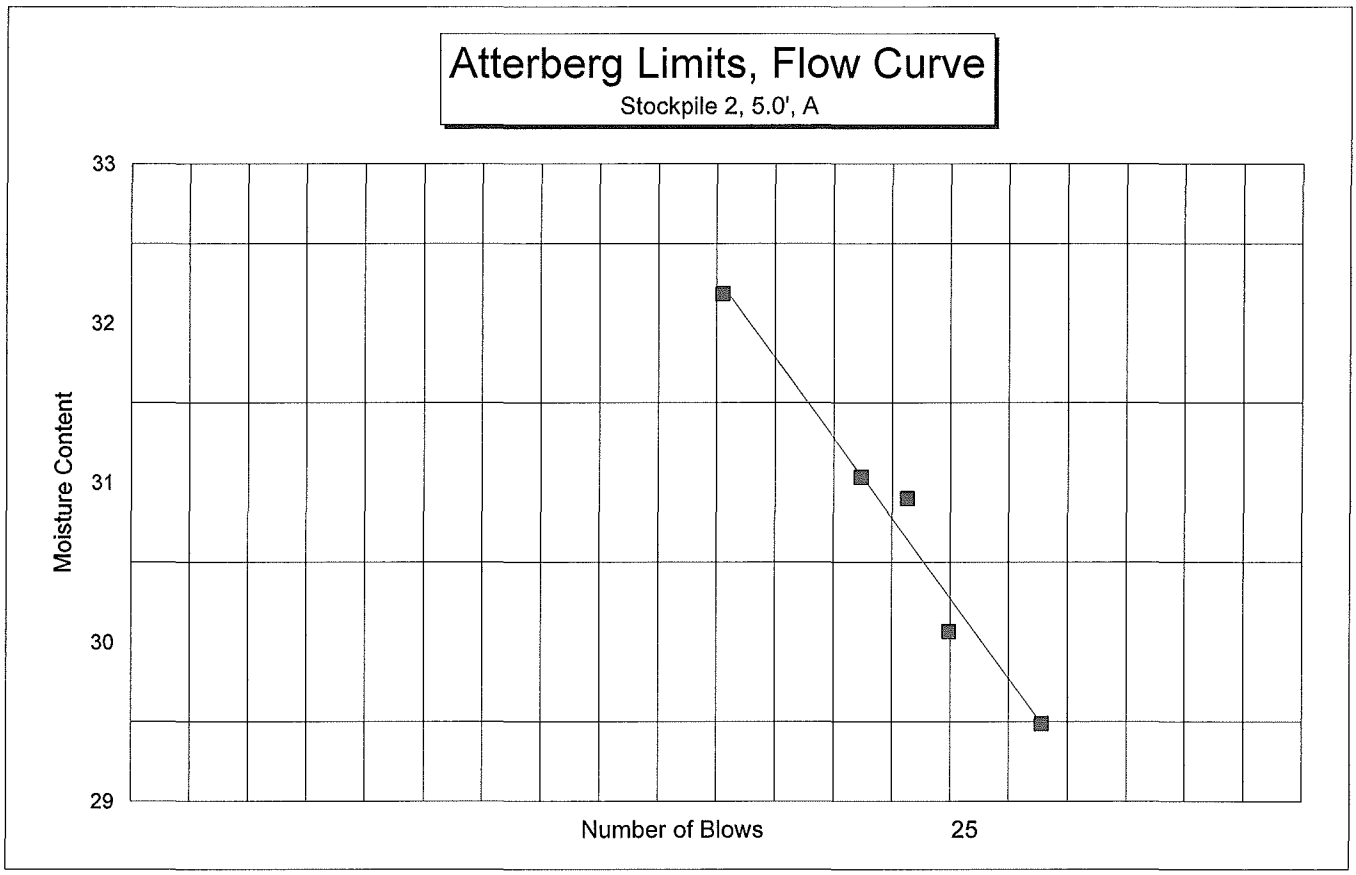
	1	2	3	4	5
Number of Blows	30	25	23	21	16
Wt Dish & Wet Soil	11.02	10.83	10.45	10.66	11.50
Wt Dish & Dry Soil	8.77	8.59	8.25	8.41	8.98
Wt of Moisture	2.25	2.24	2.20	2.25	2.52
Wt of Dish	1.14	1.14	1.13	1.16	1.15
Wt of Dry Soil	7.63	7.45	7.12	7.25	7.83
Moisture Content	29.49	30.07	30.90	31.03	32.18

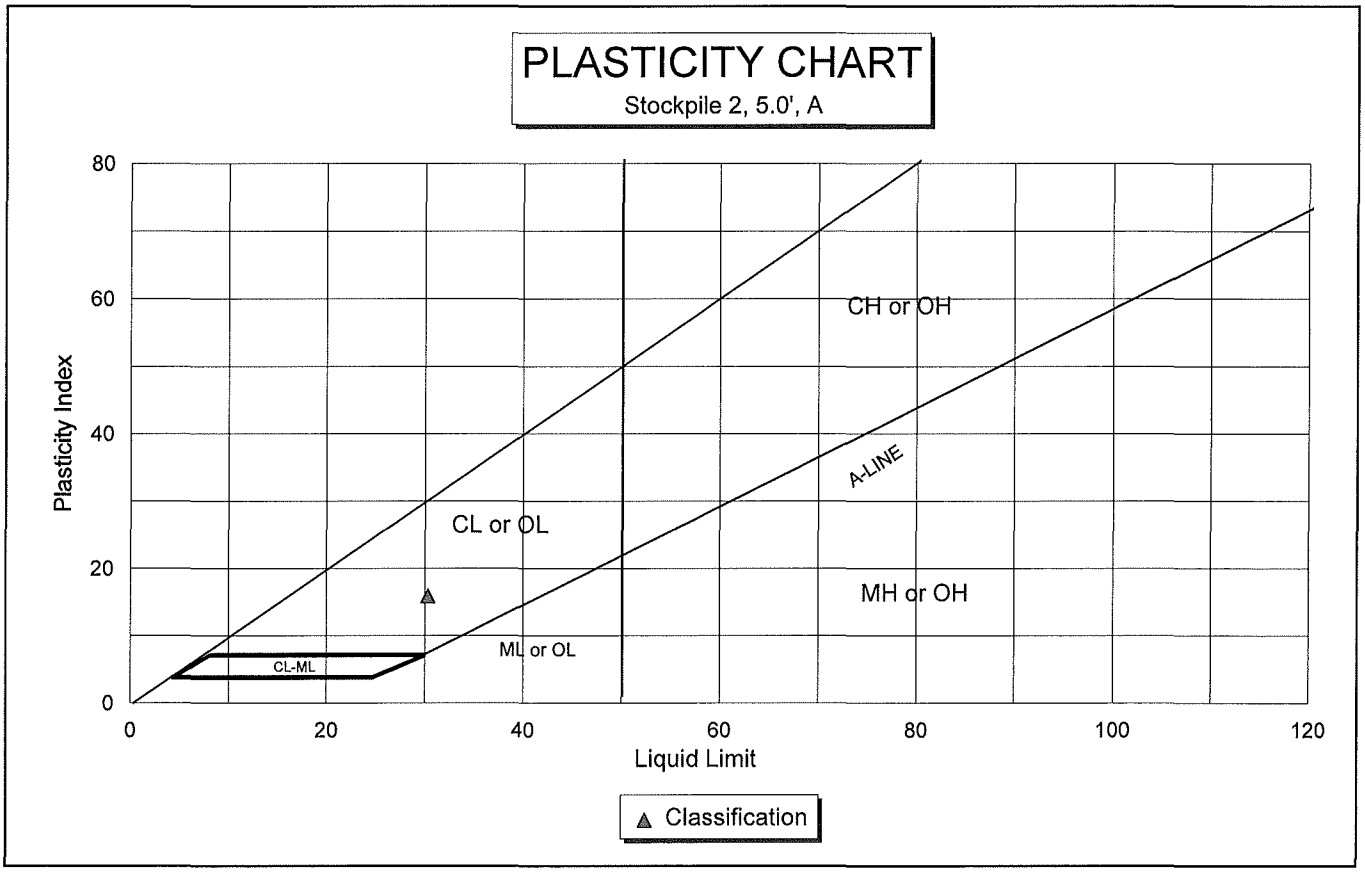
Liquid Limit	30.3
Plastic Limit	14.4
Plasticity Index	15.9

Atterberg Classification CL

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG0250A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 2, 5.0', A
Moisture Content
33
32
31
30
29
Number of Blows
25


PLASTICITY CHART
Stockpile 2, 5.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 3	DATE SAMPLED	10/12/10
DEPTH	6.0'	DATE TESTED	10/27/10 PW
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.49	10.76	10.76
Wt Dish & Dry Soil	9.36	9.55	9.53
Wt of Moisture	1.13	1.21	1.23
Wt of Dish	1.13	1.14	1.15
Wt of Dry Soil	8.23	8.41	8.38
Moisture Content	13.73	14.39	14.68

Liquid Limit Determination — Device Number 0860

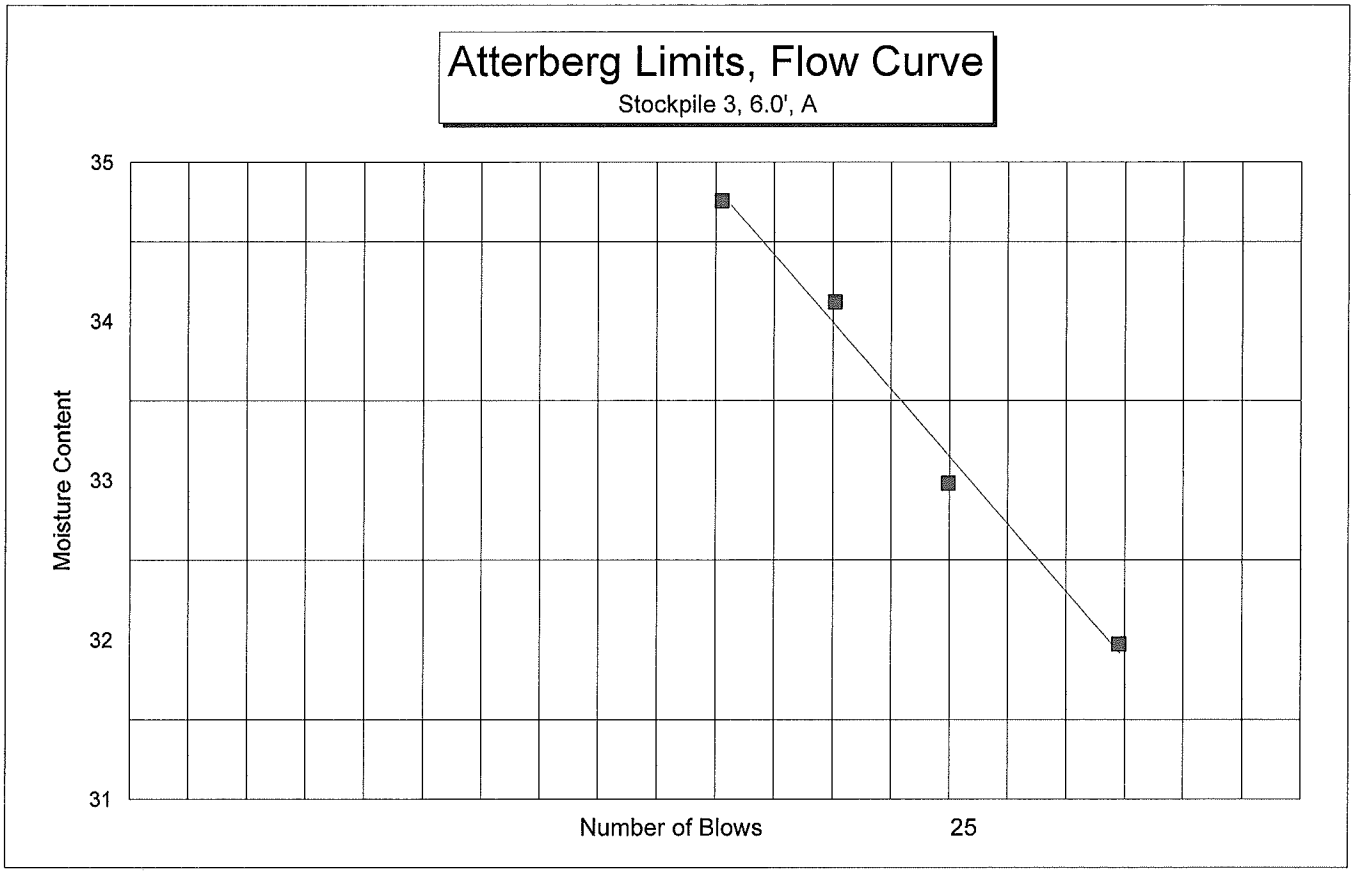
	1	2	3	4
Number of Blows	35	16	25	20
Wt Dish & Wet Soil	14.74	15.36	14.95	17.60
Wt Dish & Dry Soil	11.45	11.70	11.53	13.41
Wt of Moisture	3.29	3.66	3.42	4.19
Wt of Dish	1.16	1.17	1.16	1.13
Wt of Dry Soil	10.29	10.53	10.37	12.28
Moisture Content	31.97	34.76	32.98	34.12

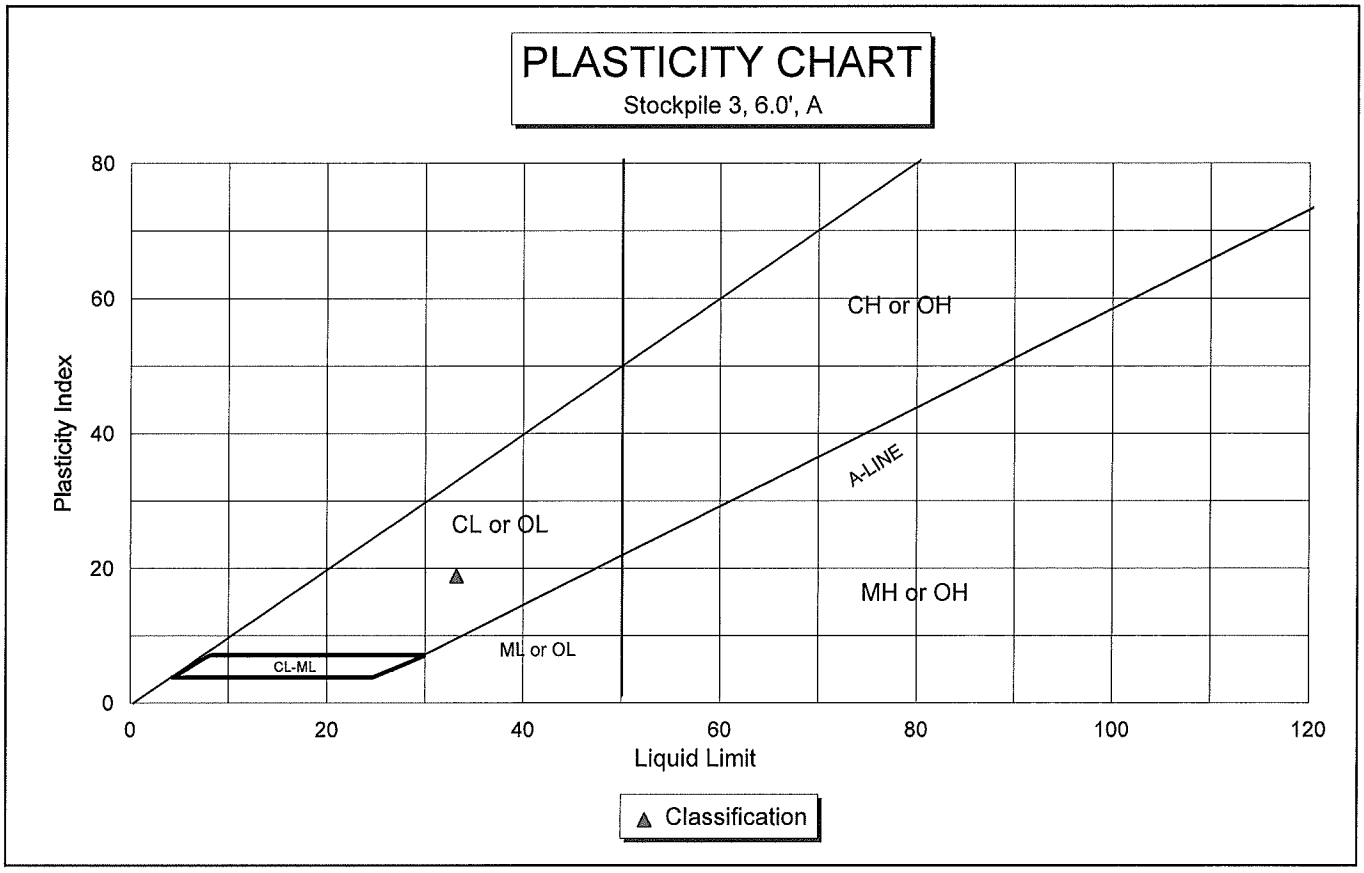
Liquid Limit	33.2
Plastic Limit	14.3
Plasticity Index	18.9

Atterberg Classification CL

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG0360A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 3, 6.0', A
Moisture Content
35
34
33
32
31
Number of Blows
25


PLASTICITY CHART
Stockpile 3, 6.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 4	DATE SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	11/03/10 PW
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.11	10.31	10.26
Wt Dish & Dry Soil	8.88	9.06	9.02
Wt of Moisture	1.23	1.25	1.24
Wt of Dish	1.14	1.16	1.14
Wt of Dry Soil	7.74	7.90	7.88
Moisture Content	15.89	15.82	15.74

Liquid Limit Determination — Device Number 0860

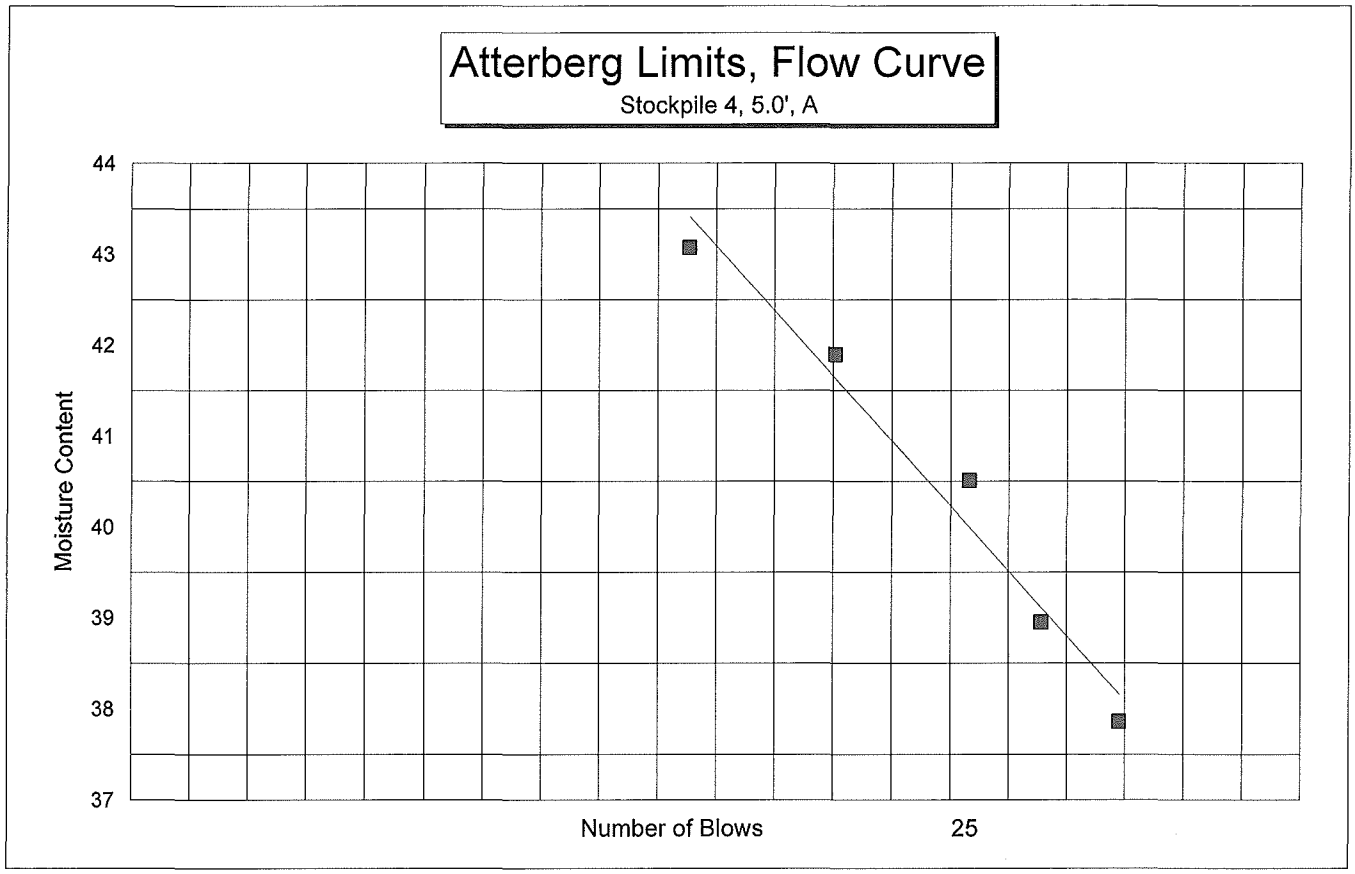
	1	2	3	4	5
Number of Blows	35	30	26	20	15
Wt Dish & Wet Soil	16.36	18.13	17.07	16.99	15.30
Wt Dish & Dry Soil	12.18	13.37	12.48	12.31	11.04
Wt of Moisture	4.18	4.76	4.59	4.68	4.26
Wt of Dish	1.14	1.15	1.15	1.14	1.15
Wt of Dry Soil	11.04	12.22	11.33	11.17	9.89
Moisture Content	37.86	38.95	40.51	41.90	43.07

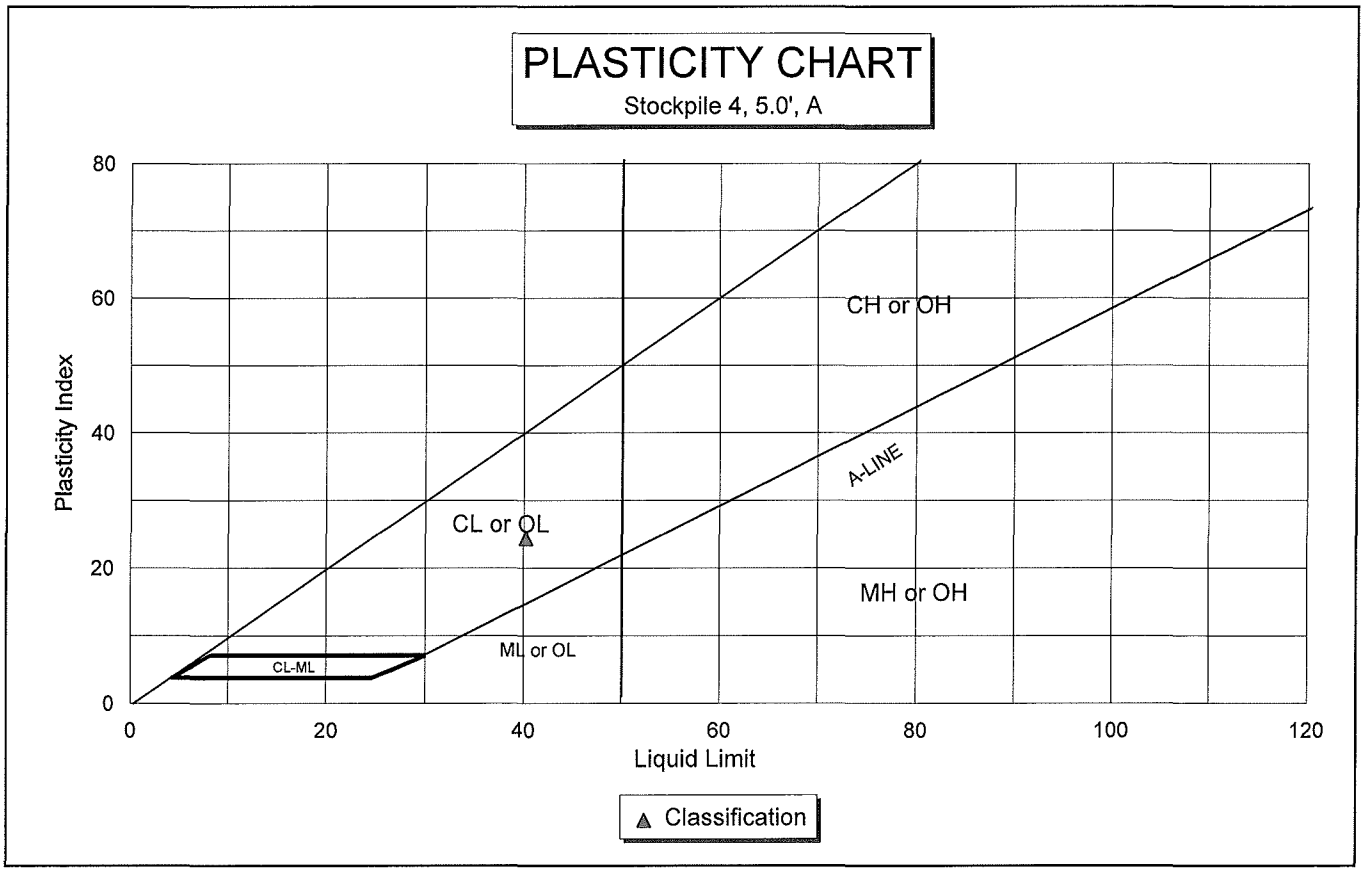
Liquid Limit	40.2
Plastic Limit	15.8
Plasticity Index	24.4

Atterberg Classification CL

Data entry by: MLM Date: 11/04/2010
Checked by: BKL Date: 11/4/10
FileName: MHG0S45A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 4, 5.0', A
Moisture Content
44
43
42
41
40
39
38
37
Number of Blows
25


PLASTICITY CHART
Stockpile 4, 5.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 5	DATE SAMPLED	10/12/10
DEPTH	6.0'	DATE TESTED	10/27/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	9.49	11.27	9.56
Wt Dish & Dry Soil	8.31	9.85	8.39
Wt of Moisture	1.18	1.42	1.17
Wt of Dish	1.14	1.14	1.13
Wt of Dry Soil	7.17	8.71	7.26
Moisture Content	16.46	16.30	16.12

Liquid Limit Determination — Device Number 1080

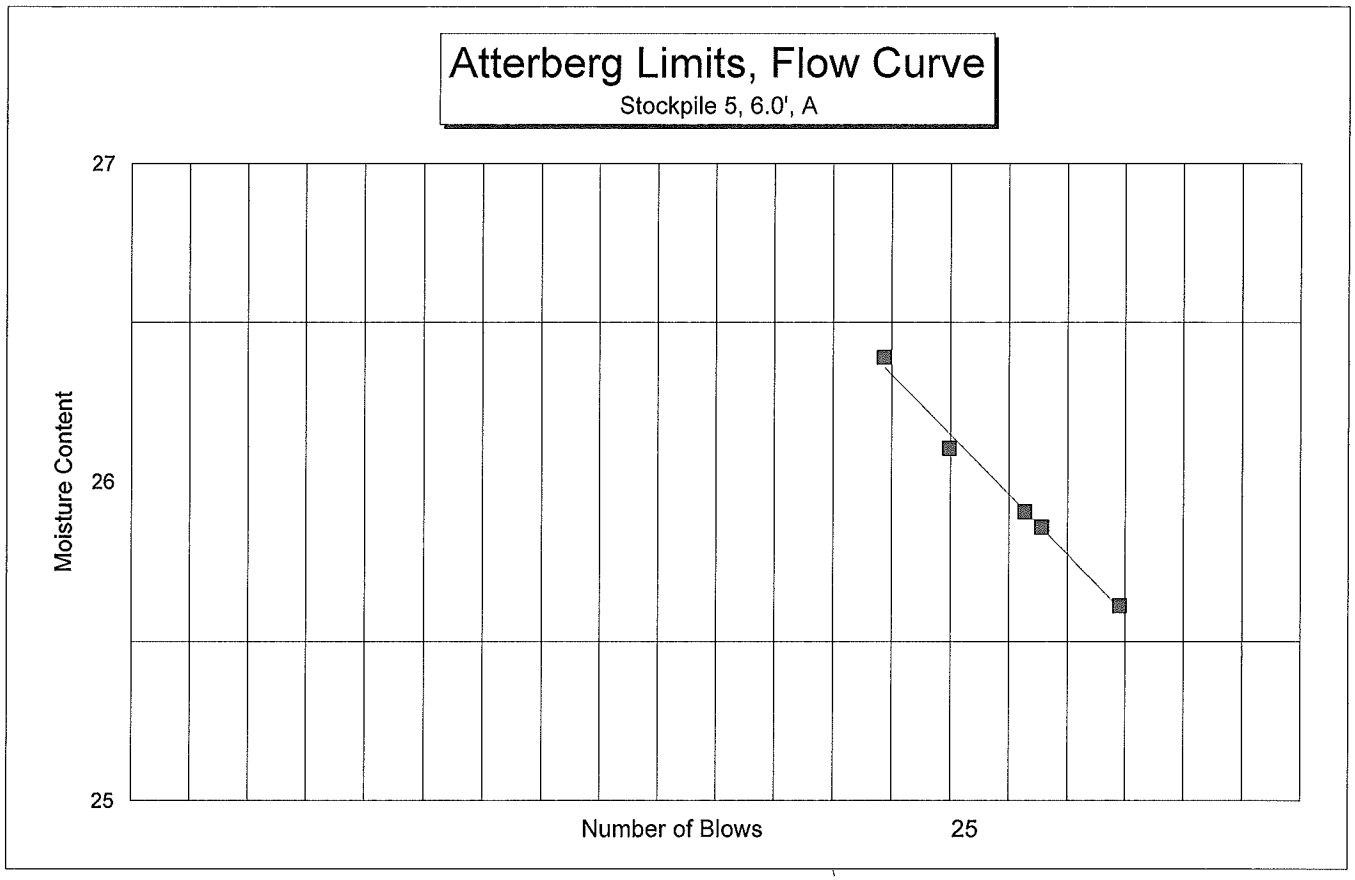
	1	2	3	4	5
Number of Blows	35	22	25	29	30
Wt Dish & Wet Soil	11.37	10.88	10.57	10.50	11.34
Wt Dish & Dry Soil	9.28	8.84	8.62	8.57	9.23
Wt of Moisture	2.09	2.04	1.95	1.93	2.11
Wt of Dish	1.12	1.11	1.15	1.12	1.07
Wt of Dry Soil	8.16	7.73	7.47	7.45	8.16
Moisture Content	25.61	26.39	26.10	25.91	25.86

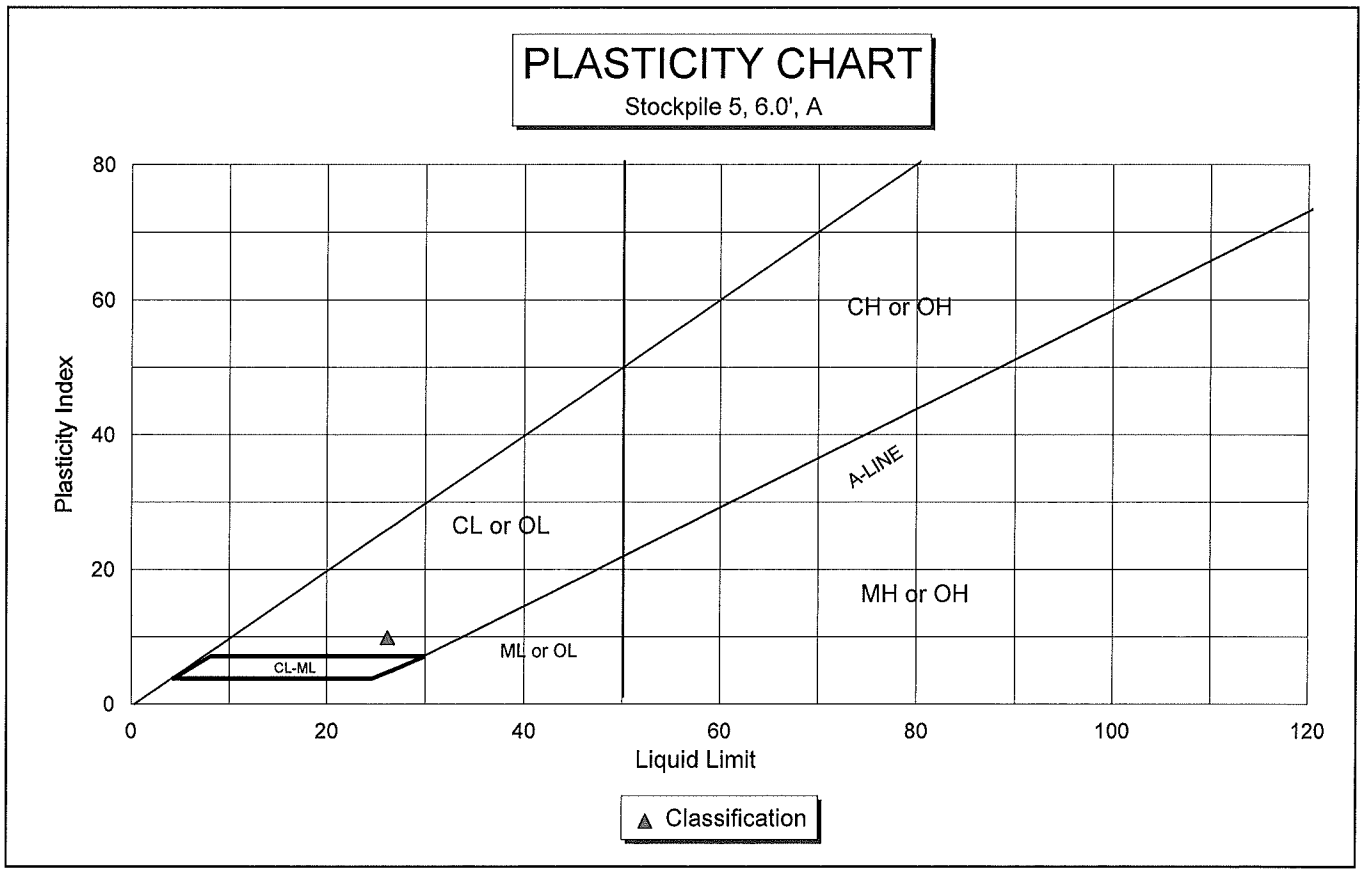
Liquid Limit	26.2
Plastic Limit	16.3
Plasticity Index	9.9

Atterberg Classification CL

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG0560A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 5, 6.0', A
Moisture Content
27
26
25
Number of Blows
25


PLASTICITY CHART
Stockpile 5, 6.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 6	DATE SAMPLED	
DEPTH	2.0'	DATE TESTED	11/03/10 LB
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2
Wt Dish & Wet Soil	7.04	7.01
Wt Dish & Dry Soil	6.40	6.39
Wt of Moisture	0.64	0.62
Wt of Dish	1.15	1.12
Wt of Dry Soil	5.25	5.27
Moisture Content	12.19	11.76

Liquid Limit Determination — Device Number 1075

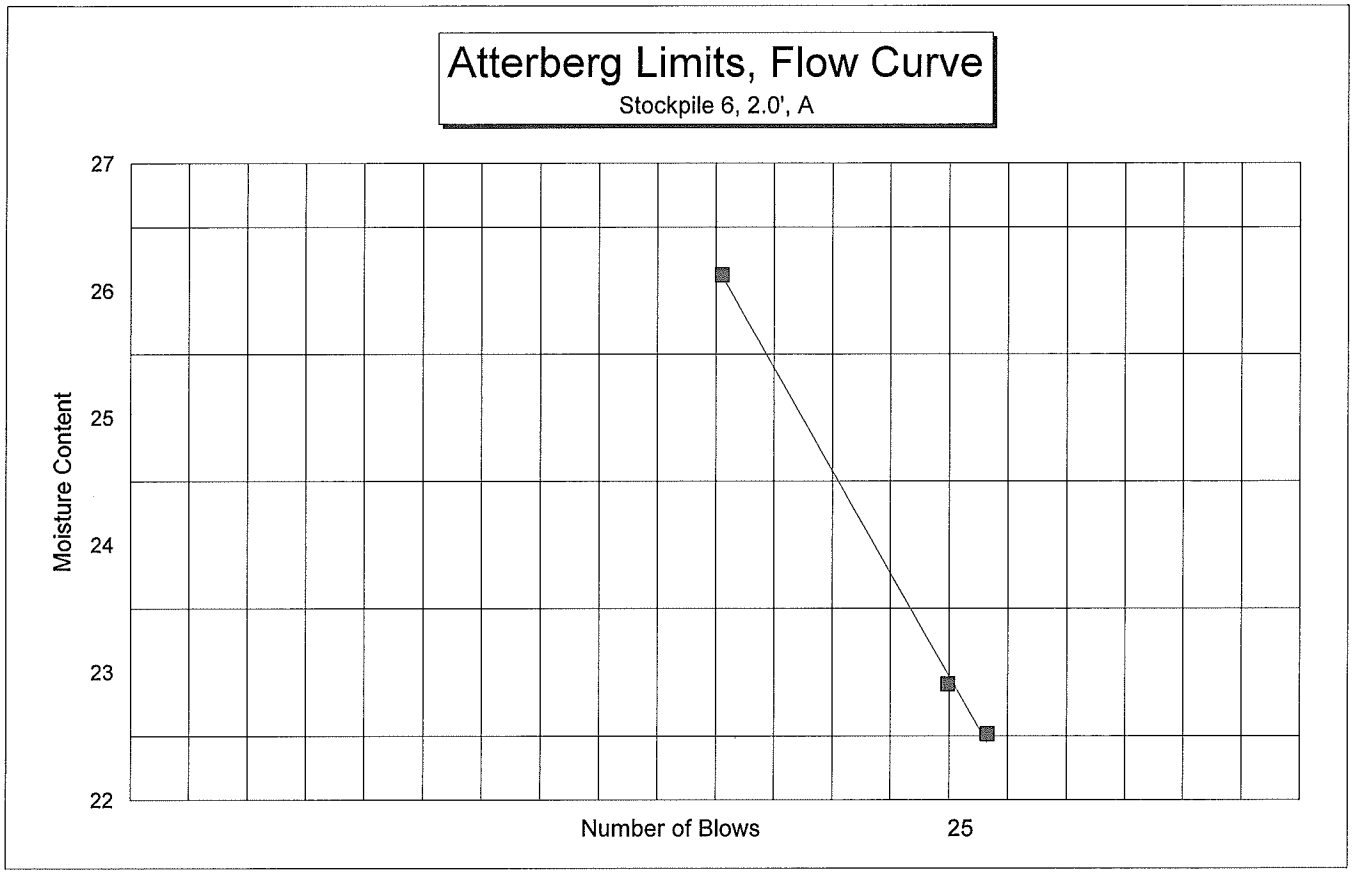
	1	2	3
Number of Blows	25	16	27
Wt Dish & Wet Soil	16.70	21.03	20.01
Wt Dish & Dry Soil	13.80	16.91	16.54
Wt of Moisture	2.90	4.12	3.47
Wt of Dish	1.14	1.14	1.13
Wt of Dry Soil	12.66	15.77	15.41
Moisture Content	22.91	26.13	22.52

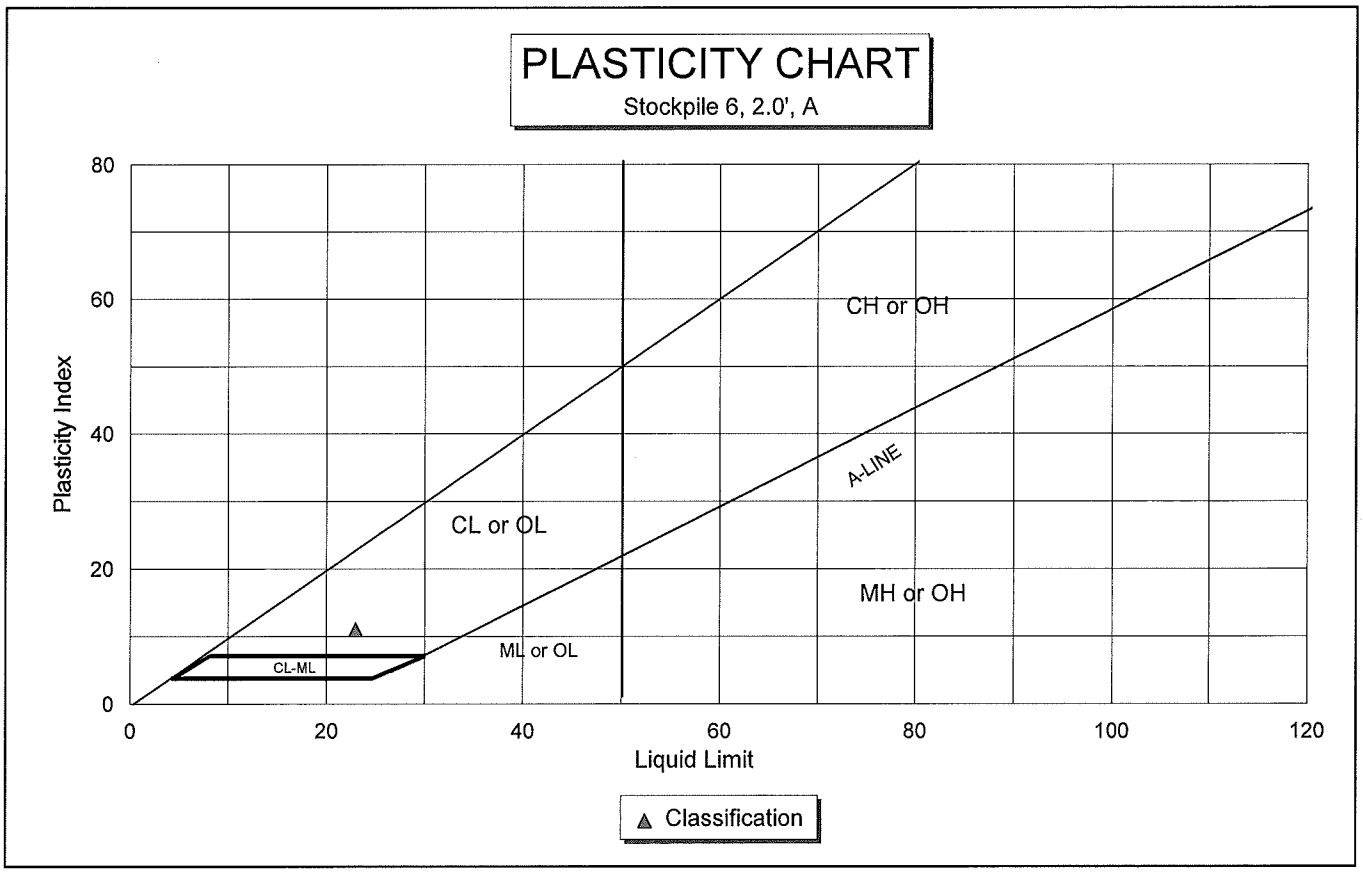
Liquid Limit	23.0
Plastic Limit	12.0
Plasticity Index	11.0

Atterberg Classification CL

Data entry by: LB Date: 11/04/2010
Checked by: [illegible] Date: 11/04/10
FileName: MHG0CKP6

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 6, 2.0', A
Moisture Content
27
26
25
24
23
22
Number of Blows
25


PLASTICITY CHART
Stockpile 6, 2.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 7	DATE SAMPLED	10/12/10
DEPTH	0.0	DATE TESTED	11/05/10 BKL
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2
Wt Dish & Wet Soil	7.12	7.12
Wt Dish & Dry Soil	6.46	6.47
Wt of Moisture	0.66	0.65
Wt of Dish	1.16	1.16
Wt of Dry Soil	5.30	5.31
Moisture Content	12.45	12.24

Liquid Limit Determination — Device Number 1075

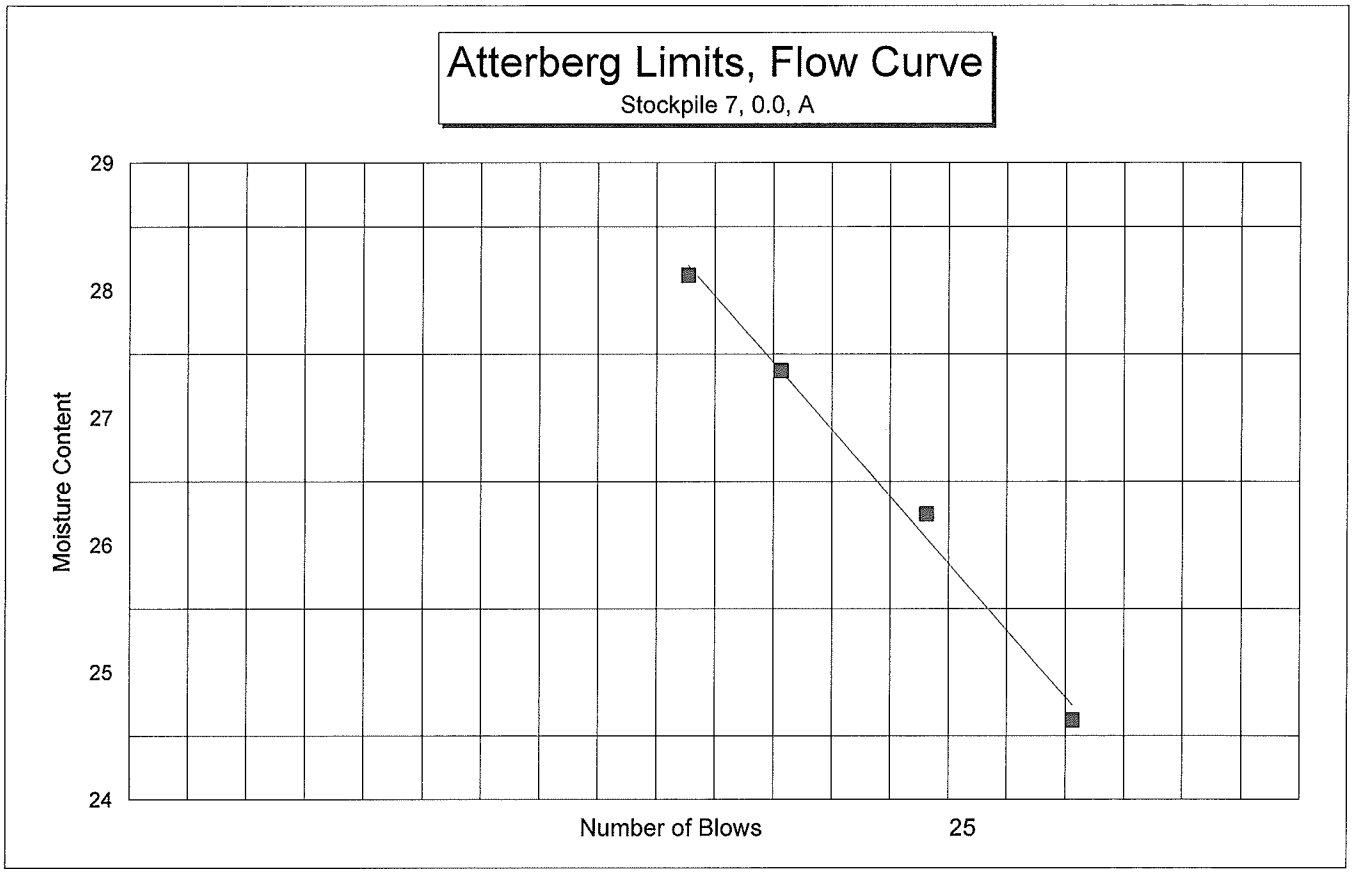
	1	2	3	4
Number of Blows	15	18	24	32
Wt Dish & Wet Soil	10.39	10.65	10.74	10.21
Wt Dish & Dry Soil	8.36	8.60	8.74	8.42
Wt of Moisture	2.03	2.05	2.00	1.79
Wt of Dish	1.14	1.11	1.12	1.15
Wt of Dry Soil	7.22	7.49	7.62	7.27
Moisture Content	28.12	27.37	26.25	24.62

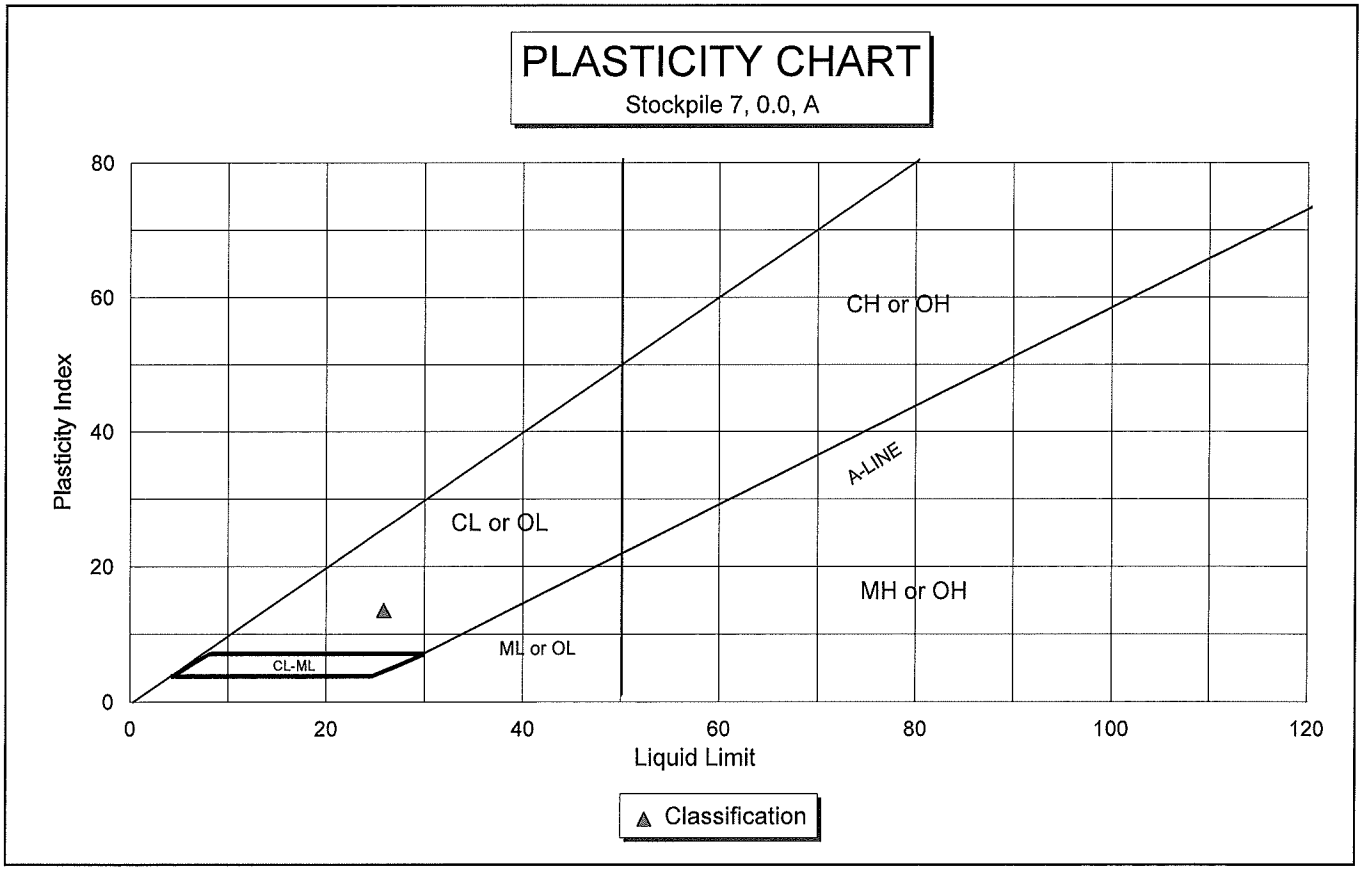
Liquid Limit	25.9
Plastic Limit	12.3
Plasticity Index	13.5

Atterberg Classification CL

Data entry by: MLM Date: 11/08/2010
Checked by: LB Date: 11-09-10
FileName: MHG0S70A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 7, 0.0, A
Moisture Content
29
28
27
26
25
24
Number of Blows
25


PLASTICITY CHART
Stockpile 7, 0.0, A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 8	DATE SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	11/08/10 TMR
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	8.47	8.40	8.40
Wt Dish & Dry Soil	7.74	7.73	7.70
Wt of Moisture	0.73	0.67	0.70
Wt of Dish	1.15	1.14	1.15
Wt of Dry Soil	6.59	6.59	6.55
Moisture Content	11.08	10.17	10.69

Liquid Limit Determination — Device Number 1080

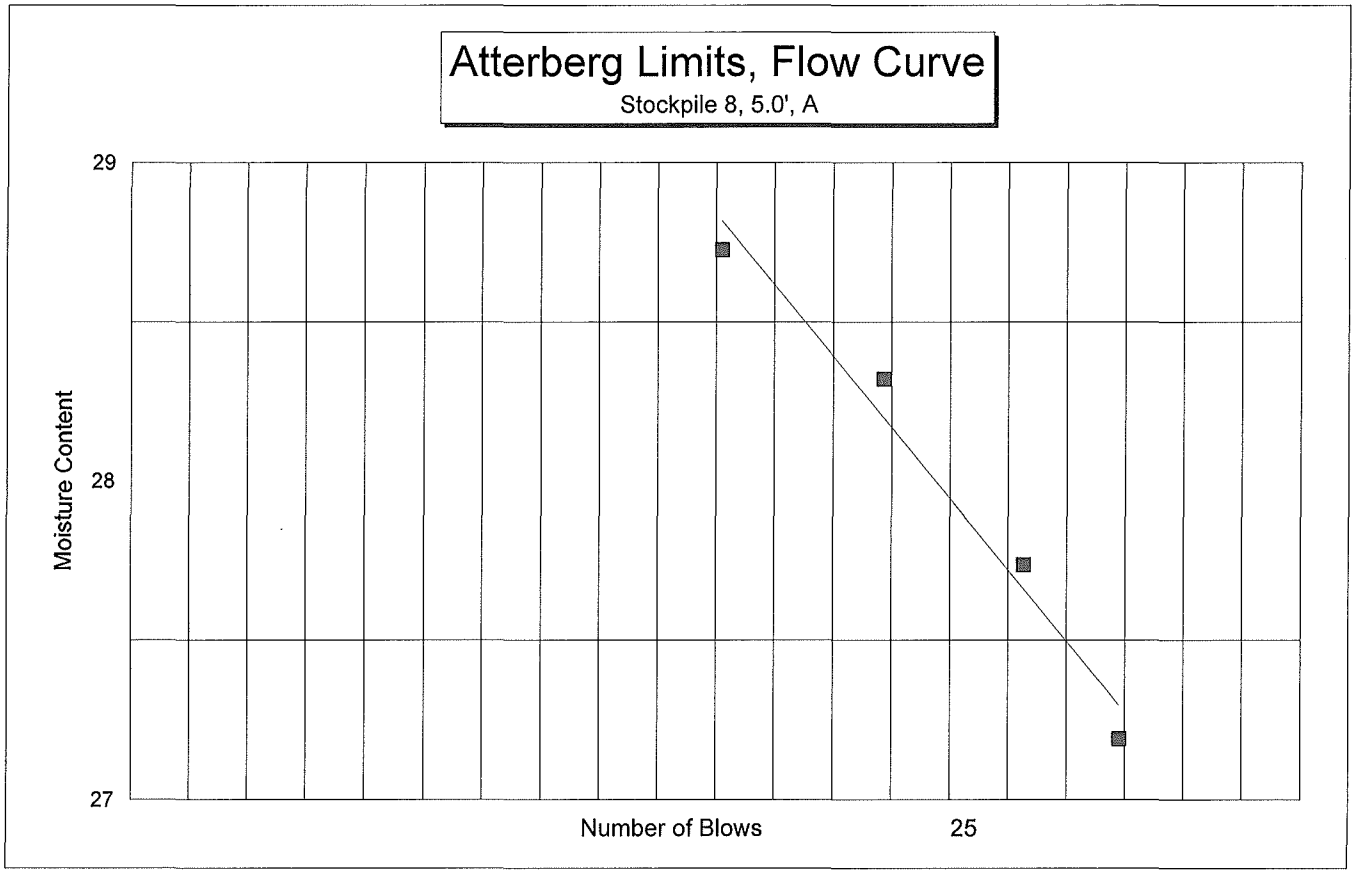
	1	2	3	4
Number of Blows	16	22	29	35
Wt Dish & Wet Soil	10.61	9.91	7.88	13.93
Wt Dish & Dry Soil	8.49	7.97	6.41	11.20
Wt of Moisture	2.12	1.94	1.47	2.73
Wt of Dish	1.11	1.12	1.11	1.16
Wt of Dry Soil	7.38	6.85	5.30	10.04
Moisture Content	28.73	28.32	27.74	27.19

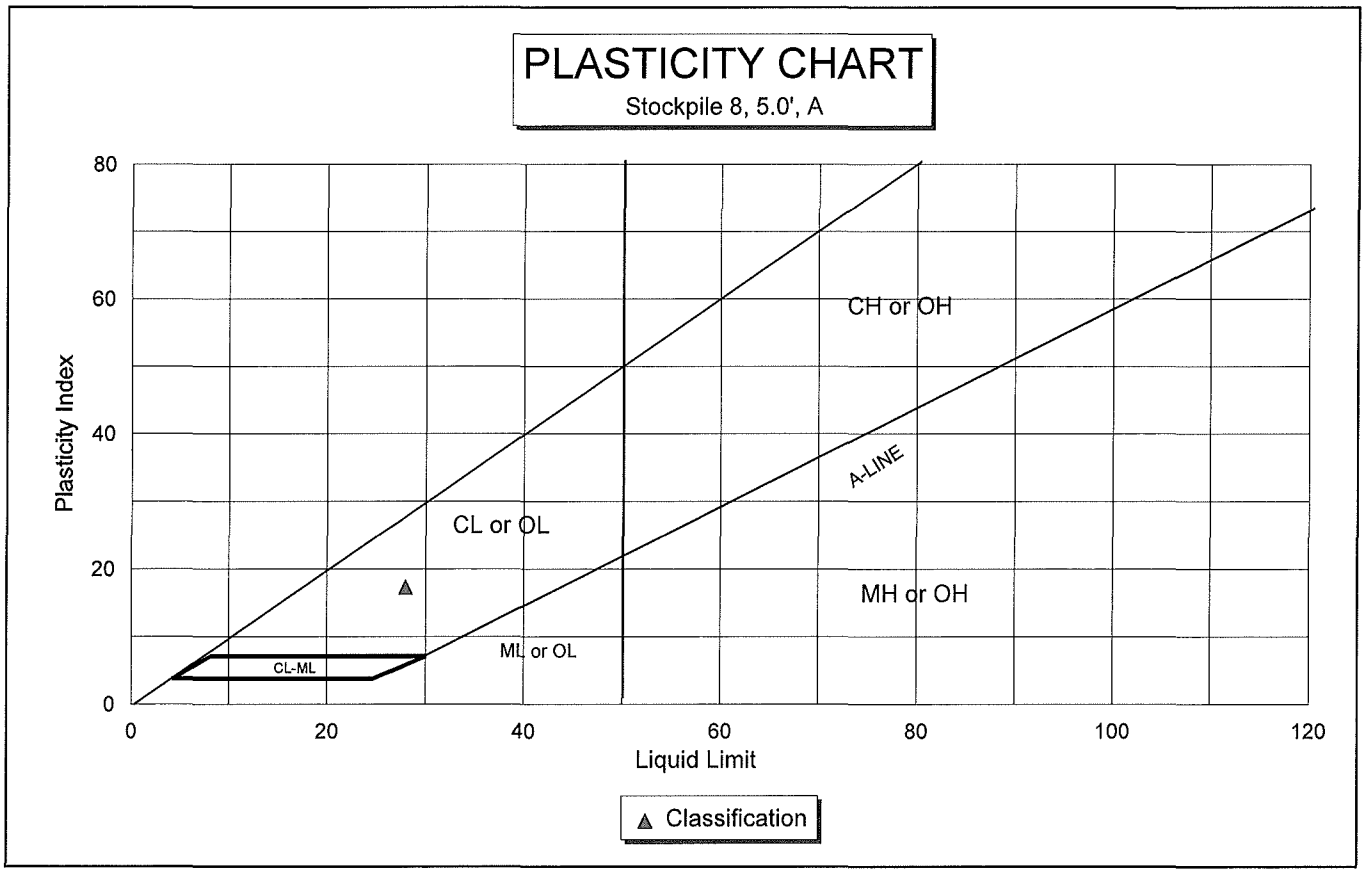
Liquid Limit	28.0
Plastic Limit	10.6
Plasticity Index	17.3

Atterberg Classification CL

Data entry by: MLM Date: 11/09/2010
Checked by: BKC Date: 11/9/10
FileName: MHG0S850

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 8, 5.0', A
29
28
27
Moisture Content
Number of Blows
25


PLASTICITY CHART
Stockpile 8, 5.0', A
80
60
40
20
0
Plasticity Index
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 9	DATE SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	10/27/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.28	10.65	12.42
Wt Dish & Dry Soil	8.97	9.31	10.83
Wt of Moisture	1.31	1.34	1.59
Wt of Dish	1.14	1.13	1.14
Wt of Dry Soil	7.83	8.18	9.69
Moisture Content	16.73	16.38	16.41

Liquid Limit Determination — Device Number 1080

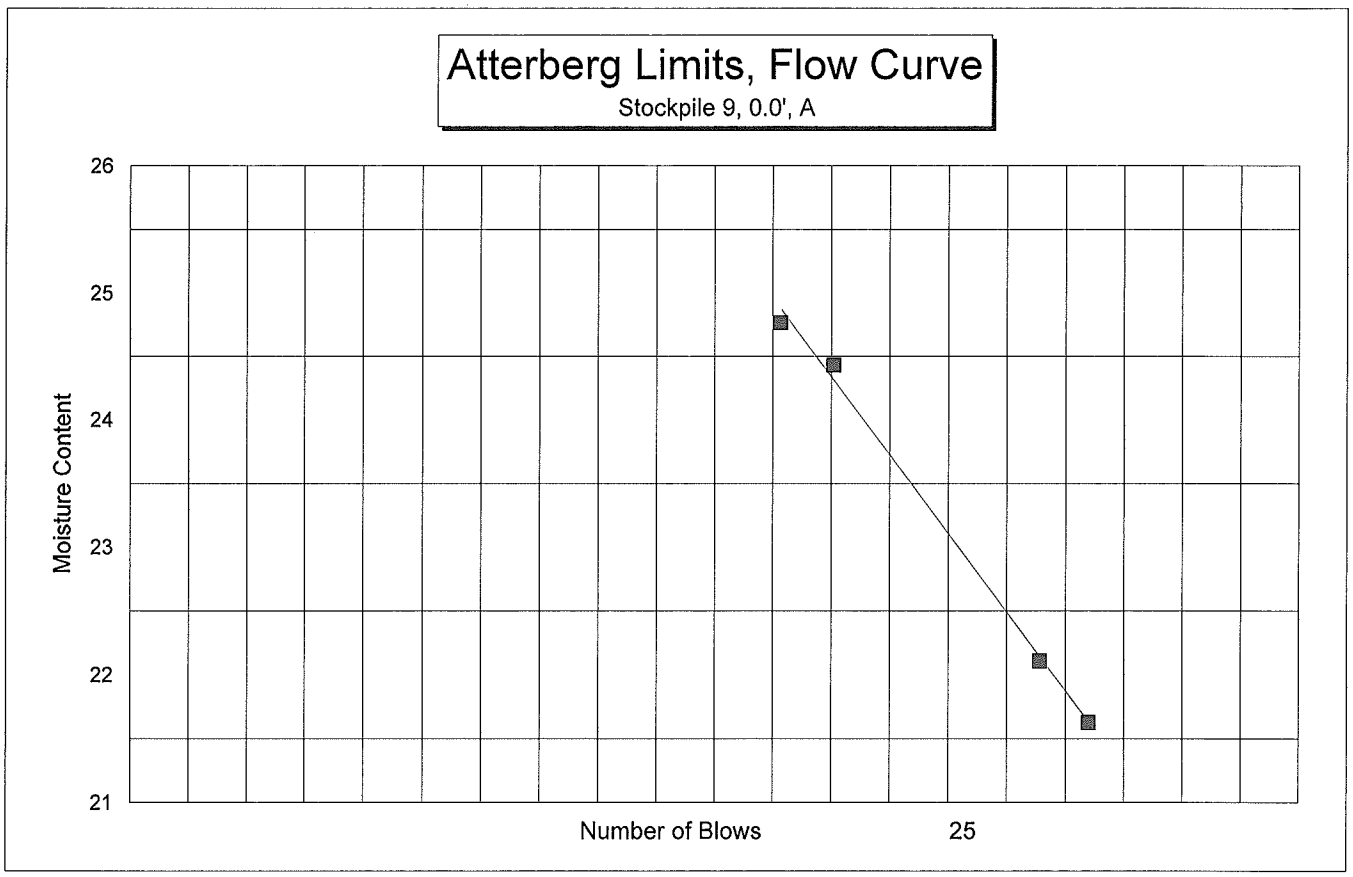
	1	2	3	4
Number of Blows	33	30	18	20
Wt Dish & Wet Soil	12.52	11.80	11.75	10.46
Wt Dish & Dry Soil	10.50	9.87	9.64	8.63
Wt of Moisture	2.02	1.93	2.11	1.83
Wt of Dish	1.16	1.14	1.12	1.14
Wt of Dry Soil	9.34	8.73	8.52	7.49
Moisture Content	21.63	22.11	24.77	24.43

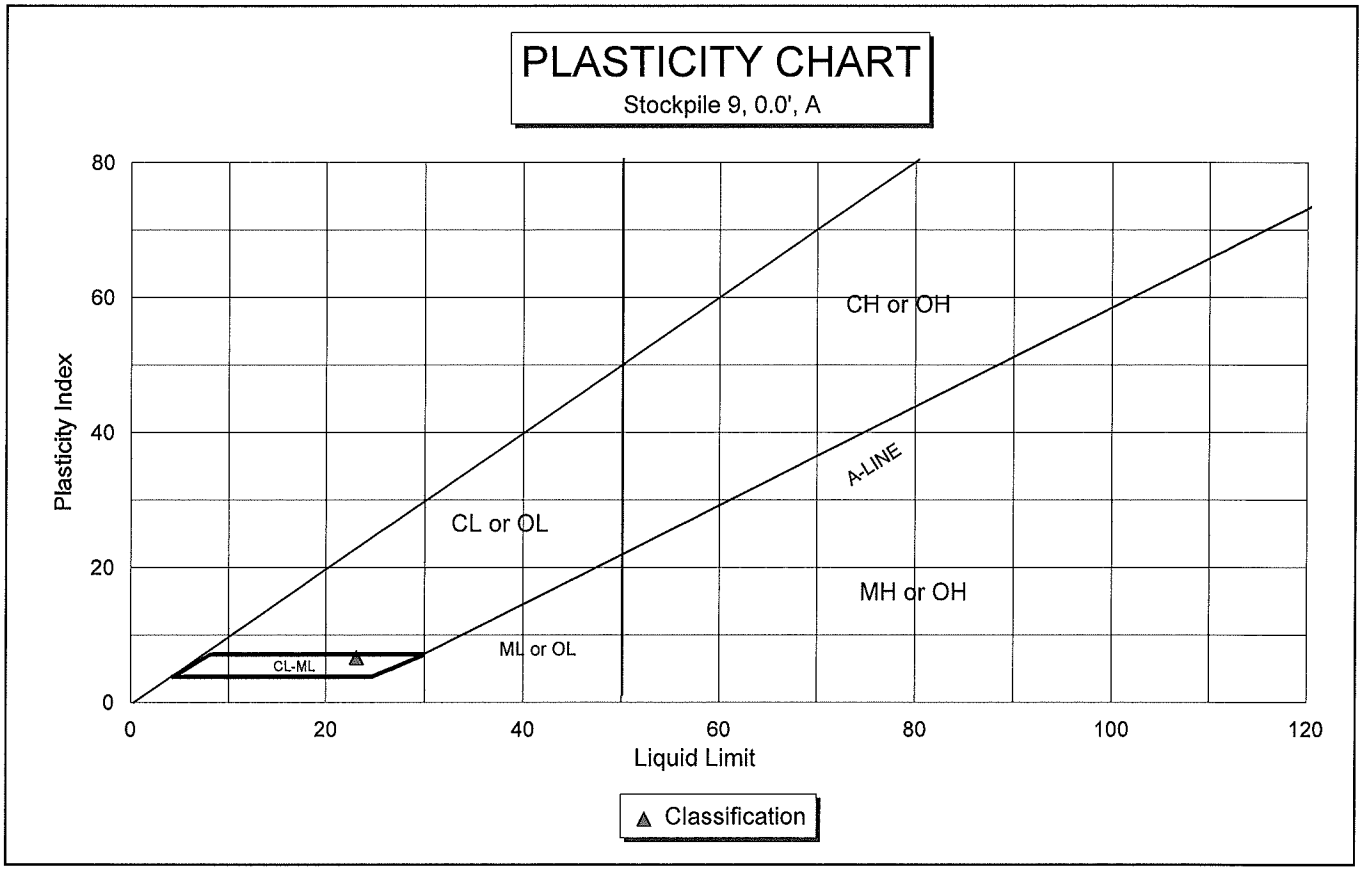
Liquid Limit	23.1
Plastic Limit	16.5
Plasticity Index	6.6

Atterberg Classification CL-ML

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG090A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 9, 0.0', A
Moisture Content
26
25
24
23
22
21
Number of Blows
25


PLASTICITY CHART
Stockpile 9, 0.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 10	DATE SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	10/28/10 PW
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	11.61	12.10	11.57
Wt Dish & Dry Soil	10.05	10.40	9.95
Wt of Moisture	1.56	1.70	1.62
Wt of Dish	1.15	1.08	1.06
Wt of Dry Soil	8.90	9.32	8.89
Moisture Content	17.53	18.24	18.17

Liquid Limit Determination — Device Number 0860

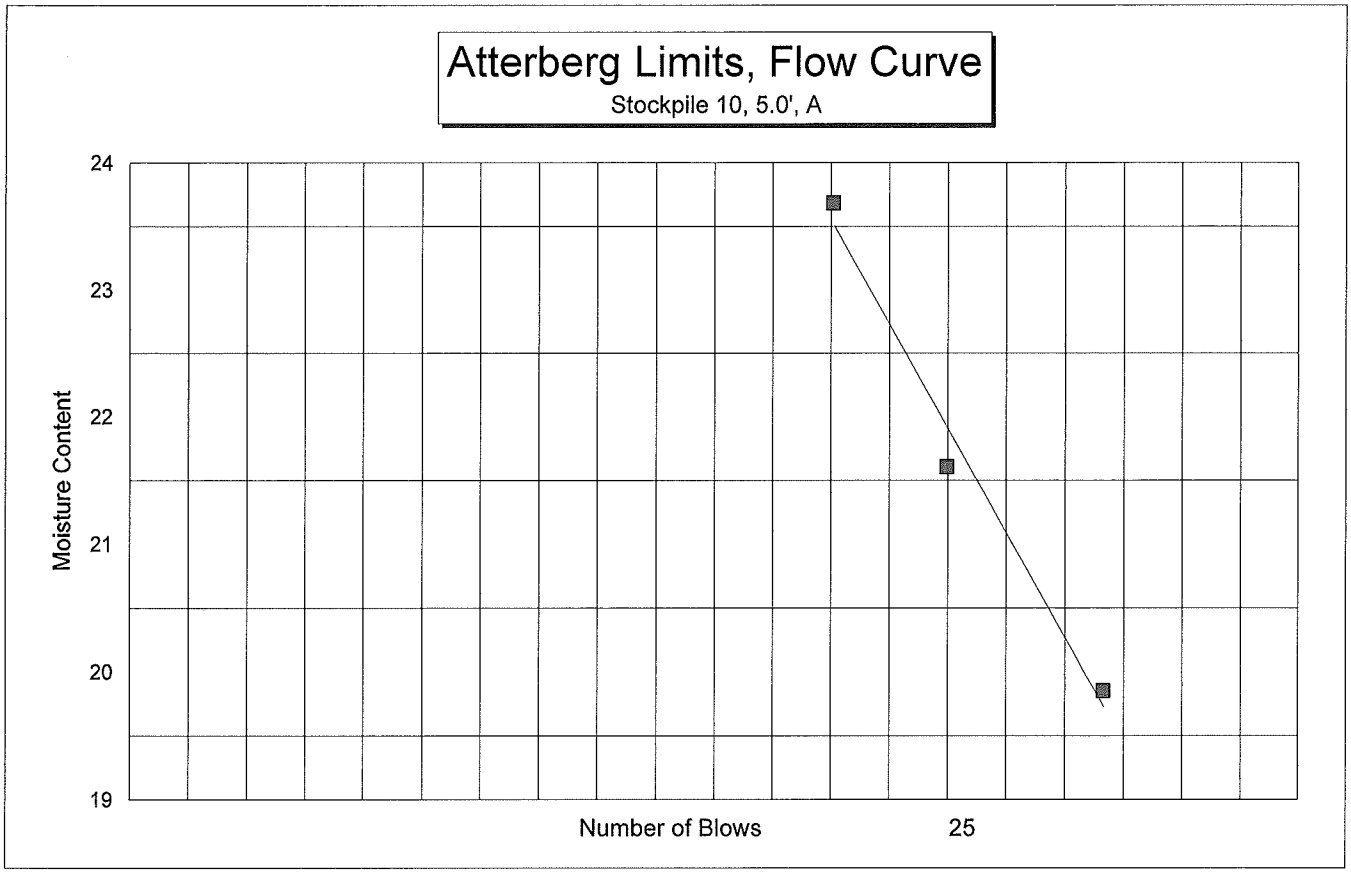
	1	2	3
Number of Blows	34	20	25
Wt Dish & Wet Soil	14.92	15.72	17.87
Wt Dish & Dry Soil	12.64	12.93	14.89
Wt of Moisture	2.28	2.79	2.99
Wt of Dish	1.15	1.15	1.07
Wt of Dry Soil	11.49	11.78	13.82
Moisture Content	19.85	23.68	21.61

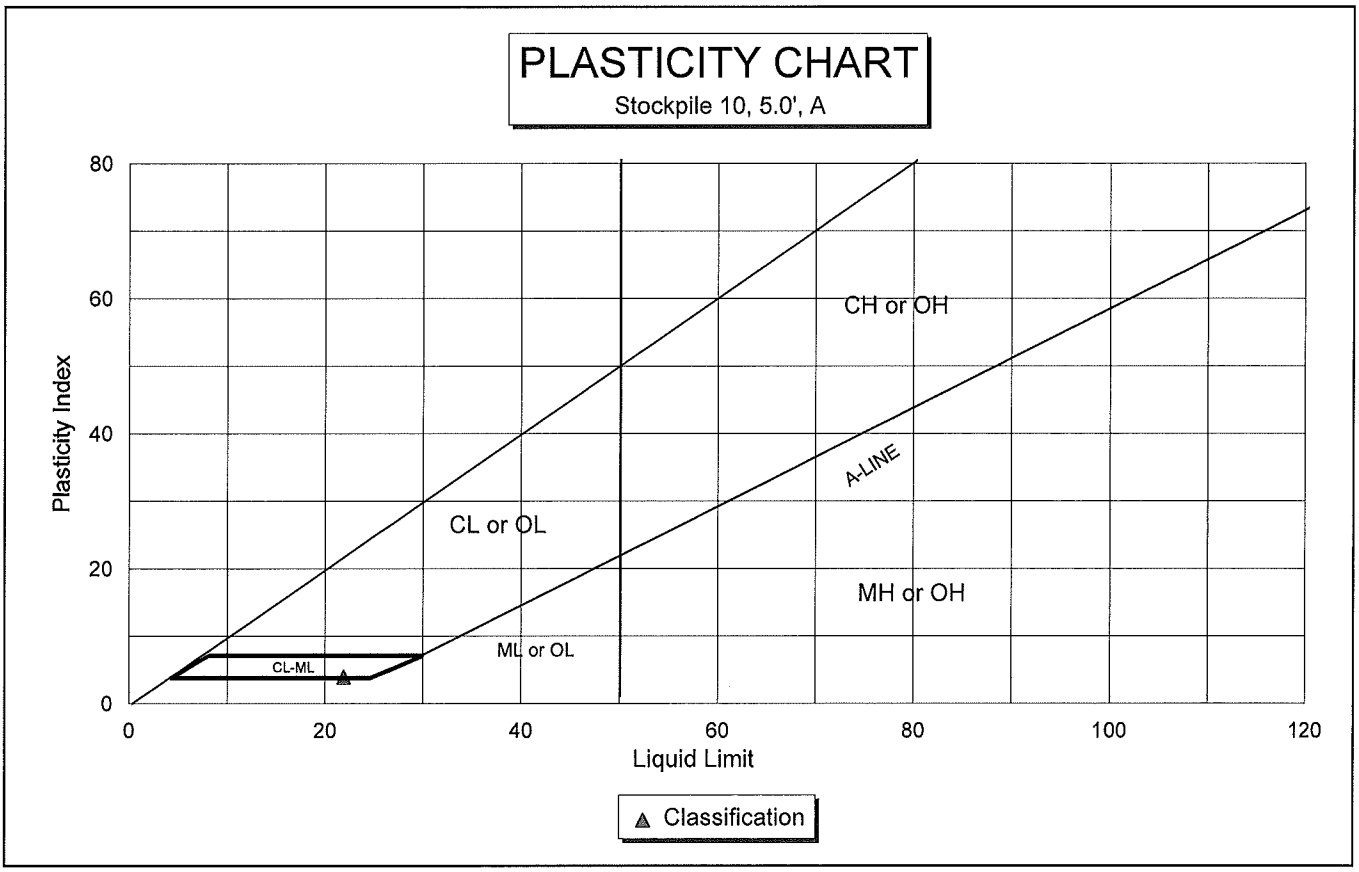
Liquid Limit	21.9
Plastic Limit	18.0
Plasticity Index	3.9

Atterberg Classification ML

Data entry by: MLM Date: 10/29/2010
Checked by: BKL Date: 10/29/10
FileName: MHG0105A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 10, 5.0', A
Moisture Content
24
23
22
21
20
19
Number of Blows
25


PLASTICITY CHART
Stockpile 10, 5.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 11	DATE SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	11/05/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	11.41	13.44	12.03
Wt Dish & Dry Soil	9.95	11.71	10.55
Wt of Moisture	1.46	1.73	1.48
Wt of Dish	1.14	1.12	1.15
Wt of Dry Soil	8.81	10.59	9.40
Moisture Content	16.57	16.34	15.74

Liquid Limit Determination — Device Number 1080

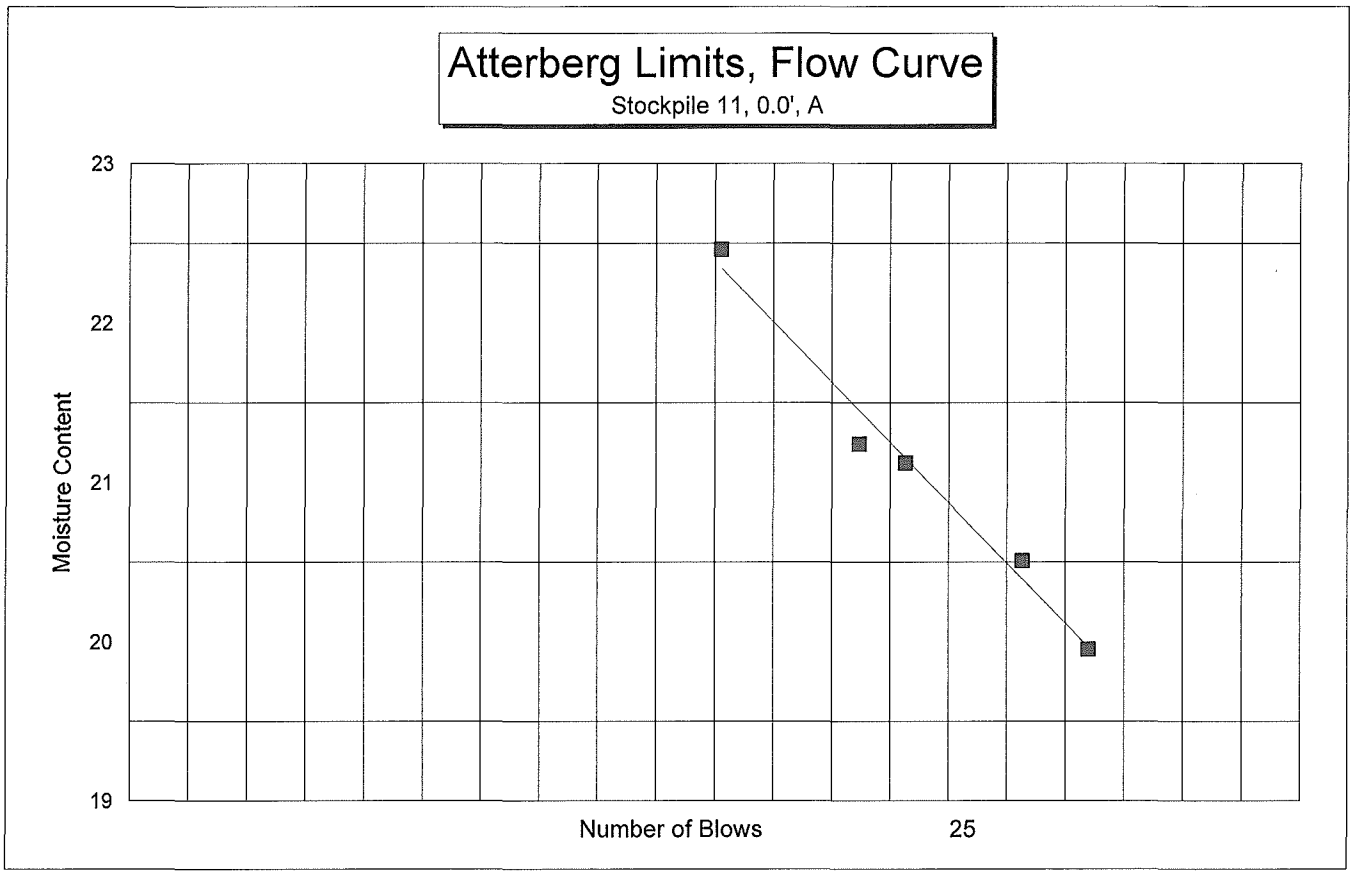
	1	2	3	4	5
Number of Blows	33	29	23	21	16
Wt Dish & Wet Soil	16.83	14.89	14.74	14.62	14.29
Wt Dish & Dry Soil	14.22	12.55	12.37	12.26	11.88
Wt of Moisture	2.61	2.34	2.37	2.36	2.41
Wt of Dish	1.14	1.14	1.15	1.15	1.15
Wt of Dry Soil	13.08	11.41	11.22	11.11	10.73
Moisture Content	19.95	20.51	21.12	21.24	22.46

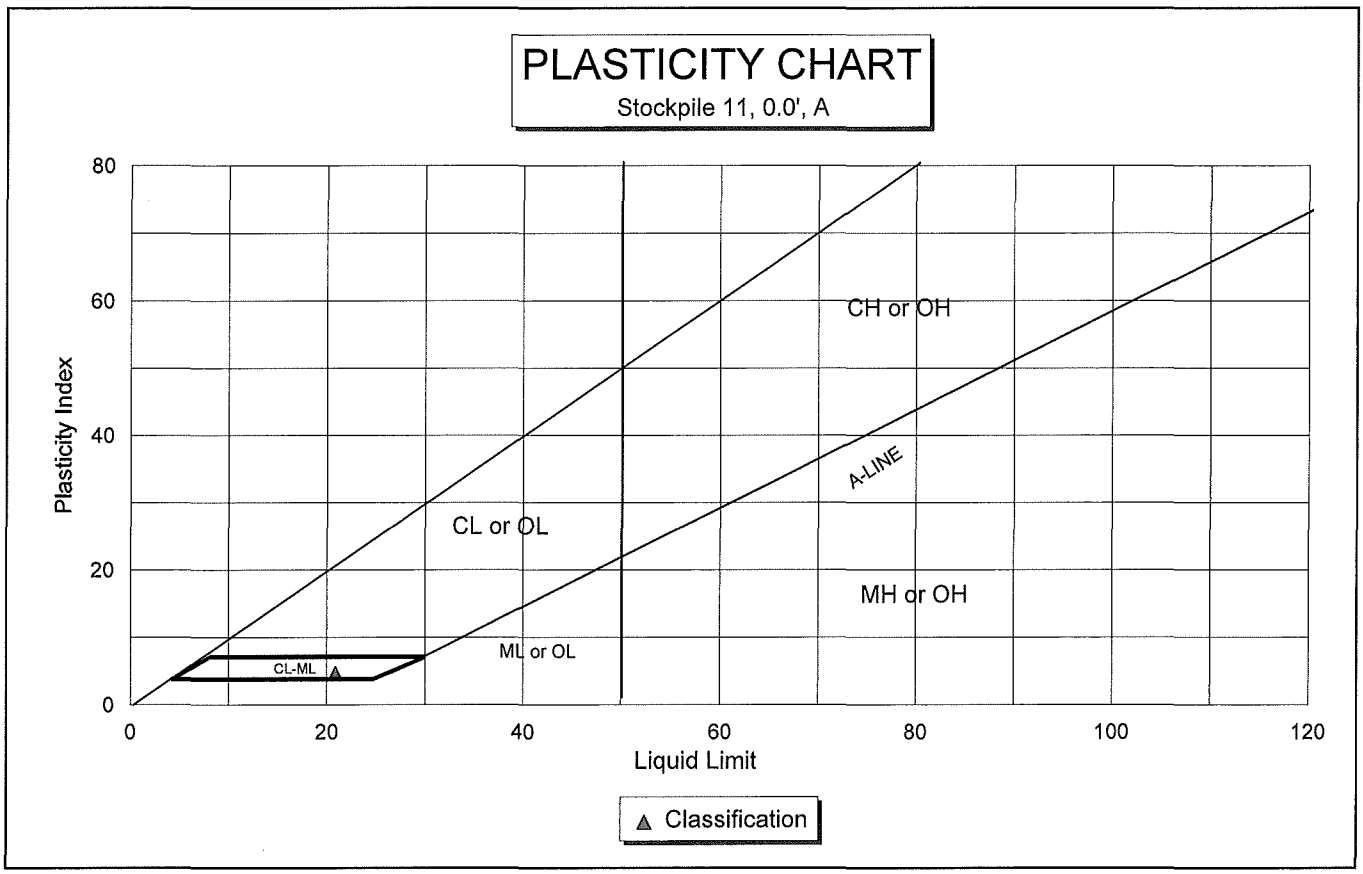
Liquid Limit	20.9
Plastic Limit	16.2
Plasticity Index	4.7

Atterberg Classification CL-ML

Data entry by: MLM Date: 11/08/2010
Checked by: LB Date: 11-09-10
FileName: MHG0S11A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 11, 0.0', A
Moisture Content
23
22
21
20
19
Number of Blows
25


PLASTICITY CHART
Stockpile 11, 0.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 12	DATE SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	10/27/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2
Wt Dish & Wet Soil	13.07	15.00
Wt Dish & Dry Soil	11.56	13.25
Wt of Moisture	1.51	1.75
Wt of Dish	1.13	1.12
Wt of Dry Soil	10.43	12.13
Moisture Content	14.48	14.43

Liquid Limit Determination — Device Number 1080

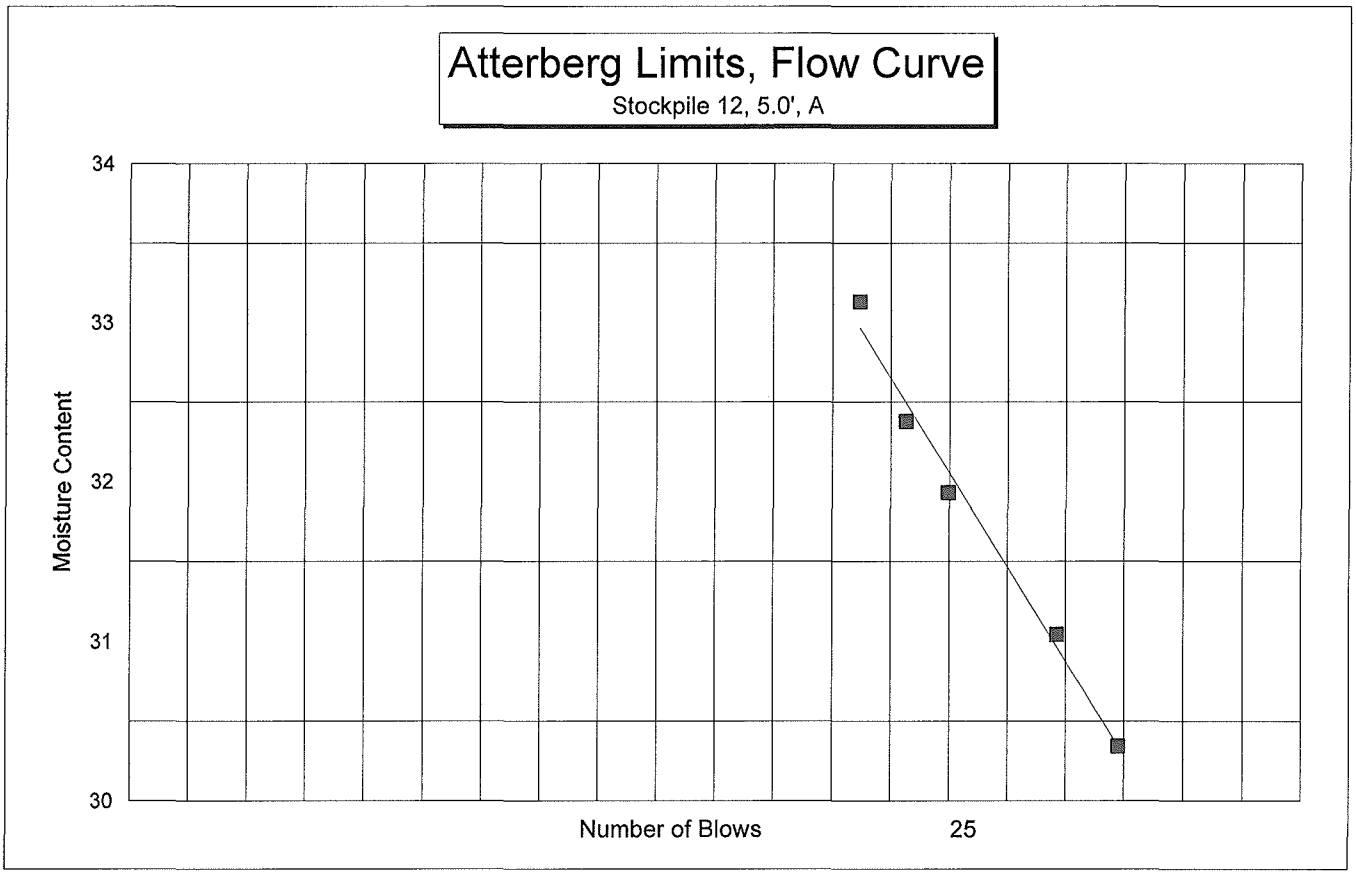
	1	2	3	4	5
Number of Blows	35	31	25	23	21
Wt Dish & Wet Soil	10.60	10.67	10.86	10.85	9.88
Wt Dish & Dry Soil	8.40	8.41	8.51	8.48	7.71
Wt of Moisture	2.20	2.26	2.35	2.37	2.17
Wt of Dish	1.15	1.13	1.15	1.16	1.16
Wt of Dry Soil	7.25	7.28	7.36	7.32	6.55
Moisture Content	30.34	31.04	31.93	32.38	33.13

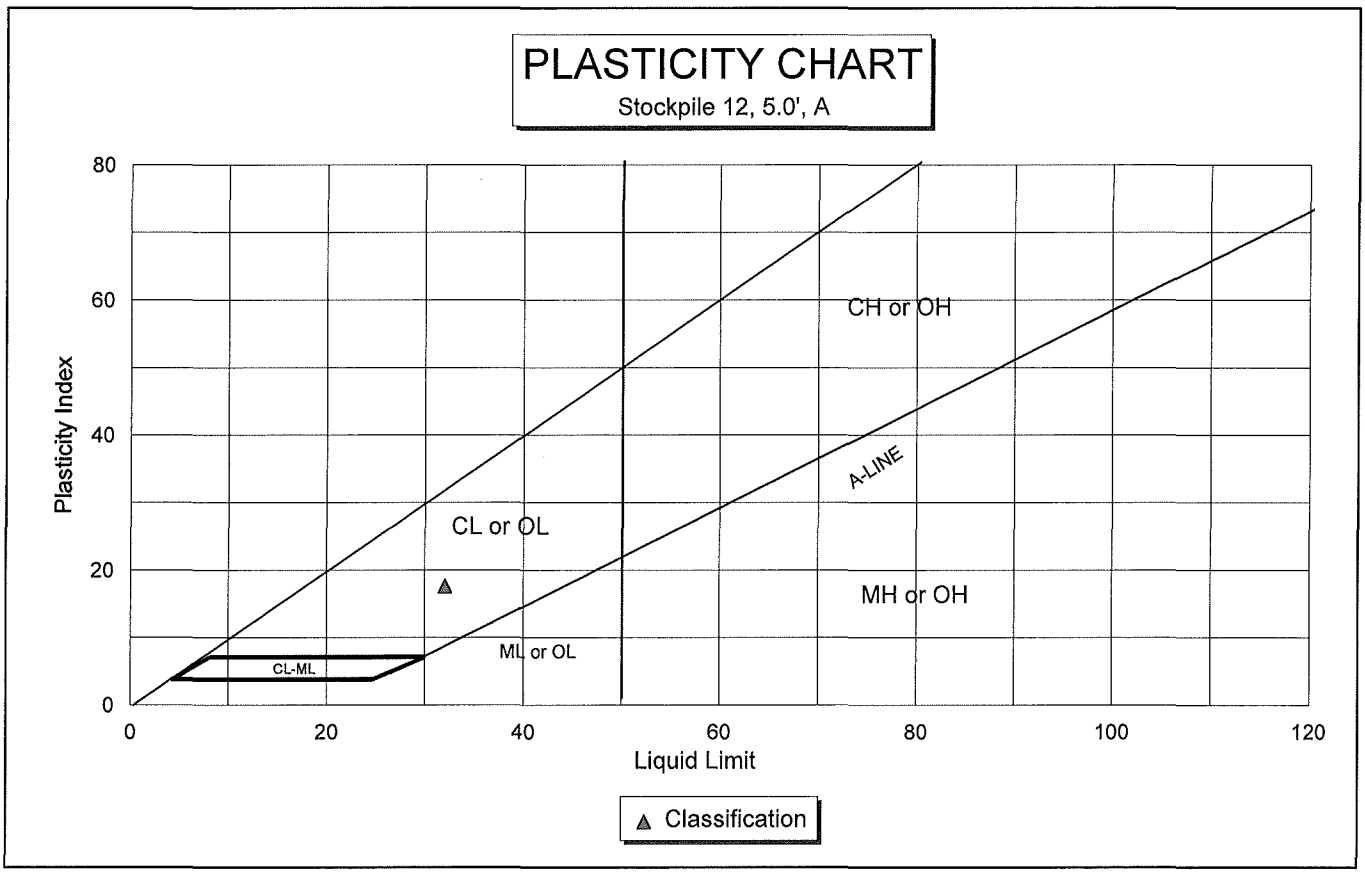
Liquid Limit	32.1
Plastic Limit	14.5
Plasticity Index	17.6

Atterberg Classification CL

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG01250

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 12, 5.0', A
Moisture Content
34
33
32
31
30
Number of Blows
25


PLASTICITY CHART
Stockpile 12, 5.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 13	DATE SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	10/27/10 MLM
SAMPLE NO.	A		
SOIL DESCR.	1009740		
LOCATION	Denison White Mesa Mill Project		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.58	11.06	10.25
Wt Dish & Dry Soil	9.48	9.93	9.18
Wt of Moisture	1.10	1.13	1.07
Wt of Dish	1.12	1.14	1.12
Wt of Dry Soil	8.36	8.79	8.06
Moisture Content	13.16	12.86	13.28

Liquid Limit Determination — Device Number 1080

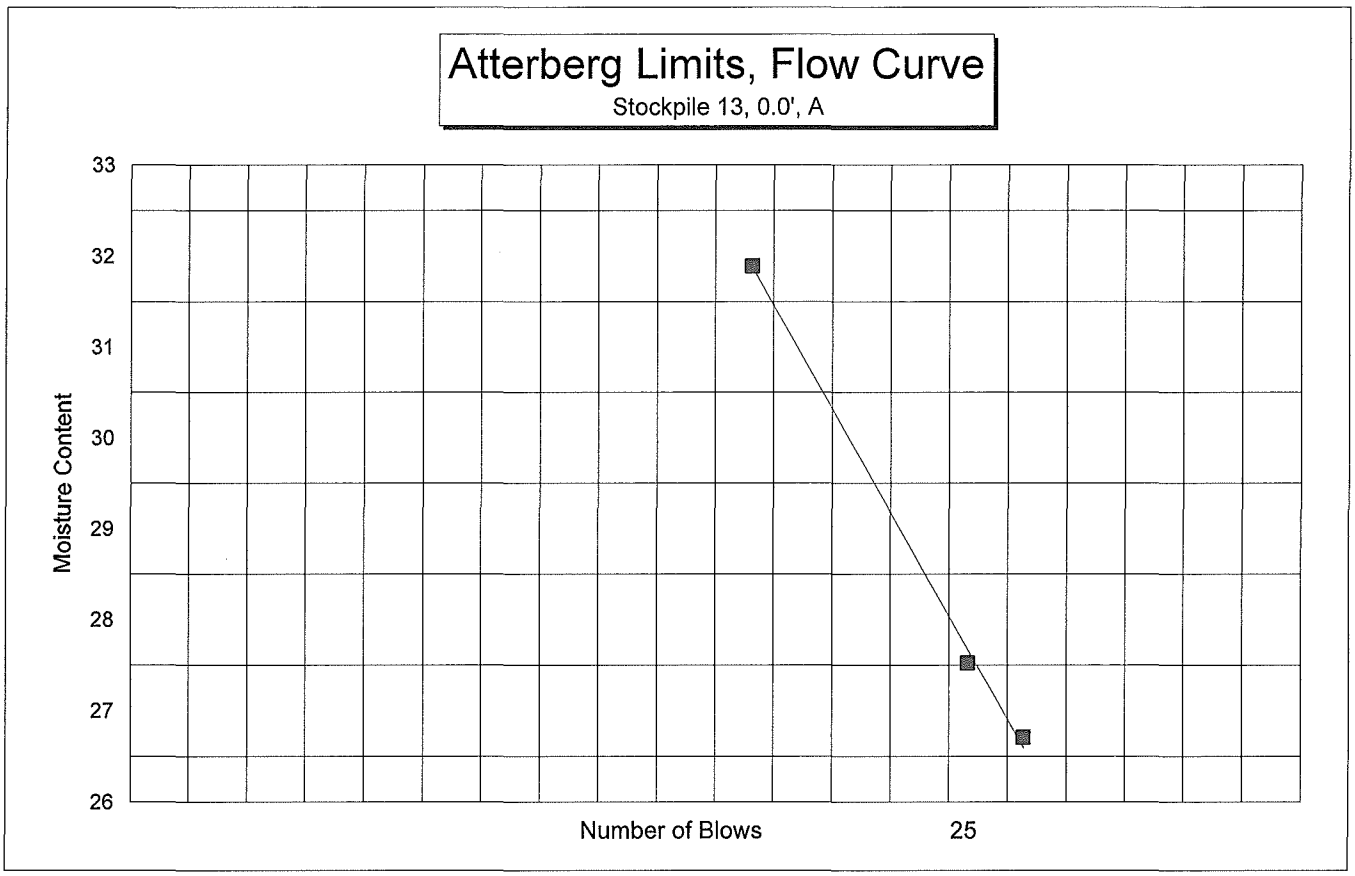
	1	2	3
Number of Blows	29	26	17
Wt Dish & Wet Soil	11.35	11.77	11.20
Wt Dish & Dry Soil	9.20	9.48	8.77
Wt of Moisture	2.15	2.29	2.43
Wt of Dish	1.15	1.16	1.15
Wt of Dry Soil	8.05	8.32	7.62
Moisture Content	26.71	27.52	31.89

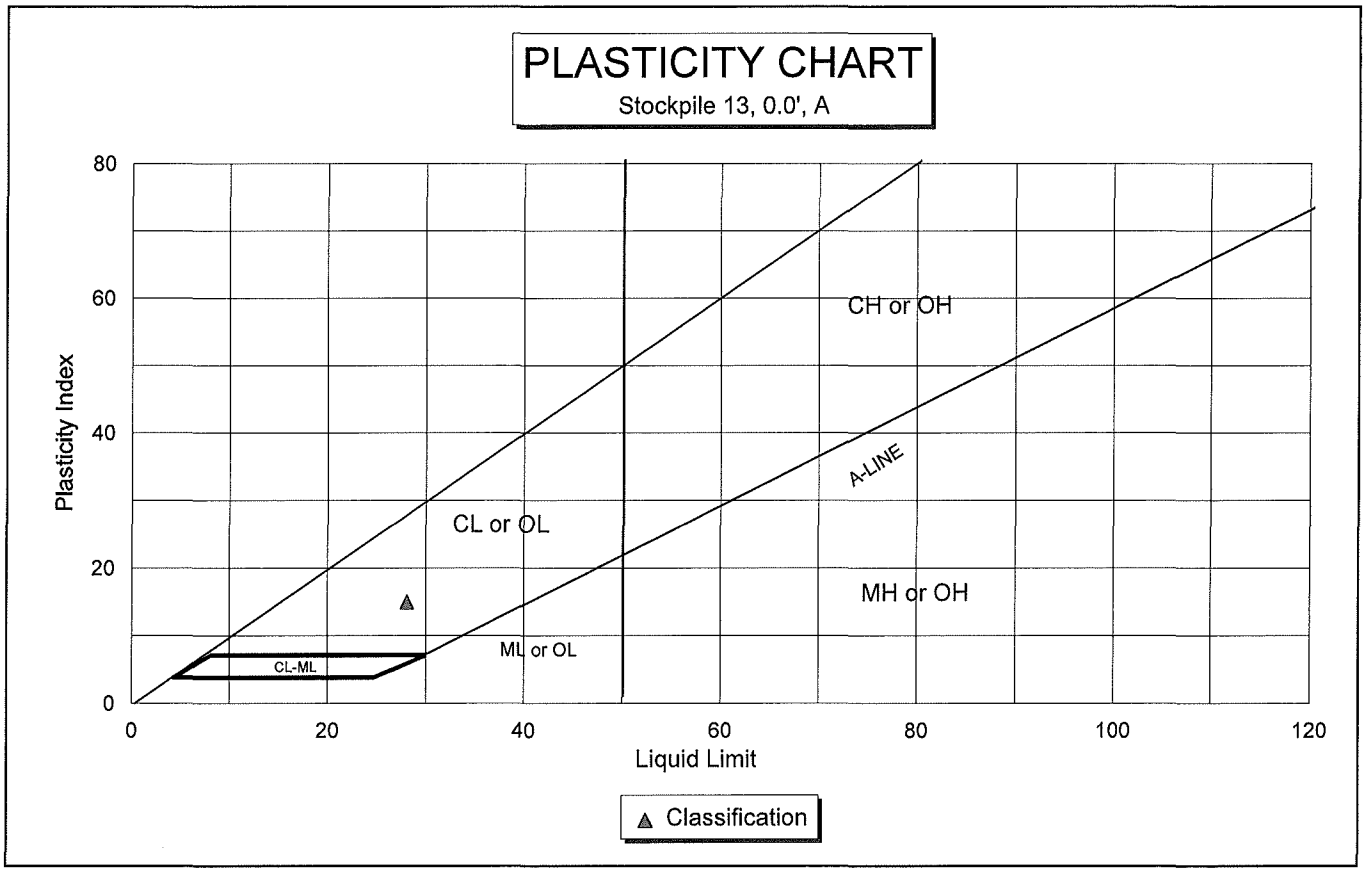
Liquid Limit	28.1
Plastic Limit	13.1
Plasticity Index	15.0

Atterberg Classification CL

Data entry by: MLM Date: 10/28/2010
Checked by: BKL Date: 10/28/10
FileName: MHG0130A

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
Stockpile 13, 0.0', A
Moisture Content
33
32
31
30
29
28
27
26
Number of Blows
25


PLASTICITY CHART
Stockpile 13, 0.0', A
Plasticity Index
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

MECHANICAL ANALYSIS
WITH HYDROMETER
ASTM D 422

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A South	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	112.71
Wt. Dry Soil & Pan (g)	111.29
Wt. Lost Moisture (g)	1.42
Wt. of Pan Only (g)	3.23
Wt. of Dry Soil (g)	108.06
Moisture Content %	1.3
Wt. Hydrom. Sample Wet (g)	69.24
Wt. Hydrom. Sample Dry (g)	68.34

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	2215.88
Weight of + #10 Before Washing (g)	20.38
Weight of + #10 After Washing (g)	18.67
Weight of - #10 Wet (g)	2195.50
Weight of - #10 Dry (g)	2168.71
Wt. Total Sample Dry (g)	2187.38
Calc. Wt. "W" (g)	68.93
Calc. Mass + #10	0.59

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	6.84	6.84	6.84	0.3	99.7
#4	0.00	3.97	3.97	10.81	0.5	99.5
#10	0.00	7.86	7.86	18.67	0.9	99.1
#20	1.76	4.38	2.62	2.62	4.7	95.3
#40	1.79	13.48	11.69	14.31	21.6	78.4
#60	1.74	25.97	24.23	38.54	56.8	43.2
#100	1.77	11.13	9.36	47.90	70.3	29.7
#200	1.77	6.76	4.99	52.89	77.6	22.4

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS1AS

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A South	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

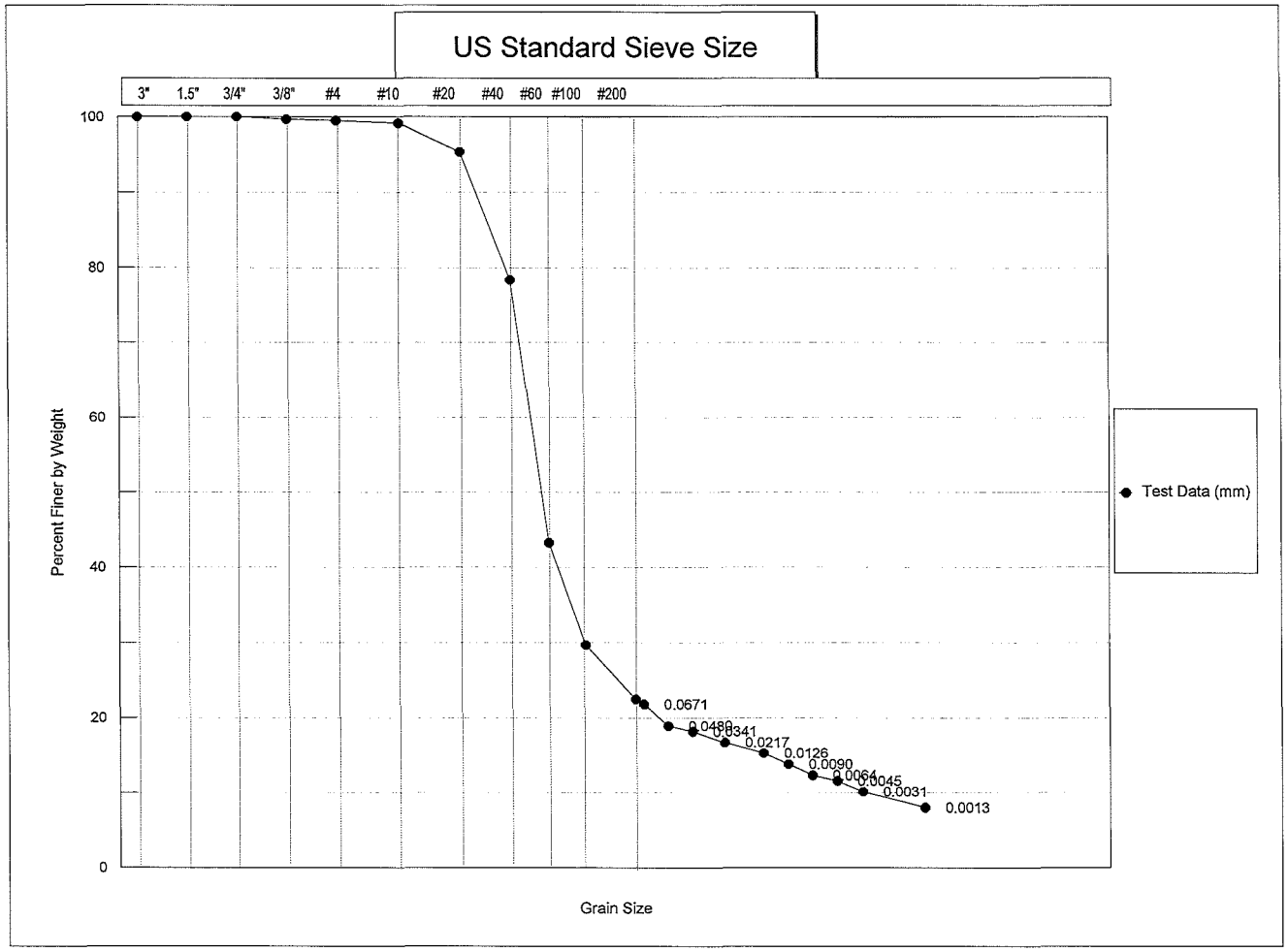
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.1
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01315
Value of "alpha"	1.00	Wt. Dry Sample "W"	68.930
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	20.00	15.00	21.8	21.8	13.01	0.0671
1.0	18.00	13.00	18.9	18.9	13.34	0.0480
2.0	17.50	12.50	18.1	18.1	13.42	0.0341
5.0	16.50	11.50	16.7	16.7	13.58	0.0217
15.0	15.50	10.50	15.2	15.2	13.75	0.0126
30.0	14.50	9.50	13.8	13.8	13.91	0.0090
60.0	13.50	8.50	12.3	12.3	14.08	0.0064
120.0	13.00	8.00	11.6	11.6	14.16	0.0045
250.0	12.00	7.00	10.2	10.2	14.32	0.0031
1440.0	10.50	5.50	8.0	8.0	14.57	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by:_____ Date:_____
FileName: MHHYS1AS

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 1
Depth: 5.0'

Sample No.: A South

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	SAMPLED	10/12/10 --
DEPTH	12.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	B South	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	104.78
Wt. Dry Soil & Pan (g)	102.31
Wt. Lost Moisture (g)	2.47
Wt. of Pan Only (g)	3.07
Wt. of Dry Soil (g)	99.24
Moisture Content %	2.5
Wt. Hydrom. Sample Wet (g)	63.26
Wt. Hydrom. Sample Dry (g)	61.72

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	2715.20
Weight of + #10 Before Washing (g)	373.00
Weight of + #10 After Washing (g)	355.13
Weight of - #10 Wet (g)	2342.20
Weight of - #10 Dry (g)	2302.76
Wt. Total Sample Dry (g)	2657.89
Calc. Wt. "W" (g)	71.24
Calc. Mass + #10	9.52

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	177.82	177.82	177.82	6.7	93.3
3/4"	0.00	165.87	165.87	343.69	12.9	87.1
3/8"	0.00	2.41	2.41	346.10	13.0	87.0
#4	0.00	1.85	1.85	347.95	13.1	86.9
#10	0.00	7.18	7.18	355.13	13.4	86.6
#20	1.78	2.64	0.86	0.86	14.6	85.4
#40	1.83	6.50	4.67	5.53	21.1	78.9
#60	1.78	15.80	14.02	19.55	40.8	59.2
#100	1.78	9.73	7.95	27.50	52.0	48.0
#200	1.74	9.87	8.13	35.63	63.4	36.6

Data entered by: MLM Date: 11/04/2010
Data checked by: KP Date: 11/4/10
FileName: MHHYS112

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 1	SAMPLED	10/12/10 --
DEPTH	12.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	B South	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

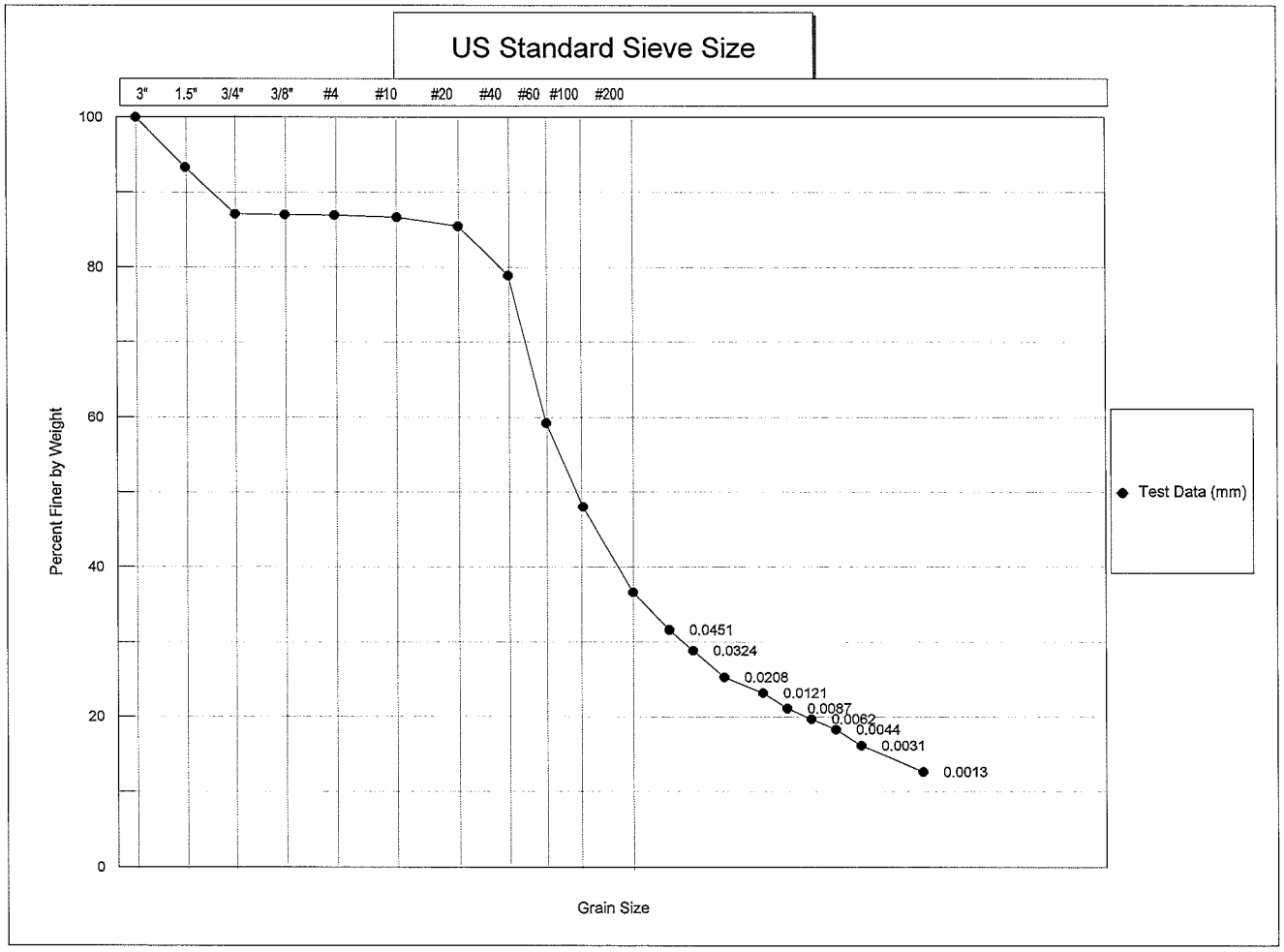
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.1
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01315
Value of "alpha"	1.00	Wt. Dry Sample "W"	71.241
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	--	--	--	--	--	--
1.0	27.50	22.50	31.6	31.6	11.78	0.0451
2.0	25.50	20.50	28.8	28.8	12.11	0.0324
5.0	23.00	18.00	25.3	25.3	12.52	0.0208
15.0	21.50	16.50	23.2	23.2	12.76	0.0121
30.0	20.00	15.00	21.1	21.1	13.01	0.0087
60.0	19.00	14.00	19.7	19.7	13.17	0.0062
120.0	18.00	13.00	18.2	18.2	13.34	0.0044
250.0	16.50	11.50	16.1	16.1	13.58	0.0031
1440.0	14.00	9.00	12.6	12.6	13.99	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by:_____ Date:_____
FileName: MHHYS112

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 1
Depth: 12.0'
Sample No.: B South
Classification: **Classification Not Performed**

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 2	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	101.41
Wt. Dry Soil & Pan (g)	97.96
Wt. Lost Moisture (g)	3.45
Wt. of Pan Only (g)	3.14
Wt. of Dry Soil (g)	94.82
Moisture Content %	3.6
Wt. Hydrom. Sample Wet (g)	60.53
Wt. Hydrom. Sample Dry (g)	58.40

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1717.36
Weight of + #10 Before Washing (g)	2.66
Weight of + #10 After Washing (g)	2.52
Weight of - #10 Wet (g)	1714.70
Weight of - #10 Dry (g)	1654.64
Wt. Total Sample Dry (g)	1657.16
Calc. Wt. "W" (g)	58.49
Calc. Mass + #10	0.09

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.99	0.99	0.99	0.1	99.9
#10	0.00	1.53	1.53	2.52	0.2	99.8
#20	1.79	2.37	0.58	0.58	1.1	98.9
#40	1.74	2.41	0.67	1.25	2.3	97.7
#60	1.77	3.27	1.50	2.75	4.9	95.1
#100	1.76	4.29	2.53	5.28	9.2	90.8
#200	1.78	20.51	18.73	24.01	41.2	58.8

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS25A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 2	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

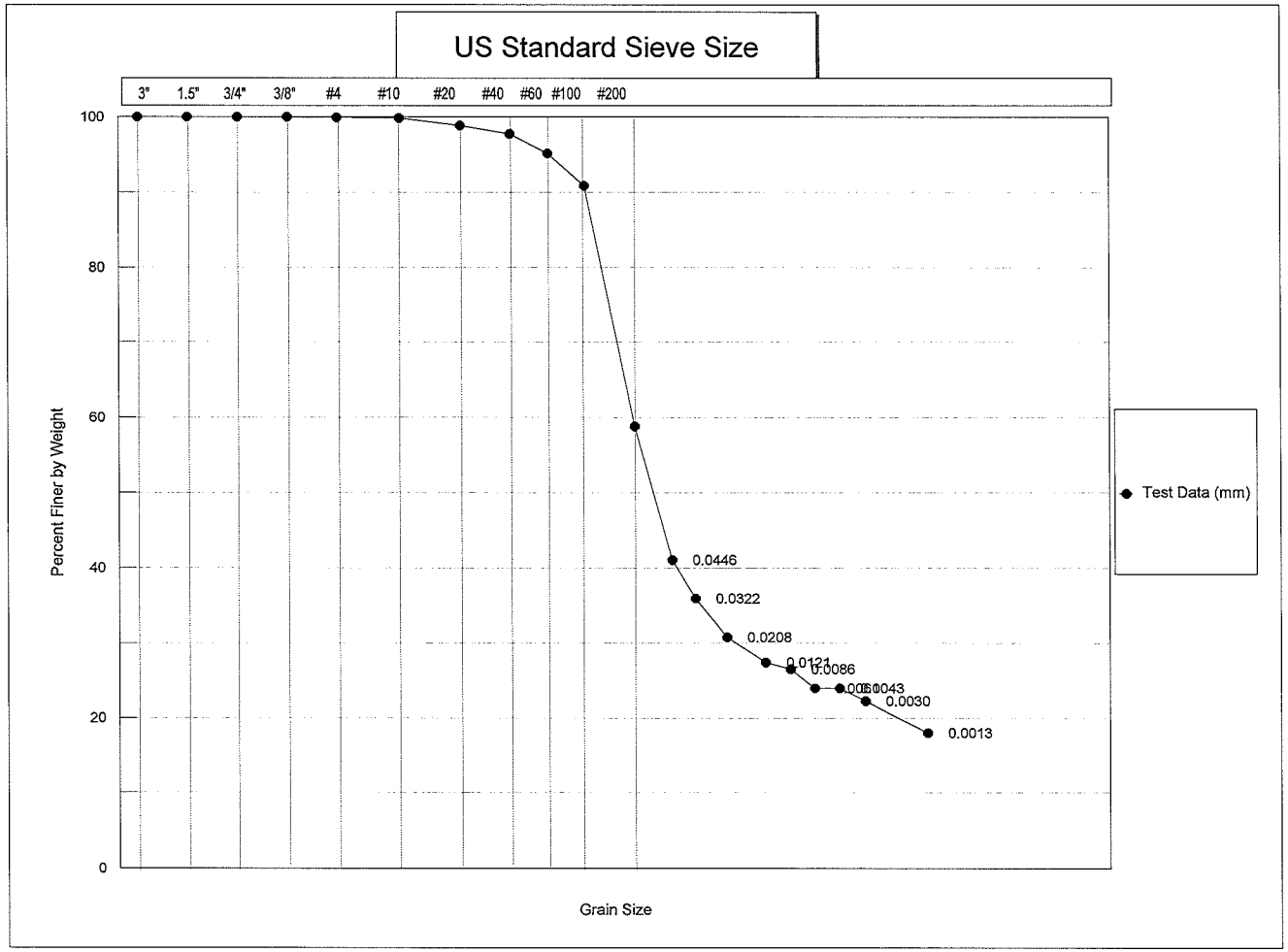
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.3
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01312
Value of "alpha"	1.00	Wt. Dry Sample "W"	58.489
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	--	--	--	--	--	--
1.0	29.00	24.00	41.0	41.0	11.53	0.0446
2.0	26.00	21.00	35.9	35.9	12.03	0.0322
5.0	23.00	18.00	30.8	30.8	12.52	0.0208
15.0	21.00	16.00	27.4	27.4	12.85	0.0121
30.0	20.50	15.50	26.5	26.5	12.93	0.0086
60.0	19.00	14.00	23.9	23.9	13.17	0.0061
120.0	19.00	14.00	23.9	23.9	13.17	0.0043
250.0	18.00	13.00	22.2	22.2	13.34	0.0030
1451.0	15.50	10.50	18.0	18.0	13.75	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS25A

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 2
Depth: 5.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 3	SAMPLED	10/12/10 --
DEPTH	6.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	83.64
Wt. Dry Soil & Pan (g)	80.02
Wt. Lost Moisture (g)	3.62
Wt. of Pan Only (g)	2.99
Wt. of Dry Soil (g)	77.03
Moisture Content %	4.7
Wt. Hydrom. Sample Wet (g)	63.20
Wt. Hydrom. Sample Dry (g)	60.36

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	2309.30
Weight of + #10 Before Washing (g)	2.80
Weight of + #10 After Washing (g)	2.03
Weight of - #10 Wet (g)	2306.50
Weight of - #10 Dry (g)	2203.71
Wt. Total Sample Dry (g)	2205.74
Calc. Wt. "W" (g)	60.42
Calc. Mass + #10	0.06

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.73	0.73	0.73	0.0	100.0
#10	0.00	1.30	1.30	2.03	0.1	99.9
#20	1.77	2.20	0.43	0.43	0.8	99.2
#40	1.77	2.58	0.81	1.24	2.1	97.9
#60	1.81	4.70	2.89	4.13	6.9	93.1
#100	1.73	9.08	7.35	11.48	19.1	80.9
#200	1.78	11.67	9.89	21.37	35.5	64.5

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS36A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 3	SAMPLED	10/12/10 --
DEPTH	6.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

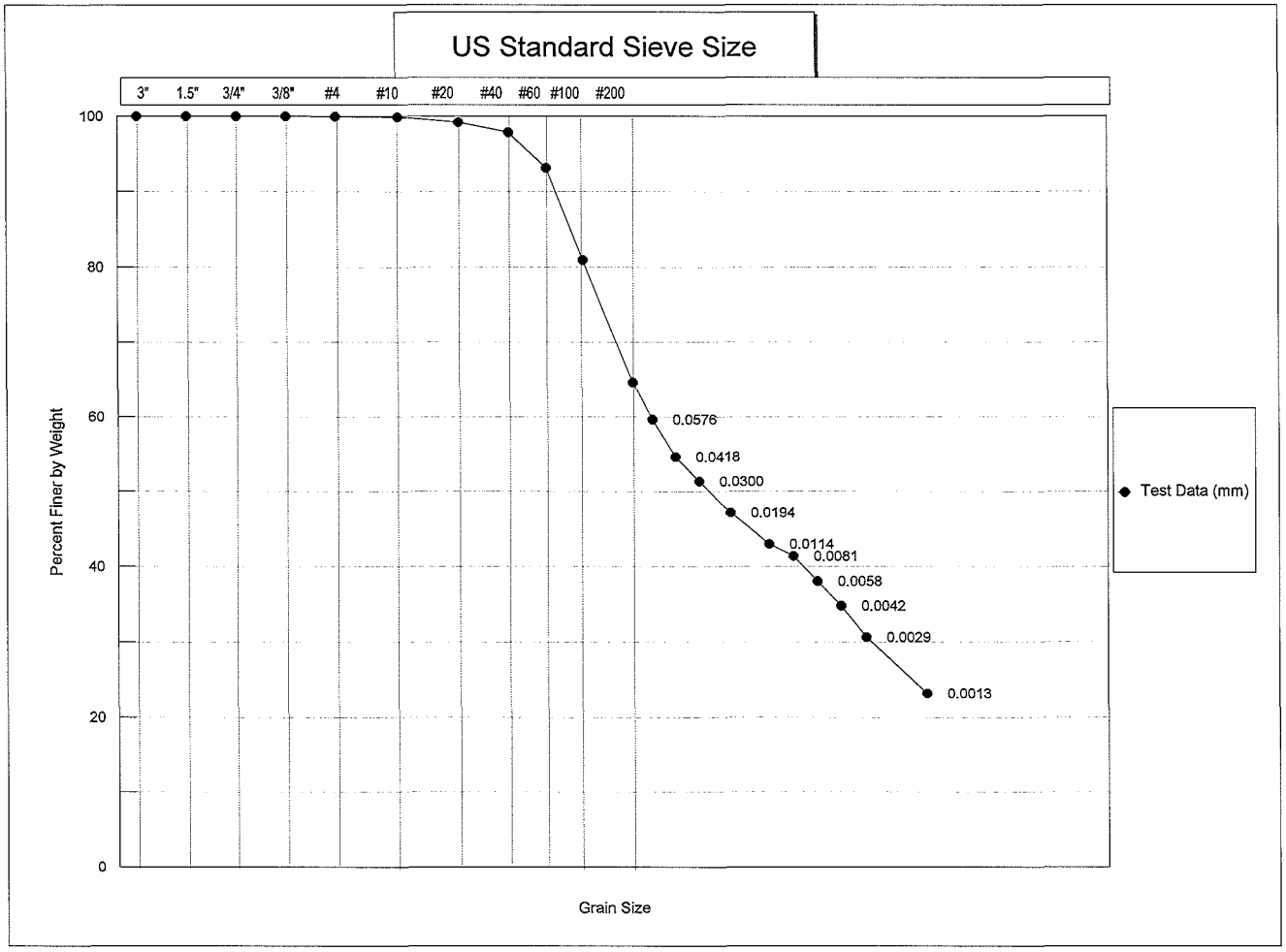
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.0
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01317
Value of "alpha"	1.00	Wt. Dry Sample "W"	60.420
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	41.00	36.00	59.6	59.6	9.57	0.0576
1.0	38.00	33.00	54.6	54.6	10.06	0.0418
2.0	36.00	31.00	51.3	51.3	10.39	0.0300
5.0	33.50	28.50	47.2	47.2	10.80	0.0194
15.0	31.00	26.00	43.0	43.0	11.21	0.0114
30.0	30.00	25.00	41.4	41.4	11.37	0.0081
60.0	28.00	23.00	38.1	38.1	11.70	0.0058
120.0	26.00	21.00	34.8	34.8	12.03	0.0042
250.0	23.50	18.50	30.6	30.6	12.44	0.0029
1440.0	19.00	14.00	23.2	23.2	13.17	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS36A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 3
Depth: 6.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 4	SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes	
NATURAL	No	
Wt. Wet Soil & Pan (g)		103.65
Wt. Dry Soil & Pan (g)		97.39
Wt. Lost Moisture (g)		6.26
Wt. of Pan Only (g)		3.14
Wt. of Dry Soil (g)		94.25
Moisture Content %		6.6
Wt. Hydrom. Sample Wet (g)		60.83
Wt. Hydrom. Sample Dry (g)		57.04

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1447.32
Weight of + #10 Before Washing (g)	2.12
Weight of + #10 After Washing (g)	1.76
Weight of - #10 Wet (g)	1445.20
Weight of - #10 Dry (g)	1355.53
Wt. Total Sample Dry (g)	1357.29
Calc. Wt. "W" (g)	57.12
Calc. Mass + #10	0.07

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.95	0.95	0.95	0.1	99.9
#10	0.00	0.81	0.81	1.76	0.1	99.9
#20	3.06	3.44	0.38	0.38	0.8	99.2
#40	3.02	4.36	1.34	1.72	3.1	96.9
#60	3.11	5.57	2.46	4.18	7.4	92.6
#100	3.05	5.21	2.16	6.34	11.2	88.8
#200	2.97	6.74	3.77	10.11	17.8	82.2

Data entered by: MLM Date: 10/29/2010
Data checked by: KR Date: 11/1/10
FileName: MHHY450A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 4	SAMPLED	10/12/10
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

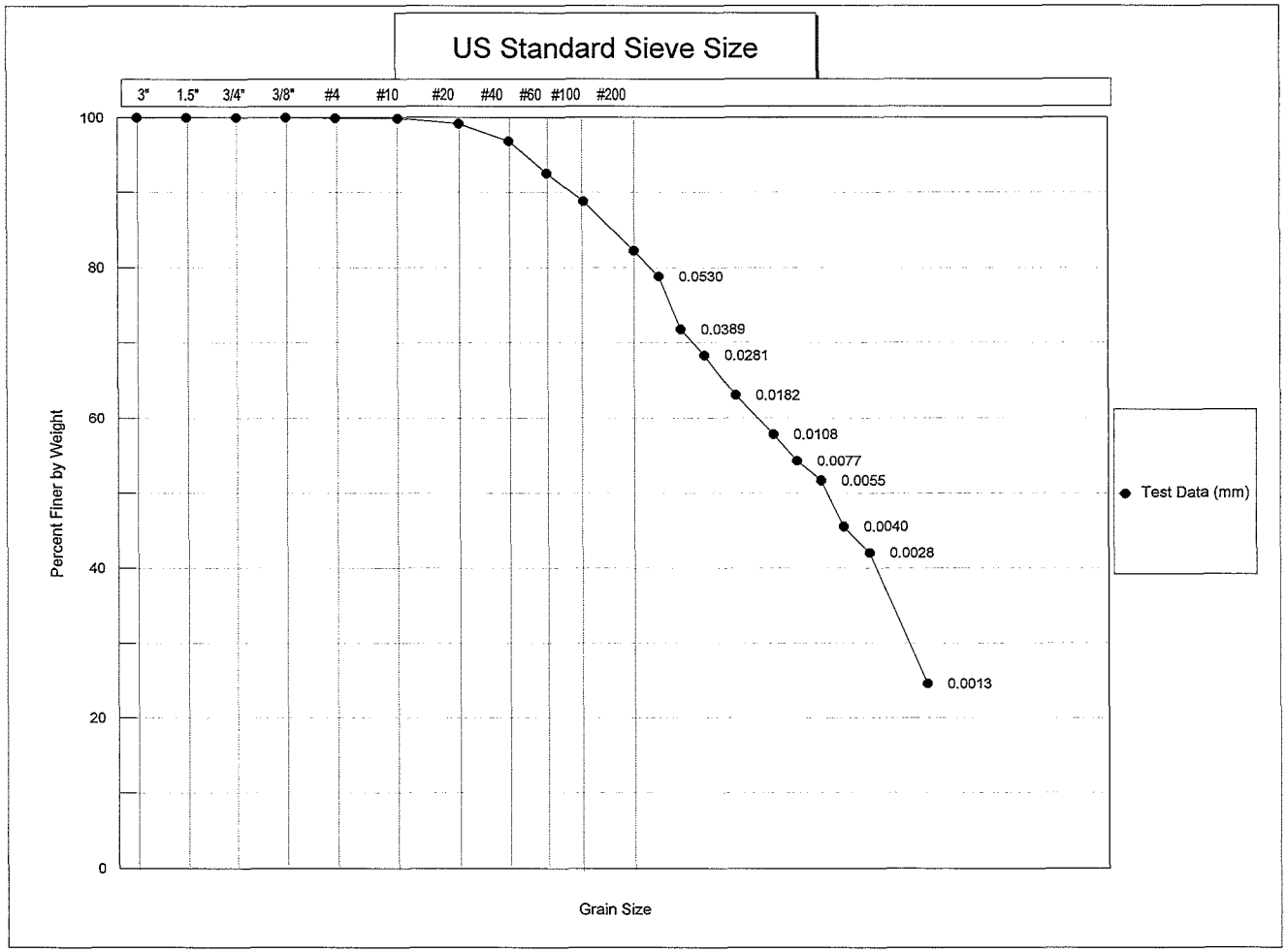
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.0
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01317
Value of "alpha"	1.00	Wt. Dry Sample "W"	57.118
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	50.00	45.00	78.8	78.8	8.09	0.0530
1.0	46.00	41.00	71.8	71.8	8.75	0.0389
2.0	44.00	39.00	68.3	68.3	9.07	0.0281
5.0	41.00	36.00	63.0	63.0	9.57	0.0182
15.0	38.00	33.00	57.8	57.8	10.06	0.0108
30.0	36.00	31.00	54.3	54.3	10.39	0.0077
60.0	34.50	29.50	51.6	51.6	10.63	0.0055
120.0	31.00	26.00	45.5	45.5	11.21	0.0040
250.0	29.00	24.00	42.0	42.0	11.53	0.0028
1440.0	19.00	14.00	24.5	24.5	13.17	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 10/29/2010
Data checked by: KL Date: 11/1/10
FileName: MHHY450A

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES	PEBBLE GRAVEL				SAND			SILT	CLAY
TO BOULDERS	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 4
Depth: 5.0'
Sample No.: A
Classification: **Classification Not Performed**

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 5	SAMPLED	
DEPTH	6.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No

Wt. Wet Soil & Pan (g)	262.62
Wt. Dry Soil & Pan (g)	256.89
Wt. Lost Moisture (g)	5.73
Wt. of Pan Only (g)	6.60
Wt. of Dry Soil (g)	250.29
Moisture Content %	2.3
Wt. Hydrom. Sample Wet (g)	66.35
Wt. Hydrom. Sample Dry (g)	64.87

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	66.35
Weight of + #10 Before Washing (g)	0.00
Weight of + #10 After Washing (g)	0.00
Weight of - #10 Wet (g)	66.35
Weight of - #10 Dry (g)	64.87
Wt. Total Sample Dry (g)	64.87
Calc. Wt. "W" (g)	64.87
Calc. Mass + #10	0.00

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.00	0.00	0.00	0.0	100.0
#20	3.03	3.06	0.03	0.03	0.0	100.0
#40	3.00	3.15	0.15	0.18	0.3	99.7
#60	3.08	3.71	0.63	0.81	1.2	98.8
#100	2.99	4.29	1.30	2.11	3.3	96.7
#200	3.13	20.58	17.45	19.56	30.2	69.8

Data entered by: MLM Date: 11/19/2010
Data checked by: BK Date: 11/19/10
FileName: MHHYS66A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 5	SAMPLED	
DEPTH	6.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

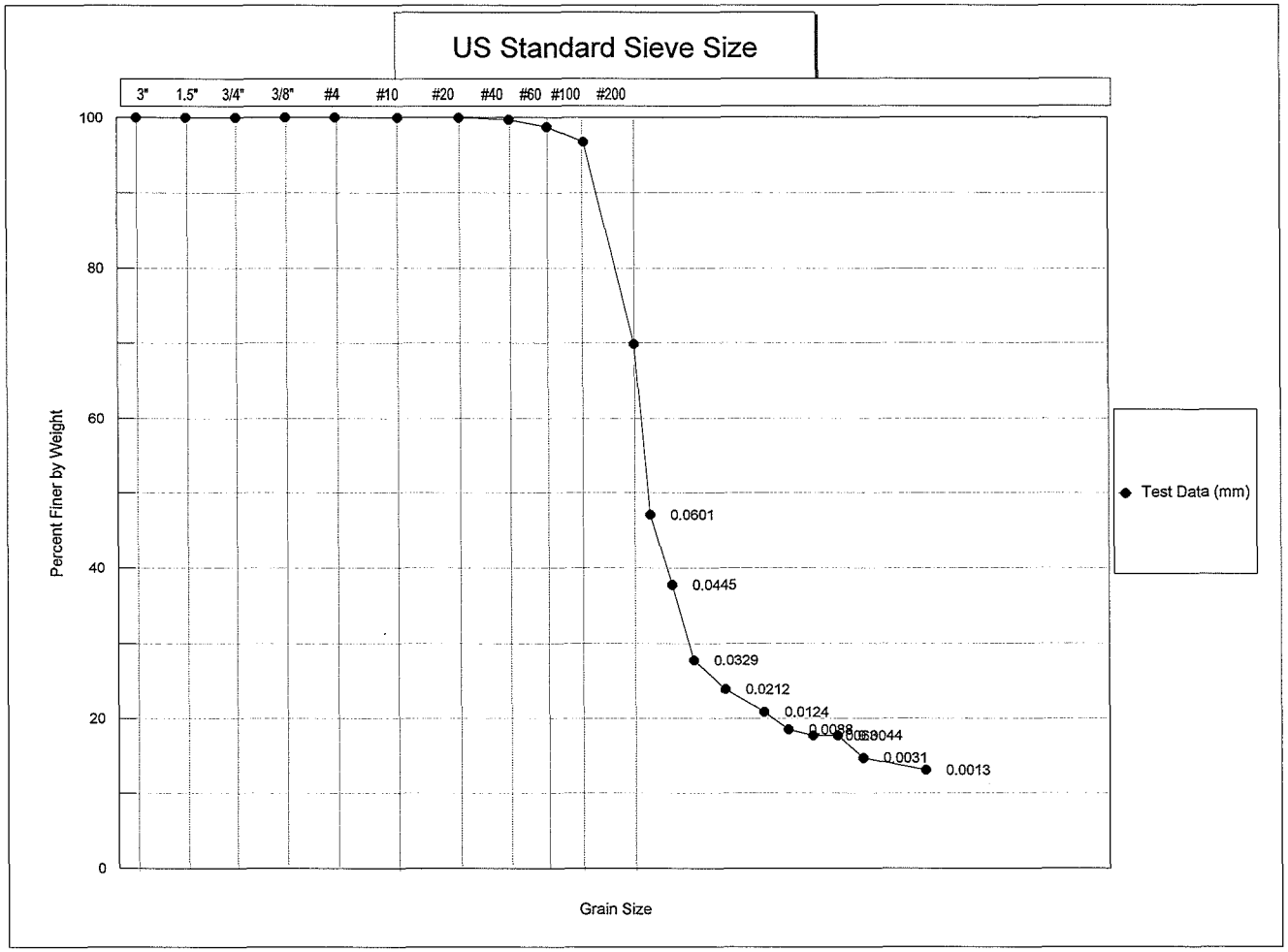
Hydrometer #	ASTM 152 H	Temp., Deg. C	22.2
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01329
Value of "alpha"	1.00	Wt. Dry Sample "W"	64.865
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	-1.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	37.00	30.50	47.0	47.0	10.22	0.0601
1.0	31.00	24.50	37.8	37.8	11.21	0.0445
2.0	24.50	18.00	27.7	27.7	12.27	0.0329
5.0	22.00	15.50	23.9	23.9	12.68	0.0212
15.0	20.00	13.50	20.8	20.8	13.01	0.0124
30.0	18.50	12.00	18.5	18.5	13.26	0.0088
60.0	18.00	11.50	17.7	17.7	13.34	0.0063
120.0	18.00	11.50	17.7	17.7	13.34	0.0044
250.0	16.00	9.50	14.6	14.6	13.67	0.0031
1440.0	15.00	8.50	13.1	13.1	13.83	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/19/2010
Data checked by: BLC Date: 11/19/10
FileName: MHHYS66A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 5
Depth: 6.0'
Sample No.: A
Classification: **Classification Not Performed**

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 6	SAMPLED	
DEPTH	2.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes	
NATURAL	No	
Wt. Wet Soil & Pan (g)		383.02
Wt. Dry Soil & Pan (g)		374.28
Wt. Lost Moisture (g)		8.74
Wt. of Pan Only (g)		6.73
Wt. of Dry Soil (g)		367.55
Moisture Content %		2.4
Wt. Hydrom. Sample Wet (g)		65.22
Wt. Hydrom. Sample Dry (g)		63.71

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	65.22
Weight of + #10 Before Washing (g)	0.00
Weight of + #10 After Washing (g)	0.00
Weight of - #10 Wet (g)	65.22
Weight of - #10 Dry (g)	63.71
Wt. Total Sample Dry (g)	63.71
Calc. Wt. "W" (g)	63.71
Calc. Mass + #10	0.00

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.00	0.00	0.00	0.0	100.0
#20	3.29	3.94	0.65	0.65	1.0	99.0
#40	3.04	4.05	1.01	1.66	2.6	97.4
#60	3.03	6.51	3.48	5.14	8.1	91.9
#100	3.26	14.22	10.96	16.10	25.3	74.7
#200	3.21	17.03	13.82	29.92	47.0	53.0

Data entered by: MLM Date: 11/18/2010
Data checked by: BKL Date: 11/18/10
FileName: MHHYS62A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 6	SAMPLED	
DEPTH	2.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

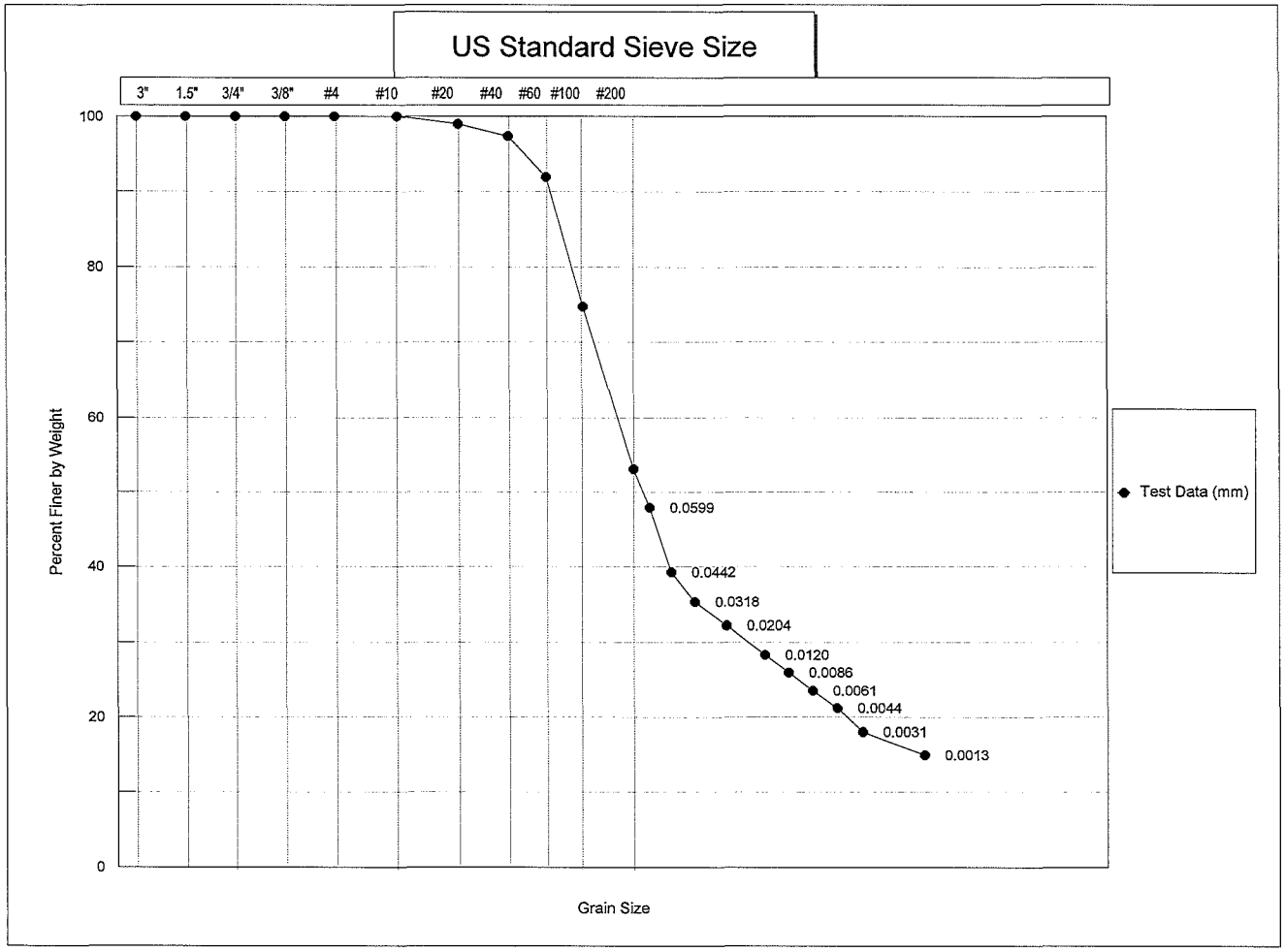
Hydrometer #	ASTM 152 H	Temp., Deg. C	22.5
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01325
Value of "alpha"	1.00	Wt. Dry Sample "W"	63.705
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	-1.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	37.00	30.50	47.9	47.9	10.22	0.0599
1.0	31.50	25.00	39.2	39.2	11.12	0.0442
2.0	29.00	22.50	35.3	35.3	11.53	0.0318
5.0	27.00	20.50	32.2	32.2	11.86	0.0204
15.0	24.50	18.00	28.3	28.3	12.27	0.0120
30.0	23.00	16.50	25.9	25.9	12.52	0.0086
60.0	21.50	15.00	23.5	23.5	12.76	0.0061
120.0	20.00	13.50	21.2	21.2	13.01	0.0044
250.0	18.00	11.50	18.1	18.1	13.34	0.0031
1440.0	16.00	9.50	14.9	14.9	13.67	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/18/2010
Data checked by: BKL Date: 11/18/10
FileName: MHHYS62A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 6
Depth: 2.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 7	SAMPLED	
DEPTH	0.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes	
NATURAL	No	
Wt. Wet Soil & Pan (g)		262.38
Wt. Dry Soil & Pan (g)		257.88
Wt. Lost Moisture (g)		4.50
Wt. of Pan Only (g)		8.59
Wt. of Dry Soil (g)		249.29
Moisture Content %		1.8
Wt. Hydrom. Sample Wet (g)		64.62
Wt. Hydrom. Sample Dry (g)		63.47

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	64.62
Weight of + #10 Before Washing (g)	0.00
Weight of + #10 After Washing (g)	0.00
Weight of - #10 Wet (g)	64.62
Weight of - #10 Dry (g)	63.47
Wt. Total Sample Dry (g)	63.47
Calc. Wt. "W" (g)	63.47
Calc. Mass + #10	0.00

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.00	0.00	0.00	0.0	100.0
#20	3.08	3.53	0.45	0.45	0.7	99.3
#40	3.25	3.89	0.64	1.09	1.7	98.3
#60	3.08	4.48	1.40	2.49	3.9	96.1
#100	3.14	5.55	2.41	4.90	7.7	92.3
#200	3.10	21.95	18.85	23.75	37.4	62.6

Data entered by: MLM Date: 11/19/2010
Data checked by: BKL Date: 11/19/10
FileName: MHHYS70A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 7	SAMPLED	
DEPTH	0.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

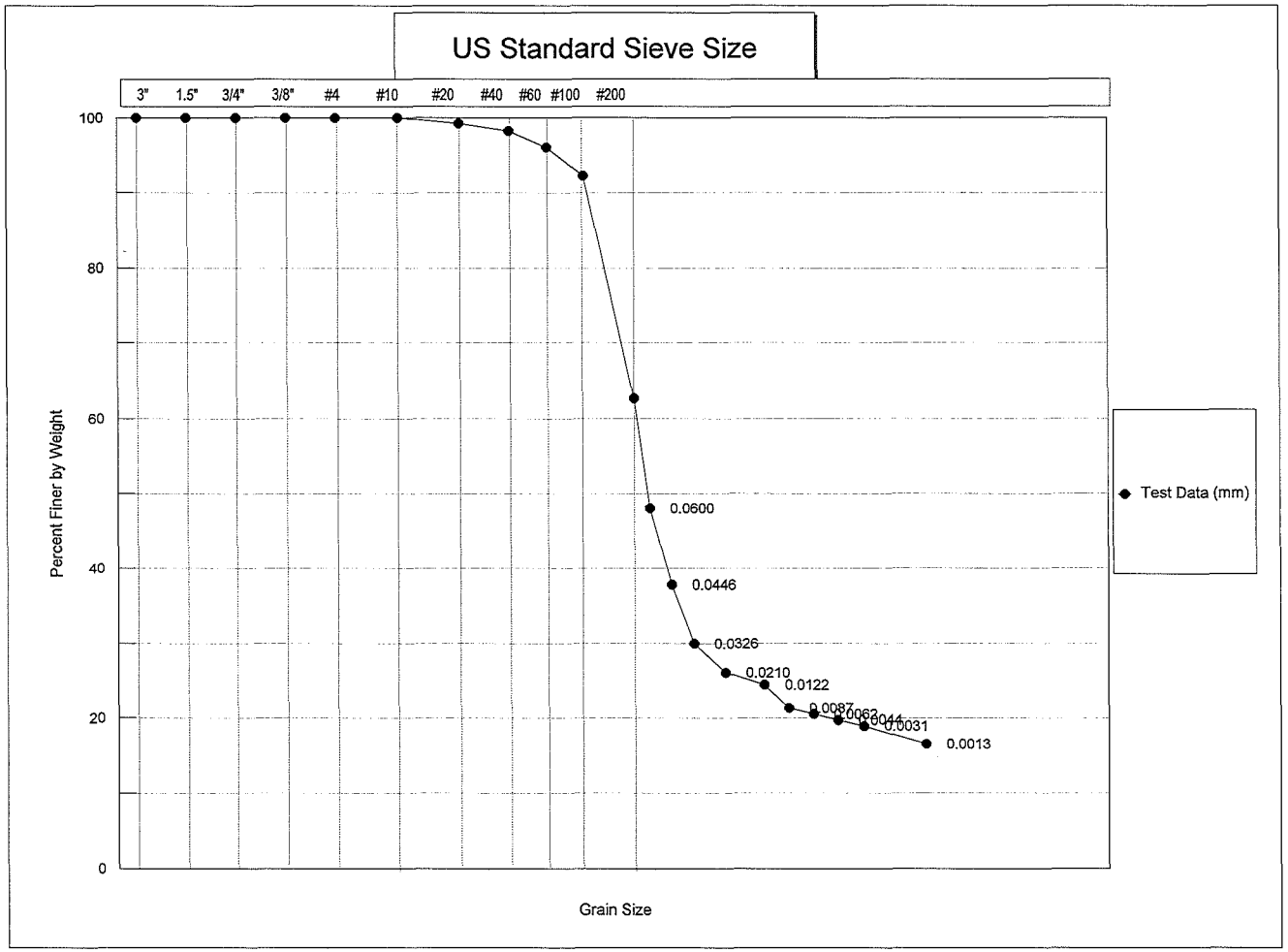
Hydrometer #	ASTM 152 H	Temp., Deg. C	22.4
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01326
Value of "alpha"	1.00	Wt. Dry Sample "W"	63.474
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	-1.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	37.00	30.50	48.1	48.1	10.22	0.0600
1.0	30.50	24.00	37.8	37.8	11.29	0.0446
2.0	25.50	19.00	29.9	29.9	12.11	0.0326
5.0	23.00	16.50	26.0	26.0	12.52	0.0210
15.0	22.00	15.50	24.4	24.4	12.68	0.0122
30.0	20.00	13.50	21.3	21.3	13.01	0.0087
60.0	19.50	13.00	20.5	20.5	13.09	0.0062
120.0	19.00	12.50	19.7	19.7	13.17	0.0044
250.0	18.50	12.00	18.9	18.9	13.26	0.0031
1440.0	17.00	10.50	16.5	16.5	13.50	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/18/2010
Data checked by: BKL Date: 11/18/10
FileName: MHHYS70A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 7
Depth: 0.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 8	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	110.10
Wt. Dry Soil & Pan (g)	108.82
Wt. Lost Moisture (g)	1.28
Wt. of Pan Only (g)	2.99
Wt. of Dry Soil (g)	105.83
Moisture Content %	1.2
Wt. Hydrom. Sample Wet (g)	68.19
Wt. Hydrom. Sample Dry (g)	67.37

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	2051.90
Weight of + #10 Before Washing (g)	40.60
Weight of + #10 After Washing (g)	14.13
Weight of - #10 Wet (g)	2011.30
Weight of - #10 Dry (g)	2013.42
Wt. Total Sample Dry (g)	2027.55
Calc. Wt. "W" (g)	67.85
Calc. Mass + #10	0.47

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.69	0.69	0.69	0.0	100.0
#10	0.00	13.44	13.44	14.13	0.7	99.3
#20	1.77	2.13	0.36	0.36	1.2	98.8
#40	1.81	2.30	0.49	0.85	1.9	98.1
#60	1.83	4.28	2.45	3.30	5.6	94.4
#100	1.77	12.00	10.23	13.53	20.6	79.4
#200	1.79	17.51	15.72	29.25	43.8	56.2

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS85A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 8	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

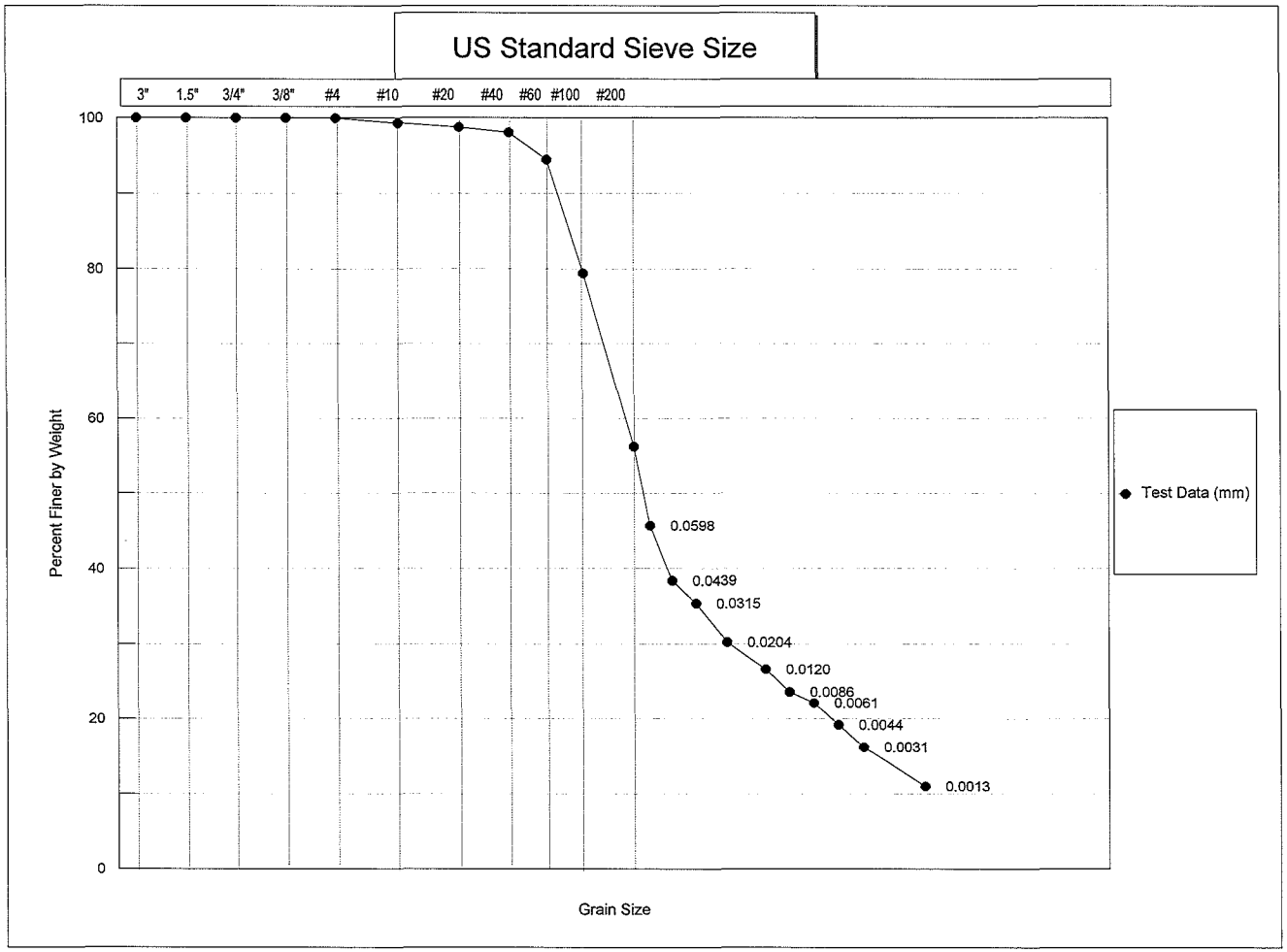
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.3
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01312
Value of "alpha"	1.00	Wt. Dry Sample "W"	67.847
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	36.00	31.00	45.7	45.7	10.39	0.0598
1.0	31.00	26.00	38.3	38.3	11.21	0.0439
2.0	29.00	24.00	35.4	35.4	11.53	0.0315
5.0	25.50	20.50	30.2	30.2	12.11	0.0204
15.0	23.00	18.00	26.5	26.5	12.52	0.0120
30.0	21.00	16.00	23.6	23.6	12.85	0.0086
60.0	20.00	15.00	22.1	22.1	13.01	0.0061
120.0	18.00	13.00	19.2	19.2	13.34	0.0044
250.0	16.00	11.00	16.2	16.2	13.67	0.0031
1442.0	12.50	7.50	11.1	11.1	14.24	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS85A

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 8
Depth: 5.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 9	SAMPLED	
DEPTH	0.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	305.13
Wt. Dry Soil & Pan (g)	299.78
Wt. Lost Moisture (g)	5.35
Wt. of Pan Only (g)	6.79
Wt. of Dry Soil (g)	292.99
Moisture Content %	1.8
Wt. Hydrom. Sample Wet (g)	71.63
Wt. Hydrom. Sample Dry (g)	70.35

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	71.63
Weight of + #10 Before Washing (g)	0.00
Weight of + #10 After Washing (g)	0.00
Weight of - #10 Wet (g)	71.63
Weight of - #10 Dry (g)	70.35
Wt. Total Sample Dry (g)	70.35
Calc. Wt. "W" (g)	70.35
Calc. Mass + #10	0.00

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.00	0.00	0.00	0.0	100.0
#20	2.99	3.03	0.04	0.04	0.1	99.9
#40	3.05	3.09	0.04	0.08	0.1	99.9
#60	3.27	3.55	0.28	0.36	0.5	99.5
#100	3.04	4.04	1.00	1.36	1.9	98.1
#200	3.11	25.90	22.79	24.15	34.3	65.7

Data entered by: MLM Date: 11/18/2010
Data checked by: BKL Date: 11/19/10
FileName: MHHYS90A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 9	SAMPLED	
DEPTH	0.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

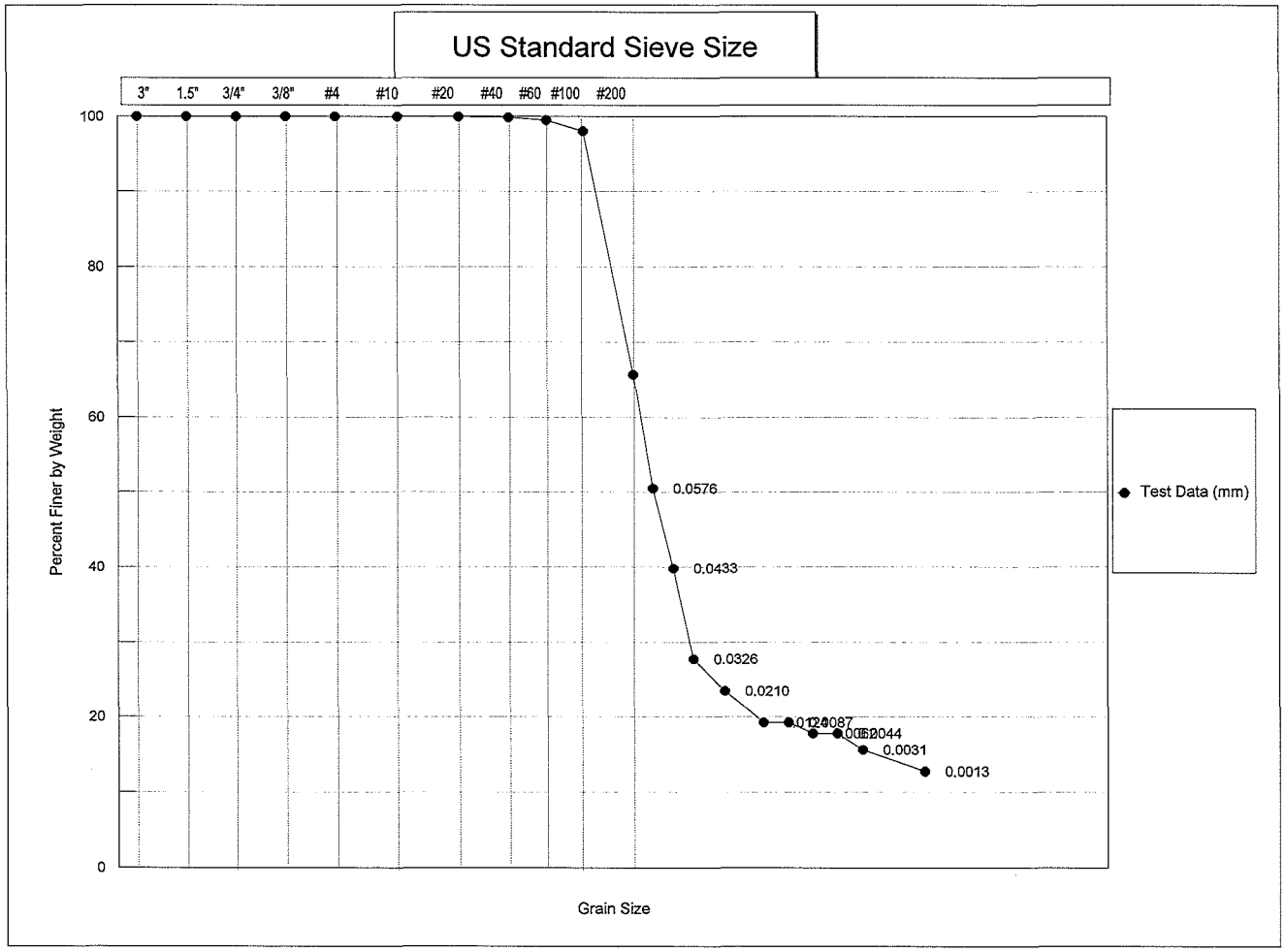
Hydrometer #	ASTM 152 H	Temp., Deg. C	22.3
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01328
Value of "alpha"	1.00	Wt. Dry Sample "W"	70.345
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	-1.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	42.00	35.50	50.5	50.5	9.40	0.0576
1.0	34.50	28.00	39.8	39.8	10.63	0.0433
2.0	26.00	19.50	27.7	27.7	12.03	0.0326
5.0	23.00	16.50	23.5	23.5	12.52	0.0210
15.0	20.00	13.50	19.2	19.2	13.01	0.0124
30.0	20.00	13.50	19.2	19.2	13.01	0.0087
60.0	19.00	12.50	17.8	17.8	13.17	0.0062
120.0	19.00	12.50	17.8	17.8	13.17	0.0044
250.0	17.50	11.00	15.6	15.6	13.42	0.0031
1440.0	15.50	9.00	12.8	12.8	13.75	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/19/2010
Data checked by: BKL Date: 11/19/10
FileName: MHHYS90A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 9
Depth: 0.0'
Sample No.: A
Classification: **Classification Not Performed**

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 10	SAMPLED	
DEPTH	5.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No

Wt. Wet Soil & Pan (g)	256.44
Wt. Dry Soil & Pan (g)	251.58
Wt. Lost Moisture (g)	4.86
Wt. of Pan Only (g)	8.35
Wt. of Dry Soil (g)	243.23
Moisture Content %	2.0
Wt. Hydrom. Sample Wet (g)	61.57
Wt. Hydrom. Sample Dry (g)	60.36

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	61.57
Weight of + #10 Before Washing (g)	0.00
Weight of + #10 After Washing (g)	0.00
Weight of - #10 Wet (g)	61.57
Weight of - #10 Dry (g)	60.36
Wt. Total Sample Dry (g)	60.36
Calc. Wt. "W" (g)	60.36
Calc. Mass + #10	0.00

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.00	0.00	0.00	0.0	100.0
#20	3.04	3.07	0.03	0.03	0.0	100.0
#40	3.10	3.21	0.11	0.14	0.2	99.8
#60	3.10	3.67	0.57	0.71	1.2	98.8
#100	3.07	4.13	1.06	1.77	2.9	97.1
#200	3.21	21.12	17.91	19.68	32.6	67.4

Data entered by: MLM Date: 11/18/2010
Data checked by: BKL Date: 11/18/10
FileName: MHHYS10A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 10	SAMPLED	
DEPTH	5.0'	DATE TESTED	11/15/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

Hydrometer #	ASTM 152 H	Temp., Deg. C	22.4
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01326
Value of "alpha"	1.00	Wt. Dry Sample "W"	60.364
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	-1.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	37.00	30.50	50.5	50.5	10.22	0.0600
1.0	29.00	22.50	37.3	37.3	11.53	0.0450
2.0	23.00	16.50	27.3	27.3	12.52	0.0332
5.0	20.00	13.50	22.4	22.4	13.01	0.0214
15.0	18.00	11.50	19.1	19.1	13.34	0.0125
30.0	17.50	11.00	18.2	18.2	13.42	0.0089
60.0	17.00	10.50	17.4	17.4	13.50	0.0063
120.0	16.00	9.50	15.7	15.7	13.67	0.0045
250.0	15.00	8.50	14.1	14.1	13.83	0.0031
1440.0	14.00	7.50	12.4	12.4	13.99	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/18/2010
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FileName: MHHYS10A

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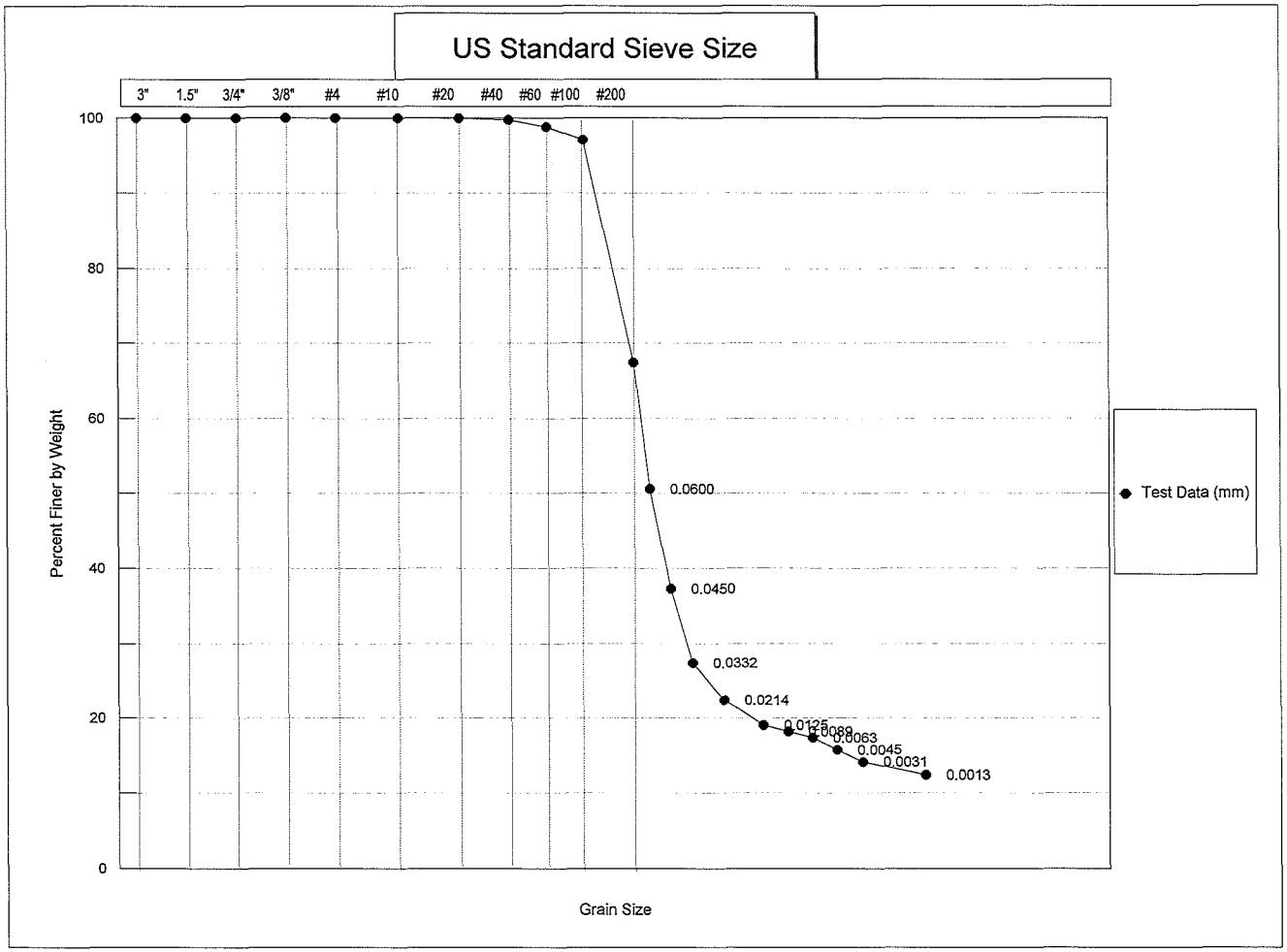


COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 10
Depth: 5.0'
Sample No.: A
Classification: **Classification Not Performed**

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 11	SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	103.39
Wt. Dry Soil & Pan (g)	101.41
Wt. Lost Moisture (g)	1.98
Wt. of Pan Only (g)	3.13
Wt. of Dry Soil (g)	98.28
Moisture Content %	2.0
Wt. Hydrom. Sample Wet (g)	66.77
Wt. Hydrom. Sample Dry (g)	65.46

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	2472.51
Weight of + #10 Before Washing (g)	7.41
Weight of + #10 After Washing (g)	6.93
Weight of - #10 Wet (g)	2465.10
Weight of - #10 Dry (g)	2416.89
Wt. Total Sample Dry (g)	2423.82
Calc. Wt. "W" (g)	65.64
Calc. Mass + #10	0.19

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	1.89	1.89	1.89	0.1	99.9
#4	0.00	3.87	3.87	5.76	0.2	99.8
#10	0.00	1.17	1.17	6.93	0.3	99.7
#20	2.96	3.19	0.23	0.23	0.6	99.4
#40	3.08	3.75	0.67	0.90	1.7	98.3
#60	3.17	7.63	4.46	5.36	8.5	91.5
#100	3.06	8.85	5.80	11.16	17.3	82.7
#200	2.99	20.77	17.78	28.93	44.4	55.6

Data entered by: MLM Date: 10/29/2010
Data checked by: [illegible] Date: 11/1/10
FileName: MHHY110A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 11	SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	10/26/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

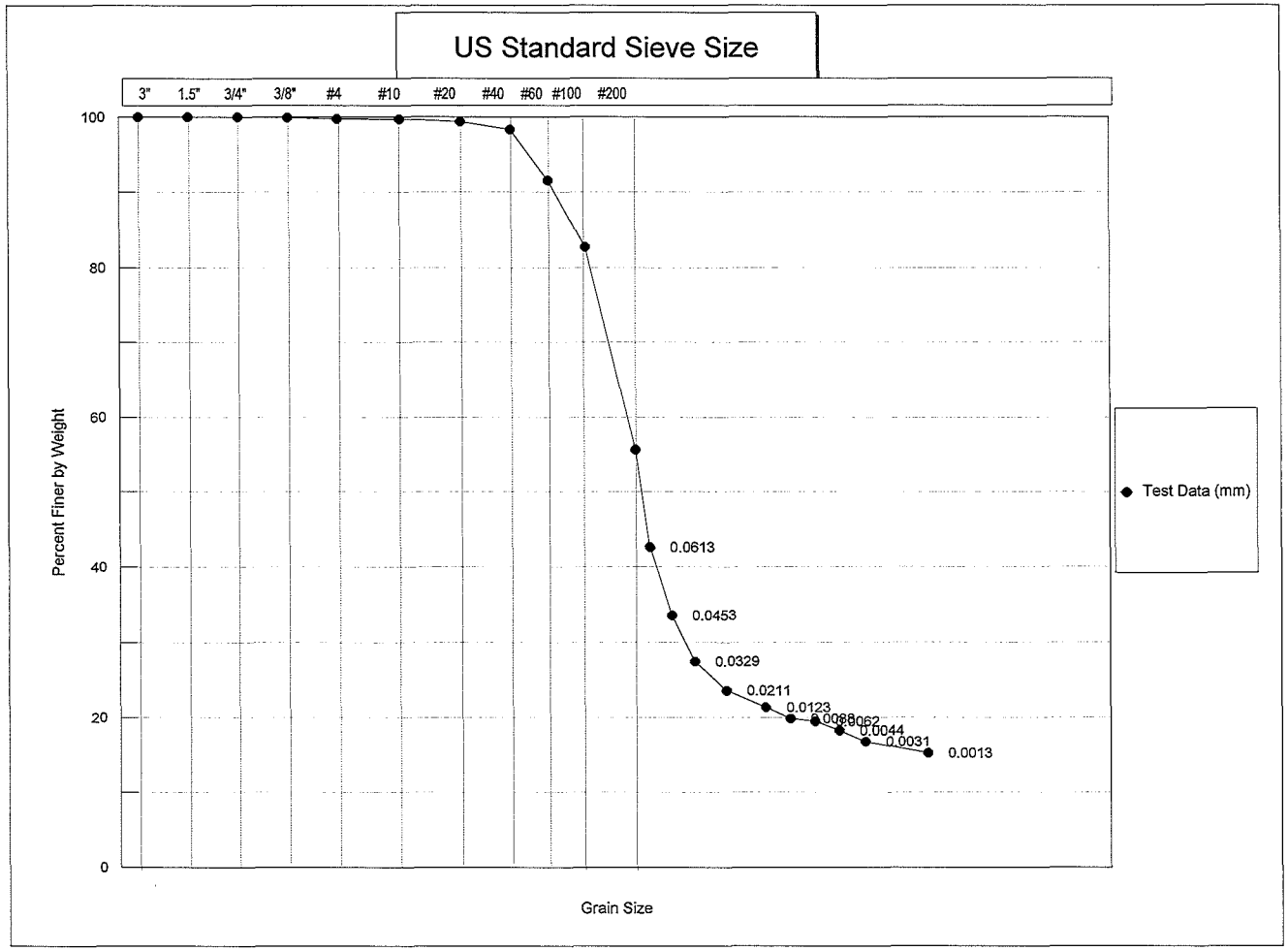
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.2
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01314
Value of "alpha"	1.00	Wt. Dry Sample "W"	65.643
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	33.00	28.00	42.7	42.7	10.88	0.0613
1.0	27.00	22.00	33.5	33.5	11.86	0.0453
2.0	23.00	18.00	27.4	27.4	12.52	0.0329
5.0	20.50	15.50	23.6	23.6	12.93	0.0211
15.0	19.00	14.00	21.3	21.3	13.17	0.0123
30.0	18.00	13.00	19.8	19.8	13.34	0.0088
60.0	17.75	12.75	19.4	19.4	13.38	0.0062
120.0	17.00	12.00	18.3	18.3	13.50	0.0044
250.0	16.00	11.00	16.8	16.8	13.67	0.0031
1440.0	15.00	10.00	15.2	15.2	13.83	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 10/29/2010
Data checked by: KR Date: 10/1/10
FileName: MHHY110A

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 11
Depth: 0.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 12	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/25/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	95.32
Wt. Dry Soil & Pan (g)	91.82
Wt. Lost Moisture (g)	3.50
Wt. of Pan Only (g)	3.16
Wt. of Dry Soil (g)	88.66
Moisture Content %	4.0
Wt. Hydrom. Sample Wet (g)	61.16
Wt. Hydrom. Sample Dry (g)	58.84

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1732.46
Weight of + #10 Before Washing (g)	0.36
Weight of + #10 After Washing (g)	0.33
Weight of - #10 Wet (g)	1732.10
Weight of - #10 Dry (g)	1666.29
Wt. Total Sample Dry (g)	1666.62
Calc. Wt. "W" (g)	58.85
Calc. Mass + #10	0.01

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	0.00	0.00	0.00	0.0	100.0
#10	0.00	0.33	0.33	0.33	0.0	100.0
#20	1.79	2.05	0.26	0.26	0.5	99.5
#40	1.83	2.28	0.45	0.71	1.2	98.8
#60	1.77	2.33	0.56	1.27	2.2	97.8
#100	1.78	3.32	1.54	2.81	4.8	95.2
#200	1.78	22.86	21.08	23.89	40.6	59.4

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS12A

ADVANCED TERRA TESTING, Inc. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 12	SAMPLED	10/12/10 --
DEPTH	5.0'	DATE TESTED	10/25/10 DPM
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

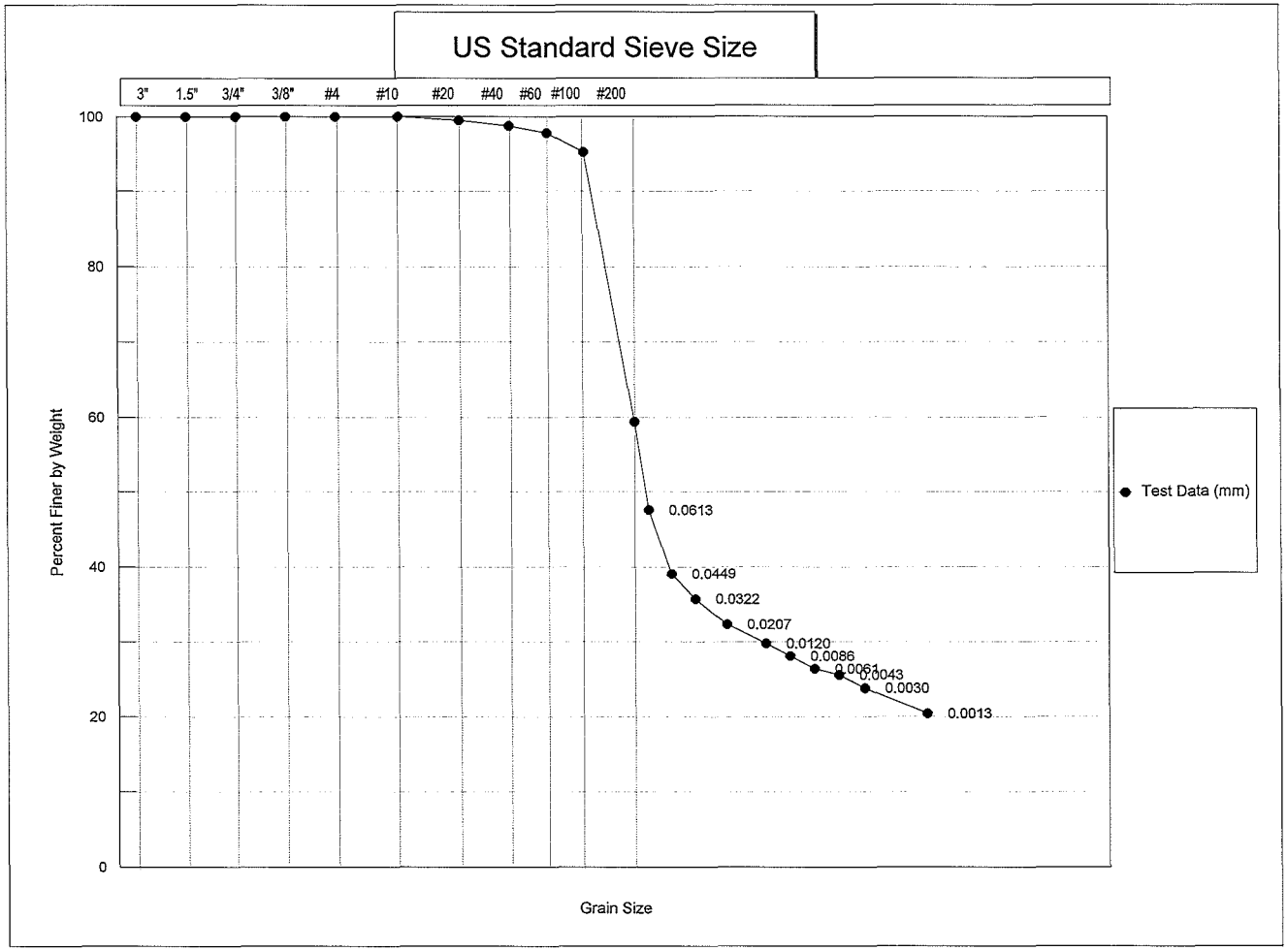
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.2
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01314
Value of "alpha"	1.00	Wt. Dry Sample "W"	58.850
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.5		
Meniscus Corr'n	0.5		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	33.00	28.00	47.6	47.6	10.88	0.0613
1.0	28.00	23.00	39.1	39.1	11.70	0.0449
2.0	26.00	21.00	35.7	35.7	12.03	0.0322
5.0	24.00	19.00	32.3	32.3	12.35	0.0207
15.0	22.50	17.50	29.7	29.7	12.60	0.0120
30.0	21.50	16.50	28.0	28.0	12.76	0.0086
60.0	20.50	15.50	26.3	26.3	12.93	0.0061
120.0	20.00	15.00	25.5	25.5	13.01	0.0043
250.0	19.00	14.00	23.8	23.8	13.17	0.0030
1440.0	17.00	12.00	20.4	20.4	13.50	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/04/2010
Data checked by: KR Date: 11/4/10
FileName: MHHYS12A

ADVANCED TERRA TESTING, Inc. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Classification: **Classification Not Performed**

Boring No.: Stockpile 12
Depth: 5.0'

Sample No.: A

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 13	SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	11/09/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	103.51
Wt. Dry Soil & Pan (g)	99.73
Wt. Lost Moisture (g)	3.78
Wt. of Pan Only (g)	3.13
Wt. of Dry Soil (g)	96.60
Moisture Content %	3.9
Wt. Hydrom. Sample Wet (g)	62.53
Wt. Hydrom. Sample Dry (g)	60.18

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1684.57
Weight of + #10 Before Washing (g)	4.67
Weight of + #10 After Washing (g)	4.12
Weight of - #10 Wet (g)	1679.90
Weight of - #10 Dry (g)	1617.17
Wt. Total Sample Dry (g)	1621.29
Calc. Wt. "W" (g)	60.33
Calc. Mass + #10	0.15

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	0.00	2.47	2.47	2.47	0.2	99.8
#10	0.00	1.65	1.65	4.12	0.3	99.7
#20	3.00	4.45	1.45	1.45	2.6	97.4
#40	3.09	4.72	1.63	3.07	5.3	94.7
#60	3.08	6.97	3.89	6.96	11.8	88.2
#100	3.03	10.05	7.02	13.98	23.4	76.6
#200	3.00	14.05	11.05	25.03	41.7	58.3

Data entered by: MLM Date: 11/12/2010
Data checked by: [illegible] Date: 11/13/10
FileName: MHHYS13A

ADVANCED TERRA TESTING, INC. ATT

HYDROMETER ANALYSIS - SEDIMENTATION DATA
ASTM D 422

CLIENT	MWH	JOB NO.	2512-53
BORING NO.	Stockpile 13	SAMPLED	10/12/10
DEPTH	0.0'	DATE TESTED	11/09/10 WAR
SAMPLE NO.	A	WASH SIEVE	Yes
SOIL DESCR.	1009740	DRY SIEVE	No
LOCATION	Denison White Mesa Mill Project		

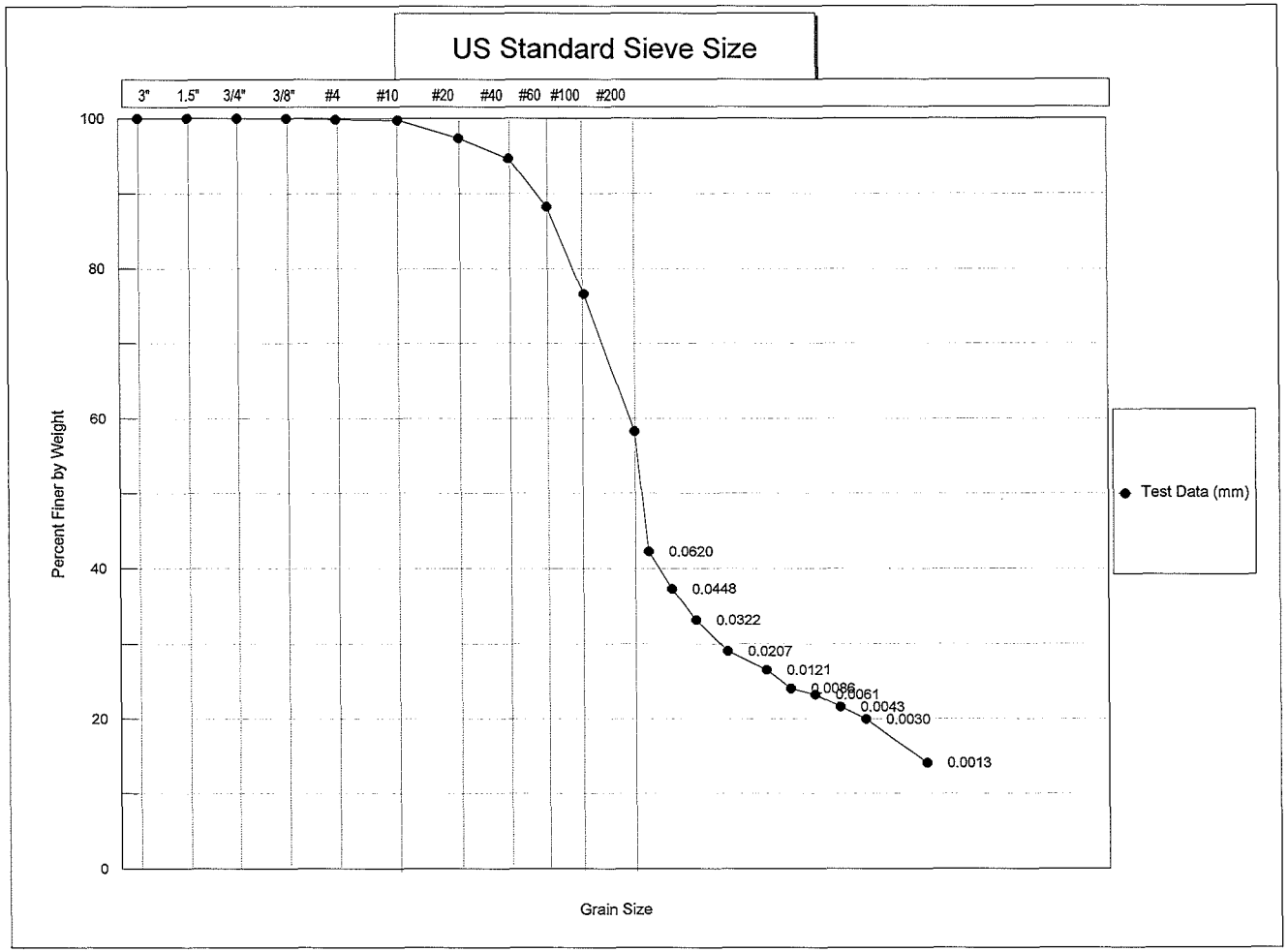
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.8
Sp. Gr. of Soil	2.65	Temp. Coef. K	0.01304
Value of "alpha"	1.00	Wt. Dry Sample "W"	60.329
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	5.0		
Meniscus Corr'n	0.0		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	30.50	25.50	42.3	42.3	11.29	0.0620
1.0	27.50	22.50	37.3	37.3	11.78	0.0448
2.0	25.00	20.00	33.2	33.2	12.19	0.0322
5.0	22.50	17.50	29.0	29.0	12.60	0.0207
15.0	21.00	16.00	26.5	26.5	12.85	0.0121
30.0	19.50	14.50	24.0	24.0	13.09	0.0086
60.0	19.00	14.00	23.2	23.2	13.17	0.0061
120.0	18.00	13.00	21.5	21.5	13.34	0.0043
250.0	17.00	12.00	19.9	19.9	13.50	0.0030
1440.0	13.50	8.50	14.1	14.1	14.08	0.0013

Grain Diameter = K*(SQRT(L/T))

Data entered by: MLM Date: 11/12/2010
Data checked by: Cal Date: 11/13/10
FileName: MHHYS13A

ADVANCED TERRA TESTING, INC. ATT



COBBLES	GRAVEL		SAND			SILT OR CLAY (mm)
	COARSE	FINE	CRS	MEDIUM	FINE	

USCS

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WENTWORTH

Client: MWH
Job Number: 2512-53
Boring No.: Stockpile 13
Depth: 0.0'
Sample No.: A
Classification: **Classification Not Performed**

APPENDIX B

FREEZE/THAW MODELING

B.1 BACKGROUND

Titan Environmental Corporation (Titan) performed a freeze/thaw analysis as part of a Tailings Cover Design (1996). This current appendix presents an update to the Titan (1996) analysis with the current soil properties proposed for the cover over the White Mesa tailing disposal cells. This update reflects modifications to the proposed cover to incorporate an evapotranspiration (ET) cover, a revised cover grading design, and results of cover material testing conducted in 2010 (ATT, 2010).

The monolithic ET cover system evaluated in this appendix consists of the following materials listed below from top to bottom:

- 0.5 ft (15 cm) Erosion Protection Layer (gravel-admixture)
- 3.5 ft (107 cm) Water Storage/Biointrusion/Frost Protection/Radon Attenuation Layer (loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation Layer (highly compacted loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation and Grading Layer (loam to sandy clay)

The loam to sandy clay soil used to construct the ET cover, referred to in previous reports (Titan 1996, Knight Piesold 1999) as random/platform fill, is stockpiled at the site.

B.2 DESCRIPTION OF MODEL AND INPUT VALUES

A digital computer program ModBerg (CRREL) was used to estimate the depth of frost penetration at the site. ModBerg uses the Modified Berggren Equation (CRREL, 1968) and input from a built-in long-term weather database. The Modified Berggren Equation is recommended in DOE (1988) for evaluating freeze/thaw. Model input requirements include the following:

- N-Factor: a constant used to translate air freezing index to surface freezing index, and accounts for some properties of the outer layer of a soil layer structure such as reflection and absorption of solar radiation. An n-factor of 0.6 was used, as recommended by DOE (1989) to represent a vegetated surface.
- Soil Type
- Layer Thicknesses of Soil
- Moisture Content and Dry Unit Weight of Soil
- Design Air Freezing index: The air freezing index is the number of degree-days between the highest and lowest points on a curve of cumulative degree-days versus time for one freezing season. It is a measure of the combined duration and magnitude of below-freezing temperatures occurring during any given freezing season. The Modberg database has a built in database that contains this information for locations included in their database. The design air freezing index used in the Modberg program is approximately the 91 percentile of freezing indices for 30 years of record. Titan (1996) used Grand Junction, CO as a representative site. The version of Modberg used in

Titan (1996) listed a design air freezing index for Grand Junction of 1101 degree days. However, this data has since been updated in the Modberg database and is currently listed as 900 degree days. The current version of Modberg does not allow for modification to the climate data.

- Design Length of Freezing Season: The number of days during the winter when the average daily temperature is consistently below the freezing point of water. The length of the freezing season for Grand Junction is 86 days, and is the value used in both Titan (1996) and the current analysis.
- Mean Annual Temperature: The average of the mean daily temperatures for a year. The mean annual temperature for Blanding was given by Dames & Moore (1978) as 49.8 degrees F. However, the current version of ModBerg does not allow for manipulation of the climate data. Therefore, the mean annual temperature for Grand Junction, CO (site used by Titan that has sufficient climate data and was determined to have similar climate and elevation to Blanding, UT) was used. The mean annual temperature for Grand Junction is 53.1 degrees F.
- Heat Capacity: Calculated by Modberg based on soil type, moisture content, and dry density. It is a measure of the ability of a material to contain heat through a range of temperatures.
- Thermal Conductivity: Calculated by ModBerg based on soil input of moisture content and dry density. It is a measure of the ability of a material to conduct heat across its boundaries in response to temperature gradient.
- Latent Heat of Fusion: Calculated by ModBerg based on soil type, moisture content, and dry density. It is a measure of the amount of heat that is needed to cause a phase change (freezing or thawing) for a unit of mass of the material.

Table B.1 reflects the soil parameters used in the analysis. The input parameters used in the model are based on recent laboratory testing results for samples of random fill, in addition to available data from previous work by others, including Chen and Associates (1978, 1979, 1987), Rogers and Associates Engineering Corporation (1988), Western Colorado Testing (1999), IUC (1999), and Titan (1996). The available data from recent testing as well as previous testing performed by others is included in Appendix A. The input parameters and values used in the model are outlined below.

B.2.4 Density and Long-Term Moisture Content

The densities and water content of the cover materials used in the model are based on laboratory testing results. The values are summarized in Table B.1 and discussed in more detail below.

Table B.1. Densities and Long-Term Moisture Contents of Cover Materials

Material	Degree of Compaction (%)	Placed Density (pcf)	Gravimetric Water Content (%)
Erosion Protection	---	124.2*	5.7
Random fill (low compaction water storage, rooting zone)	85% SP	99.2	7.8
Random Fill (high compaction)	95% SP	110.9	7.8
Random Fill (in place, low compaction, platform fill)	80% SP	93.4	7.8

SP = standard proctor compaction
* Estimated by applying 25% rock correction factor

The dry density values used in the model for the random fill layers were estimated by laboratory tests (Chen and Associates, 1978, 1979, 1987, Western Colorado Testing, 1999, Geosyntec, 2006). The referenced reports are provided as part of Appendix A.1. The proposed cover system has three layers of random fill placed at different levels of compaction. The lower layer of random fill consists of 2.5 feet of random fill that is assumed to be dumped and minimally compacted by construction equipment to approximately 80 percent standard Proctor. The middle layer (2.5 feet) of random fill will be compacted to 95 percent of standard Proctor. In Cell 2 and parts of Cell 3, the lower layer of random fill is already placed and is approximately 3 feet. It is assumed the upper 6 inches of this fill will be part of the middle random fill layer and can be compacted by additional passes of compactors to reach 95 percent of standard Proctor compaction. The uppermost 3.5 feet of random fill will be placed at 85 percent of standard Proctor compaction in order to optimize water storage and rooting characteristics for plant growth.

The 0.5 foot erosion protection layer is assumed to be rock mulch consisting of topsoil material mixed with 25 percent gravel. The density of the erosion protection layer was assumed to be 124.2 pcf, based on laboratory testing results for random fill (Chen and Associates, 1978, 1979, 1987, IUC 1999) and an applied rock correction based on 25% gravel.

Long-term moisture contents were estimated based on measured water contents from samples collected at depths greater than 120 cm (3.9 feet), and estimated water contents using the empirical equation by Rawls and Brakenseik (1982). The long-term water contents reflect expected moisture contents in the future and are dependent upon soil characteristics and not water contents of soils at time of compaction. More details regarding the determination of long-term moisture contents can be found in Appendix C: Radon Emanation Modeling. It should be noted that the analysis in Titan (1996) used optimum water content using standard Proctor compaction characteristics. Over the long-term, the water content of the cover soils is expected to dry due evaporation, soil suction, and effects of plant rooting. The use of optimum water content in the analysis is not conservative, because water acts as an insulating layer and thereby reduces the depth of frost.

B.3 MODEL RESULTS

The freeze/thaw calculations show the total depth of frost penetration to be 27.1 inches (2.26 ft). This implies that the upper 27 inches of cover will likely experience a decrease in density and increased hydraulic conductivity with freeze/thaw cycles. However, because the total cover has a thickness of 9 feet, the impacts of freeze and thaw will not have significant impacts to the overall integrity of the cover. This is especially true because the upper 3.5 feet of random fill cover are assumed to be lightly compacted (85% standard Proctor) in order to sustain plant growth, which is thought to be similar to the natural densities of surface soils in the site area. Model output is provided in Attachment B.1

B.5 REFERENCES

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ATTACHMENT B.1

MODBERG MODEL OUTPUT

"

```
                    ------------------------
                    --- ModBerg Results ---
                    -----------------------

Project Location: Grand Junction WSO A, Colorado

Air Design Freezing Index        =   900 F-days
N-Factor                         =  0.60
Surface Design Freezing Index    =   540 F-days
Mean Annual Temperature          =  53.1 deg F
Design Length of Freezing Season =  86 days

-------------------------------------------------------
Layer
#:Type           t    w%    d    Cf  Cu   Kf   Ku     L
-------------------------------------------------------
1-Coarse         6.0  5.7 124.2  25  28   1.2  1.4  1,019
2-Fine          21.1  7.8  99.2  21  25    .5   .5  1,114
-------------------------------------------------------

t  = Layer thickness, in inches.
w% = Moisture content, in percentage of dry density.
d  = Dry density, in lbs/cubic ft.
Cf = Heat Capacity of frozen phase, in BTU/(cubic ft degree F).
Cu = Heat Capacity of thawed phase, in BTU/(cubic ft degree F).
Kf = Thermal conductivity in frozen phase, in BTU/(ft hr degree).
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).
L  = Latent heat of fusion, in BTU / cubic ft.

*******************************************************
  Total Depth of Frost Penetration = 2.26 ft = 27.1 in.
*******************************************************"
```

APPENDIX C

RADON EMANATION MODELING

C.1 BACKGROUND

This appendix presents the results of modeling the emanation of radon-222 from the top surface of the proposed cover over the White Mesa tailing impoundments to achieve the State of Utah's long-term radon emanation standard for uranium mill tailings (Utah Administrative Code, Rule 313-24). These results comprise an update of radon emanation modeling presented in Attachment F of the 2009 Reclamation Plan (Denison, 2009) and Appendix H of the Infiltration and Contaminant Transport Modeling Report (Denison, 2010). This appendix provides a summary of further analyses of radon attenuation through the proposed evapotranspiration (ET) cover, and incorporates the revised cover grading design, and results of cover material testing conducted in 2010.

The monolithic ET cover system evaluated in this appendix consists of the following layers from top to bottom:

- 0.5 ft (15 cm) Erosion Protection Layer (gravel-admixture)
- 3.5 ft (107 cm) Water Storage/Biointrusion/Frost Protection/Radon Attenuation Layer (loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation Layer (highly compacted loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation and Grading Layer (loam to sandy clay)

The loam to sandy clay soil used to construct the ET cover, referred to in previous reports (Titan 1996, Knight Piesold 1999) as random/platform fill, is stockpiled at the site.

C.2 DESCRIPTION OF MODEL AND INPUT VALUES

The thickness of the reclamation cover necessary to limit radon emanation from the disposal areas was analyzed using the NRC RADON model (NRC, 1989). The model utilizes the one-dimensional radon diffusion equation, which uses the physical and radiological characteristics of the tailings and overlying materials to calculate the rate of radon emanation from the tailings through the cover. The model was used to calculate the cover thickness required to limit the radon emanation rate through the top of the cover to 20 picocuries per square meter per second (pCi/m^2-s), following the guidance presented in U.S. Nuclear Regulatory Commission (NRC) publications NUREG/CR-3533 and Regulatory Guide 3.64 (NRC 1984, 1989). The rate of emanation standard is applied to the average emanation over the entire surface of the disposal area.

The input parameters used in the model are based on engineering experience with similar projects, recent laboratory testing results for samples of random fill, in addition to available data from previous work by others, including Chen and Associates (1978, 1979, 1987), Rogers and Associates Engineering Corporation (1988), Western Colorado Testing (1999a, 1999b), IUC (2000), and Titan (1996). The available data from recent testing as well as previous testing performed by others is summarized in Appendix A. The input parameters and values used in the model are outlined below.

C.2.1 Thickness of Tailings

The thickness of tailings currently deposited in Cells 2 & 3 is approximately 30 ft (914 cm), while the anticipated tailings thickness deposited in Cells 4A & 4B will be approximately 42 ft (1,280 cm). As documented in NRC Regulatory Guide 3.64, a tailings thickness greater than 100 to 200 cm is effectively equivalent to an infinitely thick radon source. Therefore, a thickness of 500 cm may be used in RADON to represent an equivalent infinitely thick tailings source of radon.

C.2.2 Radium Activity Concentration

The radium-226 activity concentration value for the tailings in the impoundments is estimated based on measured lab data from Rogers & Associates (1988); their original laboratory report is included as part of Appendix A.1. The radium activity of the random fill and erosion protection layer is assumed to be zero, based on guidance in Regulatory Guide 3.64 (NRC, 1989) which states that radium activity in the cover soils may be neglected for cover design purposes provided the cover soils are obtained from background materials that are not associated with ore formations or other radium-enriched materials. The values used in the model are as follows:

Table C.1. Radium Activity Concentrations

Material	Radium Activity Concentration (pCi/g)
Tailings	981
Random Fill	0
Erosion Protection	0

C.2.3 Radon Emanation Coefficient

The radon emanation coefficient used in the model is estimated from measured laboratory data (Rogers & Associates, 1988) as 0.19 for all layers. Because site-specific laboratory data is available, the NRC's default value of 0.35 is not appropriate.

C.2.4 Specific Gravity, Density and Porosity

The densities and porosities of the tailings and cover materials used in the model are based on laboratory testing results. The values are summarized in Table C.2 and discussed in more detail below.

Table C.2. Density and Porosity Values

Material	Specific Gravity	Degree of Compaction (%)	Placed Density (pcf)	Porosity
Erosion Protection	2.67	---	124.2*	0.25
Random fill (low compaction water storage, rooting zone)	2.67	85% SP	99.2	0.40
Random Fill (high compaction)	2.67	95% SP	110.9	0.33
Random Fill (in place, low compaction, platform fill)	2.67	80% SP	93.4	0.44
Tailings	2.75	70% SP	74.3	0.57

SP = standard proctor compaction
* Estimated by applying 25% rock correction factor

The specific gravity of the tailings was estimated as 2.75, and the dry density of the tailings was estimated as 74.3 pcf, based on laboratory tests (Chen and Associates, 1987 and Western Colorado Testing, 1999b) and assuming the tailings are at 70% of the average laboratory measured maximum dry density. The referenced reports are provided as part of Appendix A. The porosity of the tailings was calculated using the estimated specific gravity and dry density based on the following equation:

$$n = 1 - \left(\frac{\gamma_d}{G_s \gamma_w}\right) \qquad \text{(Eq. C.1)}$$

where

n = porosity,
γ_d = dry density of soil,
G_s = specific gravity of soil, and
γ_w = unit weight of water.

The specific gravity and dry density values used in the model for the random fill layers were estimated by laboratory tests (Chen and Associates, 1978, 1979, 1987, Western Colorado Testing, 1999a, Geosyntec, 2006). The referenced reports are provided as part of Appendix A.1. The porosity values for the layers were calculated using equation C.1. The proposed cover system has three layers of random fill placed at different levels of compaction. The lower layer of random fill consists of a minimum thickness of 2.5 feet of random fill that is assumed to be dumped and minimally compacted by construction equipment to approximately 80 percent standard Proctor. The middle layer (2.5 feet) of random fill will be compacted to 95 percent of standard Proctor. In Cell 2 and parts of Cell 3, the lower layer of random fill is already placed and is approximately 3 feet. It is assumed the upper 6 inches of this fill will be part of the middle random fill layer and can be compacted by additional passes of compactors to reach 95 percent of standard Proctor compaction. The uppermost 3.5 feet of random fill will be placed at 85 percent of standard Proctor compaction in order to optimize water storage and rooting characteristics for plant growth.

The 0.5 foot erosion protection layer is assumed to be rock mulch consisting of topsoil material mixed with 25 percent gravel. The specific gravity and density of the erosion protection layer was assumed to be 2.67 and 124.2 pcf, respectively, based on laboratory testing results for random fill (Chen and Associates, 1978, 1979, 1987, IUC 2000) and applying a rock correction based on 25% gravel.

C.2.5 Long-term Moisture Content

The long-term moisture content value for the tailings is assumed to be 6 percent. This is a conservative assumption, per NRC Regulatory Guide 3.64 (NRC, 1989), which represents the lower bound for moisture in western soils and is typically used as a default value for the long-term water content of tailings.

MWH, Inc. (MWH) collected representative samples from the on-site random fill and topsoil stockpiles for use in estimating the long-term moisture contents for the random fill and erosion protection cover layers (see Appendix A.2). The laboratory results from these samples were used in conjunction with two methods from NRC (1989) to estimate long-term water contents for the random fill and erosion protection layers. The two NRC (1989) methods used were: (1) obtain measured water contents from samples collected at depths greater than 120 cm (3.9 feet); and (2) estimate water contents using the empirical equation by Rawls and Brakenseik (1982). The Rawls and Brakenseik (1982) equation is as follows:

$$\theta = 0.026 + 0.005z + 0.0158y \quad \text{(Eq. C.2)}$$

where

θ= volumetric water content,
z = percent clay in soil, and
y = percent organic matter in soil.

Volumetric water content is related to gravimetric water content, w, by the following equation:

$$w = \frac{\theta \cdot \gamma_w}{\gamma_d} \quad \text{(Eq. C.3)}$$

where

w = gravimetric water content,
γ_w = unit weight of water, and
γ_d = dry unit weight of sample during measurement of volumetric water content.

For samples in which both gravimetric water content was obtained for the sample at depth and percent clay was measured, the Rawls and Brakenseik volumetric water content was compared to the measured gravimetric water content. Using best-fit procedures, it was determined that a dry density of 91.4 pcf resulted in the best correlation between the two methods for the site data. A preference of methods was established in which measured gravimetric water content of deep samples was used prior to estimating water content based on the Rawls and Brakenseik equation. A weighted average procedure that accounts for the size of each stockpile was incorporated to determine the average gravimetric water content for the random fill and topsoil. The compaction densities and average long-term moisture contents are summarized in Table C.3. A table showing the estimation of the long-term water content is provided as Attachment C.1.

Table C.3. Compaction Densities and Estimated Long-Term Moisture Contents

Material	Degree of Compaction (%)	Placed Density (pcf)	Gravimetric Water Content (%)
Erosion Protection	---	124.2	5.7
Random fill (low compaction water storage, rooting zone)	85% SP	99.2	7.8
Random Fill (high compaction)	95% SP	110.9	7.8
Random Fill (in place, low compaction, platform fill)	80% SP	93.4	7.8
Tailings	70% SP	74.3	6.0

C.2.6 Diffusion Coefficient

The radon diffusion coefficient used in the RADON model can either be calculated within the model (based on an empirical relationship dependent upon porosity and the degree of saturation) or input directly in the model using values measured from laboratory testing. Although laboratory test data was available for the tailings and the cover material (Rogers & Associates 1988), tests were performed at porosities and water contents different than those estimated to represent long-term conditions. Therefore, the empirical relationship in RADON was used, resulting in the calculated values summarized in Table C.4 below.

Table C.4. Calculated Radon Diffusion Coefficients

Material	Degree of Saturation (%)	Diffusion Coefficient (cm^2/s)
Erosion Protection	44.7	0.0123
Random Fill (low compaction water storage, rooting zone)	30.7	0.0248
Random Fill (high compaction)	41.6	0.0152
Random Fill (in place, low compaction, platform fill)	26.7	0.0294
Tailings	12.5	0.0499

C.3 MODEL RESULTS

The radon emanation modeling results show that the designed cover system will reduce the rate of radon emanation to values below the limit of 20 picocuries per square meter per second (pCi/m^2-s) averaged over the entire area of the tailings impoundments, which is the regulatory criterion (Utah Administrative Code, Rule 313-24). The RADON model output is provided in Attachment C.2.

C.4 IMPACTS OF INCREASED THICKNESS OF RANDOM FILL

Radon modeling as discussed above assumed that the lower layer of random fill was placed at 80 percent of standard Proctor compaction, and had a thickness of 2.5 feet (assuming top 6 inches can be compacted to 95% standard Proctor compaction prior to placement of additional fill). However, based on the assumption that the top of tailings is 18 inches below the top of the flexible membrane liner (FML), the thickness of existing random fill in Cell 2 is significantly thicker than 3.0 feet in some areas. Additional modeling was performed to determine the minimum thickness of highly compacted random fill required in order to meet regulatory criterion. This modeling indicates that for every extra foot of low-compaction (80% standard Proctor compaction), the highly compacted (95% standard Proctor compaction) can be reduced in thickness by 0.64 ft. This trend is shown in Figure C.1. The RADON model output is provided in Attachment C.3.

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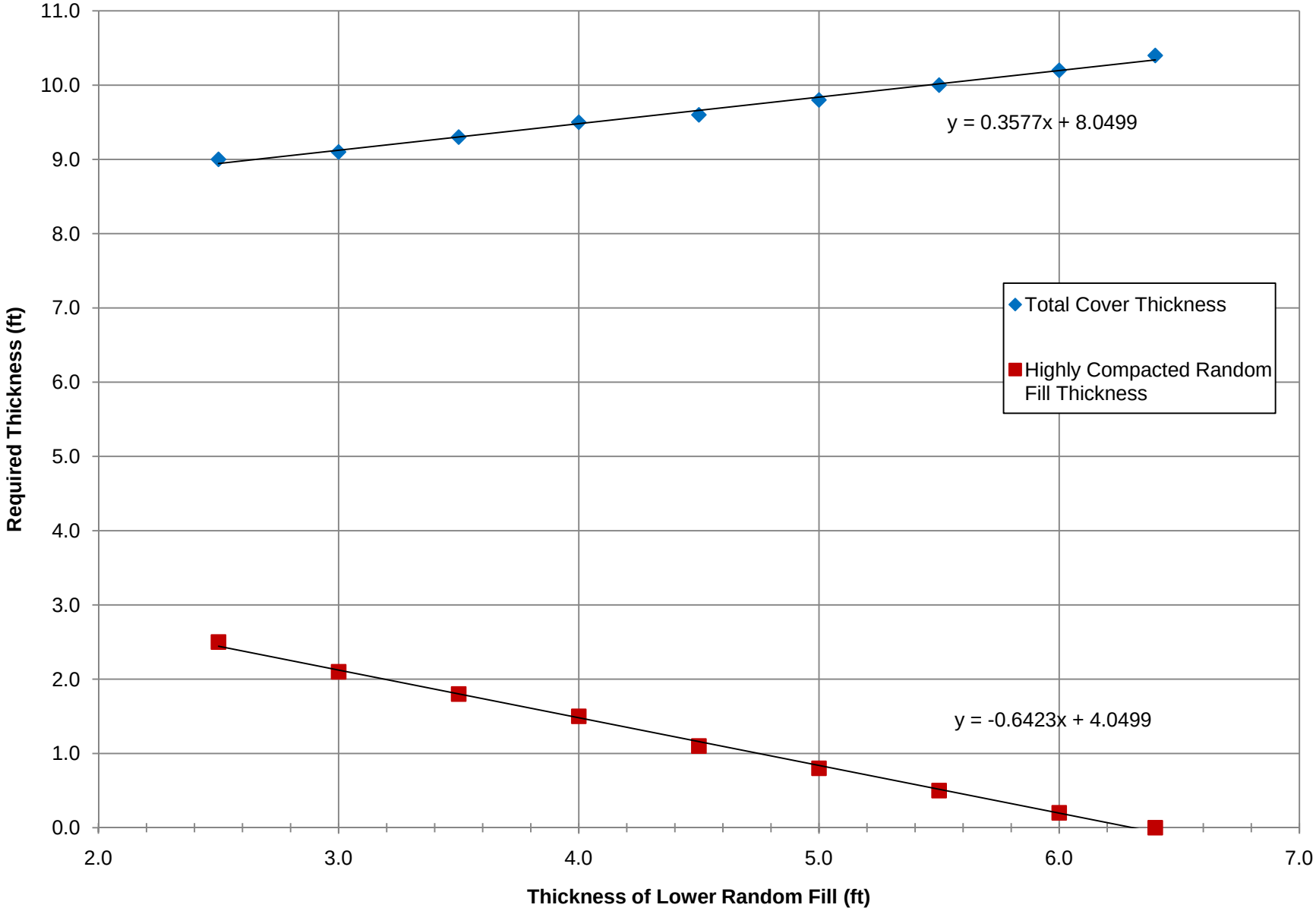

DENISON MINES
Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
RADON EMANATION
INCREASED THICKNESS OF LOWER
RANDOM FILL VS TOTAL COVER THICKNESS

MWH

DATE
AUG 2011

FIGURE C.1

FILENAME
Radon grading plan evaluation.xlsx

ATTACHMENT C.1

LONG-TERM MOISTURE CONTENT ESTIMATION TABLES

DENISON MINES WHITE MESA MILL

Table 1. Estimation of Long-Term Water Contents

Borrow Stockpile ID	Material Description	Estimated Stockpile Volume[1] (cy)	Sample ID	Sample Depth (ft)	% Clay[2]	Measured Gravimetric Water Content (%)	Gravimetric Water Content Est. using Rawls Eqn.[3] (%)	Comments
E1	Topsoil	15,900						not sampled
E2	Silty Sand/Clayey Sand Random Fill	92,000	A	5		4.5		
			B	12	14.0		6.6	sample from working face at south end of stockpile
E3	Random Fill	16,800						not sampled
E4	Sandy Clay Random Fill	66,600	A	5		8.6		
E5	Sandy Clay Random Fill	68,800	A	6		9.0		
E6	Clay Random Fill	100,700	A	5		14.4		
E7	Sandy Clay Random Fill	74,900	A	6		5.7		
E8	Sandy Clay Random Fill	227,300	A	2	16.1		7.3	
W1	Sandy Clay Random Fill	85,700	A	5		8.8		
W2	Sandy Clay Random Fill	584,500	A	surface	15.8		7.2	
W3	Topsoil (Sandy Silty Clay)	84,800	A	surface	13.1		6.3	
W4	Topsoil (Sandy Silt)	90,000	A	5		5.3		
W5	Random Fill	965,200						not sampled
W6	Topsoil (Sandy Silty Clay)	93,400	A	surface	11.1		5.6	
W7	Sandy Clay Random Fill	39,500	A	5		8.7		
W8	Random Fill	900,000						not sampled
W9	Sandy Clay Random Fill	300,000	A	surface	17.4		7.7	
Weighted Average Gravimetric Water Content (%):			Random Fill:			7.8		
			Topsoil (adj. of addition of 25% gravel):			5.7		

Notes:
1. Volumes estimated using 2009 topography and assuming a relatively flat bottom surface, except for stockpiles W8 and W9. The volumes for stockpiles W8 and W9 were estimated based on the volume of material excavated from Cell 4B (1,360,000 cy) less the material used to construct the Cell 4B berm (83,000 cy), and assuming stockpile W8 is approximately 3x larger than W9 (based on visual observation).
2. % Clay corrected for 25% gravel added to topsoil admixture.
3. Gravimetric water content of random fill samples calculated using dry density of 91.4 pcf.

ATTACHMENT C.2

RADON MODEL OUTPUT

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: White Mesa 030811
DESCRIPTION: White Mesa Mill

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
NO. OF THE LAYER TO BE OPTIMIZED	3	
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Tailings		
THICKNESS	500	cm
POROSITY	.57	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	8.172D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.125	
CALCULATED DIFFUSION COEFFICIENT	4.990D-02	cm^2 s^-1
LAYER 2 Random Fill 80% Compaction		
THICKNESS	76.2	cm
POROSITY	.439	
MEASURED MASS DENSITY	1.5	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.267	
CALCULATED DIFFUSION COEFFICIENT	2.944D-02	cm^2 s^-1
LAYER 3 Random Fill 95% Compaction		
THICKNESS	1	cm
POROSITY	.334	
MEASURED MASS DENSITY	1.78	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1

MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.416	
CALCULATED DIFFUSION COEFFICIENT	1.520D-02	cm^2 s^-1

LAYER 4 Random Fill 85% Compaction

THICKNESS	106.7	cm
POROSITY	.404	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.307	
CALCULATED DIFFUSION COEFFICIENT	2.478D-02	cm^2 s^-1

LAYER 5 Erosion Protection Layer

THICKNESS	15.2	cm
POROSITY	.254	
MEASURED MASS DENSITY	1.99	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	5.7	%
MOISTURE SATURATION FRACTION	.447	
CALCULATED DIFFUSION COEFFICIENT	1.226D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	3	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	4.990D-02	5.700D-01	8.172D-04	1.253D-01	1.190
2	7.620D+01	2.944D-02	4.390D-01	0.000D+00	2.665D-01	1.500
3	1.000D+00	1.520D-02	3.340D-01	0.000D+00	4.157D-01	1.780
4	1.067D+02	2.478D-02	4.040D-01	0.000D+00	3.070D-01	1.590
5	1.520D+01	1.226D-02	2.540D-01	0.000D+00	4.466D-01	1.990

BARE SOURCE FLUX FROM LAYER 1: 6.891D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	2.111D+02	2.598D+05
2	7.620D+01	8.352D+01	1.459D+05
3	7.470D+01	4.310D+01	3.827D+04
4	1.067D+02	2.042D+01	1.135D+04
5	1.520D+01	2.002D+01	0.000D+00

ATTACHMENT C.3

RADON MODEL OUTPUT FOR VARIABLE THICKNESS OF RANDOM FILL

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**5/31/2011**
Detail:	**Radon Emanation: Depth of Interim Fill vs Total Cover Thickness**	**Computed By:**	**RTS**

Existing Interim Fill (ft)	Modeled Random Fill at 80%[1] (ft)	Required Thickness of 95% SP Layer (ft)	Additional Fill needed for 3 layers of Cover Construction (ft)	Total Cover thickness Required at Point (ft)
3.0	2.5	2.5	6.0	9.0
3.5	3.0	2.1	5.6	9.1
4.0	3.5	1.8	5.3	9.3
4.5	4.0	1.5	5.0	9.5
5.0	4.5	1.1	4.6	9.6
5.5	5.0	0.8	4.3	9.8
6.0	5.5	0.5	4.0	10.0
6.5	6.0	0.2	3.7	10.2
6.9	6.4	0.0	3.5	10.4

[1] Assumes top 6 inches will be compacted to 95% Standard Proctor

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: White mesa 4.0 ft interim cover

DESCRIPTION: White Mesa: 4.0 ft of existing interim cover, top 6 inches compacted.

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
NO. OF THE LAYER TO BE OPTIMIZED	3	
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Tailings

THICKNESS	500	cm
POROSITY	.57	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	8.172D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.125	
CALCULATED DIFFUSION COEFFICIENT	4.990D-02	cm^2 s^-1

LAYER 2 Random fill 80% Compaction

THICKNESS	106.7	cm
POROSITY	.439	
MEASURED MASS DENSITY	1.5	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	

CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.267	
CALCULATED DIFFUSION COEFFICIENT	2.944D-02	cm^2 s^-1

LAYER 3 Random Fill 95% Compaction

THICKNESS	1	cm
POROSITY	.334	
MEASURED MASS DENSITY	1.78	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.416	
CALCULATED DIFFUSION COEFFICIENT	1.520D-02	cm^2 s^-1

LAYER 4 Random Fill 85% Compaction

THICKNESS	106.7	cm
POROSITY	.404	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.307	
CALCULATED DIFFUSION COEFFICIENT	2.478D-02	cm^2 s^-1

LAYER 5 Erosion Protection Layer

THICKNESS	15.2	cm
POROSITY	.254	
MEASURED MASS DENSITY	1.99	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	5.7	%
MOISTURE SATURATION FRACTION	.447	
CALCULATED DIFFUSION COEFFICIENT	1.226D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	3	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	4.990D-02	5.700D-01	8.172D-04	1.253D-01	1.190
2	1.067D+02	2.944D-02	4.390D-01	0.000D+00	2.665D-01	1.500
3	1.000D+00	1.520D-02	3.340D-01	0.000D+00	4.157D-01	1.780
4	1.067D+02	2.478D-02	4.040D-01	0.000D+00	3.070D-01	1.590
5	1.520D+01	1.226D-02	2.540D-01	0.000D+00	4.466D-01	1.990

BARE SOURCE FLUX FROM LAYER 1: 6.891D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	2.229D+02	2.534D+05
2	1.067D+02	6.809D+01	1.116D+05
3	5.481D+01	4.309D+01	3.826D+04
4	1.067D+02	2.041D+01	1.135D+04
5	1.520D+01	2.002D+01	0.000D+00

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: White mesa 6 ft interim cover

DESCRIPTION: White Mesa: 6 ft of existing interim cover, top 6 inches compacted.

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
NO. OF THE LAYER TO BE OPTIMIZED	3	
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Tailings

THICKNESS	500	cm
POROSITY	.57	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	8.172D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.125	
CALCULATED DIFFUSION COEFFICIENT	4.990D-02	cm^2 s^-1

LAYER 2 Random fill 80% Compaction

THICKNESS	168	cm
POROSITY	.439	
MEASURED MASS DENSITY	1.5	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	

CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.267	
CALCULATED DIFFUSION COEFFICIENT	2.944D-02	cm^2 s^-1

LAYER 3 Random Fill 95% Compaction

THICKNESS	1	cm
POROSITY	.334	
MEASURED MASS DENSITY	1.78	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.416	
CALCULATED DIFFUSION COEFFICIENT	1.520D-02	cm^2 s^-1

LAYER 4 Random Fill 85% Compaction

THICKNESS	106.7	cm
POROSITY	.404	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.307	
CALCULATED DIFFUSION COEFFICIENT	2.478D-02	cm^2 s^-1

LAYER 5 Erosion Protection Layer

THICKNESS	15.2	cm
POROSITY	.254	
MEASURED MASS DENSITY	1.99	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	5.7	%
MOISTURE SATURATION FRACTION	.447	
CALCULATED DIFFUSION COEFFICIENT	1.226D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	3	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	4.990D-02	5.700D-01	8.172D-04	1.253D-01	1.190
2	1.680D+02	2.944D-02	4.390D-01	0.000D+00	2.665D-01	1.500
3	1.000D+00	1.520D-02	3.340D-01	0.000D+00	4.157D-01	1.780
4	1.067D+02	2.478D-02	4.040D-01	0.000D+00	3.070D-01	1.590
5	1.520D+01	1.226D-02	2.540D-01	0.000D+00	4.466D-01	1.990

BARE SOURCE FLUX FROM LAYER 1: 6.891D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	2.343D+02	2.472D+05
2	1.680D+02	4.812D+01	6.080D+04
3	1.583D+01	4.310D+01	3.827D+04
4	1.067D+02	2.042D+01	1.135D+04
5	1.520D+01	2.002D+01	0.000D+00

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: White Mesa 6.9 ft interim cover

DESCRIPTION: White Mesa: 6.9 ft of existing interim cover, top 6 inches compacted

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
NO. OF THE LAYER TO BE OPTIMIZED	3	
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Tailings

THICKNESS	500	cm
POROSITY	.57	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	8.172D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.125	
CALCULATED DIFFUSION COEFFICIENT	4.990D-02	cm^2 s^-1

LAYER 2 Random fill 80% Compaction

THICKNESS	195	cm
POROSITY	.439	
MEASURED MASS DENSITY	1.5	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	

CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.267	
CALCULATED DIFFUSION COEFFICIENT	2.944D-02	cm^2 s^-1

LAYER 3 Random Fill 95% Compaction

THICKNESS	1	cm
POROSITY	.334	
MEASURED MASS DENSITY	1.78	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.416	
CALCULATED DIFFUSION COEFFICIENT	1.520D-02	cm^2 s^-1

LAYER 4 Random Fill 85% Compaction

THICKNESS	106.7	cm
POROSITY	.404	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	7.8	%
MOISTURE SATURATION FRACTION	.307	
CALCULATED DIFFUSION COEFFICIENT	2.478D-02	cm^2 s^-1

LAYER 5 Erosion Protection Layer

THICKNESS	15.2	cm
POROSITY	.254	
MEASURED MASS DENSITY	1.99	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	5.7	%
MOISTURE SATURATION FRACTION	.447	
CALCULATED DIFFUSION COEFFICIENT	1.226D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	3	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	4.990D-02	5.700D-01	8.172D-04	1.253D-01	1.190
2	1.950D+02	2.944D-02	4.390D-01	0.000D+00	2.665D-01	1.500
3	1.000D+00	1.520D-02	3.340D-01	0.000D+00	4.157D-01	1.780
4	1.067D+02	2.478D-02	4.040D-01	0.000D+00	3.070D-01	1.590
5	1.520D+01	1.226D-02	2.540D-01	0.000D+00	4.466D-01	1.990

BARE SOURCE FLUX FROM LAYER 1: 6.891D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	2.366D+02	2.460D+05
2	1.950D+02	4.301D+01	4.428D+04
3	0.000D+00	4.301D+01	3.819D+04
4	1.067D+02	2.038D+01	1.133D+04
5	1.520D+01	1.998D+01	0.000D+00

APPENDIX D

VEGETATION AND BIOTINTRUSION EVALUATION

D.1 INTRODUCTION

This appendix provides an evaluation of vegetation that would be used as an integral part of an evapotranspiration (ET) cover proposed for reclamation of tailing cells at the White Mesa Mill Site. A critical component of an ET cover is the plant community that will be established on the cover and will function over the long term to provide protection from wind and water erosion and assist in removing water through the process of transpiration. In this appendix, issues related to the short-term establishment and long-term sustainability of vegetation proposed as part of the ET cover are addressed. These issues include: plant species selection, ecological characteristics of species (i.e., longevity, sustainability, compatibility, competition, rooting depth and root distribution), characteristics of the established plant community (i.e., percent plant cover and leaf area index [LAI]), and soil requirements for sustained plant growth. In addition, plant root growth and animal burrowing activity are discussed in relation to their potential for biointrusion into the covered tailing.

D.2 PROPOSED SPECIES FOR ET COVER RECLAMATION

The following 12 species (10 grasses and 2 forbs) are proposed for the ET cover system at the White Mesa Mill Site. These species were selected for their adaptability to site conditions, compatibility, and long-term sustainability. Species were also selected based on the assumption that institutional controls will prohibit grazing by domestic livestock. The proposed species are:

- Western wheatgrass, variety Arriba (*Pascopyrum smithii*)
- Bluebunch wheatgrass, variety Goldar (*Pseudoroegneria spicata*)
- Slender wheatgrass, variety San Luis (*Elymus trachycaulus*)
- Streambank wheatgrass, variety Sodar (*Elymus lanceolatus* ssp. *psammophilus*)
- Pubescent wheatgrass, variety Luna (*Thinopyrum intermedium* ssp. *barbulatum*)
- Indian ricegrass, variety Paloma (*Achnatherum hymenoides*)
- Sandberg bluegrass, variety Canbar (*Poa secunda*)
- Sheep fescue, variety Covar (*Festuca ovina*)
- Squirreltail, variety Toe Jam Creek (*Elymus elymoides*)
- Blue grama, variety Hachita (*Bouteloua gracilis*)
- Common yarrow, no variety (*Achillea millefolium*)
- White sage, no variety (*Artemisia ludoviciana*).

These species are described in more detail later in this appendix.

D.3 PROPOSED SEEDING RATES

Given a mixture of the species listed above, Table D-1 presents broadcast seeding rates for each species. Seeding rates were developed based on the objective of establishing a permanent cover of grasses and forbs in a mixture that would promote compatibility among species and minimize competitive exclusion or loss of species over time.

The number of seeds placed in a unit area of soil is called the seeding rate. The total seeding rate is the sum of the individual species seeding rates. Seeding rates are normally expressed as the number of seeds per square foot or pounds per acre. Many different seeding rates for the same species can be found in the literature. The primary reason for these differences is that some rates are for monocultures and other rates are for diverse mixtures.

Seeding rates are developed on the basis of number of seeds per unit area (e.g. number of seeds per square foot). Once this number is determined, then it can be converted to weight per unit area (e.g. pounds per acre). Since each species produces seed that weighs a different amount, the development of seeding rates based purely on weight per unit area will produce erroneous rates that will tend to over emphasize small seeded species and under-emphasize large seeded species. For example, blue grama has approximately 700,000 seeds per pound, while Indian ricegrass has approximately 175,000 seeds per pound. If seeding rates were calculated simply on the basis of weight per unit area, without recognizing the fact that a pound of blue grama seed has four times the number of seeds per pound as Indian ricegrass, it would be very easy to over plant blue grama and under plant Indian ricegrass.

Table D-1. Species and Seeding Rates Proposed for ET Cover at the White Mesa Mill Site

Scientific Name	Common Name	Native/ Introduced	Seeding Rate (# PLS seeds/ft^2) †	Seeding Rate (lbs PLS/acre)†
Grasses				
Pascopyrum smithii	Western wheatgrass	Native	6.0	3.0
Pseudoroegneria spicata	Bluebunch wheatgrass	Native	8.0	3.0
Elymus trachycaulus	Slender wheatgrass	Native	5.0	2.0
Elymus lanceolatus	Streambank wheatgrass	Native	5.5	2.0
Elymus elymoides	Squirreltail	Native	7.0	2.0
Thinopyrum intermedium	Pubescent wheatgrass	Introduced‡	1.5	1.0
Achnatherum hymenoides	Indian ricegrass	Native	8.0	4.0
Poa secunda	Sandberg bluegrass	Native	9.0	0.5
Festuca ovina	Sheep fescue	Native	9.0	1.0
Bouteloua gracilis	Blue grama	Native	13.0	1.0
Forbs				
Achillea millefolium	Common yarrow	Native	23.0	0.5
Artemisia ludoviciana	White sage	Native	23.0	0.5
Total			118.0	21.0

†Seeding rate is for broadcast seed and presented as number of pure live seeds per ft^2 and pounds of pure live seed per acre. ‡Introduced refers to species that have been 'introduced' from another geographic region, typically outside of North America. Also referred to as 'exotic' species.

Seeding rate may be calculated from an expected field emergence for each species and the desired number of plants per unit area. For purposes of calculation, field emergence for small seeded grasses and forbs is assumed to be around 50% if germination is greater than 80%. Field emergence is assumed to be around 30% if germination is between 60 and 80%. The Natural Resource Conservation Service recommends a seeding rate of 20 to 30 pure live seeds per square foot as a minimum number of seeds when drill seeding in areas with an annual precipitation between 6 and 18 inches. Twenty pure live seeds per square foot, with an expected field emergence of 50% should produce an adequate number of plants on the seeded area to control erosion and suppress annual invasion. This seeding rate is primarily for

favorable growing conditions, soils that are not extreme in texture, gentle slopes, north or east facing aspect, good moisture, and adequate soil nutrients. When conditions are less favorable or when the seed is broadcast, seeding rates are increased up to a level that is two to four times the drill rate for favorable conditions. A multiplier of 4x was used in establishing the proposed seeding rate.

A CQAQC Plan for application rates and procedures for confirming that specified application rates are achieved is as follows. The first step begins with a seed order. Seed will be purchased as pounds of pure live seed. Each State has a seed certifying agency and certification programs may be adopted by seed growers (e.g. Utah State Department of Agriculture and Food). Certification of a container of seed assures the customer that the seed is correctly identified and genetically pure. The State agency responsible for seed certification sets minimum standards for mechanical purity and germination for each species of seed. When certified, a container of seed must be labeled as to origin, germination percentage, date of the germination test, percentage of pure seed (by weight), other crop and weed seeds, and inert material. The certification is the consumer's best guarantee that the seed being purchased meets minimum standards and the quality specified.

Once the seed is obtained, seed labels will be checked to determine the percent PLS and the date that the seed was tested for percent purity and percent germination. If the test date is greater than 6 months old, the seed will be tested again before being accepted. Seed will be applied using a broadcasting method. This procedure will use a centrifugal type broadcaster, also called an end gate seeder. These broadcasters operate with an electric motor and are usually mounted on the back of a small tractor and generally have an effective spreading width of about 20 feet or more. Prior to seeding, a known area will be covered with a tarp and seed will be distributed using the broadcaster and simulating conditions that would exist under actual seeding conditions. Seed will then be collected and weighed to determine actual seeding rate in terms of pounds per acre. This process will be repeated until the specified seeding rate is obtained. During the seeding process, the seeding rate will be verified at least once by comparing pounds of seed applied to the size of the area seeded. In addition, seed will be applied in two separate passes. One-half of the seed will be spread in one direction and the other half of seed will be spread in a perpendicular direction. This will ensure that seed distribution across the site is highly uniform and also provide the opportunity to adjust the seeding rate if the specified rate is not being achieved.

D.4 ECOLOGICAL CHARACTERISTICS OF PROPOSED SPECIES AND ESTABLISHED PLANT COMMUNITY

D.4.1 Longevity and Sustainability

All of the species proposed for reclamation of the tailings cells are long-lived, except for slender wheatgrass (*Elymus trachycaulus*) and squirreltail (*Elymus elymoides*). Slender wheatgrass is a perennial bunchgrass that is short-lived (5 to 10 years) but has the ability to reseed and spread vegetatively with rhizomes. Squirreltail is also a short-lived perennial but has the ability to establish quickly and is highly effective in competing with undesirable annual grasses. Both of these species are included in the proposed seed mixture because of their ability to provide quick cover for erosion protection and to effectively compete with annual and biennial species that cannot be relied upon to provide consistent and sustainable plant cover. The use of these species will facilitate the establishment of the remaining long-lived perennials that have been documented to be highly adapted to the elevation, climate, and soil conditions found at the

White Mesa Mill Site (Monsen et al., 2004; Alderson and Sharp, 1994; Wasser, 1982; Thornburg, 1982).

The perennial grasses and forbs in the proposed seed mixture include species that develop individual plants that are long lived (30 years or more) and are able to reproduce either by seed or vegetative plant parts like rhizomes and tillers. The use of these species in reclamation of the tailing cells will ensure a permanent or sustainable plant cover because of the highly adapted nature of these species to existing site conditions, their tolerance to environmental stresses such as drought, fire, and herbivory, and their ability to effectively reproduce over time.

The use of a mixture of species for the ET cover also contributes to longevity and sustainability. The establishment of a diverse community has many advantages over a monoculture for sustained plant growth. The use of a variety of species ensures that diverse microsites that may exist over a seeded site are properly matched with species that are adapted to those specific environmental conditions. In addition, a mixture of species reverses the loss of plant diversity and enhances natural recovery processes following impacts from insects, disease organisms, and adverse climatic events. Finally, mixtures provide improved ground cover and surface stability, along with reducing weed invasion by fully utilizing plant resources such as water, nutrients, sunlight and space. Weeds in this context are typically annual or biennial plants considered to be undesirable or troublesome, especially growing where they are not wanted.

D.4.2 Compatibility

Reclamation research and its application have been ongoing in the U.S. since the early 1900s. First with the reseeding of millions of acres following the dust bowl of the 1930s. Then, improvements of large tracts of arid and semiarid rangelands between the 1960s and 1980s following more than a half a century of rangeland exploitation through overgrazing. In 1985 the U.S. Department of Agriculture Conservation Reserve Program was implemented which resulted in the conversion of more than 40 million acres of marginal farm land to permanent grasslands through an extensive seeding program. Finally, there have been tens of thousands of acres of mined lands reclaimed across the U.S. with the implementation of federal and state rules and regulations governing mine land reclamation. Over this time period, there have been thousands of reclamation publications in the form of books, scientific journal articles, symposium proceedings, and government publications. Many publications have reported on the performance of individual species and mixtures of species under semiarid conditions similar to southeastern Utah (e.g., Plummer et al., 1968; Monsen et al., 2004). All of this work has led to a knowledge base about species compatibility. Species that are seeded together in mixtures must be compatible as young, developing plants or certain individuals will succeed and others will fail. The species proposed for the ET cover at the White Mesa Mill Site are all compatible with each other and seeding rates will be used to prevent overseeding species that may be aggressive [e.g., pubescent wheatgrass (*Thinopyrum intermedium*)] and could potentially dominate the site (Monsen et al., 2004). These species are commonly seeded together and many studies have shown excellent interspecies compatibility (e.g., DePuit et al., 1978; DePuit, 1982; Redente et al., 1984; Sydnor and Redente, 2000; Newman and Redente, 2001). Finally, to increase compatibility and to reduce competition among seeded species, sites would be broadcast seeded as opposed to drill seeded. According to Monsen et al. (2004), drill seeding causes species in a mixture to be placed in potentially competitive situations, while broadcasted seeds are not placed in as close contact with each other as with drilling and therefore are less likely to be negatively impacted from competition.

D.4.3 Competition

There are two ways to view competition. In the context of establishing an ET cover on the tailing cells, the use of seeded species to compete with weeds or woody plants is a desirable attribute. However, competition among seeded species with the potential loss of any of these species is undesirable. Therefore, as stated earlier, the proposed seed mixtures is comprised of species that can coexist and also fully utilize plant resources to keep weeds or woody species from colonizing and excluding seeded species. The establishment of weeds, especially invasives (i.e., non-native species whose introduction causes economic and environmental harm) is unacceptable because of the potential loss of seeded perennial species and the subsequent reduction in species diversity, plant cover, and overall sustainability. The establishment of deep rooted woody plants is unacceptable because of the potential for biointrusion through the cover and into the tailings material. Once established, the proposed seed mixture will produce a grass-forb community of highly adapted and productive species that will effectively compete with undesirable species, including shrubs native to the area. Paschke et al. (2003) present a literature review on shrub establishment on mined lands and conclude that one of the primary reasons that shrub establishment does not occur in mined land reclamation is because of competition from herbaceous species. This finding is also supported by DePuit et al. (1980), DePuit (1988), Munshower (1994), and Monsen et al. (2004). Because of the highly adapted and competitive nature of the species that will be seeded, the invasion of indigenous woody species will be inhibited, and intrusion into the cover below the water storage layer (top 4 feet (122 cm) of the cover) from their roots is not anticipated to occur. Woody species in this environment are slow-growing and not nearly as competitive for water and nutrients as the proposed grass and forb species (Monsen et al., 2004). In addition, species like sagebrush, piñon pine, and Utah juniper have become dominant components of the regional flora primarily because of decades of overgrazing that has removed more palatable grasses and forbs and allowed less palatable woody species to establish and expand their range (Dames and Moore, 1978; Ellison, 1960). This process is referred to as retrogression (Holechek et al., 1998). These conditions will not occur on the tailing cells cover and therefore will not be a factor favoring the establishment of woody species.

D.4.4 Percent Plant Cover and Leaf Area Index

Monitoring of an alternative cover at the Monticello, Utah Uranium Mill Tailings Disposal Site showed that the plant cover performed well over a seven year period. Plant cover ranged from 5.5% during the first growing season to nearly 46% in the seventh growing season (Waugh et al., 2008). A total of 18 species were seeded at the Monticello Site and of these 18 species, eight species contributed 70% of the total plant cover. Approximately one half of the species proposed for the White Mesa Site were seeded at Monticello and of the eight best-performing species, four of these species are in the White Mesa mixture. High performing species used at Monticello that are not proposed for White Mesa include three introduced species that can be highly competitive (i.e. smooth brome, crested wheatgrass, and alfalfa) and were not considered acceptable for the White Mesa Site. Based on these results and the similarity in environmental conditions between Monticello and White Mesa, a plant cover estimate of 40% was determined to be a reasonable estimate for a long-term average, while a percent plant cover of 30% was assigned as a worst case scenario under drought conditions. The percent vegetative cover at White Mesa is expected to be slightly less than what would be found at Monticello because the average annual precipitation at White Mesa is approximately 13 inches compared to 15 inches at Monticello and the average annual maximum/minimum air temperatures are 64/37°F for White Mesa and 59/33°F for Monticello. The slightly greater precipitation and lower

temperatures at Monticello are due to its slightly higher elevation of 7,000 feet compared to 5,600 feet at White Mesa.

Long-term average plant cover for the tailing cells along with monthly leaf area index (LAI) values were estimated for the proposed ET cover at the White Mesa Site. Three primary publications were used to estimate monthly LAI for the ET cover, including: Groeneveld (1997), Scurlock et al. (2001), and Fang et al. (2008). Table D-2 presents a compilation of LAI values based on North American data sets that were focused on semiarid herbaceous plant communities. It is important to note that the proposed species for the ET cover include both cool- and warm-season species. This combination of species will maximize the length of the growing season and transpiration from early spring to late fall. Cool-season species are more productive and use more water during the cooler times of the growing season, while warm-season species are more productive and use more water during the warmest period of the year.

Table D-2. Leaf Area Index for the ET Cover at White Mesa Mill Site

Month											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
0	0	0.3	0.7	0.6	0.6	1.8	2.4	2.6	0.8	0.1	0

The formation of desert pavement and potential impact on plant cover has been raised as an issue for discussion. Desert pavements are armored surfaces composed of angular or rounded rock fragments, usually one or two stones thick, set on or in a matrix of finer material (Cooke and Warren, 1973). These surfaces form on arid soils through deflation of fine material by wind or water erosion due to a lack of protection by surface vegetation (Cooke and Warren, 1973). Desert pavements are not common in semiarid regions and do not occur where either wind or water erosion are controlled by plant cover (Hendricks, 1991), as would be the case for the White Mesa cover system. In addition, there is no evidence of desert pavement formation either on the White Mesa Site or areas surrounding the site. Even with the use of a topsoil layer amended with gravel, there is no supporting evidence to indicate a potential for desert pavement formation or an associated decrease in plant cover over the long term.

D.5 BIOINTRUSION

D.5.1 Plant Intrusion

The proposed cover system is a monolithic ET cover that consists of the following layers from top to bottom: 15 cm of a topsoil-gravel erosion protection layer over 107 cm of a water storage, biointursion and radon attenuation layer over 75 cm of a highly compacted radon attenuation layer over 75 cm of a grading and radon attenuation layer. The proposed cover system does not contain a biobarrier (e.g. cobble layer) to minimize potential intrusion by plant roots or burrowing animals. The proposed cover system is designed to minimize both plant root and burrowing animal intrusion through the use of thick layers of soil cover in combination with a highly compacted layer placed at a depth that is below the expected rooting and burrowing depths among species that may inhabit the site. The thickness of the cover, the use of a highly compacted radon attenuation layer located at a depth between 122 and 197 cm, and a final 75 cm layer below the compacted zone will all contribute to minimizing any biointrusion through the cover. Considering the plant species that may inhabit that tailing cells and the thickness and physical nature of the cover, it is not anticipated that root growth will extend below 122 cm or into the very top portion of the highly compacted zone.

The plant species that are proposed for establishment on the cover system are characterized by rooting depths that are far less than the depth of the biointrusion and radon attenuation layers that extend to a depth of 6.5 feet (197 cm) (15 cm of topsoil-gravel over 107 cm of a water storage/biointrusion layer over a 75 cm radon attenuation layer). Table D-3 lists the plant species proposed for establishment along with their maximum rooting depths obtained from the literature.

The species with the deepest rooting system is pubescent wheatgrass, with a maximum rooting depth of 185 cm. It is highly unlikely that this species or any other species will root below a depth of 122 cm, which is the combined depth of the erosion protection layer and the biointrusion layer. Root growth into the highly compacted radon attenuation layer that begins at a depth of 122 cm will be restricted because of the high density of this material (95% Standard Proctor). In addition, both root density and the size of roots decrease at a rapid rate with rooting depth, further decreasing the potential for root growth into the compacted radon attenuation layer of the cover system.

Table D-3. Rooting Depths for Species Proposed for Establishment on the Cover System

Scientific Name	Common Name	Rooting Depth (cm)
Pascopyrum smithii	Western wheatgrass	109[a]
Pseudoroegneria spicata	Bluebunch wheatgrass	122[b]
Elymus trachycaulus	Slender wheatgrass	109[a]
Elymus lanceolatus	Streambank wheatgrass	165[c]
Elymus elymoides	Squirreltail	30[d]
Thinopyrum intermedium	Pubescent wheatgrass	185[a]
Achnatherum hymenoides	Indian ricegrass	84[e]
Poa secunda	Sandberg bluegrass	45[f]
Festuca ovina	Sheep fescue	56[b]
Bouteloua gracilis	Blue grama	119[e]
Achillea millefolium	Common yarrow	105[f]
Artemisia ludoviciana	White sage	20[d]

[a]Wyatt et al., 1980; [b]Weaver and Clements, 1938; [c]Coupland and Johnson, 1965;[d]Foxx and Tierney, 1987; [e]Spence, 1937; [f]USDA, 2011

Table D-4 illustrates the reduction in root mass with depth for two of the species proposed for establishment on the cover system. Both western wheatgrass and blue grama have very little root mass in the 90 to 120 cm depth and no root mass below 120 cm. The root architecture of these two species is typical of grasses found in semi-arid environments and are representative of the all species proposed for establishment.

Table D-4. Percent of Root Mass by Depth for Two of the Proposed Species for Establishment of the Cover System*

Species	0-30 cm	30-60 cm	60-90 cm	90-120 cm	120-150 cm
Western wheatgrass	65	14	12	9	0
Blue grama	94	4	1	1	0

*Weaver 1954

In addition to the information presented on root architecture above, the following provides further documentation of rooting depths and root distribution or root density by depth. Six primary publications were used to estimate root densities by depth for the plant community that would establish on the cover system, including: Hopkins (1953), Bartos and Sims (1974), Sims and Singh (1978), Lee and Lauenroth (1994), Jackson et al. (1996), and Gill et al. (1999). Table D-5 presents an estimate of effective root densities by depth for the proposed cover system.

Table D-5. Root Densities for Species Expected to Occur on the Cover System

Depth (cm)	Root Density (grams cm^{-3})
0-15	1.9
15-30	6.2
30-45	1.7
45-60	0.8
60-75	0.6
75-90	0.6
90-105	0.4
105-120	0.2
120-135	0.0

D.5.2 Animal Intrusion

Based on a review of the wildlife survey data from the 1978 Environmental Report produced for the White Mesa site (Dames and Moore, 1978), and a thorough literature review of burrowing depths and biointrusion studies, the maximum depth of on-site burrowing would be approximately one meter or slightly over three feet. Wildlife survey data for the site indicate that burrowing mammals include deer mice, kangaroo rats, chipmunks, desert cottontails, blacktailed jackrabbits, and prairie dogs. Other burrowing mammals, such as pocket gophers and badgers have not been observed in the area of the White Mesa site (Dames and Moore, 1978). Of the list of burrowing mammals that may occur on the site, the prairie dog is the species capable of burrowing to the greatest depth. Studies by Shuman and Whicker (1986) and Cline et al. (1982) conducted in southeast Wyoming, Grand Junction, Colorado and Hanford, Washington, document maximum burrowing depths of prairie dogs between 60 and 100 cm. Based on this empirical data and the potential species that may use the site as habitat, any burrowing activity that may occur would be limited to about 100 cm below ground surface. In addition, prairie dog habitat is characterized by low plant cover and vegetation that is short in vertical stature (Holechek et al. 1998). The potential for prairie dogs colonizing the tailing cells is very low because plant cover and stature will not match their habitat requirements.

Table D-6 presents the range of burrowing depths and burrow densities for the animal species that presently frequent or could be expected to frequent the site or the site vicinity. Burrowing depths are well documented in the literature, but burrow density is highly variable depending upon geographic location, specific habitat conditions and population sizes. The burrowing densities presented in the table below are estimates based on a broad search through the published literature and adjusting those densities based on home range and the conditions that would be expected on the cover system.

Table D-6. Burrowing Depths and Estimated Burrow Densities for Animal Species that Presently Frequent or could be Expected to Frequent the Site or the Site Vicinity

Species	Burrowing depths (cm)	Burrowing density (#/acre)
Deer mice	10-30[a]	10 to 30[g]
Kangaroo rats	20-30[b]	2 to 6[h,i]
Chipmunks	60-90[c]	1 to 3[j]
Desert cottontail	15-25[d]	1 to 2[k]
Blacktailed jackrabbit	3-11[e]	Depressions rather than burrows
Prairie dog	60-100[f]	0[l]

[a]Laundre and Reynolds 1993; [b]Whitaker 1980; [c]Caras 1967; [d]Ingles 1941; [e]Best 1996; [f]Shuman and Whicker 1986; [g]Weber and Hoekstra 2009; [h]Cross and Waser 2000; [i]Fields et al. 1999; [j]VanHorne et al. 1997; [k]Nevada DOW 2011; [l]Prairie dog colonization is not expected to occur on site.

D.6 EFFECT OF CLIMATE CHANGE ON PLANTS AND ANIMALS

The potential occurrence of deep-rooted plants or deep-burrowing animals as a result of future climate change is impossible to predict with any certainty. There are many climate change scenarios for the western U.S., based on general circulation models that range from climates that are wetter and cooler to drier and warmer. Most climate models predict warmer temperatures in the future but are inconsistent in terms of precipitation. A warmer and drier climate would have much different effects on vegetation than a warmer and wetter climate. In addition, higher concentrations of CO_2 in the atmosphere may lead to higher plant productivity as a result of higher water use efficiency. Finally, a shift in the timing of precipitation would also influence plant community composition, as an increase in summer precipitation would favor C_4 grasses, while an increase in winter precipitation would favor C_3 species.

In a study by Owensby et al. (1999) the effect of increased CO_2 was studied under environments of both higher and lower precipitation. In every year of the study, CO_2-enriched plots contained greater amounts of soil moisture than plots exposed to ambient CO_2 concentrations, suggesting that CO_2-enriched prairie ecosystems would have greater amounts of water at their disposal to cope with the adverse consequences of water stress. Indeed, long-term atmospheric CO_2 enrichment significantly increased both above- and belowground biomass in years of below average rainfall, while having little or no impact on growth during relatively wet years.

Elevated CO_2 did not affect the basal coverage or species composition of the ecosystem's major C_4 grasses during the eight-year study, contrary to one popular view, which suggests the replacement of C_4 species by typically more CO_2-responsive C_3 species. However, C_3 cool-season grasses and C_3 forbs did increase in basal cover and species composition, but it was at the expense of a reduction in the amount of C_3 cool-season grasses.

As the CO_2 content of the air continues to rise, it is likely that grasslands will maintain a more favorable water status when subjected to periodic moisture stress resulting from less-than-average amounts of annual precipitation. In addition, it is likely that biodiversity in these grasslands will be maintained as the atmospheric CO_2 concentration increases; for the prairie grassland that was studied, the assemblages and abundances of C_4 species did not change in response to elevated CO_2. Thus, it is not likely that C_4 species will be displaced by more photosynthetically CO_2-responsive C_3 species.

In conclusion, the occurrence of a warmer climate in southeastern Utah, with an increase in atmospheric CO_2 that might exist during the required performance period (200 – 1,000 years) is not expected to substantially change the established plant community, regardless of either a

corresponding decrease or increase in precipitation. The community should remain grass dominated with some shift in dominance among warm and cool season species. In addition, it is not expected that a change in climate within the required performance period would lead to a change in small mammal presence or in burrowing activity.

D.7 SOIL REQUIREMENTS FOR SUSTAINABLE PLANT GROWTH

There are two key components to establishing an ET cover with a sustainable plant community. The first is to select long-lived species that are adapted to the environmental conditions of the site. The second is to provide a cover soil that will function as an effective plant growth medium over the long term by supplying plants with adequate amounts of water, nutrients and rooting volume.

There are a number of soil characteristics that are particularly important to achieve long-term sustainability in semiarid environments and include the following: pH, electrical conductivity (EC), sodium levels, percent organic matter, texture, bulk density, cation exchange capacity, macronutrient concentrations, available water holding capacity, and soil microorganisms. Table D-7 presents levels for most of these soil properties that are considered necessary for long-term sustained plant growth. In addition, the table includes soil property levels from soil samples of potential cover soil collected from stock piles at the White Mesa Site in May 2009.

The soil properties of the potential cover soil that are acceptable for sustaining long-term plant growth include: pH, EC, sodium adsorption ratio (SAR), percent clay content, and extractable phosphorus. Those soil properties that appear to be deficient and would need improvement include: percent organic matter, total nitrogen, and extractable potassium.

Cation exchange capacity was not measured in the potential cover soil, but it is believed that the cover soil will have an acceptable level for sustained plant growth based on the percent clay content and a recommendation that an organic matter amendment be added to the soil during the reclamation process. Bulk density of the emplaced cover material will be specified in the cover design and will be controlled during the construction process to be within the sustainability range shown in Table D-5.

Table D-7. Soil Properties and their Range of Values Important for Sustainable Plant Growth, Along with Analytical Results of Soil Available for ET Cover Construction at the White Mesa Mill Site

Soil Property	Level for Sustainability	Reference	Levels for On-Site Soil
pH (units)	6.6 to 8.4	Munshower (1994)	7.7 to 8.1
EC (mmhos/cm)	≤4.0	Munshower (1994)	<1.5
Sodium adsorption ratio	≤12	Munshower (1994)	<0.5
Organic matter (%)	1.5 to 3.0	Brady (1974)	0 to 0.4
Texture (%)	35 to 50% clay	Brady (1974)	36 to 50% clay
Bulk density (g/cm^3)	1.2 to 1.8	Brady (1974)	1.59 to 1.99†
Water holding capacity (cm H_2O/cm soil)	0.08 to 0.16	Brady (1974)	0.084-0.14†
Cation exchange capacity (meq/100g)	5 to 30	Munshower (1994)	Not measured
Total nitrogen (%)	0.05 to 0.5	Harding (1954)	0.02 to 0.05
Extractable phosphorus (mg/kg)	6 to 11	Ludwick and Rogers (1976)	10 to 57
Extractable potassium (mg/kg)	60 to 120	Ludwick and Rogers (1976)	11 to 36

†Calculated values

In order for the potential cover soil to function as a normal soil and provide long-term sustainable support for the vegetation component of the ET cover, it will be amended to improve organic matter content, nitrogen and potassium levels. An organic matter amendment will also improve available water holding capacity and cation exchange capacity. The source of organic matter will depend upon availability in the region and could either be composted biosolids or a commercial organic amendment such as Biosol®. An organic matter amendment will also provide a source of soil microorganisms that will function to cycle nutrients over time and ensure sustainable plant growth.

D.8 ECOLOGICAL CHARACTERISTICS OF PROPOSED SPECIES

Important ecological characteristics for each species proposed for reclamation are provided in the paragraphs that follow. Species information was obtained from Monsen et al. (2004), Alderson and Sharp (1994), Wasser (1982), and Thornburg (1982). The proposed species are adapted to the elevation (5,600 feet), precipitation (13 inches per year on average), and soil textural ranges (loam to sandy clay) that are well within the environmental conditions of the White Mesa Site. Table D-8 presents a summary of the ecological characteristics discussed in the following paragraphs.

Western wheatgrass, variety Arriba (*Pascopyrum smithii*)
Western wheatgrass is a native, rhizomatous, long-lived perennial cool season grass. It grows well in a 10 to 14 inch mean annual precipitation zone and is adapted to a wide range of soil textural classes at elevation ranges up to 9,000 feet. Western wheatgrass has been an important species for restoring mining related disturbances, for erosion control and for critical area stabilization in semiarid regions because of its ease of establishment and ability to grow successfully in pure or mixed stands of both warm and cool season species. Western wheatgrass is fire tolerant and regenerates readily following burning. The variety of Arriba is known for rapidly establishing seedlings and high seed production. The

combination of its ability to spread vegetatively and reproduce by seed ensures long-term sustainability of this species.

Bluebunch wheatgrass, variety Goldar (*Pseudoroegneria spicata*)
Bluebunch wheatgrass is a native, cool season perennial bunch grass. Bluebunch wheatgrass grows on soils that vary in texture, depth and parent material. It is one of the most important and productive grasses found in sagebrush communities in the intermountain west. Bluebunch wheatgrass is fire tolerant and regenerates vegetatively following burning. This species is well adapted to a 12 to 14 inch mean annual precipitation range and is considered to be highly drought resistant. Bluebunch wheatgrass performs well in mixtures with other species and grows at elevations up to 10,000 feet.

Slender wheatgrass, variety San Luis (*Elymus trachycaulus*)
Slender wheatgrass is a native, cool season, perennial bunch grass that occasional produces rhizomes. It is a short-lived species (5 to 10 years) but it reseeds and spreads well by natural seeding, exceeding most other wheatgrasses in this characteristic. Slender wheatgrass can serve as an important pioneer species; its seedlings are vigorous and capable of establishing on harsh sites. In addition, it is able to establish and compete with weedy species. Slender wheatgrass is commonly seeded in mixtures with other grasses and forbs to restore disturbances and rehabilitate native communities. It is adapted to a wide variety of sites and is moderately drought tolerant. It performs best at sites with an annual precipitation of 15 inches or more, but can grow on sites with precipitation levels as low as 13 inches.

Streambank wheatgrass, variety Sodar (*Elymus lanceolatus* ssp. *psammophilus*)
Streambank wheatgrass is considered to be part of the thickspike wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*) taxa. Variety Sodar is a native, perennial sod grass that is highly rhizomatous and adapted to the western intermountain area. It is highly drought tolerant and performs well in mean annual precipitation ranges between 11 and 18 inches. It grows on a wide range of soil textures, from sandy to clayey. Streambank wheatgrass is commonly used in mine land reclamation and is best known for its ability to control erosion and compete with annual weeds. Its highly rhizomatous nature ensures long-term sustainability of this species.

Pubescent wheatgrass, variety Luna (*Thinopyrum intermedium* ssp. *barbulatum*)
Pubescent wheatgrass is a long-lived sod forming perennial introduced from Eurasia. It is highly drought tolerant and grows where the mean annual precipitation is 12 inches or more. It is adapted to a wide range of soil textures, from sand to clay. Pubescent wheatgrass is a highly persistent species, should be seeded at low densities to avoid competition with native species and has been found to be effective in reducing the establishment of woody plants.

Indian ricegrass, variety Paloma (*Achnatherum hymenoides*)
Indian ricegrass is a native, cool season, perennial bunchgrass with a highly fibrous root system. Indian ricegrass is one of the most common grasses on semiarid lands in the west and is one of the most drought tolerant species used in mine land reclamation. It generally occurs on sandy soils, but is found on soils ranging from sandy to heavy clays. It grows from 2,000 to 10,000 feet in areas where the mean annual precipitation is 6 to 16 inches. Indian ricegrass is slow to establish, but highly persistent once it becomes established.

Sandberg bluegrass, variety Canbar (*Poa secunda*)
Sandberg bluegrass is a native, cool season perennial bunchgrass that is adapted to all soil textures and is highly resistant to fire damage. Sandberg bluegrass is one of the more common early-season bunchgrasses in the Intermountain area. It grows at elevations from 1,000 to 12,000 feet and can be successfully established in areas with a mean annual precipitation of 12 inches or more. Established plants are not overly competitive, and therefore highly compatible with other native species.

Sheep fescue, variety Covar (*Festuca ovina*)
Sheep fescue is a short, mat-forming native perennial that grows well on infertile soils in areas with a mean annual precipitation of 10 to 14 inches. It is long-lived and highly drought tolerant. Sheep fescue is a cool season species that greens up early in the spring. The proposed variety, Covar, was introduced from Turkey and is commonly used in mine land reclamation for long-term stabilization and erosion control. This variety was selected because plants are persistent, winter hardy, and drought tolerant.

Squirreltail, variety Toe Jam Creek (*Elymus elymoides*)
Squirreltail is a short-lived perennial that is selected for its ability to establish quickly and to effectively compete with undesirable annual grasses. It grows along an elevation range from 2,000 to 11,000 feet and on all soil textures in mean annual precipitations zones of 8 to 15 inches. Squirreltail is fairly tolerant of fire because of its small size.

Blue grama, variety Hachita (*Bouteloua gracilis*)
Blue grama is a low-growing perennial warm season bunchgrass. Blue grama produces an efficient, widely spreading root system that is mostly concentrated near the soil surface. Blue grama is adapted to a variety of soil types, but does best on well-drained soils and once established, is highly drought tolerant. This species is commonly found with cool-season species and is highly compatible with other native perennials.

Common yarrow (*Achillea millefolium*)
Yarrow is a common native forb species that is rhizomatous and found growing from valley bottoms to timberline. It is commonly used in mine land reclamation, establishes easily from seed and is highly persistent. It grows on a variety of soil textures and found in a mean annual precipitation range between 13 and 18 inches.

White sage, variety Summit (*Artemisia ludoviciana*)
White sage is considered to be a pioneer rhizomatous forb species that establishes quickly on disturbed sites and is highly compatible with perennial grasses. It does best on well-drained soils, but can be found growing on a wide range of soil textures. It is adapted to sites above 5,000 feet in elevation and to sites with a mean annual precipitation above 12 inches.

This group of species will establish into a grass-forb community that is expected to remain dominated by grasses throughout the required performance period (200—1,000 years). The plant community is not expected to show successional changes because of the competitive nature of the established species and their adaptation to the elevation, climate and soil conditions found at the White Mesa Mill Site. Even with potential changes in climate over time, the expectation is for the community to remain a grassland.

Table D-8. Summary of Ecological Characteristics of Plant Species Proposed for the ET Cover at the White Mesa Mill Site

Species	Origin	Annual or Perennial	Method of Spread	Ease of Establishment[a]	Compatibility with Other Species[a]	Longevity[a]	Annual Precipitation Range (inches)	Elevation Range (feet)	Soil Texture[b]	Rooting Depth (cm)	Soil Stabilization[a]	Drought Tolerance[a]	Fire Tolerance[a]
Western wheatgrass	Native	Perennial	Vegetative	4	3	4	10-14	≤9,000	S,C,L	109	4	4	4
Bluebunch wheatgrass	Native	Perennial	Seed	4	4	4	12-14	≤10,000	S,C,L	122	4	4	4
Slender wheatgrass	Native	Perennial	Seed	4	4	2	13-18	≤10,000	S,C,L	109	2	2	2
Streambank wheatgrass	Native	Perennial	Vegetative	4	4	4	11-18	≤10,000	S,C,L	165	4	4	3
Pubescent wheatgrass	Introduced	Perennial	Vegetative	4	2	4	12-18	≤10,000	S,C,L	185	4	4	3
Indian ricegrass	Native	Perennial	Seed	3	4	4	6-16	≤10,000	S,L	84	2	4	2
Sandberg bluegrass	Native	Perennial	Seed	4	4	4	12-18	≤12,000	S,C,L	45	2	3	4
Sheep fescue	Native	Perennial	Seed	4	2	4	10-14	≤11,000	S,C, L	56	3	4	2
Squirreltail	Native	Perennial	Seed	3	4	3	8-15	≤11,000	S,C,L	30	2	4	3
Blue grama	Native	Perennial	Vegetative	2	4	4	10-16	≤10,000	S,L	119	4	4	4
Common yarrow	Native	Perennial	Vegetative	4	3	4	13-18	≤11,000	S,C,L	105	4	3	2
White sage	Native	Perennial	Vegetative	4	4	4	12-18	≥5,000	S,C,L	20	3	3	2

[a]Key to Ratings—4 = Excellent, 3 = Good, 2 = Fair, 1 = Poor; [b]Soil Texture Codes—S = Sand, C = Clay, L = Loam

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APPENDIX E

SLOPE STABILITY ANALYSIS

E.1 INTRODUCTION

This appendix presents the methods, input and results of slope stability analyses of the tailings cells at the Denison Mines (USA) Corp.'s (Denison) White Mesa Uranium Mill (Mill). The Mill is located approximately 6.0 miles south of Blanding, Utah. These analyses were conducted according to applicable stability criteria under static and seismic conditions, including geotechnical stability criteria in NRC (2003).

Slope stability analyses were performed using limit equilibrium methods with the aid of the computer program SLOPE/W (GEO-SLOPE, 2007). The SLOPE/W program calculates factors of safety by any of the following methods: (1) Ordinary Fellenius, (2) Bishop's Simplified, (3) Janbu's Simplified, (4) Spencer, (5) Morgenstern-Price, (6) U.S. Army Corps of Engineers, (7) Lowe-Karafiath, and (8) Generalized Limit Equilibrium. The Morgenstern-Price method (Morgenstern and Price, 1965) with a half-sine function for inter-slice forces was selected for performing the computations in SLOPE/W. The method uses both circular and non-circular shear surfaces and satisfies both moment and force equilibrium.

E.2 CRITICAL CONDITIONS AND GEOMETRY

Slope stability analyses are typically conducted for scenarios that represent the critical conditions for construction and operation. For the White Mesa Mill tailings cells, critical conditions for post-reclamation were evaluated and included: (1) reclaimed outside surfaces of the embankment with a 5H:1V slope, (2) existing inside surfaces of the embankments with a 2H:1V slope; (3) conservative shear strength parameters based on previous reports. The embankment cross section was assumed to be fully drained and therefore the phreatic surface was not included in the analyses.

A critical cross section was cut through the southern dike of Cell 4A near the southeast corner of the impoundment. The cross section location was selected based on overall impoundment height as well as base topography and is similar to the location used for the slope stability analyses presented in Titan (1996). The location of the cross section is shown in Figure E.1.

Slope stability analyses were performed by calculating factors of safety along circular failure surfaces for both static and pseudo-static conditions. Circular failure surface analyses were conducted by targeting deeper, full-slope failures as opposed to shallower, superficial failures. A number of failure surfaces were analyzed in order to calculate the factor of safety for the critical failure.

E.3 MATERIAL PROPERTIES

Material strength parameters used for the slope stability analysis are the same as the parameters presented in Denison (2009) for the Cell 4B slope stability analyses conducted by Geosyntec. The strength parameters for each material are discussed below and summarized in Table E.1.

Cover, Dike, and Foundation: The cover material will be obtained from the existing material at the site and therefore will have the same strength parameters as the previously-constructed dike and the existing foundation material underlying the dike. The strength parameters for this material was developed using triaxial test results from samples obtained from borings through the existing berm between Cell 4A and 4B.

Tailings Material: Based on existing operations at the site, the tailings deposits behind the dike are primarily fine sands with silt and some clay. The strength parameters of the tailings were conservatively estimated using the Naval Design Manual for Soil Mechanics DM7-01 (NAVFAC, 1986) as a 0% relative density silty sand.

Bedrock: Failures are not anticipated to occur within the bedrock underlying the embankment. Therefore, the material properties for the bedrock were modelled as those consistent with impenetrable bedrock.

Table E.1. Material Strength Parameters

Material	Unit Weight (pcf)	Cohesion (psf)	Internal Friction Angle
Cover	137	900	26°
Dike			
Foundation			
Tailings	125	0	25°
Bedrock	130	10,000	45°

E.4 SEISMIC ANALYSIS AND SEISMICITY

Stability analyses under seismic conditions were conducted as pseudo-static analyses, where a horizontal acceleration or seismic coefficient is applied to the cross-section. This seismic coefficient represents the horizontal forces applied on the structure by an earthquake. A coefficient of 0.1 g was used for the analyses based on the most recent seismic hazard analysis conducted for the site (Tetra Tech, 2010). This seismic coefficient represents the seismic loading for the Maximum Credible Earthquake (MCE) calculated to occur during the long-term life of the embankment. A summary of the site seismicity and selection of the seismic coefficient is provided in more detail below. The Tetra Tech (2020) seismic study is also provided as Attachment E.1 to this appendix, for ease of reference.

Seismicity. Seismicity of the White Mesa site has been investigated in two previous reports. The original design report for Cell 4 was prepared in 1988 by UMETCO. The geologic conditions and the potential seismic hazards were characterized in that report. In 2006 an additional seismic study was prepared by Tetra Tech, formerly MFG, to recommend a design peak ground acceleration (PGA) to use during the operational period for the design of Cell 4A at the site. The design Peak Ground Acceleration for Cell 4 was determined to be 0.09 g based on the 2002 USGS National Seismic Hazard Maps (NSHM) with a 2 percent probability of exceedance in 50 years. The report concluded that the seismic loading of 0.1 g used in the analysis of Cell 4A associated with a 2 percent probability of exceedance within 50 years was appropriate for the operational life of the disposal cell (Tetra Tech, 2006).

Tetra Tech completed an additional seismic hazard analysis in 2010. Using the most recent USGS National Seismic Hazard Maps (NSHM, 2008), with a 10,000 year return period, and the probability of exceedance of 2% for a 200-year design life, Tetra Tech determined that the Peak Ground Acceleration (PGA) for the site to be 0.15 g. Based on the most current USGS Geological Survey Earthquake Hazards Program National Maps (2008), and using the attenuation relationship of Campbell and Bozorgnia (2007), this PGA of 0.15 g is reasonable for the White Mesa site. The peak acceleration of 0.15 g was therefore used for seismic stability analyses of the tailings impoundments (Tetra Tech, 2010).

Seismic coefficient. A liquefaction analysis was conducted for the tailings and is presented in Appendix F. The results indicate the tailings are not susceptible to earthquake-induced liquefaction. For materials that do not liquefy or lose shear strength with seismic shaking, seismic slope stability is analyzed by a pseudo-static approach. This consists of application of an equivalent horizontal acceleration or seismic coefficient to the structure being analyzed (described in Seed, 1979). The seismic coefficient represents an inertial force due to strong ground motions during the design earthquake, and is represented as a fraction of the PGA at the site (typically at the base of the structure). Tetra Tech (2010) recommended using a value of 0.1 g for the seismic coefficient in accordance with IBC (2006) recommendations to multiply the PGA by 0.667 to determine a design acceleration value. The strategy of representing the seismic coefficient as a fraction of the PGA has been adopted in review of uranium tailings facility design and documented in DOE (1989). A value of 0.667 typically represents post-reclamation conditions. Based on this guidance and the recommendations in Tetra Tech (2010), the seismic coefficient used for the pseudo-static stability analysis was 0.1 g.

E.5 DISCUSSION OF STABILITY ANALYSIS RESULTS

The results of stability analyses for Cross-section A are presented in Table E.2. These values represent the lowest calculated factor of safety from a number of individual failure surfaces for a Morgenstern-Price Analysis involving circular failure.

Table E.2. Slope Stability Analysis Results

Required FOS Static Condition	Calculated FOS Static Condition	Required FOS Pseudo-Static Condition	Calculated FOS Pseudo-Static Condition
1.5	4.30	1.1	2.82

Note: FOS = factor of safety

As shown in Table E.2, all calculated factors of safety were significantly above the NRC recommended values of 1.5 for static conditions and 1.1 for pseudo-static conditions. The SLOPE/W output figures for static and pseudo-static loading conditions are provided in Attachment E.2.

E.6 REFERENCES

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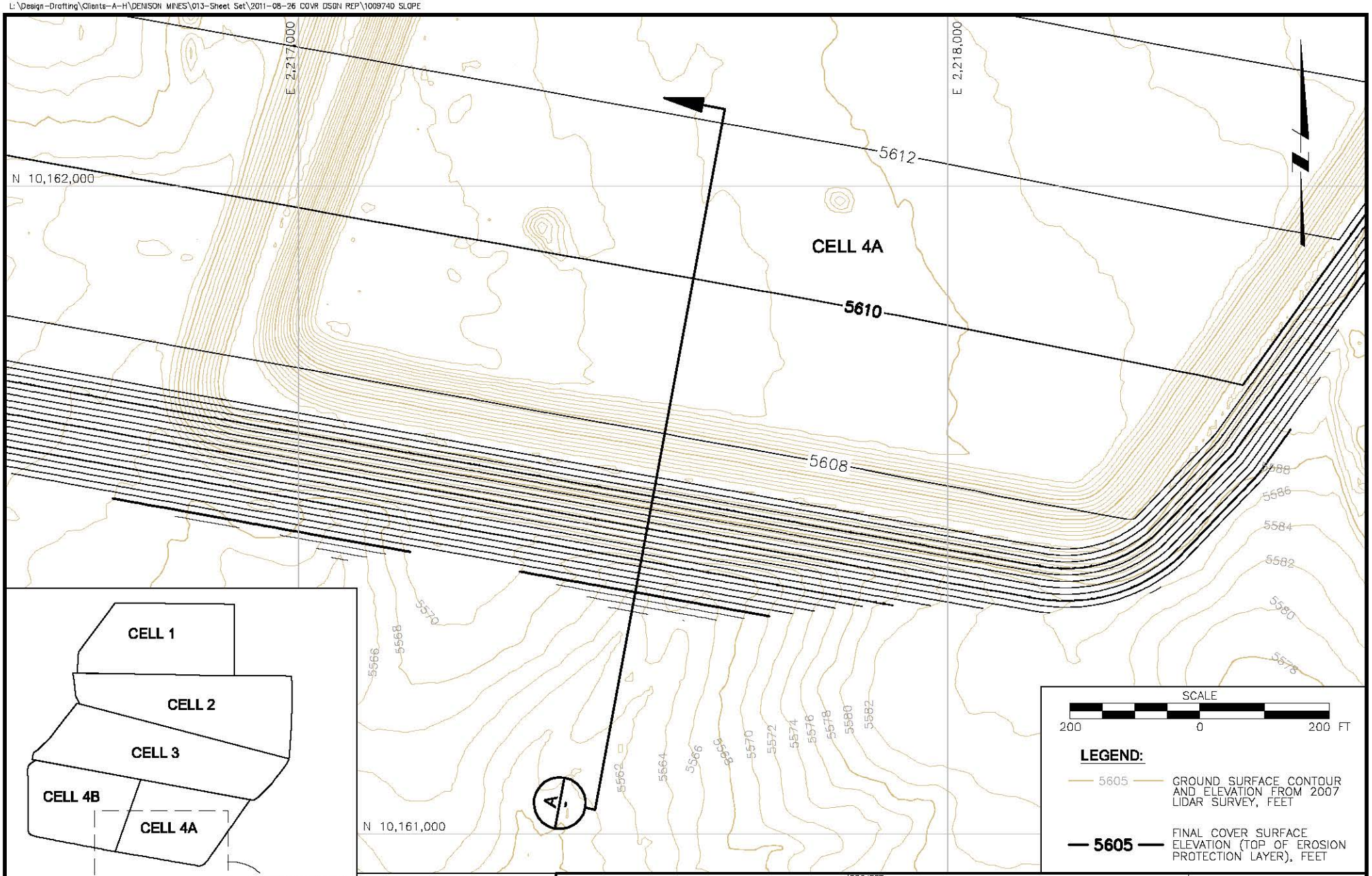

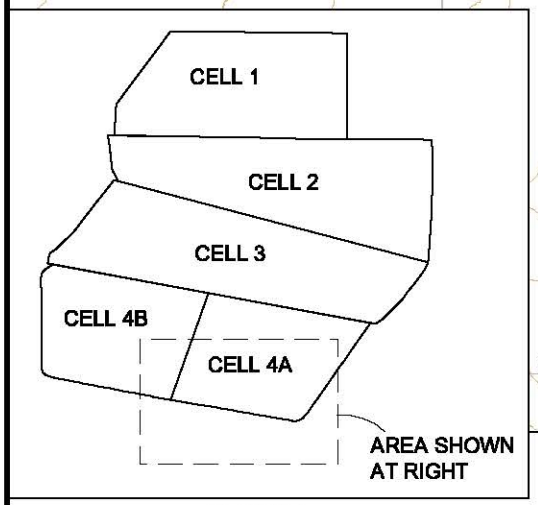

KEY MAP
NOT TO SCALE

DENISON MINES
Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
SLOPE STABILITY
CROSS SECTION LOCATION

MWH

DATE AUG 2011

FIGURE E.1

FILE NAME 1009740 SLOPE

ATTACHMENT E.1

TETRA TECH (2010)

TETRA TECH

3801 Automation Way Suite 100
Fort Collins CO 80525
Tel 970.223.9600 Fax 970.223.7171
www.tetratech.com

Technical Memorandum

To:	Mr. Harold R. Roberts	**From:**	Heather Trantham, Ph.D., P.E. Senior Staff Geotechnical Engineer
Company:	Denison Mines (USA) Corp 1050 Seventeenth Street, Suite 950 Denver, CO 80265	**Date:**	February 3, 2010
Reviewed by:	Thomas A. Chapel Principal Geotechnical Engineer		
Re:	White Mesa Uranium Facility Seismic Study update for a Proposed Cell Blanding, Utah	**Project #:**	114-182018

REGISTERED PROFESSIONAL ENGINEER
No. 6232722-2202
THOMAS A. CHAPEL
2/4/2010
STATE OF UTAH

Introduction

Denison Mines (USA) Corp is proposing to add a new uranium containment cell to the facility at Blanding, Utah. This document was prepared to address seismic concerns brought forth in comments by the UDRC as documented in the second round of Interrogatories. This seismic hazard analysis has been prepared as an update to the previous seismic study performed for the site by Tetra Tech (formerly MFG, 2006).

Project Location

The project is located near Blanding, Utah. For the purposes of these analyses, the latitude and longitude of 37.5°N and 109.5°W, respectively, were used.

Previous Work

Seismicity of the White Mesa site has been investigated in two previous reports. The original design report for Cell 4 was prepared in 1988 by UMETCO. The geologic conditions and the

potential seismic hazards were characterized in that report. The specified hazards include minor random earth quakes not associated with a

known seismic structure, and an unnamed fault located 57 km north of the project site (north of Monticello), with a fault length well defined for 3 km, and possibly as long as 11 km. The fault is a suspected Quarternary fault, but does not have strong evidence for Quaternary movement. The maximum credible earthquake (MCE) associated with this fault was estimated to have a magnitude of 6.4 based on relationships developed by Slemmons in 1977. Ground motions at the project site were estimated using attenuation curves established in 1982 by Seed and Idriss. Peak horizontal accelerations at the site from the fault were estimated to be 0.07 g.

In 2006 an additional seismic study was prepared to recommend a design peak ground acceleration (PGA) to use during the operational period for the design of Cell 4A at the site. A search performed as part of that study found one additional suspected Quaternary fault in the USGS (2006) Quaternary Fault and Fold Database. The search was performed for a region within 50 km of the site. The database lists the Shay graben fault as a Class B (suspected) Quaternary fault. In the report updated attenuation relationships were used to estimate ground motions and then compared: Abrahamson and Silva (1997), Spudich et al. (1999), and Campbell and Bozorgnia (2003). The design Peak Ground Acceleration (PGA) for Cell 4 was determined to be 0.09 g based on the 2002 USGS National Seismic Hazard Maps (NSHM) with a 2 percent probability of exceedance in 50 years. The report concluded that the seismic loading of 0.1g used in the analysis of Cell 4A associated with a 2 percent probability of exceedance within 50 years was appropriate for the operational life of the disposal cell.

The following sections address requests sent to Denson Mines (USA) Corp in an email from URS dated January 20, 2010. In addition to the information presented below, the information by Brumbaugh (2005) that was referenced in the email was also reviewed.

Regional Physiographic and Tectonic Setting

The site is located within the Colorado Plateau physiographic province in southeastern Utah. The Colorado Plateau is a broad, roughly circular region of relative structural stability within a more structurally active region of disturbed mountain systems. Broad basins and uplifts, monoclines, and belts of anticlines and synclines are characteristic of the plateau (Kelley, 1979).

The White Mesa site is located near the western edge of the Blanding Basin, east of the north-south trending Monument Uplift, south of the Abajo Mountains. It is also adjacent to the northwest trending Paradox Fold.

The contemporary seismicity of the Colorado Plateau was investigated by Wong and Humphrey (1989) based on seismic monitoring. Their study characterized the seismicity of the plateau as being of small to moderate magnitude, of a low to moderate rate of occurrence with earthquakes widely distributed. Seismicity in the plateau appears to be the result of the reactivation of preexisting faults not expressed at the surface but favorable oriented to the tectonic stress field. Very few earth quakes can be associated with known geologic structures or tectonic features in the plateau. The generally small size of the earthquakes and their widespread distribution is consistent with a highly faulted Precambrian basement and upper crust, and a moderate level of differential tectonic stresses. Earthquakes in the plateau generally occur within the upper 15 to 20 km of the

upper crust (Smith, 1978, Wong and Chapman, 1986) although events have occurred as deep as 58 km (Wong and Humphrey, 1989). The predominant mode of tectonic deformation within the plateau appears to be normal faulting on the northwest- to north-northwest-striking faults, with some localized occurrences of strike-slip displacement on the northwest- or northeast-striking planes at shallow depths. The contemporary state of stress within the plateau is characterized by approximately northeast-trending extension (Wong and Humphrey, 1989).

Seismicity

Earthquake Catalogs

The seismic hazard analysis for the site included a review of historic earthquakes which have occurred within 200 miles of the site. A radius of 200 miles is recommended by the Senior Seismic Hazard Analysis Committee (SSHAC, 1997) and the NRC (2007). The NEIC database was used and includes all recorded seismic events over a period from 1850 through January 2010. The database search was performed to incorporate the most recent seismic events in the region and to verify that estimated ground accelerations from all known events are below the design peak acceleration recommended in this report.

The largest event is estimated in the NOAA catalog to have an Mw of 5.8. This event occurred near Smithfield, Utah on August 30, 1962. The epicenter is approximately 200 miles northwest of the site.

The event closest to the site had an epicenter about 40 miles northwest of the site. This earthquake, which occurred on February 23, 1968 had an Mw of 2.8.

The list of earthquakes as described above is included in Appendix 1. The peak ground accelerations for the five most significant earthquakes on the list were calculated and are discussed below.

Seismic Hazard Analysis

Seismic hazard analyses are typically conducted using one of two methods: (1) deterministic analysis or (2) probabilistic analysis (SSHAC, 1997). In the deterministic analyses, the ground motions from the maximum credible earthquake (MCE) associated with capable faults are attenuated to the site. The ground motions from the MCE associated with the fault are attenuated to the site using established attenuation equations. Deterministic analysis was used in this seismic update and is described in the next section.

In probabilistic analyses, ground motions and the associated probability of exceedance are estimated in order for the amount of risk associated with the design ground motion 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 10,000-year return period is adopted for evaluating long-term stability of the facility. The probability that the 10,000-year event will be exceeded within a 200- to 1,000-year design life is between 2

and 10 percent. This is consistent with the International Building Code (IBC, 2006) which specifies designing for ground motions associated with a 2 percent probability of exceedance in a 50-year design life, or a return period of approximately 2,500 years. Similarly, a 2,500-year return period is appropriate during operational conditions considering a design life of 50 years.

The probability of exceedance can be represented by the following equation:

$$PE = 1 - e^{-(n/T)}$$

where PE is the probability of exceedance, n is the time period in years, and T is the return period in years.

Using the most recent USGS National Seismic Hazard Maps (NSHM, 2008), with a 10,000 year return period, and the probability of exceedance of 2% for a 200-year design life, the PGA for the site was determined to be 0.15 g. The shear wave velocity (v_s) used for the deaggragation calculation 586 m/s which corresponds to 1923 ft/s. Site Class Definitions are listed for the top 100 feet of the soil profile in Table 1613.5.2 of the International Building Code (IBC, 2006). For soils having a Standard Penetration Resistance (N-value) between 15 and 50, the shear wave velocity ranges between 600 and 1,200 ft/s. In conjunction with previous work at the site, Tetra Tech (formerly MFG) drilled a borehole at the site on June 15, 2006. The Standard Penetration values from borehole MFG-1 range from N=33 to N=50/5". The shear wave velocity chosen for the top 31' was 200 m/s (656 ft/s). For the remaining 69', a shear wave velocity of 760 m/s (2493 ft/s) corresponding to sandstone was chosen. The weighted average of the shear wave velocity for the top 100 ft was 586 m/s (1923 ft/s). The borehole log for MFG-1 is presented in Appendix 2. The data from USGS National Seismic Hazards Mapping Project, 2008 Version PSHA Deaggregation are presented in Appendix 3.

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. 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), and Grand Junction (DOE 1991b, pg. 71). A study by Wong et al (1996) also evaluated the recurrence of background events within the Colorado Plateau. Wong et al. (1996) suggests that the maximum background earthquakes as large as M_W could occur, although they are unlikely. In this update, an arbitrary event (Mw = 6.3, radial distance = 15 km) was analyzed using the most recent Campbell and Bozorgnia (2007) attenuation relationship. Results are described in the following section

Attenuation Relationships

In the previous study (MFG, 2006) three attenuation relationships to estimate the peak ground motion at the White Mesa site were used: Abrahamson and Silva (1997), Spudich et al. (1999),

and Campbell and Bozorgnia (2003). Since this report, Campbell and Bozorgnia have updated their 2003 model into a Next Generation Attenuation (NGA) Project (2007). The NGA model included the input of several other modelers and is considered an update to Abrahamson and Silva (1997), Boore, et al. (1997), Sadigh, et al. (1997), Idriss (1993 and 1996), and (Campbell and Bozorgnia (2006). The faults chosen for the analysis include the unnamed fault north of Monticello that was the basis of the design acceleration in the 1988 report, and the Shay graben faults (USGS 2006) a Class B (suspected) Quaternary fault that was included in the 2006 report. Additionally the earthquakes in the earthquake catalog created for the site were considered. The earthquakes that were considered have a calculated magnitude. The calculation of the magnitude of these earthquakes was not performed as part of this study. The accelerations felt at the White Mesa site due to these recorded events are listed in Table 1 for the 5 most relevant events. For comparison, an arbitrary event occurring 15 km from the site with a magnitude of 6.3 is used to account for the floating earthquake at the White Mesa site. The results for attenuation relations as calculated using Campbell and Bozorgnia NGA (2007) plus one standard deviation are reported are presented in Table 1. Spreadsheets detailing the calculations are included in Appendix 4.

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Table1. Peak Ground Accelerations for White Mesa

Name	Fault Length (km)	Fault Type(1)	Site Class(2)	Distance from Site (km)	MCE(3)	PGA(4)
Unnamed fault north of Monticello (possible extension of Shays graben) defined length	3.0	N	R	57.4	5.49	0.038
Unnamed fault north of Monticello (possible extension of Shays graben) total possible length	11.0	N	R	57.4	6.23	0.063
Unnamed fault north of Monticello (possible extension of Shays graben) ½ total rupture	5.5	N	R	57.4	5.84	0.049
Shay graben faults (Class B)	40.0	N	R	44.6	6.97	0.090
Earthquake on 2/21/54 from EPB catalog	-	-	-	70	4.7	0.012
Earthquake on 1/30/89 from PDE catalog	-	-	-	147	5.4	0.011
Earthquake on 2/3/95 from PDE catalog	-	-	-	139	5.3	0.011
Earthquake on 10/11/77 from PDE catalog	-	-	-	74	4.7	0.011
Earthquake on 10/11/60 from SRA catalog	-	-	-	189	5.5	0.01
Floating Earthquake	-	-	-	15	6.3	0.243

(1) Fault Type: N= Normal
(2) Site Class: R = Rock or shallow soils
(3) Wells and Coppersmith, 1994
(4) Campbell and Bozorgnia NGA, 2007

Conclusion

Using the most recent USGS National Seismic Hazard Maps (NSHM, 2008), with a 10,000 year return period, and the probability of exceedance of 2% for a 200-year design life, the PGA for the site was determined to be 0.15 g. Based on the most current USGS Geological Survey Earthquake Hazards Program National Maps (2008), and using the attenuation relationship of Campbell and Bozorgnia (2007), this PGA of 0.15 g is reasonable for the White Mesa site. This maximum PGA is a peak value. For a pseudo-static analysis, and in accordance with IBC 2006, the PGA should be multiplied by 0.667 to determine a design acceleration value. Therefore the design acceleration value for the White Mesa site is calculated to be 0.1. This value is consistent with the previous design value that was computed in the previous analysis for the site.

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APPENDIX 1: EARTHQUAKE EVENTS WITHIN 200 MILES OF THE WHITE MESA SITE

Appendix 1: Earthquake Events within 200 miles of the White Mesa Site

Source: NEIC Database

Magnitude	Year	Month	Day	Latitude (degree, North)	Longitude (degree, West)	Magnitude	Radial Distance (km)	Catalog
NOAA	1962	8	30	41.8	-111.8	5.8	320	0.007
SRA	1973	5	17	39.79	-108.37	5.7	272	0.008
PDE	1973	5	17	39.79	-108.37	5.7	180	0.012 (man made)
SRA	1959	7	21	36.8	-112.37	5.6	266	0.007
EPB	1962	8	30	41.8	-111.8	5.6	320	0.006
USHIS	1959	7	21	36.8	-112.37	5.6	266	0.007
SRA	1960	10	11	38.3	-107.6	5.5	189	0.01
USHIS	1960	10	11	38.3	-107.6	5.5	189	0.01
USHIS	1967	10	4	38.54	-112.16	5.5	260	0.007
PDE	1989	1	30	38.82	-111.61	5.4	147	0.011
PDE	1988	8	14	39.13	-110.87	5.3	141	0.01
PDE	1995	2	3	41.53	-109.64	5.3	139	0.011
EPB	1894	7	18	41.2	-112	5.3	284	0.004
USHIS	1988	8	14	39.128	-110.869	5.3	216	0.006
USHIS	1989	1	30	38.824	-111.614	5.3	236	0.006
SRA	1921	9	29	38.7	-112.1	5.2	263	0.004
SRA	1967	10	4	38.54	-112.16	5.2	260	0.004
EPB	1950	1	18	40.5	-110.5	5.2	140	0.009
USHIS	1921	9	29	38.7	-112.1	5.2	263	0.004
SRA	1966	1	23	36.98	-107.02	5.1	227	0.004
PDE	1977	9	30	40.52	-110.44	5.1	279	0.003
EPB	1962	9	5	40.7	-112	5.1	251	
SRA	1959	10	13	35.5	-111.5	5	285	
EPB	1884	11	9	41.5	-111.2	5	264	
EPB	1910	5	22	40.8	-112	5	257	
EPB	1915	7	15	40.3	-111.7	5	207	
EPB	1943	2	22	41	-111.5	5	238	
EPB	1950	2	25	40	-112	5	221	
EPB	1953	5	23	40.5	-111.5	5	203	
EPB	1958	2	13	40.5	-111.5	5	203	
USHIS	1959	10	13	35.5	-111.5	5	285	
USHIS	1963	7	7	39.53	-111.91	4.9	307	
USHIS	1966	1	23	36.98	-107.02	4.9	227	
SRA	1962	2	5	38.2	-107.6	4.7	184	

PDE	1977	10	11	40.49	-110.49	4.7	74	0.011
PDE	2003	4	17	39.52	-111.86	4.7	281	
EPB	1954	2	21	40	-109	4.7	70	0.012
EPB	1958	12	1	40.5	-112.5	4.7	279	
USHIS	1962	2	5	38.2	-107.6	4.7	184	
SRA	1976	1	5	35.84	-108.34	4.6	211	
PDE	1994	9	13	38.15	-107.98	4.6	140	
EPB	1949	3	7	40.8	-111.9	4.6	250	
USHIS	1976	1	5	35.817	-108.212	4.6	219	
SRA	1962	2	15	36.9	-112.4	4.5	265	
SRA	1962	6	5	38	-112.1	4.5	235	
PDE	1983	10	8	40.75	-111.99	4.5	177	
PDE	1998	1	2	38.21	-112.47	4.5	279	
EPB	1950	1	2	41.5	-112	4.5	306	
EPB	1956	10	3	41.5	-110.1	4.5	227	
EPB	1958	1	5	41	-112.5	4.5	304	
USHIS	1962	2	15	36.9	-112.4	4.5	265	
USHIS	1962	6	5	38	-112.1	4.5	235	
SRA	1962	1	13	38.4	-107.8	4.4	179	
SRA	1962	2	15	37	-112.9	4.4	306	
SRA	1963	7	7	39.53	-111.91	4.4	307	
SRA	1972	1	3	38.65	-112.17	4.4	266	
SRA	1986	3	24	39.234	-112.062	4.4	295	
PDE	1986	3	24	39.24	-112.01	4.4	275	
PDE	1992	6	24	38.78	-111.55	4.4	140	
PDE	2000	1	30	41.46	-109.68	4.4	263	
EPB	1957	10	26	40	-111	4.4	139	
USHIS	1972	1	3	38.65	-112.17	4.4	266	
USHIS	1986	3	24	39.236	-112.009	4.4	291	
USHIS	1988	8	18	39.132	-110.867	4.4	216	
SRA	1963	9	30	38.1	-111.22	4.3	165	
PDE	1994	9	6	38.08	-112.33	4.3	140	
PDE	1999	4	6	41.45	-107.74	4.3	262	
PDE	2000	5	27	38.34	-108.86	4.3	185	
PDE	2001	7	19	38.73	-111.52	4.3	142	
PDE	2002	1	31	40.29	-107.69	4.3	191	
EPB	1880	9	16	40.8	-112	4.3	257	
EPB	1899	12	13	41	-112	4.3	270	
EPB	1906	5	24	41.2	-112	4.3	284	
EPB	1910	7	26	41.5	-109.3	4.3	222	
EPB	1915	8	11	40.5	-112.7	4.3	294	
EPB	1916	2	4	40	-111.7	4.3	196	
EPB	1920	9	18	41.5	-112	4.3	306	
EPB	1950	5	8	40	-111.4	4.3	171	

EPB	1952	9	28	40.2	-111.5	4.3	187	
EPB	1955	2	2	40.8	-111.9	4.3	250	
EPB	1955	2	10	40.5	-107	4.3	240	
EPB	1955	5	12	41	-112	4.3	270	
EPB	1957	7	18	40	-110.5	4.3	102	
EPB	1962	9	4	41.7	-111.8	4.3	312	
EPB	1966	3	17	41.7	-111.5	4.3	297	
EPB	1967	2	14	40.1	-109	4.3	79	
EPB	1967	9	23	40.7	-112.1	4.3	258	
SRA	1966	5	8	37	-106.9	4.2	237	
SRA	1967	9	4	36.15	-111.6	4.2	239	
SRA	1977	3	5	35.91	-108.29	4.2	206	
PDE	1973	7	16	39.15	-111.51	4.2	244	
PDE	1980	5	24	39.94	-111.97	4.2	265	
PDE	1989	2	27	38.83	-111.62	4.2	275	
PDE	1992	3	16	40.47	-112.04	4.2	186	
PDE	1996	1	6	39.12	-110.88	4.2	145	
PDE	1998	6	18	37.97	-112.49	4.2	272	
PDE	1999	10	22	38.08	-112.73	4.2	263	
PDE	2000	3	7	39.75	-110.84	4.2	263	
USHIS	1977	3	5	35.748	-108.222	4.2	225	
SRA	1966	5	20	37.98	-111.85	4.1	213	
SRA	1973	12	24	35.26	-107.74	4.1	294	
PDE	1983	9	24	40.79	-108.84	4.1	291	
PDE	1995	3	20	40.18	-108.93	4.1	140	
PDE	2001	2	23	38.73	-112.56	4.1	309	
PDE	2004	11	7	38.24	-108.92	4.1	281	
USHIS	1973	12	24	35.26	-107.74	4.1	294	
SRA	1963	7	9	40.03	-111.19	4	316	
SRA	1967	2	15	40.11	-109.05	4	292	
SRA	1971	11	12	38.91	-108.68	4	172	
SRA	1972	6	2	38.67	-112.07	4	260	
SRA	1982	5	24	38.71	-112.04	4	259	
SRA	1986	8	22	37.42	-110.574	4	95	
PDE	1982	5	24	38.71	-112.04	4	273	
PDE	1986	8	22	37.42	-110.57	4	281	
PDE	1987	12	16	39.29	-111.23	4	247	
PDE	1992	7	5	39.32	-111.13	4	154	
PDE	1998	1	30	37.97	-112.55	4	319	
PDE	2001	8	9	39.66	-107.38	4	289	
EPB	1960	7	9	41.5	-112	4	306	
USHIS	1982	5	24	38.71	-112.04	4	259	
SRA	1967	8	7	36.4	-112.6	3.9	301	

SRA	1968	1	16	39.27	-112.04	3.9	296	
SRA	1970	4	21	40.1	-108.9	3.9	293	
SRA	1970	5	23	38.06	-112.47	3.9	268	
USHIS	1986	3	25	39.223	-112.011	3.9	290	
SRA	1971	1	7	39.49	-107.31	3.8	291	
SRA	1979	4	30	37.88	-111.02	3.8	140	
SRA	1963	6	19	38.02	-112.53	3.7	273	
SRA	1963	7	10	40.02	-111.25	3.7	318	
SRA	1966	7	6	40.09	-108.95	3.7	291	
SRA	1970	4	18	37.87	-111.72	3.7	199	
SRA	1971	7	10	40.24	-109.6	3.7	304	
SRA	1971	11	10	37.8	-113.1	3.7	319	
SRA	1975	1	30	39.27	-108.65	3.7	209	
SRA	1984	8	16	39.392	-111.936	3.7	298	
SRA	1967	7	22	38.8	-112.22	3.6	278	
SRA	1968	9	24	38.04	-112.08	3.6	234	
SRA	1969	4	10	38.66	-112.07	3.6	259	
SRA	1972	11	16	37.53	-112.77	3.6	288	
SRA	1983	12	9	38.577	-112.565	3.6	294	
SRA	1965	6	7	36	-112.2	3.5	292	
SRA	1966	4	23	39.1	-111.55	3.5	252	
SRA	1966	5	8	36.9	-107	3.5	231	
SRA	1968	11	17	39.52	-110.97	3.5	258	
SRA	1974	11	4	38.34	-112.24	3.5	258	
SRA	1976	4	19	35.39	-109.1	3.5	236	
SRA	1978	2	24	38.33	-112.84	3.5	307	
SRA	1979	1	12	37.73	-113.13	3.5	321	
SRA	1979	10	23	37.89	-110.93	3.5	133	
SRA	1981	5	14	39.48	-111.08	3.5	259	
SRA	1984	3	21	39.344	-111.109	3.5	248	
SRA	1962	12	11	39.36	-110.42	3.4	221	
SRA	1963	4	15	39.59	-110.35	3.4	243	
SRA	1966	6	1	36.9	-107	3.4	231	
SRA	1981	1	16	37.45	-113.11	3.4	319	
SRA	1983	8	14	38.359	-107.402	3.4	207	
SRA	1963	4	24	39.44	-110.33	3.3	227	
SRA	1963	8	16	39.48	-111.99	3.3	308	
SRA	1964	1	17	38.19	-112.62	3.3	284	
SRA	1965	1	14	39.44	-110.35	3.3	227	
SRA	1966	12	19	39	-106.5	3.3	310	
SRA	1968	6	2	39.21	-110.45	3.3	207	
SRA	1969	5	23	39.02	-111.97	3.3	274	
SRA	1978	12	9	38.66	-112.53	3.3	295	
SRA	1978	12	9	38.65	-112.52	3.3	293	
SRA	1981	1	16	37.45	-113.1	3.3	318	
SRA	1981	8	8	38.05	-112.8	3.3	296	
SRA	1982	3	5	37.37	-112.61	3.3	275	
SRA	1983	1	27	37.778	-110.674	3.3	108	
SRA	1983	8	31	36.135	-112.037	3.3	272	
SRA	1985	4	14	35.174	-109.071	3.3	260	
SRA	1986	10	5	38.631	-112.558	3.3	296	
SRA	1962	8	19	38.05	-112.09	3.2	236	
SRA	1963	11	13	38.3	-112.66	3.2	291	

SRA	1965	1	30	37.54	-113.12	3.2	319	
SRA	1965	6	29	39.5	-110.39	3.2	235	
SRA	1966	4	14	37	-107	3.2	228	
SRA	1967	10	25	39.47	-110.35	3.2	230	
SRA	1973	2	9	36.43	-110.425	3.2	144	
SRA	1974	4	29	37.81	-112.98	3.2	308	
SRA	1977	2	9	39.29	-111.11	3.2	243	
SRA	1977	6	3	39.65	-110.51	3.2	254	
SRA	1979	10	6	39.29	-111.69	3.2	275	
SRA	1980	12	21	37.53	-113.04	3.2	312	
SRA	1981	9	21	39.59	-110.42	3.2	245	
SRA	1982	2	12	37.41	-112.57	3.2	271	
SRA	1984	5	14	39.322	-107.228	3.2	283	
SRA	1986	5	14	37.294	-110.319	3.2	75	
SRA	1962	9	7	39.2	-110.89	3.1	224	
SRA	1964	8	24	38.77	-112.23	3.1	277	
SRA	1964	9	6	39.18	-111.46	3.1	253	
SRA	1964	11	29	38.97	-112.23	3.1	289	
SRA	1966	7	30	39.44	-110.36	3.1	227	
SRA	1970	2	21	39.49	-110.35	3.1	232	
SRA	1970	10	25	39.17	-111.41	3.1	249	
SRA	1971	4	22	39.41	-111.94	3.1	300	
SRA	1971	6	23	38.61	-112.71	3.1	307	
SRA	1976	8	13	38.42	-112.18	3.1	256	
SRA	1976	11	26	39.51	-111.26	3.1	270	
SRA	1979	3	19	40.18	-108.9	3.1	301	
SRA	1981	9	10	37.5	-110.56	3.1	93	
SRA	1983	3	22	39.546	-110.422	3.1	240	
SRA	1984	4	22	39.281	-107.19	3.1	282	
SRA	1963	12	24	39.56	-110.32	3	239	
SRA	1964	8	5	38.95	-110.92	3	203	
SRA	1964	9	21	38.8	-112.21	3	277	
SRA	1965	7	13	37.71	-112.98	3	308	
SRA	1965	7	20	38.03	-112.44	3	265	
SRA	1965	9	10	39.43	-111.47	3	274	
SRA	1967	4	4	38.32	-107.75	3	178	
SRA	1968	3	20	37.92	-112.28	3	249	
SRA	1970	4	14	39.65	-110.82	3	264	
SRA	1970	11	24	36.357	-112.273	3	277	
SRA	1971	12	15	36.791	-111.824	3	220	
SRA	1973	1	22	37.19	-112.97	3	309	
SRA	1976	2	28	35.91	-111.788	3	269	
SRA	1977	9	24	39.31	-107.31	3	277	
SRA	1977	11	29	36.82	-110.99	3	152	
SRA	1978	5	29	39.28	-107.32	3	274	
SRA	1978	9	23	39.32	-111.09	3	245	
SRA	1981	5	29	36.83	-110.37	3	107	
SRA	1981	7	14	36.82	-110.31	3	104	
SRA	1981	9	22	39.59	-110.39	3	244	
SRA	1982	4	17	38.22	-111.3	3	177	
SRA	1982	11	3	35.32	-108.74	3	251	
SRA	1982	11	19	36.03	-112.01	3	277	
SRA	1983	5	3	38.305	-110.633	3	133	

SRA	1984	6	12	39.143	-107.394	3	259	
SRA	1984	7	18	36.216	-111.844	3	252	
SRA	1985	6	27	39.558	-110.396	3	241	
EPB	1930	7	28	41.5	-109.3	3	222	
SRA	1963	1	10	39.5	-110.33	2.9	233	
SRA	1963	9	2	39.62	-110.4	2.9	247	
SRA	1964	2	6	37.65	-112.97	2.9	306	
SRA	1964	6	6	39.6	-110.37	2.9	245	
SRA	1964	8	12	39.15	-112.16	2.9	295	
SRA	1965	1	18	37.97	-112.85	2.9	299	
SRA	1965	3	26	39.42	-110.28	2.9	223	
SRA	1965	5	29	39.29	-110.35	2.9	212	
SRA	1966	5	1	39.08	-111.56	2.9	251	
SRA	1969	3	13	39.55	-110.41	2.9	240	
SRA	1969	11	12	37.77	-112.43	2.9	260	
SRA	1970	8	31	38.17	-112.33	2.9	259	
SRA	1972	7	13	37.56	-111.94	2.9	215	
SRA	1972	10	17	37.69	-112.93	2.9	303	
SRA	1975	1	12	38	-112.91	2.9	305	
SRA	1975	9	10	38.6	-112.59	2.9	297	
SRA	1976	8	19	39.31	-111.11	2.9	245	
SRA	1978	8	30	38.03	-112.49	2.9	269	
SRA	1978	10	14	38.19	-112.35	2.9	262	
SRA	1982	1	7	36.95	-112.88	2.9	305	
SRA	1982	2	25	39.6	-109.4	2.9	233	
SRA	1982	5	18	39.71	-110.73	2.9	267	
SRA	1982	11	22	39.74	-107.58	2.9	299	
SRA	1986	2	14	39.675	-110.525	2.9	257	
SRA	1986	4	11	38.982	-106.94	2.9	277	
PDE-Q	2009	11	27	38.96	-111.59	2.9	190	
PDE-Q	2009	12	23	40.753	-112.056	2.9	258	
PDE-Q	2010	1	5	40.36	-111.91	2.9	226	
SRA	1962	3	16	36.88	-109.72	2.8	71	
SRA	1965	2	26	39.84	-110.45	2.8	272	
SRA	1965	6	17	39.51	-111.22	2.8	268	
SRA	1965	10	22	38.99	-110.26	2.8	178	
SRA	1966	2	17	36.98	-107.02	2.8	227	
SRA	1966	2	27	36.9	-107	2.8	231	
SRA	1966	5	5	37.03	-112.38	2.8	260	
SRA	1966	5	30	38	-112.13	2.8	238	
SRA	1966	6	21	36.9	-107.1	2.8	223	
SRA	1967	11	16	39.55	-110.32	2.8	238	
SRA	1968	2	23	37.6	-110.24	2.8	66	
SRA	1968	9	20	38.49	-112.25	2.8	265	
SRA	1970	1	22	39.58	-110.41	2.8	244	
SRA	1970	12	3	35.874	-111.906	2.8	280	
SRA	1971	2	24	39.49	-110.36	2.8	233	
SRA	1973	2	10	38.06	-112.83	2.8	299	
SRA	1974	9	16	38.7	-112.55	2.8	298	
SRA	1975	9	29	35.96	-106.79	2.8	296	
SRA	1975	10	6	39.15	-111.5	2.8	253	
SRA	1976	6	30	38.85	-112.06	2.8	269	
SRA	1976	7	9	38.97	-111.48	2.8	237	

SRA	1976	11	6	39.47	-111.31	2.8	269	
SRA	1977	3	25	39.76	-110.83	2.8	276	
SRA	1980	3	1	39.62	-110.68	2.8	256	
SRA	1981	6	9	39.51	-111.26	2.8	270	
SRA	1982	2	15	39.2	-111.99	2.8	287	
SRA	1982	12	9	39.31	-111.15	2.8	247	
SRA	1983	12	15	37.575	-110.51	2.8	89	
SRA	1985	6	11	39.166	-111.47	2.8	252	
SRA	1985	9	6	39.594	-110.42	2.8	245	
PDE-Q	2010	1	11	39.7	-111.26	2.8	152	
SRA	1963	3	12	39.51	-110.66	2.7	244	
SRA	1964	3	2	39.5	-111.87	2.7	303	
SRA	1964	12	26	39.61	-110.38	2.7	246	
SRA	1965	7	5	39.23	-111.44	2.7	256	
SRA	1966	1	22	36.57	-111.99	2.7	244	
SRA	1966	3	22	36.98	-107.02	2.7	227	
SRA	1966	4	18	39.29	-112.07	2.7	299	
SRA	1967	4	3	39.44	-111.07	2.7	255	
SRA	1967	5	8	37.79	-110.17	2.7	67	
SRA	1967	5	17	37.85	-112.3	2.7	249	
SRA	1968	10	11	39.03	-110.17	2.7	179	
SRA	1970	5	21	39.41	-110.31	2.7	223	
SRA	1971	11	30	37.62	-113.09	2.7	317	
SRA	1972	4	27	39.2	-111.45	2.7	254	
SRA	1972	5	20	35.4	-107.36	2.7	301	
SRA	1972	12	18	35.42	-107.16	2.7	311	
SRA	1973	7	16	39.1	-111.43	2.7	244	
SRA	1974	5	29	39.02	-111.48	2.7	241	
SRA	1974	6	15	39.55	-110.58	2.7	246	
SRA	1974	7	12	39.43	-112.13	2.7	313	
SRA	1974	8	14	38.69	-112	2.7	255	
SRA	1974	9	3	39.55	-111	2.7	262	
SRA	1974	10	23	39.77	-110.75	2.7	274	
SRA	1974	12	25	37.87	-112.99	2.7	310	
SRA	1976	2	20	39.31	-111.14	2.7	246	
SRA	1976	8	3	38.09	-112.45	2.7	267	
SRA	1976	12	30	38.31	-112.2	2.7	253	
SRA	1977	9	21	37.11	-111.54	2.7	185	
SRA	1981	4	9	37.72	-110.54	2.7	94	
SRA	1982	1	29	39.49	-112.18	2.7	321	
SRA	1982	3	23	39.47	-112	2.7	308	
SRA	1982	8	25	38.01	-111.64	2.7	196	
SRA	1982	11	13	36.69	-106.71	2.7	263	
SRA	1983	2	12	39.311	-111.162	2.7	247	
SRA	1983	8	4	37.525	-110.452	2.7	84	
SRA	1984	1	8	39.04	-111.509	2.7	245	
SRA	1984	8	29	39.32	-111.162	2.7	248	
SRA	1985	12	3	39.701	-111.171	2.7	284	
SRA	1985	12	6	38.789	-108.899	2.7	152	
SRA	1986	5	9	38.887	-106.884	2.7	275	
SRA	1962	1	20	36.45	-110.4	2.6	141	
SRA	1962	8	10	39.28	-111.42	2.6	259	
SRA	1962	8	21	39.35	-111.03	2.6	244	
SRA	1963	3	17	39.1	-111.96	2.6	278	

SRA	1966	5	5	36.82	-112.39	2.6	267	
SRA	1966	7	24	36.9	-107	2.6	231	
SRA	1969	4	16	39.95	-110.72	2.6	291	
SRA	1969	8	19	37.64	-110.65	2.6	102	
SRA	1971	3	27	36.762	-112.393	2.6	269	
SRA	1971	6	25	39.45	-110.34	2.6	228	
SRA	1971	11	16	37.7	-113.1	2.6	318	
SRA	1972	6	26	38.19	-112.47	2.6	272	
SRA	1974	9	20	38.75	-112.33	2.6	284	
SRA	1976	3	21	39.3	-111.2	2.6	248	
SRA	1976	10	25	37.88	-112.7	2.6	285	
SRA	1977	3	5	39.3	-111.28	2.6	253	
SRA	1977	5	9	39.34	-111.1	2.6	247	
SRA	1977	8	12	36.79	-110.92	2.6	148	
SRA	1977	12	27	37.78	-112.52	2.6	268	
SRA	1979	3	29	40.27	-108.81	2.6	313	
SRA	1982	10	24	38.53	-112.28	2.6	269	
SRA	1982	11	25	39.33	-111.12	2.6	247	
SRA	1983	6	28	39.329	-111.133	2.6	247	
SRA	1984	6	8	39.733	-110.94	2.6	277	
SRA	1985	4	10	39.731	-110.936	2.6	277	
SRA	1985	5	5	39.608	-110.375	2.6	245	
SRA	1985	7	17	39.609	-110.397	2.6	246	
SRA	1985	9	24	39.588	-110.42	2.6	245	
SRA	1986	3	12	39.326	-111.094	2.6	245	
SRA	1986	7	31	38.225	-112.556	2.6	280	
SRA	1986	9	27	39.561	-110.403	2.6	241	
SRA	1962	10	1	36.14	-111.74	2.5	250	
SRA	1963	8	1	39.55	-110.33	2.5	238	
SRA	1965	5	16	37.95	-112.45	2.5	264	
SRA	1966	2	7	39.54	-111.09	2.5	265	
SRA	1966	4	28	39.49	-110.33	2.5	232	
SRA	1966	6	18	38.6	-112.7	2.5	306	
SRA	1967	2	1	37.83	-110.17	2.5	69	
SRA	1968	8	3	37.99	-112.39	2.5	260	
SRA	1969	6	18	38.75	-112.21	2.5	275	
SRA	1969	11	22	38.99	-111.49	2.5	240	
SRA	1970	10	13	38.55	-112.26	2.5	268	
SRA	1971	11	25	37.7	-113.1	2.5	318	
SRA	1972	6	14	39.48	-109.93	2.5	222	
SRA	1972	7	1	39.28	-110.25	2.5	208	
SRA	1977	5	9	39.34	-111.1	2.6	247	
SRA	1977	8	12	36.79	-110.92	2.6	148	
SRA	1977	12	27	37.78	-112.52	2.6	268	
SRA	1979	3	29	40.27	-108.81	2.6	313	
SRA	1982	10	24	38.53	-112.28	2.6	269	
SRA	1982	11	25	39.33	-111.12	2.6	247	
SRA	1983	6	28	39.329	-111.133	2.6	247	
SRA	1984	6	8	39.733	-110.94	2.6	277	
SRA	1985	4	10	39.731	-110.936	2.6	277	
SRA	1985	5	5	39.608	-110.375	2.6	245	
SRA	1985	7	17	39.609	-110.397	2.6	246	
SRA	1985	9	24	39.588	-110.42	2.6	245	
SRA	1986	3	12	39.326	-111.094	2.6	245	

SRA	1986	7	31	38.225	-112.556	2.6	280	
SRA	1986	9	27	39.561	-110.403	2.6	241	
SRA	1962	10	1	36.14	-111.74	2.5	250	
SRA	1963	8	1	39.55	-110.33	2.5	238	
SRA	1965	5	16	37.95	-112.45	2.5	264	
SRA	1966	2	7	39.54	-111.09	2.5	265	
SRA	1966	4	28	39.49	-110.33	2.5	232	
SRA	1966	6	18	38.6	-112.7	2.5	306	
SRA	1967	2	1	37.83	-110.17	2.5	69	
SRA	1968	8	3	37.99	-112.39	2.5	260	
SRA	1969	6	18	38.75	-112.21	2.5	275	
SRA	1969	11	22	38.99	-111.49	2.5	240	
SRA	1970	10	13	38.55	-112.26	2.5	268	
SRA	1971	11	25	37.7	-113.1	2.5	318	
SRA	1972	6	14	39.48	-109.93	2.5	222	
SRA	1972	7	1	39.28	-110.25	2.5	208	
SRA	1972	11	15	39	-111.43	2.5	237	
SRA	1973	9	29	38.08	-113.07	2.5	320	
SRA	1974	4	23	39.62	-110.28	2.5	244	
SRA	1974	4	27	39.27	-110.98	2.5	235	
SRA	1974	11	13	39.3	-110.24	2.5	209	
SRA	1975	1	29	39.32	-111.11	2.5	246	
SRA	1975	5	20	38.22	-112.78	2.5	299	
SRA	1975	12	20	39.49	-110.65	2.5	242	
SRA	1976	2	26	39.31	-111.06	2.5	242	
SRA	1976	5	20	35.47	-109.04	2.5	228	
SRA	1976	5	31	39.25	-111.19	2.5	243	
SRA	1976	6	13	38.9	-111.97	2.5	266	
SRA	1976	9	5	38.69	-112.42	2.5	288	
SRA	1976	10	6	39.07	-111.63	2.5	255	
SRA	1976	12	28	38.35	-111.17	2.5	174	
SRA	1977	7	9	37.89	-112.4	2.5	259	
SRA	1977	9	7	39.33	-111.12	2.5	247	
SRA	1977	11	24	38.26	-112.3	2.5	260	
SRA	1981	1	16	37.51	-113.11	2.5	319	
SRA	1981	8	14	35.27	-107.9	2.5	285	
SRA	1981	8	28	37.84	-112.93	2.5	304	
SRA	1982	1	29	39.33	-111.12	2.5	247	
SRA	1982	3	8	37.97	-112.16	2.5	240	
SRA	1982	9	19	39.2	-111.94	2.5	284	
SRA	1982	9	28	39.28	-111.15	2.5	244	
SRA	1983	2	20	39.708	-110.95	2.5	275	
SRA	1983	7	12	35.576	-107.11	2.5	302	
SRA	1984	8	9	37.65	-112.471	2.5	262	
SRA	1984	9	7	38.536	-112.287	2.5	270	
SRA	1985	5	15	39.114	-111.455	2.5	247	
SRA	1985	6	3	39.7	-110.72	2.5	266	
SRA	1985	8	6	39.557	-110.397	2.5	241	
SRA	1985	11	24	39.57	-110.477	2.5	244	
SRA	1985	12	28	39.712	-110.596	2.5	263	
SRA	1986	8	7	39.697	-110.736	2.5	266	
SRA	1986	8	31	38.966	-111.419	2.5	233	
SRA	1964	11	4	39.36	-110.29	2.4	217	
SRA	1965	11	4	39.49	-111.04	2.4	258	

SRA	1966	8	12	36.6	-107.2	2.4	227	
SRA	1968	2	26	39.52	-111.05	2.4	261	
SRA	1968	8	29	39.5	-110.38	2.4	234	
SRA	1983	6	16	38.936	-111.391	2.4	229	
SRA	1966	6	26	36.9	-107.2	2.3	214	
SRA	1966	2	6	36.98	-107.02	2.2	227	
SRA	1966	2	13	36.97	-106.96	2.2	232	
SRA	1984	4	12	39.298	-107.232	2.2	281	

APPENDIX 2: BOREHOLE LOG

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BOREHOLE LOG

PAGE: 1 OF 3

DATE: 6/15/06

BOREHOLE NO.: **MFG-1**

PROJECT INFORMATION

PROJECT: WHITE MESA

PROJECT NO.: 181413X

CLIENT: TETRA TECH EMI

OWNER: INTERNATIONAL URANIUM (IUSA) CORPORATION

LOCATION: BLANDING, UTAH

BOREHOLE LOCATION

SEE FIGURE 1

FIELD INFORMATION

DATE & TIME ARRIVED: 6/15/06 9:00AM

BOREHOLE LOGGED BY: NMT

VISITORS: NONE

WEATHER: PARTLY CLOUDY, SLIGHT BREEZE, APPROX. 80°

DRILLING INFORMATION

DRILLING COMPANY: DA SMITH DRILLING

START TIME: 11:10AM

BORING DEPTH: APPROX. 31' BORING DIA.: 6"

DRILLING METHOD: CME 75 SOLID STEM AUGER

SAMPLING METHOD: 2-IN CA SAMPLES

TIME DRILLING COMPLETE: 12:50PM

BOREHOLE COMPLETION / ABANDONMENT INFORMATION

START TIME: 12:50PM COMPLETE TIME: 1:10PM

INSTRUMENTATION: NONE BACKFILL: BENTONITE

GROUNDWATER CONDITIONS

GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING

FOLLOWING FIELD WORK

TIME OF CLEAN-UP COMPLETE: 1:10PM TIME LEFT SITE: 1:50PM

NOTES:

MFG, Inc.
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BOREHOLE LOG

PROJECT: *WHITE MESA* **PAGE:** *2 OF 3*

PROJECT NO.: *181413X* **DATE:** *6/15/06*

BOREHOLE NO.: **MFG-1**

DEPTH (FT)	CORE RECOV.	DRIVE SAMPLES SAMPLE TYPE	BLOWS (PER 6")	RECOV.	ADD'L SAMPLES	LITHOLOGY GRAPHIC	SOIL DESCRIPTION
							COAL COVER AT SURFACE (APPROX. 0.25')
0							**SILTY CLAY (0 TO APPROX. 5.5')** SLIGHTLY MOIST, LIGHT OLIVE BROWN (2.5Y 5/3), VERY STIFF SILTY CLAY FILL, TRACE SAND, TRACE PEBBLES, WHITE PRECIPITATE, ZONES OF COLOR CHANGE TO RED (2.5YR 4/6).
1							
2							APPROX. 0.5' - MOIST.
3							
4							
5							
		CA B A	11 19 33	17"			**SILTY SAND (APPROX. 5.5' TO APPROX. 30')** SLIGHTLY MOIST, RED (2.5YR 5/6), VERY DENSE SILTY SAND, FINE TO MEDIUM GRAIN, TRACE TO SOME CLAY, WHITE PRECIPITATE.
6							
7							APPROX. 6.5' - SANDSTONE FRAGMENTS, DRY, PINK (5YR 8/3), VERY DENSE, MEDIUM CEMENTATION, FINE GRAIN.
8							
9							
10							
		CA B A	15 32 43	13"			
11							
12							
13							
14							
15							APPROX. 15' - ZONES OF SANDY CLAY VARIOUS COLORS, MOIST.
		CA B A	13 18 36	18"			
16							
17							
18							
19							
20							

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BOREHOLE LOG

PROJECT: *WHITE MESA* **PAGE:** *3 OF 3*

PROJECT NO.: *181413X* **DATE:** *6/15/06*

BOREHOLE NO.: **MFG-1**

DEPTH (FT)	CORE RECOV.	DRIVE SAMPLES SAMPLE TYPE	BLOWS (PER 6")	RECOV.	ADD'L SAMPLES	LITHOLOGY GRAPHIC	SOIL DESCRIPTION
20							**SILTY SAND (APPROX. 5.5' TO APPROX. 30')** SEE DESCRIPTION ON PREVIOUS PAGE.
21		CA B A	15 29 50/6"	18"			
22							
23							
24							APPROX. 24' - SLIGHTLY MOIST.
25							
26		CA B A	12 13 20	13"			
27							
28							
29							
30							**SANDSTONE (APPROX. 30' TO E.O.B.)** SLIGHTLY MOIST, PINK (2.5YR 8/3), VERY DENSE SANDSTONE, FINE TO MEDIUM CEMENTATION, FINE GRAIN.
		CA B A	38 50/5"	13"			
31							E.O.B. = 31.0'
32							
33							
34							
35							
36							
37							
38							
39							
40							

APPENDIX 3: DEAGGREGATION OF SEISMIC HAZARD FOR PGA FROM USGS NATIONAL SEISMIC HAZARDS MAPPING PROJECT

*** Deaggregation of Seismic Hazard at One Period of Spectral Accel. ***

*** Data from U.S.G.S. National Seismic Hazards Mapping Project, 2008 version ***

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).

NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below

Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.101E-03
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00192

#This deaggregation corresponds to Mean Hazard w/all GMPEs

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
15.5	4.6	4.083	0.475	1.805	1.514	0.289	0	0
38.2	4.61	0.51	0.455	0.055	0	0	0	0
56.3	4.62	0.052	0.052	0	0	0	0	0
13.4	4.79	6.407	0.434	2.156	3.118	0.695	0.005	0
30.6	4.82	3.533	1.428	1.973	0.132	0	0	0
58.5	4.82	0.248	0.248	0	0	0	0	0
12	5.03	4.369	0.166	0.993	2.331	0.847	0.032	0
30.6	5.03	4.813	1.331	2.816	0.665	0	0	0
61	5.04	0.55	0.55	0	0	0	0	0
12.2	5.21	1.761	0.06	0.356	0.881	0.446	0.019	0
31.4	5.21	2.514	0.507	1.427	0.581	0	0	0
62	5.21	0.414	0.41	0.004	0	0	0	0
88.1	5.21	0.061	0.061	0	0	0	0	0
12.4	5.39	2.793	0.086	0.515	1.294	0.841	0.056	0
32.2	5.4	5.072	0.734	2.764	1.574	0	0	0
62.7	5.4	1.142	1.007	0.135	0	0	0	0
89.1	5.41	0.265	0.265	0	0	0	0	0
113.4	5.42	0.105	0.105	0	0	0	0	0
12.5	5.61	1.44	0.041	0.243	0.609	0.504	0.044	0
33.1	5.62	3.439	0.346	1.711	1.349	0.033	0	0
63.5	5.62	1.102	0.736	0.366	0	0	0	0
89.6	5.62	0.358	0.358	0	0	0	0	0
116.8	5.63	0.242	0.242	0	0	0	0	0
12.6	5.8	1.303	0.035	0.209	0.525	0.48	0.053	0
33.8	5.81	3.703	0.298	1.689	1.591	0.126	0	0
63.8	5.81	1.426	0.727	0.699	0	0	0	0
89.9	5.81	0.546	0.544	0.002	0	0	0	0
118.5	5.82	0.49	0.49	0	0	0	0	0

13.3	6.01	1.142	0.03	0.176	0.443	0.421	0.071	0.001
35	6.01	3.01	0.184	1.1	1.55	0.176	0	0
60.4	6.01	1.422	0.346	1.05	0.025	0	0	0
85.2	6.02	0.982	0.68	0.302	0	0	0	0
119.7	6.02	0.823	0.82	0.004	0	0	0	0
166.2	6.02	0.128	0.128	0	0	0	0	0
16.4	6.22	1.703	0.045	0.271	0.681	0.619	0.086	0.001
37.3	6.2	2.66	0.144	0.858	1.523	0.136	0	0
58.9	6.22	1.726	0.271	1.258	0.197	0	0	0
84.3	6.22	1.536	0.685	0.851	0	0	0	0
120.9	6.22	1.383	1.284	0.1	0	0	0	0
168.5	6.23	0.312	0.312	0	0	0	0	0
14.4	6.42	0.855	0.021	0.125	0.315	0.315	0.076	0.002
35.7	6.42	2.472	0.103	0.614	1.377	0.379	0	0
59.8	6.42	1.489	0.16	0.923	0.407	0	0	0
84.4	6.42	1.669	0.425	1.244	0	0	0	0
121.6	6.43	1.708	1.131	0.577	0	0	0	0
168.9	6.43	0.525	0.525	0	0	0	0	0
217.1	6.43	0.099	0.099	0	0	0	0	0
13.2	6.59	0.478	0.011	0.068	0.172	0.172	0.052	0.002
36.1	6.59	1.653	0.062	0.373	0.897	0.319	0.002	0
63.1	6.59	1.322	0.134	0.766	0.423	0	0	0
87.4	6.6	0.988	0.192	0.77	0.026	0	0	0
122.4	6.59	1.444	0.681	0.764	0	0	0	0
169.7	6.6	0.505	0.497	0.008	0	0	0	0
218.9	6.6	0.124	0.124	0	0	0	0	0
13.1	6.77	0.578	0.014	0.081	0.204	0.204	0.071	0.003
36.7	6.78	2.145	0.074	0.443	1.106	0.514	0.008	0
63	6.77	1.854	0.142	0.846	0.867	0	0	0
87.4	6.79	1.526	0.213	1.158	0.154	0	0	0
122.7	6.78	2.485	0.749	1.736	0	0	0	0
170.3	6.78	0.991	0.849	0.142	0	0	0	0
219.5	6.79	0.285	0.285	0	0	0	0	0
268.7	6.79	0.064	0.064	0	0	0	0	0
14.2	6.97	0.207	0.005	0.029	0.072	0.072	0.027	0.001
37.6	6.98	0.64	0.02	0.12	0.3	0.194	0.006	0
60.2	6.97	0.55	0.029	0.17	0.338	0.014	0	0
85.3	6.97	0.753	0.069	0.408	0.276	0	0	0
122.9	6.97	1.069	0.195	0.834	0.04	0	0	0
170.9	6.97	0.471	0.279	0.192	0	0	0	0
219.9	6.97	0.151	0.151	0	0	0	0	0
37.1	7.16	0.167	0.005	0.03	0.074	0.055	0.003	0
61.2	7.16	0.133	0.006	0.038	0.084	0.006	0	0
85	7.16	0.207	0.016	0.093	0.099	0	0	0
123.3	7.16	0.307	0.042	0.225	0.04	0	0	0
171.1	7.16	0.16	0.065	0.095	0	0	0	0

220.5 7.16 0.054 0.052 0.002 0 0 0 0

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:

Contribution from this GMPE(%): 100.0

Mean src-site R= 51.5 km; M= 5.81; eps0= 0.34. Mean calculated for all sources.

Modal src-site R= 13.4 km; M= 4.79; eps0= -0.26 from peak (R,M) bin

MODE R*= 12.2km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 3.118

Principal sources (faults, subduction, random seismicity having > 3% contribution)

Source Category: % contr. R(km) M epsilon0 (mean values).

CEUS gridded 100.00 51.5 5.81 0.34

Individual fault hazard details if its contribution to mean hazard > 2%:

Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)

#*********End of deaggregation corresponding to Mean Hazard w/all GMPEs *********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).

NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below

Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.277E-04
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00207

#This deaggregation corresponds to Toro et al. 1997

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
11.7	4.6	0.766	0.156	0.585	0.024	0	0	0
30.1	4.61	0.591	0.51	0.081	0	0	0	0
56.9	4.62	0.035	0.035	0	0	0	0	0
11.8	4.8	1.378	0.258	1.059	0.062	0	0	0
30.6	4.81	1.276	0.999	0.277	0	0	0	0
59.4	4.82	0.126	0.126	0	0	0	0	0

12.1	5.03	1.081	0.166	0.834	0.081	0	0	0
31.6	5.03	1.421	0.921	0.5	0	0	0	0
61.5	5.04	0.255	0.255	0	0	0	0	0
86.1	5.06	0.017	0.017	0	0	0	0	0
12.3	5.21	0.438	0.06	0.331	0.047	0	0	0
32.4	5.21	0.737	0.411	0.326	0	0	0	0
62.5	5.21	0.184	0.184	0	0	0	0	0
87.6	5.21	0.025	0.025	0	0	0	0	0
12.4	5.39	0.697	0.086	0.502	0.109	0	0	0
33.1	5.4	1.466	0.68	0.786	0	0	0	0
63.1	5.4	0.482	0.482	0.001	0	0	0	0
88.7	5.4	0.105	0.105	0	0	0	0	0
108.7	5.41	0.021	0.021	0	0	0	0	0
12.6	5.61	0.365	0.041	0.242	0.082	0	0	0
34.1	5.62	1.027	0.346	0.679	0.002	0	0	0
63.9	5.62	0.477	0.445	0.031	0	0	0	0
89.3	5.63	0.148	0.148	0	0	0	0	0
114.1	5.64	0.071	0.071	0	0	0	0	0
12.6	5.8	0.324	0.035	0.209	0.079	0	0	0
34.4	5.81	0.993	0.298	0.689	0.006	0	0	0
64.1	5.81	0.507	0.454	0.053	0	0	0	0
89.4	5.81	0.17	0.17	0	0	0	0	0
115.3	5.82	0.096	0.096	0	0	0	0	0
13.3	6.01	0.289	0.03	0.176	0.083	0	0	0
35.6	6.01	0.86	0.184	0.657	0.019	0	0	0
61.2	6.01	0.544	0.333	0.211	0	0	0	0
84.9	6.02	0.359	0.344	0.015	0	0	0	0
118.1	6.02	0.22	0.22	0	0	0	0	0
161.8	6.03	0.02	0.02	0	0	0	0	0
16.5	6.22	0.432	0.045	0.271	0.115	0	0	0
37.5	6.2	0.695	0.144	0.545	0.007	0	0	0
59.2	6.21	0.545	0.271	0.274	0	0	0	0
83.5	6.22	0.465	0.425	0.04	0	0	0	0
118.7	6.22	0.265	0.265	0	0	0	0	0
164.7	6.22	0.032	0.032	0	0	0	0	0
14.4	6.42	0.217	0.021	0.125	0.071	0	0	0
35.9	6.42	0.68	0.103	0.522	0.056	0	0	0
61.9	6.42	0.571	0.212	0.359	0	0	0	0
85.1	6.42	0.491	0.331	0.16	0	0	0	0
120.1	6.42	0.403	0.401	0.002	0	0	0	0
167.8	6.43	0.098	0.098	0	0	0	0	0
13.3	6.59	0.12	0.011	0.068	0.04	0	0	0
36.3	6.59	0.437	0.062	0.33	0.044	0	0	0
63.1	6.59	0.392	0.134	0.258	0	0	0	0
86.4	6.61	0.295	0.179	0.116	0	0	0	0
120.7	6.6	0.284	0.273	0.011	0	0	0	0

168.9	6.61	0.078	0.078	0	0	0	0	0
13.2	6.77	0.145	0.014	0.081	0.05	0	0	0
36.7	6.78	0.559	0.074	0.414	0.071	0	0	0
63.4	6.77	0.534	0.142	0.392	0	0	0	0
87	6.79	0.388	0.212	0.176	0	0	0	0
120.8	6.78	0.435	0.402	0.033	0	0	0	0
169.4	6.78	0.134	0.134	0	0	0	0	0
215.8	6.79	0.023	0.023	0	0	0	0	0
14.2	6.97	0.052	0.005	0.029	0.019	0	0	0
37.8	6.97	0.175	0.02	0.119	0.036	0	0	0
60.4	6.96	0.169	0.029	0.139	0.002	0	0	0
84.7	6.97	0.226	0.068	0.157	0	0	0	0
121.7	6.97	0.237	0.171	0.066	0	0	0	0
170.8	6.96	0.092	0.092	0	0	0	0	0
218.6	6.96	0.025	0.025	0	0	0	0	0
37.1	7.16	0.043	0.005	0.03	0.008	0	0	0
61.2	7.16	0.034	0.006	0.028	0	0	0	0
84.1	7.16	0.046	0.016	0.031	0	0	0	0
121.1	7.16	0.043	0.035	0.008	0	0	0	0
170	7.16	0.016	0.016	0	0	0	0	0

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:

Contribution from this GMPE(%): 27.5

Mean src-site R= 48.4 km; M= 5.77; eps0= 0.56. Mean calculated for all sources.

Modal src-site R= 33.1 km; M= 5.40; eps0= 0.69 from peak (R,M) bin

MODE R*= 11.9km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 1.059

Principal sources (faults, subduction, random seismicity having > 3% contribution)

Source Category: % contr. R(km) M epsilon0 (mean values).

CEUS gridded 27.49 48.4 5.77 0.56

Individual fault hazard details if its contribution to mean hazard > 2%:

Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)

#*********End of deaggregation corresponding to Toro et al. 1997 *********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).

NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below

Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.253E-05
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00058

#This deaggregation corresponds to Atkinson-Boore06,140 bar

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
8.6	4.61	0.102	0.064	0.038	0	0	0	0
9.5	4.8	0.254	0.147	0.106	0	0	0	0
10.7	5.03	0.255	0.146	0.108	0	0	0	0
11.7	5.21	0.125	0.064	0.061	0	0	0	0
12.9	5.4	0.24	0.115	0.124	0	0	0	0
34	5.42	0.003	0.003	0	0	0	0	0
14.2	5.62	0.154	0.072	0.081	0	0	0	0
35.5	5.63	0.006	0.006	0	0	0	0	0
15.4	5.8	0.168	0.08	0.088	0	0	0	0
37	5.82	0.013	0.013	0	0	0	0	0
13.7	6.01	0.123	0.04	0.084	0	0	0	0
31.1	6.03	0.047	0.043	0.004	0	0	0	0
54.3	6.03	0.002	0.002	0	0	0	0	0
15	6.22	0.155	0.045	0.11	0	0	0	0
33.8	6.2	0.058	0.054	0.003	0	0	0	0
55.9	6.23	0.007	0.007	0	0	0	0	0
17.6	6.42	0.138	0.044	0.094	0	0	0	0
38.5	6.42	0.039	0.038	0	0	0	0	0
57.7	6.43	0.01	0.01	0	0	0	0	0
85.7	6.44	0.006	0.006	0	0	0	0	0
123.5	6.44	0.011	0.011	0	0	0	0	0
12.8	6.59	0.054	0.011	0.043	0	0	0	0
31.9	6.59	0.068	0.045	0.023	0	0	0	0
58.6	6.59	0.01	0.01	0	0	0	0	0
85.9	6.59	0.009	0.009	0	0	0	0	0
124.7	6.57	0.011	0.011	0	0	0	0	0
125.5	6.63	0.007	0.007	0	0	0	0	0
159.7	6.6	0.003	0.003	0	0	0	0	0
12.9	6.77	0.067	0.014	0.054	0	0	0	0
32.9	6.78	0.104	0.062	0.042	0	0	0	0
60.5	6.78	0.023	0.023	0	0	0	0	0
87.9	6.8	0.017	0.017	0	0	0	0	0

125.3	6.79	0.045	0.045	0	0	0	0	0
166.6	6.8	0.016	0.016	0	0	0	0	0
15.9	6.98	0.029	0.006	0.023	0	0	0	0
36.1	6.97	0.029	0.018	0.012	0	0	0	0
58.8	6.97	0.01	0.01	0	0	0	0	0
86.2	6.98	0.01	0.01	0	0	0	0	0
124.7	7.03	0.011	0.011	0	0	0	0	0
125.8	6.92	0.012	0.012	0	0	0	0	0
169.3	6.98	0.011	0.011	0	0	0	0	0
212.8	6.99	0.001	0.001	0	0	0	0	0
13.8	7.16	0.005	0.001	0.004	0	0	0	0
34.3	7.16	0.011	0.005	0.006	0	0	0	0
60.1	7.16	0.003	0.003	0	0	0	0	0
85.8	7.16	0.004	0.004	0	0	0	0	0
125.4	7.16	0.009	0.009	0	0	0	0	0
170.3	7.16	0.005	0.005	0	0	0	0	0

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:

Contribution from this GMPE(%): 2.5

Mean src-site R= 25.8 km; M= 5.83; eps0= 0.24. Mean calculated for all sources.

Modal src-site R= 10.7 km; M= 5.03; eps0= 0.25 from peak (R,M) bin

MODE R*= 11.0km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 0.147

Principal sources (faults, subduction, random seismicity having > 3% contribution)

Source Category: % contr. R(km) M epsilon0 (mean values).

Individual fault hazard details if its contribution to mean hazard > 2%:

Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Atkinson-Boore06,140 bar
*********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W. lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).
NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below
Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.227E-04
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00331
#This deaggregation corresponds to Frankel et al. 1996

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
14.7	4.59	0.589	0.275	0.314	0.000	0.000	0.000	0.000
31.0	4.64	0.226	0.218	0.009	0.000	0.000	0.000	0.000
12.2	4.80	0.912	0.258	0.654	0.000	0.000	0.000	0.000
30.1	4.80	0.951	0.836	0.115	0.000	0.000	0.000	0.000
57.6	4.82	0.053	0.053	0.000	0.000	0.000	0.000	0.000
12.4	5.03	0.683	0.166	0.517	0.000	0.000	0.000	0.000
31.3	5.03	1.026	0.781	0.246	0.000	0.000	0.000	0.000
61.1	5.04	0.136	0.136	0.000	0.000	0.000	0.000	0.000
87.4	5.08	0.012	0.012	0.000	0.000	0.000	0.000	0.000
12.6	5.21	0.266	0.060	0.206	0.000	0.000	0.000	0.000
32.2	5.21	0.522	0.353	0.170	0.000	0.000	0.000	0.000
62.4	5.21	0.106	0.106	0.000	0.000	0.000	0.000	0.000
89.3	5.21	0.024	0.024	0.000	0.000	0.000	0.000	0.000
12.7	5.39	0.410	0.086	0.323	0.000	0.000	0.000	0.000
33.1	5.40	1.027	0.623	0.404	0.000	0.000	0.000	0.000
63.2	5.41	0.295	0.295	0.000	0.000	0.000	0.000	0.000
89.9	5.41	0.100	0.100	0.000	0.000	0.000	0.000	0.000
115.4	5.42	0.076	0.076	0.000	0.000	0.000	0.000	0.000
12.7	5.61	0.203	0.041	0.163	0.000	0.000	0.000	0.000
34.1	5.62	0.649	0.339	0.310	0.000	0.000	0.000	0.000
64.0	5.62	0.270	0.270	0.000	0.000	0.000	0.000	0.000
90.1	5.62	0.120	0.120	0.000	0.000	0.000	0.000	0.000
119.5	5.62	0.138	0.138	0.000	0.000	0.000	0.000	0.000
12.8	5.80	0.181	0.035	0.146	0.000	0.000	0.000	0.000
34.9	5.80	0.696	0.298	0.398	0.000	0.000	0.000	0.000
64.5	5.81	0.380	0.375	0.005	0.000	0.000	0.000	0.000
90.3	5.81	0.200	0.200	0.000	0.000	0.000	0.000	0.000
120.9	5.81	0.273	0.273	0.000	0.000	0.000	0.000	0.000
162.5	5.83	0.047	0.047	0.000	0.000	0.000	0.000	0.000
13.5	6.01	0.155	0.030	0.125	0.000	0.000	0.000	0.000
35.8	6.01	0.525	0.184	0.341	0.000	0.000	0.000	0.000
60.8	6.01	0.324	0.282	0.041	0.000	0.000	0.000	0.000
85.9	6.02	0.298	0.298	0.000	0.000	0.000	0.000	0.000
121.5	6.01	0.369	0.369	0.000	0.000	0.000	0.000	0.000
167.8	6.02	0.096	0.096	0.000	0.000	0.000	0.000	0.000
16.7	6.23	0.235	0.045	0.189	0.000	0.000	0.000	0.000
37.8	6.20	0.464	0.144	0.320	0.000	0.000	0.000	0.000
59.3	6.21	0.390	0.269	0.121	0.000	0.000	0.000	0.000
85.1	6.22	0.465	0.463	0.001	0.000	0.000	0.000	0.000
122.5	6.22	0.605	0.605	0.000	0.000	0.000	0.000	0.000
169.9	6.22	0.217	0.217	0.000	0.000	0.000	0.000	0.000
214.9	6.24	0.036	0.036	0.000	0.000	0.000	0.000	0.000
14.5	6.42	0.113	0.021	0.092	0.000	0.000	0.000	0.000
36.2	6.42	0.392	0.103	0.290	0.000	0.000	0.000	0.000

60.2	6.42	0.300	0.159	0.141	0.000	0.000	0.000	0.000
85.1	6.42	0.432	0.397	0.034	0.000	0.000	0.000	0.000
123.1	6.42	0.621	0.621	0.000	0.000	0.000	0.000	0.000
170.3	6.43	0.285	0.285	0.000	0.000	0.000	0.000	0.000
218.2	6.43	0.074	0.074	0.000	0.000	0.000	0.000	0.000
13.4	6.59	0.062	0.011	0.051	0.000	0.000	0.000	0.000
36.7	6.59	0.258	0.062	0.196	0.000	0.000	0.000	0.000
64.1	6.59	0.275	0.134	0.141	0.000	0.000	0.000	0.000
88.1	6.60	0.249	0.191	0.057	0.000	0.000	0.000	0.000
123.8	6.59	0.495	0.491	0.004	0.000	0.000	0.000	0.000
171.1	6.59	0.256	0.256	0.000	0.000	0.000	0.000	0.000
219.5	6.59	0.084	0.084	0.000	0.000	0.000	0.000	0.000
266.9	6.60	0.016	0.016	0.000	0.000	0.000	0.000	0.000
13.2	6.77	0.074	0.014	0.061	0.000	0.000	0.000	0.000
37.2	6.77	0.327	0.074	0.253	0.000	0.000	0.000	0.000
63.7	6.77	0.359	0.142	0.218	0.000	0.000	0.000	0.000
87.8	6.79	0.367	0.213	0.155	0.000	0.000	0.000	0.000
124.0	6.78	0.770	0.678	0.092	0.000	0.000	0.000	0.000
171.7	6.78	0.451	0.451	0.000	0.000	0.000	0.000	0.000
220.2	6.79	0.173	0.173	0.000	0.000	0.000	0.000	0.000
268.9	6.79	0.044	0.044	0.000	0.000	0.000	0.000	0.000
14.2	6.97	0.026	0.005	0.022	0.000	0.000	0.000	0.000
37.9	6.98	0.093	0.020	0.073	0.000	0.000	0.000	0.000
60.5	6.97	0.092	0.029	0.064	0.000	0.000	0.000	0.000
85.7	6.97	0.154	0.068	0.085	0.000	0.000	0.000	0.000
124.2	6.97	0.276	0.194	0.082	0.000	0.000	0.000	0.000
172.3	6.97	0.176	0.175	0.001	0.000	0.000	0.000	0.000
220.7	6.97	0.074	0.074	0.000	0.000	0.000	0.000	0.000
270.2	6.98	0.022	0.022	0.000	0.000	0.000	0.000	0.000
37.6	7.16	0.024	0.005	0.019	0.000	0.000	0.000	0.000
61.5	7.16	0.023	0.006	0.017	0.000	0.000	0.000	0.000
85.4	7.16	0.042	0.016	0.027	0.000	0.000	0.000	0.000
124.5	7.16	0.078	0.042	0.036	0.000	0.000	0.000	0.000
172.7	7.16	0.059	0.056	0.004	0.000	0.000	0.000	0.000
221.2	7.16	0.027	0.027	0.000	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Contribution from this GMPE(%): 22.5
Mean src-site R= 69.4 km; M= 5.90; eps0= 0.56. Mean calculated for all sources.
Modal src-site R= 33.1 km; M= 5.40; eps0= 0.42 from peak (R,M) bin
MODE R*= 30.7km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 0.836

Principal sources (faults, subduction, random seismicity having > 3% contribution)

Source Category:	% contr.	R(km)	M	epsilon0 (mean values).
CEUS gridded	22.46	69.4	5.90	0.56

Individual fault hazard details if its contribution to mean hazard > 2%:

Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Frankel et al., 1996 *********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).
NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below
Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.146E-04
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00385
#This deaggregation corresponds to Campbell CEUS Hybrid

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
16.1	4.60	0.902	0.406	0.496	0.000	0.000	0.000	0.000
37.0	4.61	0.085	0.085	0.000	0.000	0.000	0.000	0.000
17.1	4.80	1.808	0.755	1.053	0.000	0.000	0.000	0.000
37.5	4.80	0.252	0.252	0.000	0.000	0.000	0.000	0.000
54.0	4.82	0.010	0.010	0.000	0.000	0.000	0.000	0.000
12.5	5.03	0.795	0.166	0.629	0.000	0.000	0.000	0.000
29.3	5.03	0.959	0.648	0.311	0.000	0.000	0.000	0.000
55.7	5.04	0.025	0.025	0.000	0.000	0.000	0.000	0.000
12.7	5.21	0.300	0.060	0.241	0.000	0.000	0.000	0.000
30.0	5.21	0.476	0.287	0.190	0.000	0.000	0.000	0.000
56.9	5.21	0.021	0.021	0.000	0.000	0.000	0.000	0.000
12.8	5.39	0.450	0.086	0.364	0.000	0.000	0.000	0.000
30.9	5.40	0.923	0.502	0.421	0.000	0.000	0.000	0.000
59.1	5.41	0.067	0.067	0.000	0.000	0.000	0.000	0.000
12.9	5.61	0.218	0.041	0.177	0.000	0.000	0.000	0.000
32.0	5.62	0.595	0.288	0.307	0.000	0.000	0.000	0.000
60.4	5.62	0.070	0.070	0.000	0.000	0.000	0.000	0.000
89.3	5.63	0.012	0.012	0.000	0.000	0.000	0.000	0.000
12.9	5.80	0.190	0.035	0.155	0.000	0.000	0.000	0.000
33.0	5.80	0.652	0.283	0.368	0.000	0.000	0.000	0.000
61.2	5.81	0.113	0.113	0.000	0.000	0.000	0.000	0.000
89.9	5.82	0.029	0.029	0.000	0.000	0.000	0.000	0.000
113.7	5.83	0.020	0.020	0.000	0.000	0.000	0.000	0.000
13.6	6.01	0.161	0.030	0.132	0.000	0.000	0.000	0.000
34.5	6.01	0.511	0.184	0.327	0.000	0.000	0.000	0.000
58.4	6.01	0.132	0.132	0.000	0.000	0.000	0.000	0.000
85.2	6.02	0.057	0.057	0.000	0.000	0.000	0.000	0.000
116.8	6.02	0.043	0.043	0.000	0.000	0.000	0.000	0.000
16.9	6.23	0.246	0.045	0.201	0.000	0.000	0.000	0.000
37.1	6.20	0.465	0.144	0.321	0.000	0.000	0.000	0.000
57.7	6.22	0.200	0.179	0.021	0.000	0.000	0.000	0.000
84.4	6.22	0.115	0.115	0.000	0.000	0.000	0.000	0.000
119.1	6.22	0.098	0.098	0.000	0.000	0.000	0.000	0.000

14.6	6.42	0.115	0.021	0.094	0.000	0.000	0.000	0.000
35.8	6.42	0.411	0.103	0.308	0.000	0.000	0.000	0.000
58.8	6.42	0.178	0.134	0.044	0.000	0.000	0.000	0.000
84.5	6.43	0.139	0.139	0.000	0.000	0.000	0.000	0.000
120.1	6.43	0.134	0.134	0.000	0.000	0.000	0.000	0.000
158.3	6.44	0.010	0.010	0.000	0.000	0.000	0.000	0.000
13.4	6.59	0.063	0.011	0.051	0.000	0.000	0.000	0.000
36.4	6.59	0.275	0.062	0.213	0.000	0.000	0.000	0.000
62.0	6.59	0.168	0.115	0.053	0.000	0.000	0.000	0.000
87.6	6.60	0.097	0.097	0.000	0.000	0.000	0.000	0.000
120.9	6.59	0.133	0.133	0.000	0.000	0.000	0.000	0.000
161.1	6.59	0.015	0.015	0.000	0.000	0.000	0.000	0.000
13.2	6.77	0.075	0.014	0.061	0.000	0.000	0.000	0.000
37.2	6.78	0.352	0.074	0.278	0.000	0.000	0.000	0.000
61.8	6.77	0.257	0.140	0.117	0.000	0.000	0.000	0.000
87.3	6.79	0.179	0.171	0.008	0.000	0.000	0.000	0.000
121.3	6.79	0.268	0.268	0.000	0.000	0.000	0.000	0.000
164.2	6.79	0.042	0.042	0.000	0.000	0.000	0.000	0.000
14.3	6.97	0.027	0.005	0.022	0.000	0.000	0.000	0.000
38.1	6.98	0.102	0.020	0.082	0.000	0.000	0.000	0.000
59.7	6.97	0.081	0.029	0.053	0.000	0.000	0.000	0.000
85.3	6.98	0.092	0.068	0.024	0.000	0.000	0.000	0.000
121.7	6.98	0.123	0.121	0.002	0.000	0.000	0.000	0.000
166.0	6.98	0.024	0.024	0.000	0.000	0.000	0.000	0.000
37.8	7.16	0.026	0.005	0.021	0.000	0.000	0.000	0.000
60.9	7.16	0.022	0.006	0.016	0.000	0.000	0.000	0.000
85.1	7.16	0.031	0.016	0.015	0.000	0.000	0.000	0.000
122.3	7.16	0.044	0.037	0.007	0.000	0.000	0.000	0.000
166.7	7.16	0.012	0.012	0.000	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Contribution from this GMPE(%): 14.5
Mean src-site R= 37.9 km; M= 5.66; eps0= -0.22. Mean calculated for all sources.
Modal src-site R= 17.1 km; M= 4.80; eps0= -0.45 from peak (R,M) bin
MODE R*= 14.5km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 1.053

Principal sources (faults, subduction, random seismicity having > 3% contribution)
Source Category: % contr. R(km) M epsilon0 (mean values).
CEUS gridded 14.51 37.9 5.66 -0.22
Individual fault hazard details if its contribution to mean hazard > 2%:
Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Campbell CEUS Hybrid *********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.

Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).
NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below
Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.153E-04
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00185
#This deaggregation corresponds to Silva 1-corner

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
11.6	4.60	0.317	0.156	0.160	0.000	0.000	0.000	0.000
29.9	4.61	0.248	0.248	0.000	0.000	0.000	0.000	0.000
55.5	4.62	0.009	0.009	0.000	0.000	0.000	0.000	0.000
11.8	4.80	0.633	0.258	0.376	0.000	0.000	0.000	0.000
30.8	4.80	0.668	0.662	0.007	0.000	0.000	0.000	0.000
58.2	4.81	0.059	0.059	0.000	0.000	0.000	0.000	0.000
12.1	5.03	0.496	0.166	0.329	0.000	0.000	0.000	0.000
31.9	5.03	0.723	0.658	0.065	0.000	0.000	0.000	0.000
61.2	5.04	0.129	0.129	0.000	0.000	0.000	0.000	0.000
12.2	5.21	0.201	0.060	0.142	0.000	0.000	0.000	0.000
32.7	5.21	0.370	0.307	0.063	0.000	0.000	0.000	0.000
62.3	5.21	0.096	0.096	0.000	0.000	0.000	0.000	0.000
86.5	5.21	0.011	0.011	0.000	0.000	0.000	0.000	0.000
12.4	5.39	0.323	0.086	0.236	0.000	0.000	0.000	0.000
33.5	5.40	0.731	0.550	0.181	0.000	0.000	0.000	0.000
63.1	5.40	0.259	0.259	0.000	0.000	0.000	0.000	0.000
88.6	5.41	0.055	0.055	0.000	0.000	0.000	0.000	0.000
12.5	5.61	0.168	0.041	0.127	0.000	0.000	0.000	0.000
34.3	5.62	0.478	0.315	0.162	0.000	0.000	0.000	0.000
63.9	5.62	0.230	0.230	0.000	0.000	0.000	0.000	0.000
89.3	5.62	0.070	0.070	0.000	0.000	0.000	0.000	0.000
111.3	5.63	0.027	0.027	0.000	0.000	0.000	0.000	0.000
12.6	5.80	0.155	0.035	0.120	0.000	0.000	0.000	0.000
34.9	5.80	0.525	0.296	0.229	0.000	0.000	0.000	0.000
64.4	5.81	0.320	0.320	0.000	0.000	0.000	0.000	0.000
89.6	5.81	0.120	0.120	0.000	0.000	0.000	0.000	0.000
116.1	5.82	0.078	0.078	0.000	0.000	0.000	0.000	0.000
13.3	6.01	0.136	0.030	0.107	0.000	0.000	0.000	0.000
35.8	6.01	0.407	0.184	0.223	0.000	0.000	0.000	0.000
60.8	6.01	0.273	0.258	0.015	0.000	0.000	0.000	0.000
84.7	6.02	0.203	0.203	0.000	0.000	0.000	0.000	0.000
118.4	6.02	0.129	0.129	0.000	0.000	0.000	0.000	0.000
160.4	6.03	0.011	0.011	0.000	0.000	0.000	0.000	0.000
16.5	6.23	0.207	0.045	0.162	0.000	0.000	0.000	0.000
37.8	6.20	0.369	0.144	0.225	0.000	0.000	0.000	0.000
59.5	6.21	0.334	0.262	0.072	0.000	0.000	0.000	0.000
83.9	6.22	0.336	0.336	0.000	0.000	0.000	0.000	0.000
119.9	6.22	0.241	0.241	0.000	0.000	0.000	0.000	0.000

167.5	6.23	0.051	0.051	0.000	0.000	0.000	0.000	0.000
14.4	6.42	0.104	0.021	0.083	0.000	0.000	0.000	0.000
36.1	6.42	0.326	0.103	0.223	0.000	0.000	0.000	0.000
60.3	6.42	0.262	0.159	0.102	0.000	0.000	0.000	0.000
84.2	6.42	0.328	0.318	0.009	0.000	0.000	0.000	0.000
120.9	6.43	0.279	0.279	0.000	0.000	0.000	0.000	0.000
169.6	6.43	0.093	0.093	0.000	0.000	0.000	0.000	0.000
215.1	6.44	0.017	0.017	0.000	0.000	0.000	0.000	0.000
13.2	6.59	0.059	0.011	0.047	0.000	0.000	0.000	0.000
36.5	6.59	0.220	0.062	0.157	0.000	0.000	0.000	0.000
64.1	6.59	0.242	0.134	0.108	0.000	0.000	0.000	0.000
87.5	6.60	0.188	0.172	0.016	0.000	0.000	0.000	0.000
121.8	6.59	0.244	0.244	0.000	0.000	0.000	0.000	0.000
170.9	6.59	0.097	0.097	0.000	0.000	0.000	0.000	0.000
218.8	6.59	0.029	0.029	0.000	0.000	0.000	0.000	0.000
13.1	6.77	0.071	0.014	0.057	0.000	0.000	0.000	0.000
37.1	6.78	0.285	0.074	0.211	0.000	0.000	0.000	0.000
63.7	6.77	0.319	0.142	0.177	0.000	0.000	0.000	0.000
87.3	6.79	0.288	0.212	0.076	0.000	0.000	0.000	0.000
122.4	6.78	0.419	0.417	0.002	0.000	0.000	0.000	0.000
171.5	6.79	0.199	0.199	0.000	0.000	0.000	0.000	0.000
220.2	6.79	0.075	0.075	0.000	0.000	0.000	0.000	0.000
268.9	6.80	0.019	0.019	0.000	0.000	0.000	0.000	0.000
14.2	6.97	0.025	0.005	0.021	0.000	0.000	0.000	0.000
37.8	6.98	0.083	0.020	0.063	0.000	0.000	0.000	0.000
60.5	6.97	0.083	0.029	0.055	0.000	0.000	0.000	0.000
85.1	6.97	0.125	0.068	0.057	0.000	0.000	0.000	0.000
122.8	6.97	0.163	0.153	0.011	0.000	0.000	0.000	0.000
172.2	6.97	0.089	0.089	0.000	0.000	0.000	0.000	0.000
221.0	6.98	0.038	0.038	0.000	0.000	0.000	0.000	0.000
270.8	6.98	0.013	0.013	0.000	0.000	0.000	0.000	0.000
37.4	7.16	0.022	0.005	0.017	0.000	0.000	0.000	0.000
61.5	7.16	0.021	0.006	0.015	0.000	0.000	0.000	0.000
84.9	7.16	0.036	0.016	0.020	0.000	0.000	0.000	0.000
123.3	7.16	0.050	0.040	0.009	0.000	0.000	0.000	0.000
172.6	7.16	0.033	0.033	0.000	0.000	0.000	0.000	0.000
221.6	7.16	0.015	0.015	0.000	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Contribution from this GMPE(%): 15.2
Mean src-site R= 58.4 km; M= 5.87; eps0= 0.70. Mean calculated for all sources.
Modal src-site R= 33.5 km; M= 5.40; eps0= 0.74 from peak (R,M) bin
MODE R*= 30.9km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 0.662

Principal sources (faults, subduction, random seismicity having > 3% contribution)
Source Category: % contr. R(km) M epsilon0 (mean values).

CEUS gridded 15.19 58.4 5.87 0.70
Individual fault hazard details if its contribution to mean hazard > 2%:
Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Silva 1-corner *********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).
NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below
Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.142E-04
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00371
#This deaggregation corresponds to Tavakoli and Pezeshk 05

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
14.2	4.60	0.603	0.279	0.323	0.000	0.000	0.000	0.000
34.9	4.62	0.018	0.018	0.000	0.000	0.000	0.000	0.000
15.6	4.80	1.361	0.620	0.742	0.000	0.000	0.000	0.000
36.2	4.81	0.089	0.089	0.000	0.000	0.000	0.000	0.000
17.3	5.03	1.223	0.489	0.734	0.000	0.000	0.000	0.000
37.3	5.04	0.166	0.166	0.000	0.000	0.000	0.000	0.000
12.6	5.21	0.292	0.060	0.233	0.000	0.000	0.000	0.000
29.1	5.21	0.373	0.239	0.134	0.000	0.000	0.000	0.000
55.3	5.21	0.008	0.008	0.000	0.000	0.000	0.000	0.000
12.7	5.39	0.446	0.086	0.360	0.000	0.000	0.000	0.000
30.3	5.40	0.812	0.452	0.361	0.000	0.000	0.000	0.000
57.5	5.42	0.038	0.038	0.000	0.000	0.000	0.000	0.000
12.9	5.61	0.218	0.041	0.177	0.000	0.000	0.000	0.000
31.7	5.62	0.578	0.278	0.301	0.000	0.000	0.000	0.000
59.7	5.62	0.054	0.054	0.000	0.000	0.000	0.000	0.000
89.2	5.63	0.008	0.008	0.000	0.000	0.000	0.000	0.000
12.9	5.80	0.191	0.035	0.156	0.000	0.000	0.000	0.000
33.0	5.81	0.669	0.283	0.386	0.000	0.000	0.000	0.000
60.8	5.81	0.105	0.105	0.000	0.000	0.000	0.000	0.000
90.1	5.82	0.028	0.028	0.000	0.000	0.000	0.000	0.000
115.3	5.83	0.024	0.024	0.000	0.000	0.000	0.000	0.000
13.6	6.01	0.162	0.030	0.132	0.000	0.000	0.000	0.000
34.7	6.01	0.546	0.184	0.362	0.000	0.000	0.000	0.000
58.2	6.01	0.141	0.139	0.002	0.000	0.000	0.000	0.000
85.6	6.02	0.064	0.064	0.000	0.000	0.000	0.000	0.000
118.6	6.02	0.062	0.062	0.000	0.000	0.000	0.000	0.000
17.0	6.23	0.248	0.045	0.202	0.000	0.000	0.000	0.000
37.3	6.20	0.509	0.144	0.366	0.000	0.000	0.000	0.000
57.6	6.22	0.231	0.191	0.040	0.000	0.000	0.000	0.000
84.9	6.22	0.142	0.142	0.000	0.000	0.000	0.000	0.000
120.4	6.23	0.151	0.151	0.000	0.000	0.000	0.000	0.000

157.9	6.24	0.009	0.009	0.000	0.000	0.000	0.000	0.000
14.6	6.42	0.115	0.021	0.094	0.000	0.000	0.000	0.000
36.2	6.42	0.445	0.103	0.342	0.000	0.000	0.000	0.000
58.8	6.42	0.215	0.144	0.071	0.000	0.000	0.000	0.000
84.9	6.43	0.182	0.182	0.000	0.000	0.000	0.000	0.000
121.1	6.43	0.215	0.215	0.000	0.000	0.000	0.000	0.000
161.5	6.43	0.027	0.027	0.000	0.000	0.000	0.000	0.000
13.4	6.59	0.063	0.011	0.051	0.000	0.000	0.000	0.000
36.9	6.59	0.295	0.062	0.233	0.000	0.000	0.000	0.000
62.2	6.59	0.207	0.126	0.082	0.000	0.000	0.000	0.000
87.9	6.60	0.133	0.133	0.000	0.000	0.000	0.000	0.000
121.9	6.59	0.218	0.218	0.000	0.000	0.000	0.000	0.000
164.3	6.59	0.036	0.036	0.000	0.000	0.000	0.000	0.000
13.2	6.77	0.075	0.014	0.061	0.000	0.000	0.000	0.000
37.6	6.77	0.373	0.074	0.299	0.000	0.000	0.000	0.000
62.0	6.77	0.314	0.142	0.173	0.000	0.000	0.000	0.000
87.5	6.79	0.246	0.206	0.040	0.000	0.000	0.000	0.000
122.3	6.79	0.437	0.433	0.004	0.000	0.000	0.000	0.000
166.1	6.79	0.094	0.094	0.000	0.000	0.000	0.000	0.000
14.3	6.97	0.027	0.005	0.022	0.000	0.000	0.000	0.000
38.4	6.98	0.106	0.020	0.086	0.000	0.000	0.000	0.000
59.9	6.97	0.096	0.029	0.068	0.000	0.000	0.000	0.000
85.7	6.97	0.124	0.068	0.056	0.000	0.000	0.000	0.000
122.6	6.98	0.196	0.167	0.029	0.000	0.000	0.000	0.000
167.2	6.98	0.051	0.051	0.000	0.000	0.000	0.000	0.000
38.0	7.16	0.027	0.005	0.022	0.000	0.000	0.000	0.000
61.1	7.16	0.025	0.006	0.019	0.000	0.000	0.000	0.000
85.4	7.16	0.040	0.016	0.025	0.000	0.000	0.000	0.000
123.2	7.16	0.067	0.042	0.025	0.000	0.000	0.000	0.000
167.7	7.16	0.023	0.023	0.000	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Contribution from this GMPE(%): 14.1
Mean src-site R= 44.4 km; M= 5.83; eps0= -0.21. Mean calculated for all sources.
Modal src-site R= 15.6 km; M= 4.80; eps0= -0.27 from peak (R,M) bin
MODE R*= 12.3km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 0.742

Principal sources (faults, subduction, random seismicity having > 3% contribution)
Source Category: % contr. R(km) M epsilon0 (mean values).
CEUS gridded 14.06 44.4 5.83 -0.21
Individual fault hazard details if its contribution to mean hazard > 2%:
Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Tavakoli and Pezeshk 05
*********#

PSHA Deaggregation. %contributions. site: White_Mesa long: 109.500 W., lat: 37.500 N.
Vs30(m/s)= 760.0 (some WUS atten. models use Site Class not Vs30).
NSHMP 2007-08 See USGS OFR 2008-1128. dM=0.2 below
Return period: 9900 yrs. Exceedance PGA =0.1511 g. Weight * Computed_Rate_Ex 0.381E-05
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00086
#This deaggregation corresponds to Atkinson-Boore06,200 bar

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
9.3	4.61	0.146	0.084	0.062	0.000	0.000	0.000	0.000
10.3	4.80	0.357	0.207	0.150	0.000	0.000	0.000	0.000
11.7	5.03	0.353	0.178	0.175	0.000	0.000	0.000	0.000
12.9	5.21	0.171	0.081	0.090	0.000	0.000	0.000	0.000
33.9	5.21	0.002	0.002	0.000	0.000	0.000	0.000	0.000
14.1	5.40	0.325	0.151	0.174	0.000	0.000	0.000	0.000
35.4	5.42	0.011	0.011	0.000	0.000	0.000	0.000	0.000
15.5	5.61	0.205	0.097	0.108	0.000	0.000	0.000	0.000
37.0	5.62	0.017	0.017	0.000	0.000	0.000	0.000	0.000
15.3	5.79	0.189	0.074	0.115	0.000	0.000	0.000	0.000
31.6	5.84	0.062	0.055	0.007	0.000	0.000	0.000	0.000
55.1	5.83	0.002	0.002	0.000	0.000	0.000	0.000	0.000
12.9	6.01	0.127	0.030	0.098	0.000	0.000	0.000	0.000
30.9	6.01	0.103	0.084	0.019	0.000	0.000	0.000	0.000
56.2	6.02	0.007	0.007	0.000	0.000	0.000	0.000	0.000
15.6	6.22	0.180	0.045	0.135	0.000	0.000	0.000	0.000
34.6	6.20	0.101	0.086	0.014	0.000	0.000	0.000	0.000
57.0	6.22	0.019	0.019	0.000	0.000	0.000	0.000	0.000
86.0	6.23	0.011	0.011	0.000	0.000	0.000	0.000	0.000
124.0	6.24	0.021	0.021	0.000	0.000	0.000	0.000	0.000
18.3	6.42	0.163	0.044	0.120	0.000	0.000	0.000	0.000
39.0	6.42	0.068	0.059	0.009	0.000	0.000	0.000	0.000
58.3	6.43	0.023	0.023	0.000	0.000	0.000	0.000	0.000
85.9	6.43	0.021	0.021	0.000	0.000	0.000	0.000	0.000
124.7	6.35	0.009	0.009	0.000	0.000	0.000	0.000	0.000
125.1	6.45	0.036	0.036	0.000	0.000	0.000	0.000	0.000
162.5	6.44	0.012	0.012	0.000	0.000	0.000	0.000	0.000
13.1	6.59	0.058	0.011	0.046	0.000	0.000	0.000	0.000
33.0	6.59	0.100	0.056	0.044	0.000	0.000	0.000	0.000
58.9	6.59	0.022	0.022	0.000	0.000	0.000	0.000	0.000
86.0	6.59	0.024	0.024	0.000	0.000	0.000	0.000	0.000
125.6	6.59	0.052	0.052	0.000	0.000	0.000	0.000	0.000
167.5	6.59	0.020	0.020	0.000	0.000	0.000	0.000	0.000
13.0	6.77	0.071	0.014	0.057	0.000	0.000	0.000	0.000
33.9	6.78	0.146	0.072	0.074	0.000	0.000	0.000	0.000
61.2	6.78	0.048	0.048	0.000	0.000	0.000	0.000	0.000

88.0	6.79	0.040	0.040	0.000	0.000	0.000	0.000	0.000
125.7	6.79	0.111	0.111	0.000	0.000	0.000	0.000	0.000
169.6	6.79	0.055	0.055	0.000	0.000	0.000	0.000	0.000
214.6	6.81	0.009	0.009	0.000	0.000	0.000	0.000	0.000
16.2	6.98	0.031	0.006	0.025	0.000	0.000	0.000	0.000
36.9	6.97	0.041	0.019	0.022	0.000	0.000	0.000	0.000
59.2	6.97	0.018	0.018	0.000	0.000	0.000	0.000	0.000
86.2	6.98	0.022	0.022	0.000	0.000	0.000	0.000	0.000
124.7	7.07	0.009	0.009	0.000	0.000	0.000	0.000	0.000
125.7	6.96	0.042	0.042	0.000	0.000	0.000	0.000	0.000
170.7	6.98	0.029	0.029	0.000	0.000	0.000	0.000	0.000
218.5	6.98	0.008	0.008	0.000	0.000	0.000	0.000	0.000
13.8	7.16	0.005	0.001	0.004	0.000	0.000	0.000	0.000
35.2	7.16	0.014	0.005	0.009	0.000	0.000	0.000	0.000
60.4	7.16	0.005	0.005	0.000	0.000	0.000	0.000	0.000
85.8	7.16	0.008	0.008	0.000	0.000	0.000	0.000	0.000
125.6	7.16	0.018	0.018	0.000	0.000	0.000	0.000	0.000
171.2	7.16	0.012	0.012	0.000	0.000	0.000	0.000	0.000
219.9	7.16	0.004	0.004	0.000	0.000	0.000	0.000	0.000

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Contribution from this GMPE(%): 3.8
Mean src-site R= 36.7 km; M= 5.89; eps0= 0.31. Mean calculated for all sources.
Modal src-site R= 10.3 km; M= 4.80; eps0= 0.25 from peak (R,M) bin
MODE R*= 12.3km; M*= 4.80; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 0.207

Principal sources (faults, subduction, random seismicity having > 3% contribution)
Source Category: % contr. R(km) M epsilon0 (mean values).
CEUS gridded 3.77 36.7 5.89 0.31
Individual fault hazard details if its contribution to mean hazard > 2%:
Fault ID % contr. Rcd(km) M epsilon0 Site-to-src azimuth(d)
#*********End of deaggregation corresponding to Atkinson-Boore06,200 bar
*********#

********** Intermountain Seismic
Belt**********

APPENDIX 4: DETERMINATION OF PEAK GROUND ACCELERATIONS (PGA) USING CAMPBELL AND BOZORGNIA (2007)

CALCUATION OF GROUND MOTION FOR CAMPBELL-BOZORGNIA NGA MODEL (MAR 2008, EARTHQUAKE SPECTRA):

Explanatory Variables

M
5.49

R_{RUP}
57.40

R_{JB}
57.40

F_{RV}
0

F_{NM}
1

Z_{TOR}
3.00

δ
60

V_{S30}
586

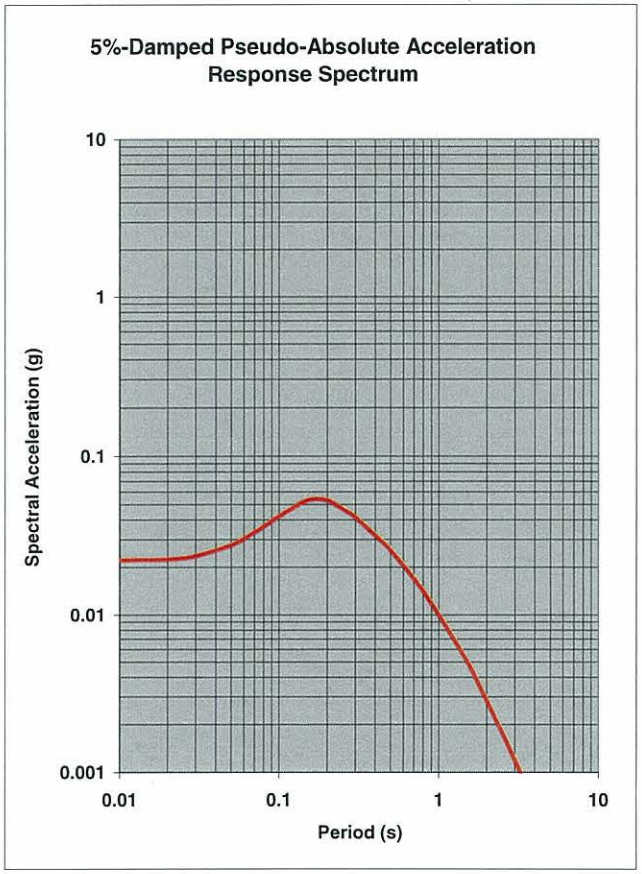
$Z_{2.5}$
0.00

Geometric Mean and Arbitrary Horizontal Components

GMP	T (s)	Median	α	σ	τ	σ_C	σ_T	σ_{Arb}	Median + sigma
PSA (g)	0.010	2.221E-02	-0.0065	0.4761	0.2190	0.1660	0.5241	0.5497	
	0.020	2.249E-02	-0.0067	0.4781	0.2190	0.1660	0.5258	0.5514	
	0.030	2.364E-02	-0.0081	0.4867	0.2350	0.1650	0.5404	0.5651	
	0.050	2.778E-02	-0.0125	0.5064	0.2580	0.1620	0.5683	0.5910	
	0.075	3.490E-02	-0.0147	0.5159	0.2920	0.1580	0.5928	0.6135	
	0.10	4.211E-02	-0.0144	0.5270	0.2860	0.1700	0.5996	0.6233	
	0.15	5.324E-02	-0.0110	0.5290	0.2800	0.1800	0.5985	0.6250	
	0.20	5.352E-02	-0.0068	0.5322	0.2490	0.1860	0.5875	0.6163	
	0.25	4.702E-02	-0.0031	0.5332	0.2400	0.1910	0.5847	0.6151	
	0.30	4.173E-02	0.0000	0.5440	0.2150	0.1980	0.5849	0.6175	
	0.40	3.216E-02	0.0000	0.5410	0.2170	0.2060	0.5829	0.6182	
	0.50	2.604E-02	0.0000	0.5500	0.2140	0.2080	0.5902	0.6257	
	0.75	1.565E-02	0.0000	0.5680	0.2270	0.2210	0.6117	0.6504	
	1.0	1.012E-02	0.0000	0.5680	0.2550	0.2250	0.6226	0.6620	
	1.5	5.153E-03	0.0000	0.5640	0.2960	0.2220	0.6370	0.6745	
	2.0	2.884E-03	0.0000	0.5710	0.2960	0.2260	0.6432	0.6817	
	3.0	1.221E-03	0.0000	0.5580	0.3260	0.2290	0.6463	0.6856	
	4.0	6.337E-04	0.0000	0.5760	0.2970	0.2370	0.6481	0.6900	
	5.0	3.953E-04	0.0000	0.6010	0.3590	0.2370	0.7001	0.7391	
	7.5	1.739E-04	0.0000	0.6280	0.4280	0.2710	0.7600	0.8069	
	10.0	9.719E-05	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	
PGA (g)	0	2.221E-02	-0.0065	0.4761	0.2190	0.1660	0.5241	0.5497	0.038
PGV (c/s)	-1	1.063E+00	0.0000	0.4840	0.2030	0.1900	0.5248	0.5582	
PGD (cm)	-2	2.413E-01	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	

Calculated Variables

A_{1100}
1.803E-02



DEFINITION OF PARAMETERS:

PSA	=	Pseudo-absolute acceleration response spectrum (g; 5% damping)
PGA	=	Peak ground acceleration (g)
PGV	=	Peak ground velocity (cm/s)
PGD	=	Peak ground displacement (cm)
M	=	Moment magnitude
R_{RUP}	=	Closest distance to coseismic rupture (km)
R_{JB}	=	Closest distance to surface projection of coseismic rupture (km)
F_{RV}	=	Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM}	=	Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique
Z_{TOR}	=	Depth to top of coseismic rupture (km)
δ	=	Average dip of rupture plane (degrees)
V_{S30}	=	Average shear-wave velocity in top 30m of site profile
A_{1100}	=	PGA on rock with Vs30 = 1100 m/s (g)
$Z_{2.5}$	=	Depth of 2.5 km/s shear-wave velocity horizon (km)

Unnamed fault possible extention of Shays graben defined length 3.0 km

CALCUATION OF GROUND MOTION FOR CAMPBELL-BOZORGNIA NGA MODEL (MAR 2008, EARTHQUAKE SPECTRA):

Explanatory Variables

M
6.23

R_{RUP}
57.40

R_{JB}
57.40

F_{RV}
0

F_{NM}
1

Z_{TOR}
3.00

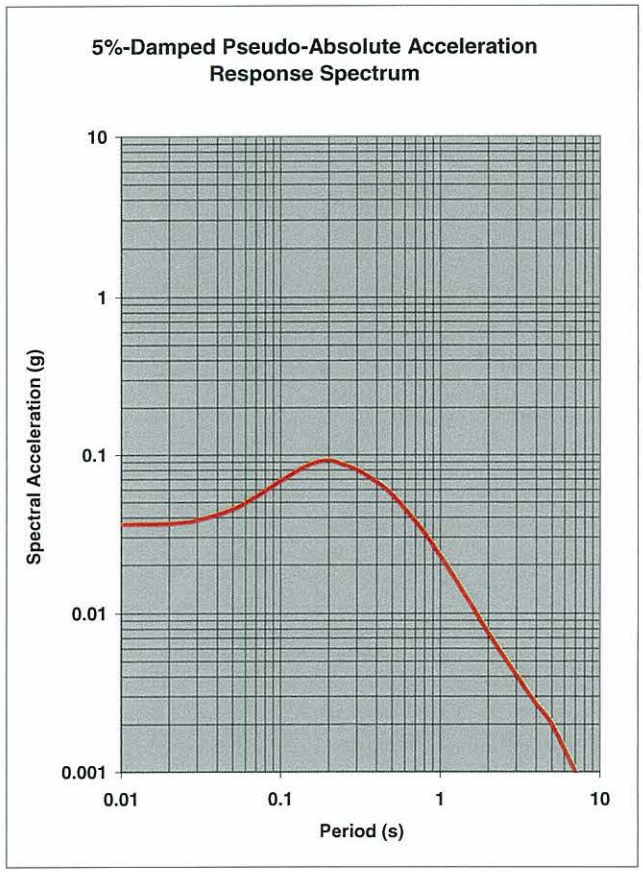
δ
60

V_{S30}
586

$Z_{2.5}$
0.00

Geometric Mean and Arbitrary Horizontal Components

GMP	T (s)	Median	α	σ	τ	σ_C	σ_T	σ_{Arb}	Median + sigma
PSA (g)	0.010	3.622E-02	-0.0104	0.4750	0.2190	0.1660	0.5230	0.5487	
	0.020	3.667E-02	-0.0107	0.4769	0.2190	0.1660	0.5248	0.5504	
	0.030	3.852E-02	-0.0130	0.4852	0.2350	0.1650	0.5391	0.5638	
	0.050	4.513E-02	-0.0202	0.5042	0.2580	0.1620	0.5664	0.5891	
	0.075	5.664E-02	-0.0236	0.5134	0.2920	0.1580	0.5906	0.6114	
	0.10	6.838E-02	-0.0231	0.5247	0.2860	0.1700	0.5975	0.6213	
	0.15	8.664E-02	-0.0178	0.5271	0.2800	0.1800	0.5969	0.6234	
	0.20	9.283E-02	-0.0111	0.5310	0.2490	0.1860	0.5865	0.6153	
	0.25	8.689E-02	-0.0050	0.5327	0.2400	0.1910	0.5843	0.6147	
	0.30	8.119E-02	-0.0001	0.5440	0.2150	0.1980	0.5849	0.6175	
	0.40	6.769E-02	0.0000	0.5410	0.2170	0.2060	0.5829	0.6182	
	0.50	5.644E-02	0.0000	0.5500	0.2140	0.2080	0.5902	0.6257	
	0.75	3.507E-02	0.0000	0.5680	0.2270	0.2210	0.6117	0.6504	
	1.0	2.323E-02	0.0000	0.5680	0.2550	0.2250	0.6226	0.6620	
	1.5	1.225E-02	0.0000	0.5640	0.2960	0.2220	0.6370	0.6745	
	2.0	7.683E-03	0.0000	0.5710	0.2960	0.2260	0.6432	0.6817	
	3.0	4.170E-03	0.0000	0.5580	0.3260	0.2290	0.6463	0.6856	
	4.0	2.737E-03	0.0000	0.5760	0.2970	0.2370	0.6481	0.6900	
	5.0	2.043E-03	0.0000	0.6010	0.3590	0.2370	0.7001	0.7391	
	7.5	8.990E-04	0.0000	0.6280	0.4280	0.2710	0.7600	0.8069	
	10.0	5.024E-04	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	
PGA (g)	0	3.622E-02	-0.0104	0.4750	0.2190	0.1660	0.5230	0.5487	0.063
PGV (c/s)	-1	2.365E+00	0.0000	0.4840	0.2030	0.1900	0.5248	0.5582	
PGD (cm)	-2	1.247E+00	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	



Calculated Variables

A_{1100}
2.952E-02

DEFINITION OF PARAMETERS:

PSA	=	Pseudo-absolute acceleration response spectrum (g; 5% damping)
PGA	=	Peak ground acceleration (g)
PGV	=	Peak ground velocity (cm/s)
PGD	=	Peak ground displacement (cm)
M	=	Moment magnitude
R_{RUP}	=	Closest distance to coseismic rupture (km)
R_{JB}	=	Closest distance to surface projection of coseismic rupture (km)
F_{RV}	=	Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM}	=	Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique
Z_{TOR}	=	Depth to top of coseismic rupture (km)
δ	=	Average dip of rupture plane (degrees)
V_{S30}	=	Average shear-wave velocity in top 30m of site profile
A_{1100}	=	PGA on rock with Vs30 = 1100 m/s (g)
$Z_{2.5}$	=	Depth of 2.5 km/s shear-wave velocity horizon (km)

Unnamed fault possible extention of Shays graben total possible length 11.0 km

CALCUATION OF GROUND MOTION FOR CAMPBELL-BOZORGNIA NGA MODEL (MAR 2008, EARTHQUAKE SPECTRA):

Explanatory Variables

M
5.84

R_{RUP}
57.40

R_{JB}
57.40

F_{RV}
0

F_{NM}
1

Z_{TOR}
3.00

δ
60

V_{S30}
586

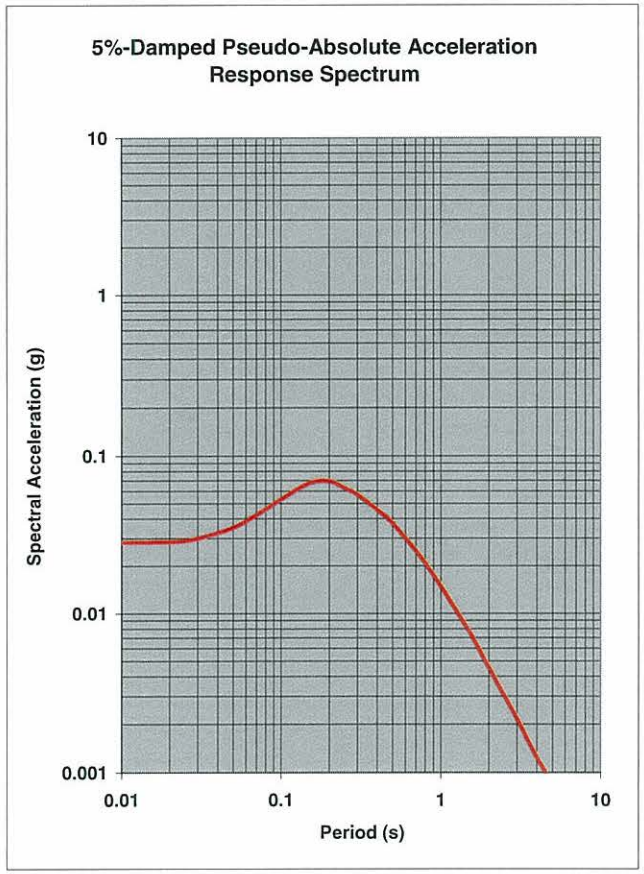
$Z_{2.5}$
0.00

Geometric Mean and Arbitrary Horizontal Components

GMP	T (s)	Median	α	σ	τ	σ_C	σ_T	σ_{Arb}	Median + sigma
PSA (g)	0.010	2.807E-02	-0.0081	0.4756	0.2190	0.1660	0.5236	0.5493	
	0.020	2.843E-02	-0.0084	0.4776	0.2190	0.1660	0.5254	0.5510	
	0.030	2.988E-02	-0.0101	0.4861	0.2350	0.1650	0.5399	0.5645	
	0.050	3.506E-02	-0.0158	0.5054	0.2580	0.1620	0.5675	0.5902	
	0.075	4.402E-02	-0.0184	0.5149	0.2920	0.1580	0.5919	0.6126	
	0.10	5.314E-02	-0.0181	0.5260	0.2860	0.1700	0.5988	0.6224	
	0.15	6.724E-02	-0.0139	0.5282	0.2800	0.1800	0.5978	0.6243	
	0.20	6.963E-02	-0.0086	0.5317	0.2490	0.1860	0.5871	0.6159	
	0.25	6.299E-02	-0.0039	0.5330	0.2400	0.1910	0.5845	0.6149	
	0.30	5.726E-02	-0.0001	0.5440	0.2150	0.1980	0.5849	0.6175	
	0.40	4.577E-02	0.0000	0.5410	0.2170	0.2060	0.5829	0.6182	
	0.50	3.760E-02	0.0000	0.5500	0.2140	0.2080	0.5902	0.6257	
	0.75	2.299E-02	0.0000	0.5680	0.2270	0.2210	0.6117	0.6504	
	1.0	1.505E-02	0.0000	0.5680	0.2550	0.2250	0.6226	0.6620	
	1.5	7.803E-03	0.0000	0.5640	0.2960	0.2220	0.6370	0.6745	
	2.0	4.608E-03	0.0000	0.5710	0.2960	0.2260	0.6432	0.6817	
	3.0	2.190E-03	0.0000	0.5580	0.3260	0.2290	0.6463	0.6856	
	4.0	1.268E-03	0.0000	0.5760	0.2970	0.2370	0.6481	0.6900	
	5.0	8.600E-04	0.0000	0.6010	0.3590	0.2370	0.7001	0.7391	
	7.5	3.784E-04	0.0000	0.6280	0.4280	0.2710	0.7600	0.8069	
	10.0	2.114E-04	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	
PGA (g)	0	2.807E-02	-0.0081	0.4756	0.2190	0.1660	0.5236	0.5493	0.049
PGV (c/s)	-1	1.554E+00	0.0000	0.4840	0.2030	0.1900	0.5248	0.5582	
PGD (cm)	-2	5.249E-01	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	

Calculated Variables

A_{1100}
2.283E-02



DEFINITION OF PARAMETERS:

PSA	=	Pseudo-absolute acceleration response spectrum (g; 5% damping)
PGA	=	Peak ground acceleration (g)
PGV	=	Peak ground velocity (cm/s)
PGD	=	Peak ground displacement (cm)
M	=	Moment magnitude
R_{RUP}	=	Closest distance to coseismic rupture (km)
R_{JB}	=	Closest distance to surface projection of coseismic rupture (km)
F_{RV}	=	Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM}	=	Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique
Z_{TOR}	=	Depth to top of coseismic rupture (km)
δ	=	Average dip of rupture plane (degrees)
V_{S30}	=	Average shear-wave velocity in top 30m of site profile
A_{1100}	=	PGA on rock with Vs30 = 1100 m/s (g)
$Z_{2.5}$	=	Depth of 2.5 km/s shear-wave velocity horizon (km)

Unnamed fault possible extention of Shays graben 1/2 total rupture 5.5 km

CALCUATION OF GROUND MOTION FOR CAMPBELL-BOZORGNIA NGA MODEL (MAR 2008, EARTHQUAKE SPECTRA):

Explanatory Variables

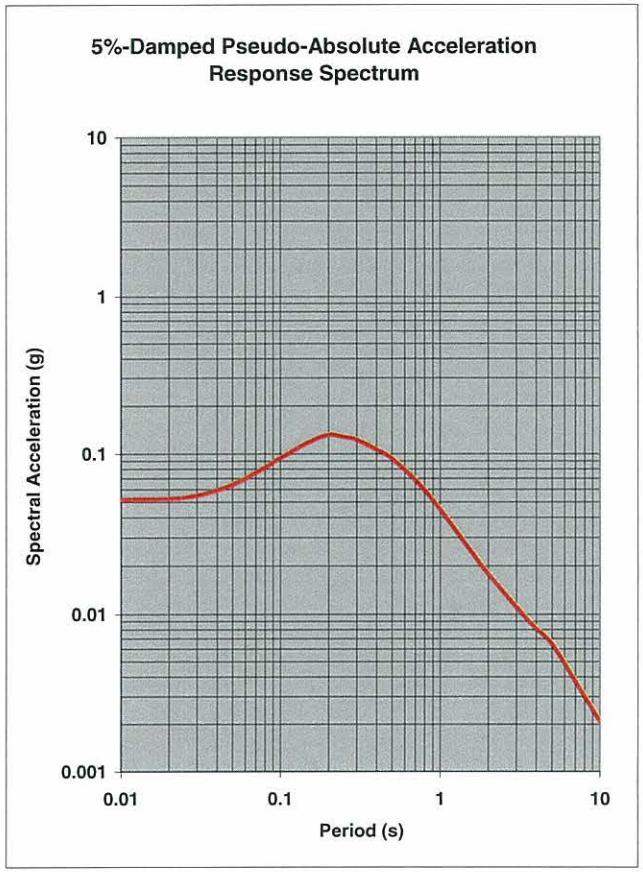
M	6.97
R_{RUP}	57.40
R_{JB}	57.40
F_{RV}	0
F_{NM}	1
Z_{TOR}	3.00
δ	60
V_{S30}	586
$Z_{2.5}$	0.00

Geometric Mean and Arbitrary Horizontal Components

GMP	T (s)	Median	α	σ	τ	σ_C	σ_T	σ_{Arb}	Median + sigma
PSA (g)	0.010	5.192E-02	-0.0148	0.4737	0.2190	0.1660	0.5219	0.5477	
	0.020	5.257E-02	-0.0152	0.4756	0.2190	0.1660	0.5236	0.5493	
	0.030	5.516E-02	-0.0184	0.4837	0.2350	0.1650	0.5378	0.5625	
	0.050	6.428E-02	-0.0285	0.5018	0.2580	0.1620	0.5642	0.5870	
	0.075	7.926E-02	-0.0333	0.5107	0.2920	0.1580	0.5883	0.6092	
	0.10	9.475E-02	-0.0327	0.5221	0.2860	0.1700	0.5953	0.6191	
	0.15	1.195E-01	-0.0252	0.5251	0.2800	0.1800	0.5951	0.6218	
	0.20	1.329E-01	-0.0157	0.5298	0.2490	0.1860	0.5854	0.6142	
	0.25	1.290E-01	-0.0071	0.5321	0.2400	0.1910	0.5838	0.6142	
	0.30	1.239E-01	-0.0001	0.5440	0.2150	0.1980	0.5849	0.6175	
	0.40	1.077E-01	0.0000	0.5410	0.2170	0.2060	0.5829	0.6182	
	0.50	9.478E-02	0.0000	0.5500	0.2140	0.2080	0.5902	0.6257	
	0.75	6.458E-02	0.0000	0.5680	0.2270	0.2210	0.6117	0.6504	
	1.0	4.566E-02	0.0000	0.5680	0.2550	0.2250	0.6226	0.6620	
	1.5	2.641E-02	0.0000	0.5640	0.2960	0.2220	0.6370	0.6745	
	2.0	1.814E-02	0.0000	0.5710	0.2960	0.2260	0.6432	0.6817	
	3.0	1.123E-02	0.0000	0.5580	0.3260	0.2290	0.6463	0.6856	
	4.0	8.208E-03	0.0000	0.5760	0.2970	0.2370	0.6481	0.6900	
	5.0	6.640E-03	0.0000	0.6010	0.3590	0.2370	0.7001	0.7391	
	7.5	3.412E-03	0.0000	0.6280	0.4280	0.2710	0.7600	0.8069	
	10.0	2.128E-03	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	
PGA (g)	0	5.192E-02	-0.0148	0.4737	0.2190	0.1660	0.5219	0.5477	0.090
PGV (c/s)	-1	5.196E+00	0.0000	0.4840	0.2030	0.1900	0.5248	0.5582	
PGD (cm)	-2	6.442E+00	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	

Calculated Variables

A_{1100}
4.252E-02



DEFINITION OF PARAMETERS:

PSA	= Pseudo-absolute acceleration response spectrum (g; 5% damping)
PGA	= Peak ground acceleration (g)
PGV	= Peak ground velocity (cm/s)
PGD	= Peak ground displacement (cm)
M	= Moment magnitude
R_{RUP}	= Closest distance to coseismic rupture (km)
R_{JB}	= Closest distance to surface projection of coseismic rupture (km)
F_{RV}	= Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM}	= Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique
Z_{TOR}	= Depth to top of coseismic rupture (km)
δ	= Average dip of rupture plane (degrees)
V_{S30}	= Average shear-wave velocity in top 30m of site profile
A_{1100}	= PGA on rock with Vs30 = 1100 m/s (g)
$Z_{2.5}$	= Depth of 2.5 km/s shear-wave velocity horizon (km)

CALCUATION OF GROUND MOTION FOR CAMPBELL-BOZORGNIA NGA MODEL (MAR 2008, EARTHQUAKE SPECTRA):

Explanatory Variables

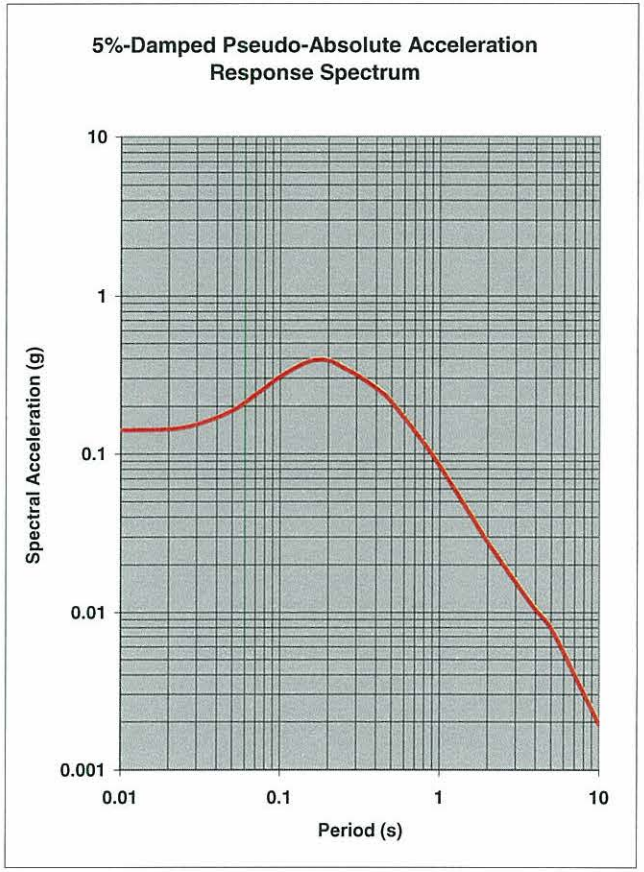
M	6.30
R_{RUP}	15.00
R_{JB}	15.00
F_{RV}	0
F_{NM}	1
Z_{TOR}	3.00
δ	60
V_{S30}	586
$Z_{2.5}$	0.00

Geometric Mean and Arbitrary Horizontal Components

GMP	T (s)	Median	α	σ	τ	σ_C	σ_T	σ_{Arb}	Median + sigma
PSA (g)	0.010	1.409E-01	-0.0372	0.4673	0.2190	0.1660	0.5161	0.5421	
	0.020	1.434E-01	-0.0383	0.4690	0.2190	0.1660	0.5176	0.5436	
	0.030	1.540E-01	-0.0461	0.4757	0.2350	0.1650	0.5306	0.5557	
	0.050	1.889E-01	-0.0707	0.4898	0.2580	0.1620	0.5536	0.5768	
	0.075	2.503E-01	-0.0825	0.4973	0.2920	0.1580	0.5767	0.5979	
	0.10	3.092E-01	-0.0813	0.5090	0.2860	0.1700	0.5838	0.6081	
	0.15	3.840E-01	-0.0634	0.5149	0.2800	0.1800	0.5861	0.6131	
	0.20	3.923E-01	-0.0399	0.5234	0.2490	0.1860	0.5796	0.6087	
	0.25	3.519E-01	-0.0182	0.5293	0.2400	0.1910	0.5811	0.6117	
	0.30	3.180E-01	-0.0003	0.5439	0.2150	0.1980	0.5849	0.6175	
	0.40	2.614E-01	0.0000	0.5410	0.2170	0.2060	0.5829	0.6182	
	0.50	2.138E-01	0.0000	0.5500	0.2140	0.2080	0.5902	0.6257	
	0.75	1.278E-01	0.0000	0.5680	0.2270	0.2210	0.6117	0.6504	
	1.0	8.480E-02	0.0000	0.5680	0.2550	0.2250	0.6226	0.6620	
	1.5	4.485E-02	0.0000	0.5640	0.2960	0.2220	0.6370	0.6745	
	2.0	2.844E-02	0.0000	0.5710	0.2960	0.2260	0.6432	0.6817	
	3.0	1.581E-02	0.0000	0.5580	0.3260	0.2290	0.6463	0.6856	
	4.0	1.061E-02	0.0000	0.5760	0.2970	0.2370	0.6481	0.6900	
	5.0	8.060E-03	0.0000	0.6010	0.3590	0.2370	0.7001	0.7391	
	7.5	3.546E-03	0.0000	0.6280	0.4280	0.2710	0.7600	0.8069	
	10.0	1.982E-03	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	
PGA (g)	0	1.409E-01	-0.0372	0.4673	0.2190	0.1660	0.5161	0.5421	0.242
PGV (c/s)	-1	8.793E+00	0.0000	0.4840	0.2030	0.1900	0.5248	0.5582	
PGD (cm)	-2	4.919E+00	0.0000	0.6670	0.4850	0.2900	0.8247	0.8742	

Calculated Variables

A_{1100}
1.183E-01



DEFINITION OF PARAMETERS:

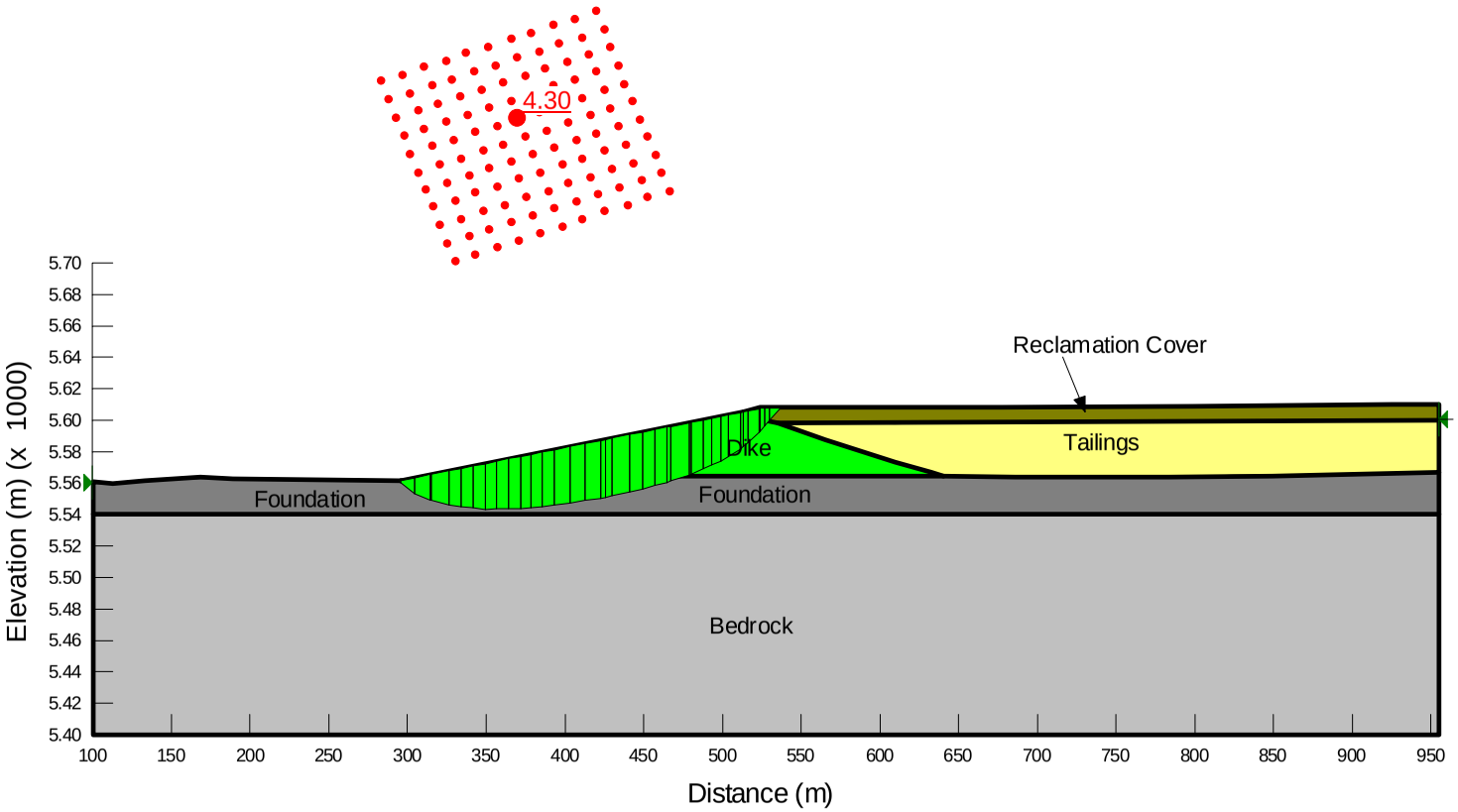
PSA	=	Pseudo-absolute acceleration response spectrum (g; 5% damping)
PGA	=	Peak ground acceleration (g)
PGV	=	Peak ground velocity (cm/s)
PGD	=	Peak ground displacement (cm)
M	=	Moment magnitude
R_{RUP}	=	Closest distance to coseismic rupture (km)
R_{JB}	=	Closest distance to surface projection of coseismic rupture (km)
F_{RV}	=	Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM}	=	Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique
Z_{TOR}	=	Depth to top of coseismic rupture (km)
δ	=	Average dip of rupture plane (degrees)
V_{S30}	=	Average shear-wave velocity in top 30m of site profile
A_{1100}	=	PGA on rock with Vs30 = 1100 m/s (g)
$Z_{2.5}$	=	Depth of 2.5 km/s shear-wave velocity horizon (km)

ATTACHMENT E.2

SLOPE/W MODEL RESULTS

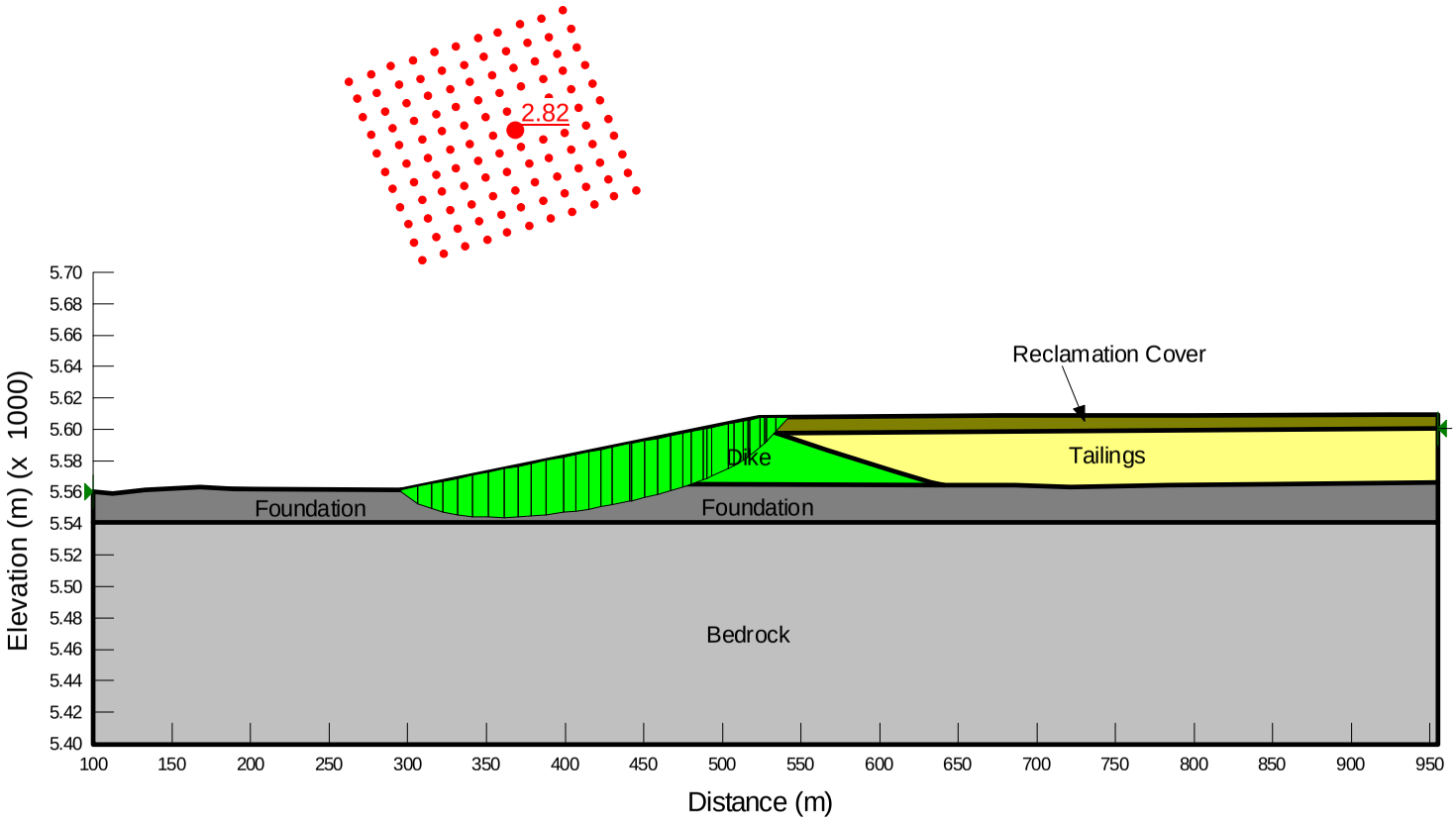
Denison Mines
White Mesa Mill
Cross Section A
Slope Stability Analysis

CASE 1 - Static Loading Conditions
Required Factor of Safety = 1.5



Denison Mines
White Mesa Mill
Cross Section A
Slope Stability Analysis

CASE 2 - Pseudo-Static (k = 0.1g) Loading Conditions
Required Factor of Safety = 1.1



APPENDIX F

SETTLEMENT AND LIQUEFACTION ANALYSES

F.1 BACKGROUND

This appendix presents the results of modeling settlement and liquefaction potential of tailings for the White Mesa Uranium Mill tailings disposal cells. Settlement analysis for the tailings disposal cells has not been previously conducted. These analyses have been performed to estimate future settlement due to tailings dewatering and cover loading. The liquefaction analysis is an update to modeling presented in Attachment E of Revision 4.0 of the Reclamation Plan (Denison, 2009). The updated modeling incorporates a more recent reference (Youd et al. 2001) and modifications to the proposed cover to incorporate an evapotranspiration (ET) cover.

The monolithic ET cover system evaluated in this appendix consists of the following layers from top to bottom:

- 0.5 ft (15 cm) Erosion Protection Layer (gravel-admixture)
- 3.5 ft (107 cm) Water Storage/Biointrusion/Frost Protection/Radon Attenuation Layer (loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation Layer (highly compacted loam to sandy clay)
- 2.5 ft (75 cm) Radon Attenuation and Grading Layer (loam to sandy clay)

F.2 SETTLEMENT ANALYSIS

F.2.1 Method of Analysis

General. Settlement was estimated for a column representing the maximum depth of tailings in each of Cells 2, 3, 4A, and 4B. Settlement of the tailings was modeled by applying loadings corresponding to interim cover placement, final cover placement, and tailings dewatering. Compression index (C_c) and coefficient of consolidation (c_v) were estimated using observed settlement monument data. Current loadings at each monitoring location were used to compare the consolidation model to actual conditions. Average values of C_c and c_v were applied to the column representing the maximum depth of tailings in each cell in order to estimate maximum future settlement due to additional loadings.

Current Settlement Monitoring. Twenty settlement monuments were installed in Cell 2 and six monuments were installed in the east portion of Cell 3. Monuments were installed shortly after the interim cover was placed over the tailings. Depth of tailings at each monument location was estimated by comparing the base of the cells (D'Appolonia 1981, D'Appolonia 1982, Geosyntec 2006, Geosyntec 2007) with the estimated top surface of tailings. The top surface of tailings is assumed to be 18 inches below the top of berm, or at the top of the flexible membrane liner (FML). The depth of existing interim cover is estimated to be the difference between the top of tailings and the ground surface as estimated from the LiDar survey taken in 2007.

Observed settlement is assumed to be due to loading from interim cover placement. Additional loading of tailings in Cell 2 is due to approximately 7.5 feet of dewatering (from maximum allowable fluid elevation of 5610.5 ft to approximately 5602 ft) from operation of the slimes drain. Dewatering began in January 2009, and is ongoing.

Settlement is estimated using consolidation theory, and observed settlement is assumed to be due to primary consolidation (i.e. creep and initial compression are neglected). Settlement is calculated using the following equation:

$$S = \frac{C_C H}{1+e_0} \log \frac{p_0+\Delta p}{p_0} \qquad \text{(Eq. 1)}$$

Where

C_c = compression index,
H = depth of tailings (ft),
e_0 = initial void ratio of tailings,
p_0 = initial average effective overburden pressure (psf), and
Δp = increase in effective vertical pressure (psf).

In addition, the percent of total settlement at time t can be estimated using the following equation:

$$U\% = \frac{\left(4T_v/\pi\right)^{0.5}}{\left[1+\left(4T_v/\pi\right)^{2.8}\right]^{0.179}} \qquad \text{(Eq. 2)}$$

Where

U = percent of total settlement at time t, and
T_v = time factor.

$$T_v = \frac{c_v t}{H_{dr}^2} \qquad \text{(Eq. 3)}$$

Where

c_v= coefficient of consolidation (ft^2/d),
t = time (d), and
H_{dr} = length of drainage path (ft).

<u>1-D Column Geometry.</u> A one-dimensional (1-D) column was used to analyze the settlement representing the maximum thickness of tailings in each cell. The stress state for each column is modeled at the midpoint of the tailings. In general, cover construction consists of 2.5 ft of interim cover and 6.5 ft of final cover. Table F.1 summarizes the current loading on each column, along with estimated future loading.

Table F.1 Summary of Geometry for 1-D Column Representing Maximum Tailings Depth

	Cell 2	Cell 3	Cell 4A/4B
Initial Conditions			
Thickness of Tailings (ft)	32.5	38.5	40.5
Depth of Existing Interim Cover (ft)	2.3	---	---
Depth of Water (ft)	21.0	35.5	37.5
Loading Conditions			
Depth of Additional Interim Cover (ft)	---	2.5	2.5
Depth of Final Cover (ft)	7.7	6.5	6.5
Depth of Water (ft)	0	0	0

F.2.2. Material Properties

In 1977, four tailings samples taken from the ore feed to leach were tested for grain size distribution. Results were presented in Attachment E of Revision 4.0 of the Reclamation Plan (Denison, 2009). The 1977 samples were taken as representative of the existing tailings in Cells 2 and 3. Test results indicated the percent finer than the No. 200 sieve ranged between 23 and 38 percent, with an average of 30 percent. Additional testing was performed on six tailings samples in 1999 (also included in Attachment E of Denison, 2009). Grain-size distribution tests indicated the percent finer than no. 200 sieve ranged between 23 and 83 percent, with an average of 43 percent. Specific gravity tests results indicated an average apparent specific gravity of 2.73. The dry density of the tailings is assumed to be 86.3 pcf, as was estimated in Attachment E (Denison, 2009) based on stage-capacity curves and known tailings tonnage placed in Cell 2. An initial void ratio of 0.97 and a saturated density of 117.1 pcf were calculated based on a dry tailing density of 86.3 pcf, and a specific gravity of 2.73.

This settlement analysis relies heavily on observed settlement data from the 26 settlement monuments installed in Cells 2 and 3. C_c and c_v were estimated by estimating the existing loadings on the tailings, calculating the resulting settlement at several time steps (using Equations 1-3), and varying C_c and c_v until the observed settlement curve correlated well with the calculated settlement. Interim cover loading is assumed to have occurred rapidly at the date of the first settlement monitoring reading.

Dewatering of Cell 2 began in January 2009. For simplicity, dewatering is modeled as occurring instantaneously on this date. Because of this, the modeled data show settlement due to dewatering occurring quicker than would be expected. Therefore, curve fitting to determine C_c and c_v relies heavier on the portion of the curve prior to January 2009 (before dewatering) than the latter portion of the curve. Scatter in the observed settlement readings (i.e. sharp peaks and valleys) were ignored. Figure F-1 presents an example of the measured and modeled settlement at one settlement monitoring point in Cell 2. Graphs showing actual and modeled settlement in Cells 2 and 3 are shown in Attachment F.1. Table F.2 summarizes the C_c and c_v fitting parameters.

Table F.2 Compression Index and Coefficient of Consolidation of Tailings

	C_c	c_v (cm^2/s)
Minimum value	0.03	0.0009
Maximum value	0.57	0.0120
Average value	0.16	0.0025

Table F.3 shows typical C_c and c_v parameters as given in the literature for hydraulically- placed uranium tailings.

Table F.3. Literature Values for Compression Index and Coefficient of Consolidation (Keshian and Rager, 1988).

	C_c	c_v (cm^2/s)
Range of values for slimes	0.18 - 0.87	0.00025 - 0.01
Range of values for sand/slimes	0.06 - 0.66	0.001 - 0.05
Range of values for sands	0.015 - 0.29	0.002 - 0.20

Comparison of Table F.2 and F.3 shows the minimum and maximum values of C_c and c_v are within the range of typical values of sands to slime tailings. Average values are typical of published values for sand/slimes. This correlates to well to the laboratory gradation results, which indicate average fines content of 30 to 43 percent, which corresponds to the Kesian and Rager (1988) definition of sand/slimes (fines content between 30 and 70 percent).

F.2.3 Results

Additional settlement of tailings is modeled in two stages: (1) settlement due to interim cover construction and drawdown of phreatic surface, and (2) settlement due to final cover construction. In addition, the time required for 90 percent of consolidation to occur is estimated. The results are summarized in Table F.4. The spreadsheet calculations of are provided in Attachment F.2.

Table F.4 Estimate of Future Settlement in Cells

	Cell 2	Cell 3	Cell 4A/4B
Total Settlement due to Interim Cover Placement and Dewatering (ft)			
Min C_c	0.03	0.16	0.17
Max C_c	0.53	3.03	3.19
Ave C_c	0.14	0.83	0.87
Total Settlement due to Final Cover Placement (ft) Min C_c	0.08	0.07	0.07
Max C_c	1.54	1.37	1.39
Ave C_c	0.42	0.38	0.38
Time to Reach 90% Consolidation (yrs)			
Min c_v	7.4	10.5	11.5
Max c_v	0.6	0.8	0.8
Ave c_v	2.6	3.8	4.1

Using average consolidation properties, it is estimated that settlement due to dewatering and placement of interim cover will be approximately 2 inches in Cell 2, and about 10 inches in Cells

3, 4A and 4B. The time required to reach 90 percent of settlement is on the order of 3 to 4 years for Cells 3, 4A, and 4B.

After placement of the interim cover, settlement monuments will be installed within Cells 3, 4A, and 4B. Monuments will be monitored on a regular basis in order to verify that the majority (90%) of settlement due to dewatering and interim cover has occurred prior to placement of the final cover. At this time, additional fill may be placed in any low areas in order to maintain positive drainage of the cover surface. Additional settlement due to the construction of the final cover is estimated to be on the order of 5 to 6 inches. The estimated amount of additional settlement is sufficiently low such that ponding is not expected with a cover slope of 0.5 percent.

F.3 LIQUEFACTION ANALYSIS

F.3.1 Method of Analysis

Procedures to evaluate the potential for liquefaction were used as outlined in Youd et al. (2001). The factor of safety against liquefaction is given by the following equation:

$$FS = \frac{CRR_{7.5}}{CSR} MSF \qquad \text{(Eq. 4)}$$

Where CRR = Cyclic Resistance Ratio,
CSR = Cyclic Stress Ratio, and
MSF = Magnitude Scaling Factor.

$CRR_{7.5}$ for clean sands is related to Standard Penetration Test (SPT) blow counts normalized for overburden pressure by the following equation:

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60cs}} + \frac{(N_1)_{60cs}}{135} + \frac{50}{[10(N_1)_{60cs}+45]^2} - \frac{1}{200} \qquad \text{(Eq. 5)}$$

Where $(N_1)_{60cs}$ = SPT blow count normalized for an overburden pressure of 100 kPa, and corrected for the influence of fines content using methods recommended in Youd et al. (2001).

CSR is calculated by:

$$CSR = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right) r_d \qquad \text{(Eq. 6)}$$

Where a_{max}/g = ratio of peak horizontal acceleration at the ground source to the acceleration of gravity,
σ_{vo} = total vertical overburden stress,
σ'_{vo} = effective vertical overburden stress,
r_d = stress reduction coefficient varying between approximately 0.5 for depths of 30 ft to 1.0 near the ground surface.

MSF acts as a scaling factor to adjust the CRR value to incorporate earthquakes with magnitudes other than 7.5 as follows:

$$MSF = \frac{10^{2.24}}{M_W^{2.56}} \qquad \text{(Eq. 7)}$$

F.3.2. Material Properties

Lacking site-specific data, MWH assumed that the relative density of the tailings was loose. Loose sand would exhibit uncorrected (SPT) blow counts between 4 and 10 (Terzaghi, Peck, and Mesri 1996). For purposes of this analysis, MWH assumed an average uncorrected SPT value of 4. The liquefaction analysis uses the same assumptions for soil profile, water table elevation, and density of the tailing material as described above for the settlement analysis. It is assumed that the compacted cover materials are not susceptible to liquefaction.

F.3.3. Site Seismicity

A site-specific seismic hazard analysis was performed by Tetra Tech (2010). This report references seismic hazard deaggregation done by the USGS National Seismic Hazard Maps Program (NSHMP) (USGS, 2008). The NSHMP indicates that the peak ground acceleration associated with an approximate 10,000 year return period is 0.15 g. The mean seismic source is from a magnitude (M_w) 5.81 event occurring 51.5 km from the site.

F.3.4 Results

Table F.5 presents a summary of the results of the liquefaction analysis. Further details of the calculation can be found in Attachment F.3.

Table F.5 Summary of Liquefaction Results

Depth of Tailings (ft)	CSR	$CRR_{7.5}$	MSF	Factor of Safety
6	0.13	0.14	1.92	1.93
12	0.16	0.13	1.92	1.53
18	0.17	0.12	1.92	1.38
24	0.18	0.12	1.92	1.30
30	0.17	0.11	1.92	1.26
36	0.17	0.11	1.92	1.26
42	0.16	0.11	1.92	1.29

Based on the factors of safety presented in Table F.5, the tailings are judged not to be susceptable to earthquake-induced liquefaction based on assumed geotechnical material properties and site-specific estimations of ground acceleration. The computed factors of safety against liquefaction range from 1.3 to 1.9, for an earthquake with probability of exceedance of 1 X 10^{-4}.

F.4 REFERENCES

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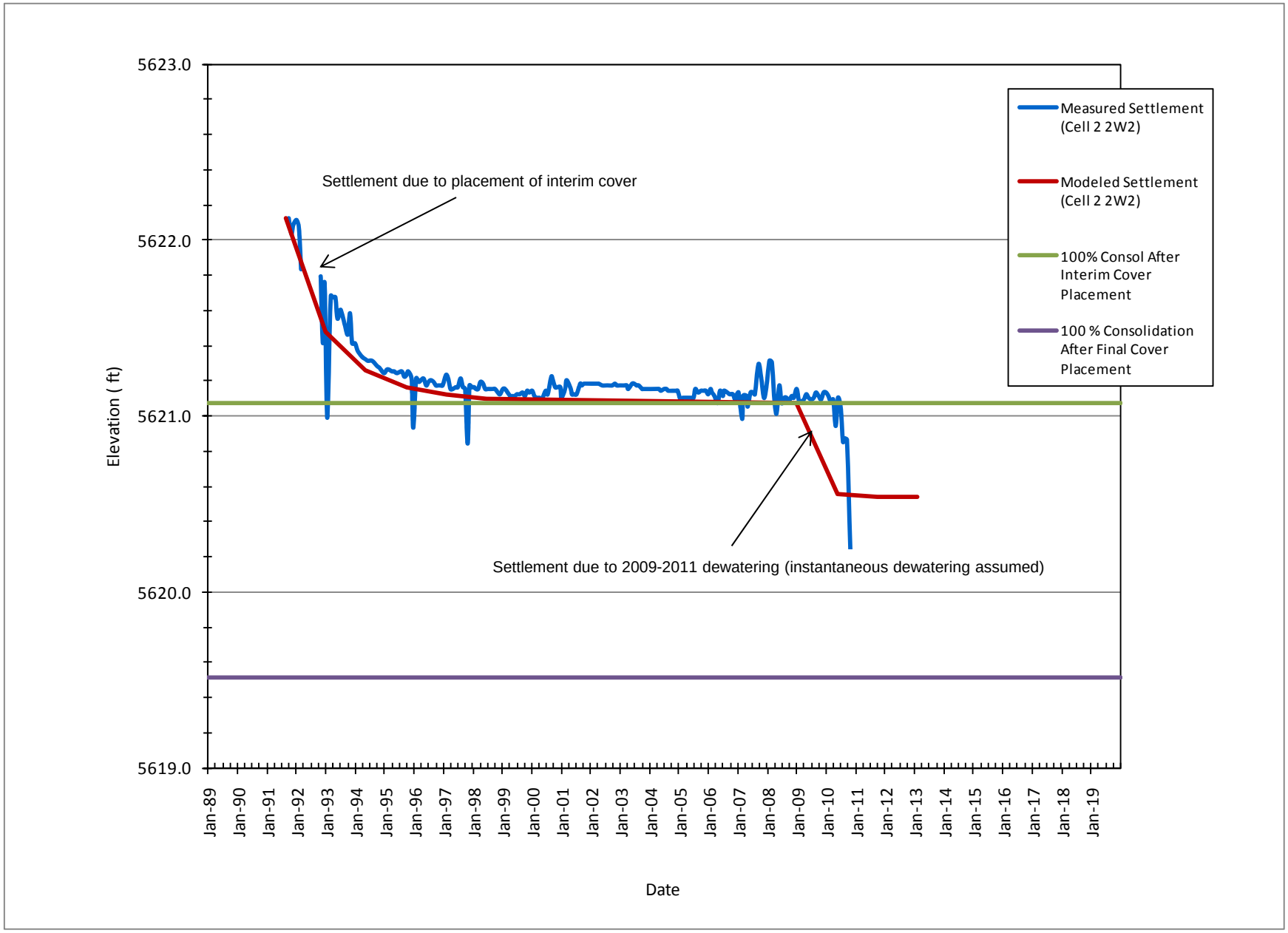

DENISON MINES

Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
TIME RATE OF SETTLEMENT CURVE
(MEASURED AND MODELED)
CELL 2 - MONITORING POINT 2W2

MWH

DATE
AUG 2011

FIGURE F-1

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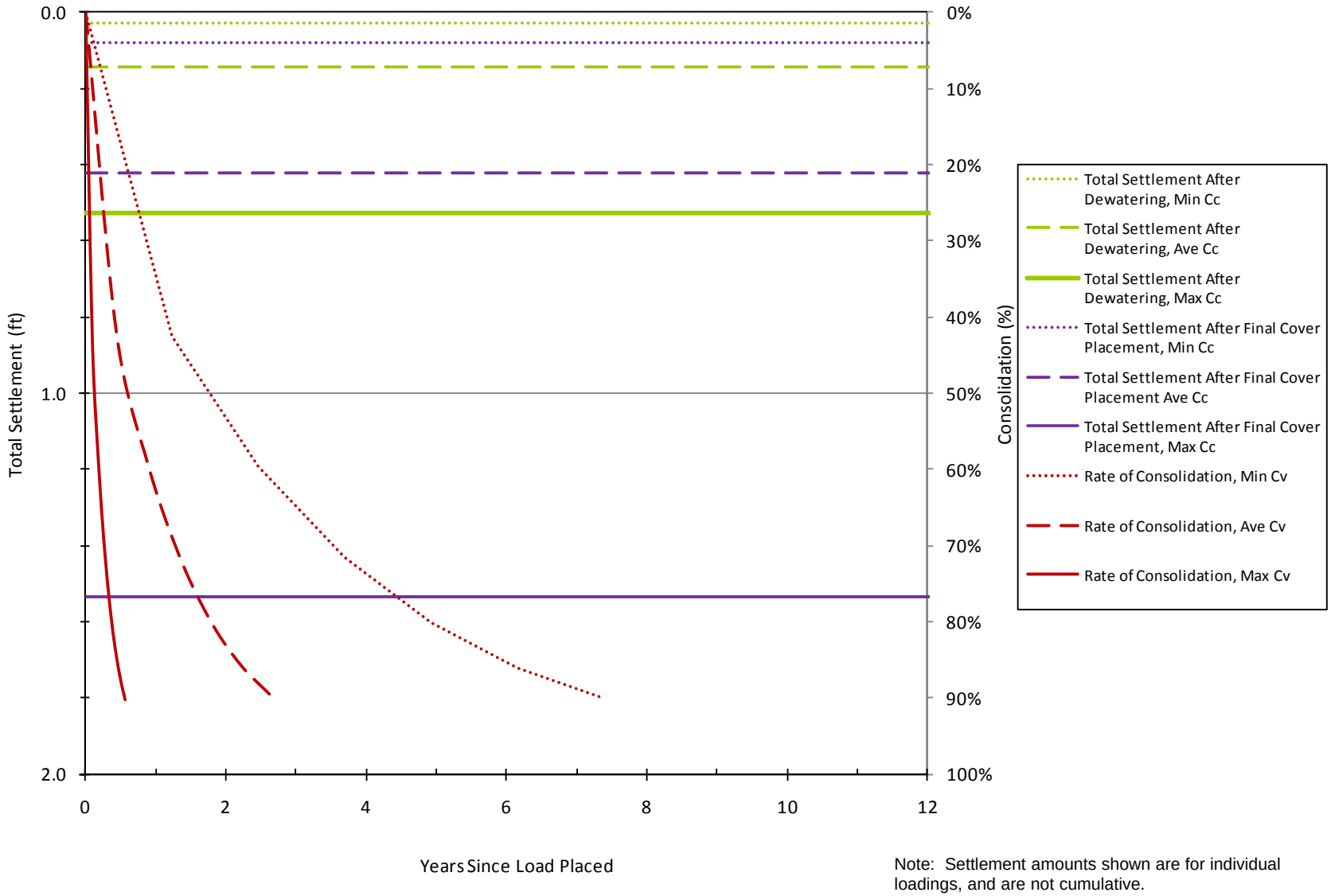
App F Figures.pptx



Note: Settlement amounts shown are for individual loadings, and are not cumulative.

DENISON MINES

Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

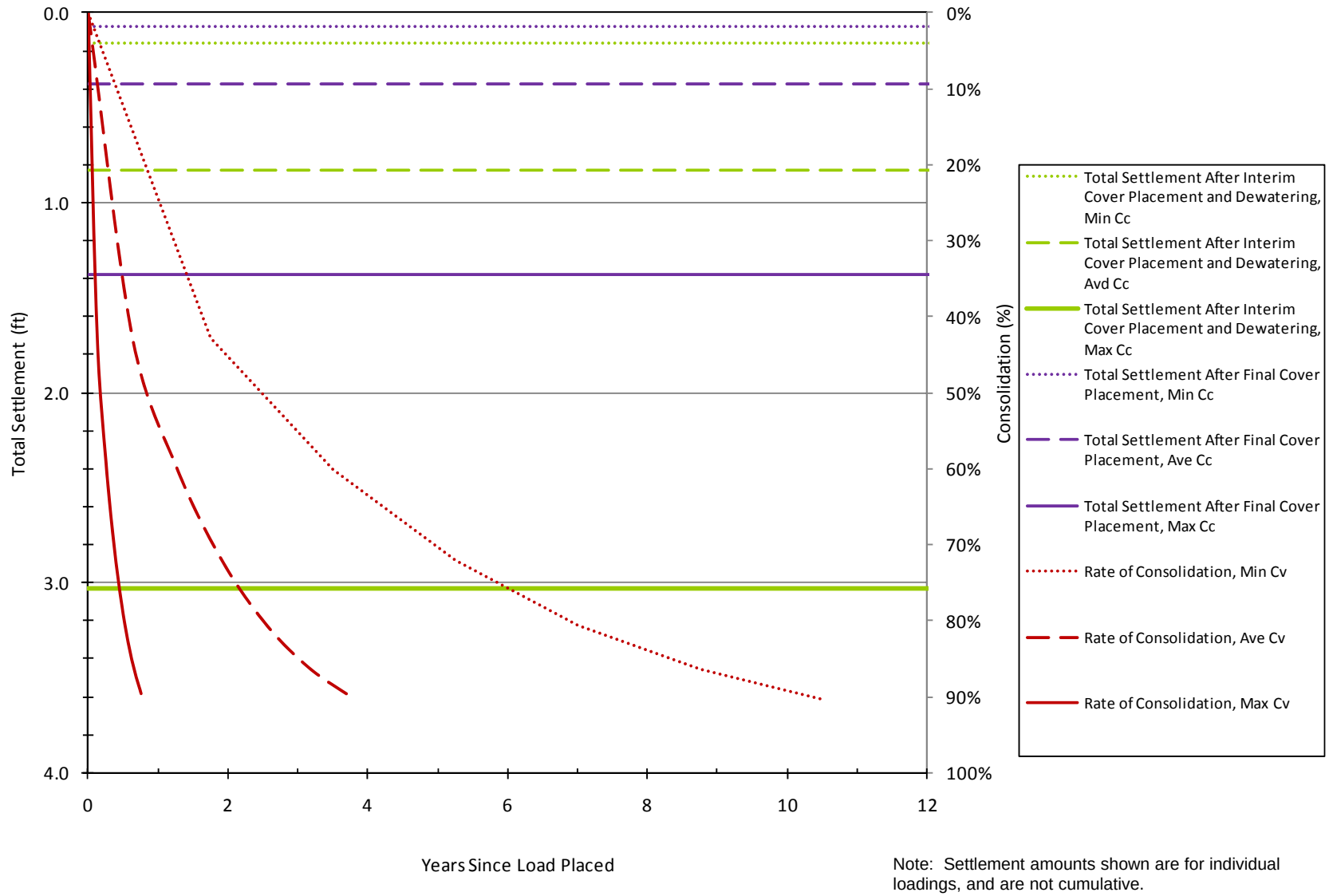
TITLE
CALCULATED SETTLEMENT AT THICKEST TAILINGS LOCATION IN CELL 2 (INTERNAL DIKE SLOPE)

MWH

DATE
AUG 2011

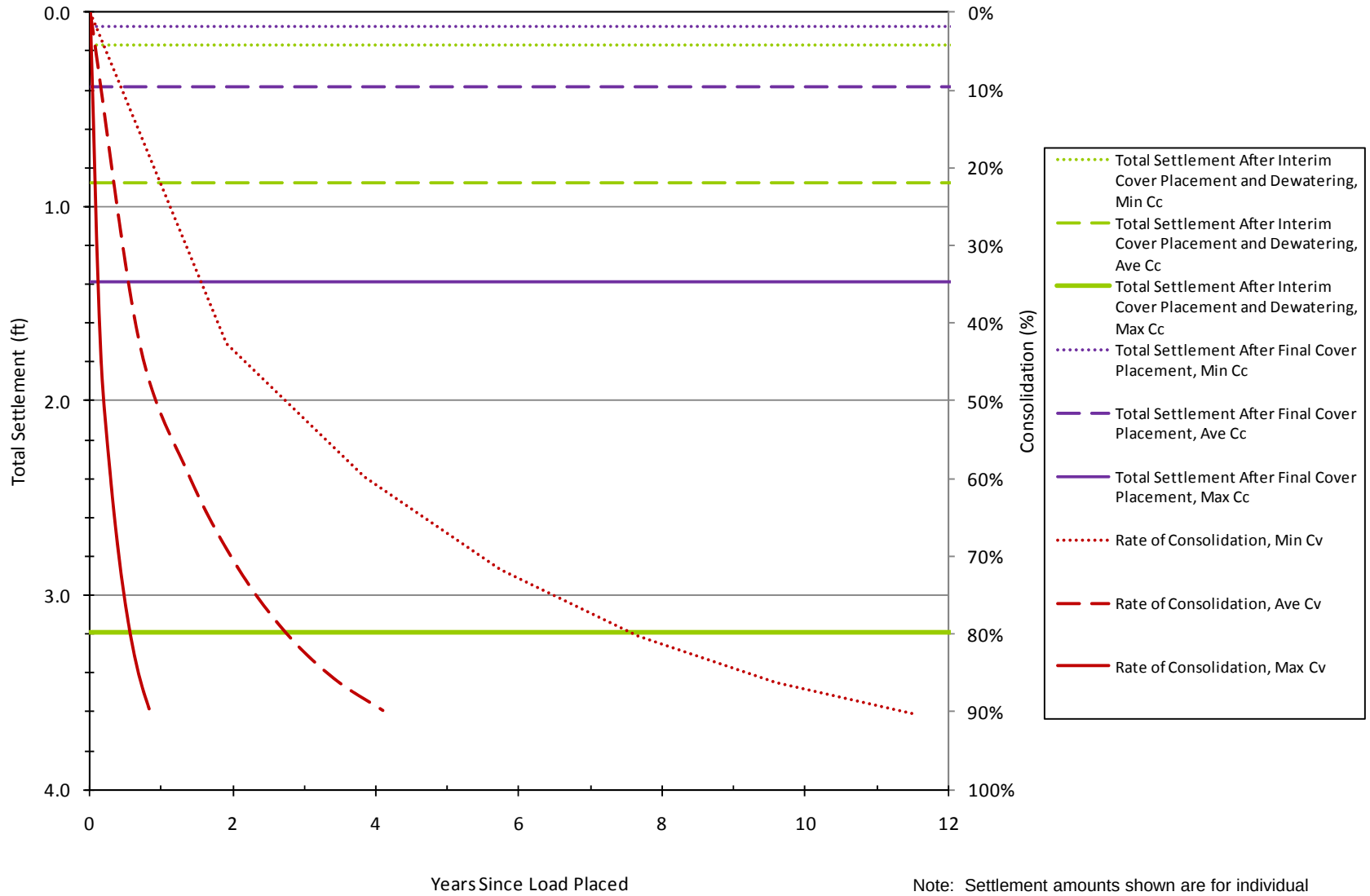
FIGURE F-2

FILENAME
App F Figures.pptx



Note: Settlement amounts shown are for individual loadings, and are not cumulative.

DENISON MINES Denison Mines (USA) Corp	PROJECT WHITE MESA MILL TAILINGS RECLAMATION	MWH	
	TITLE CALCULATED SETTLEMENT AT THICKEST TAILINGS LOCATION IN CELL 3 (INTERNAL DIKE SLOPE)	DATE AUG 2011	FIGURE F-3
		FILENAME App F Figures.pptx	



Note: Settlement amounts shown are for individual loadings, and are not cumulative.

DENISON MINES

Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
CALCULATED SETTLEMENT AT THICKEST TAILINGS LOCATION IN CELLS 4A AND 4B (INTERNAL DIKE SLOPE)

MWH

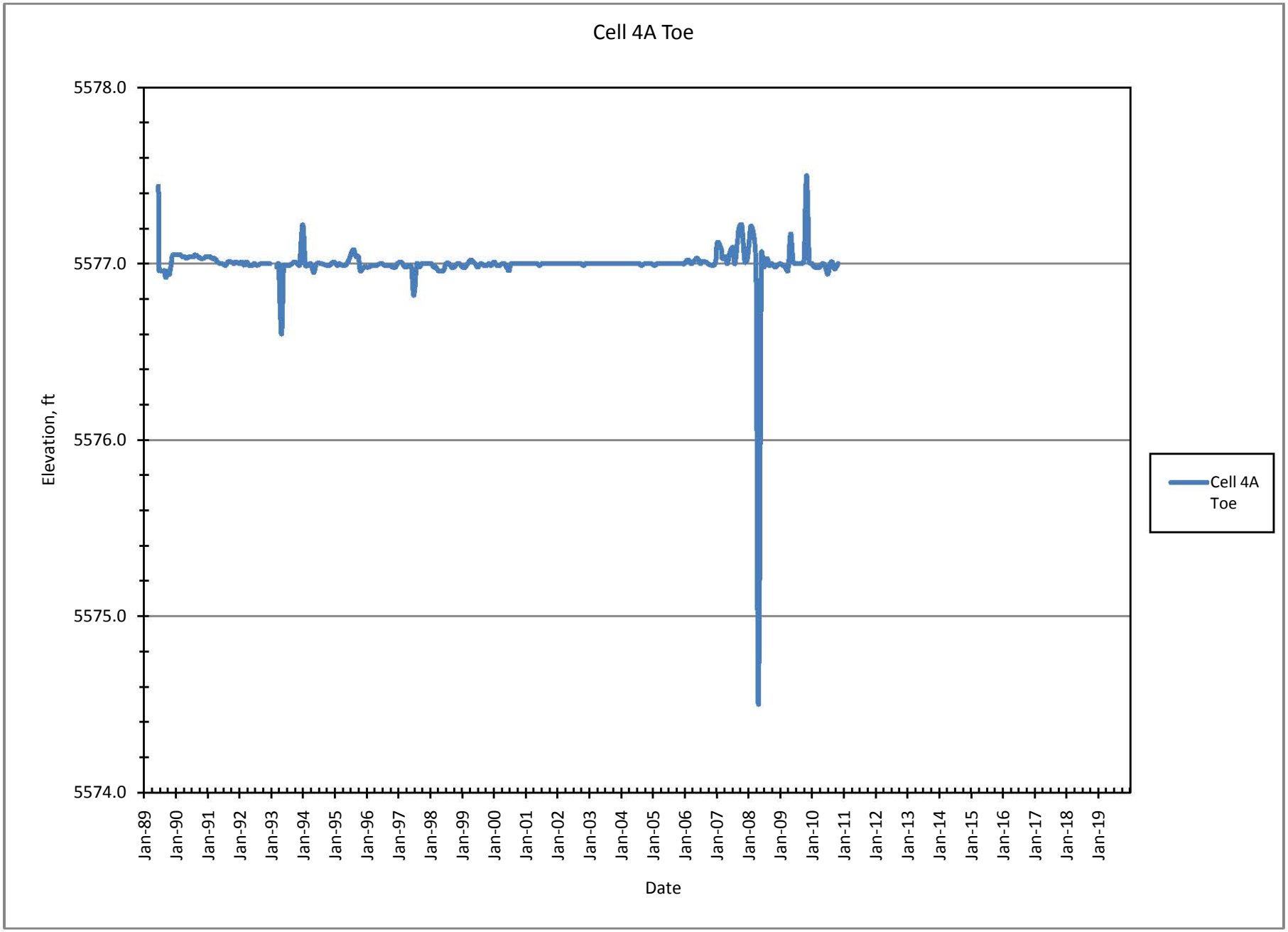
DATE
AUG 2011

FIGURE F-4

FILENAME
App F Figures.pptx

ATTACHMENT F.1

SETTLEMENT MONUMENT DATA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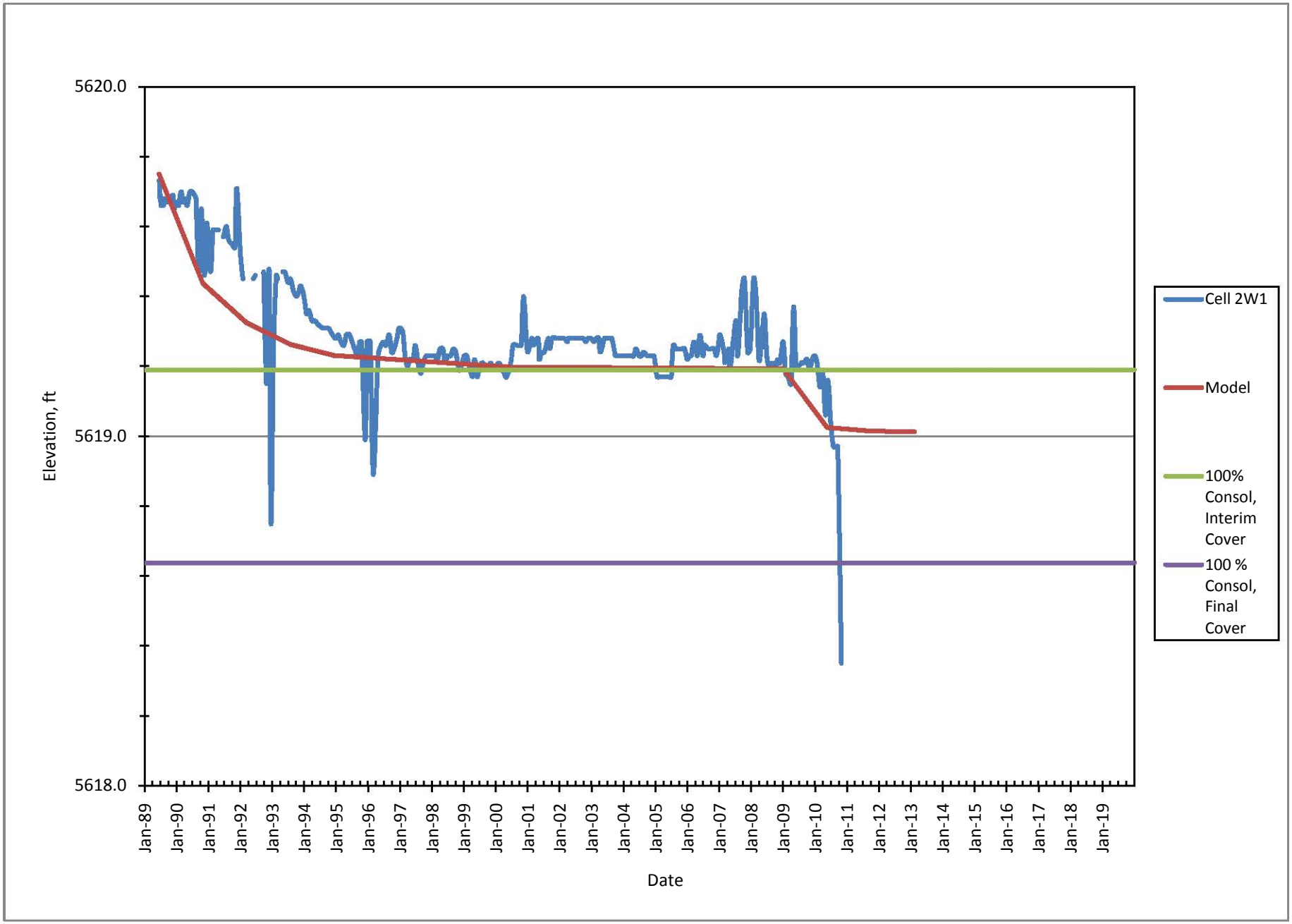
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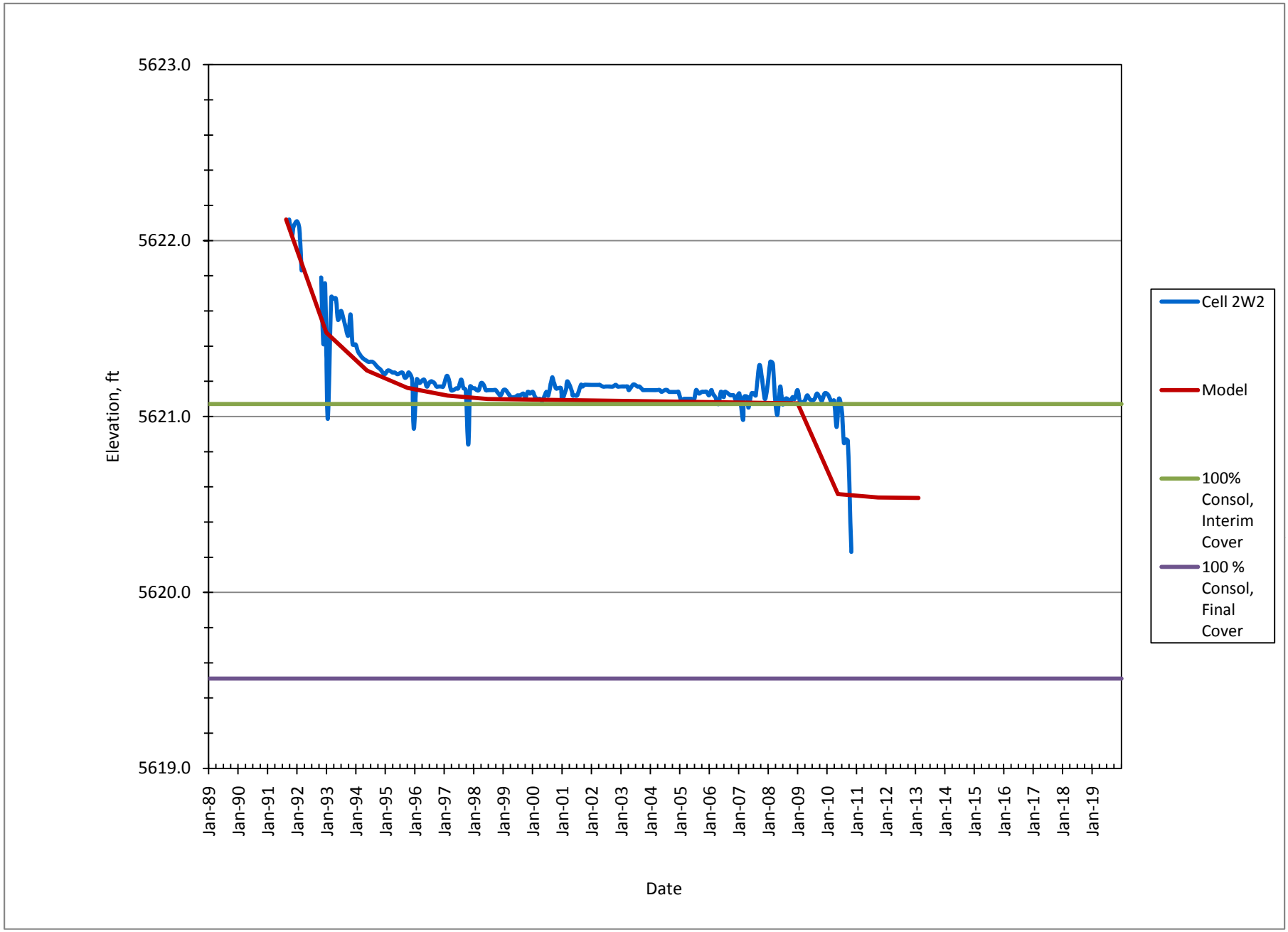
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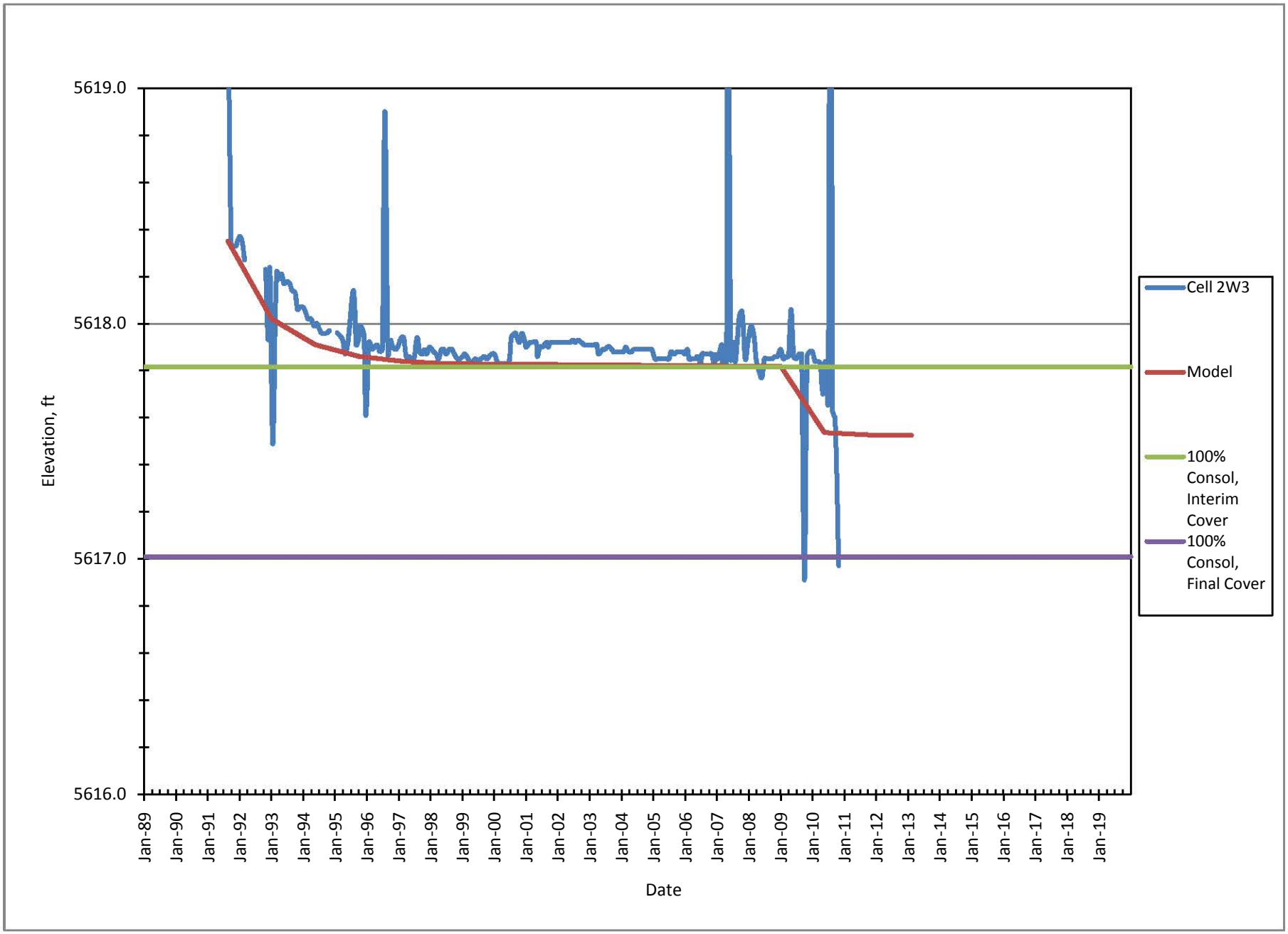
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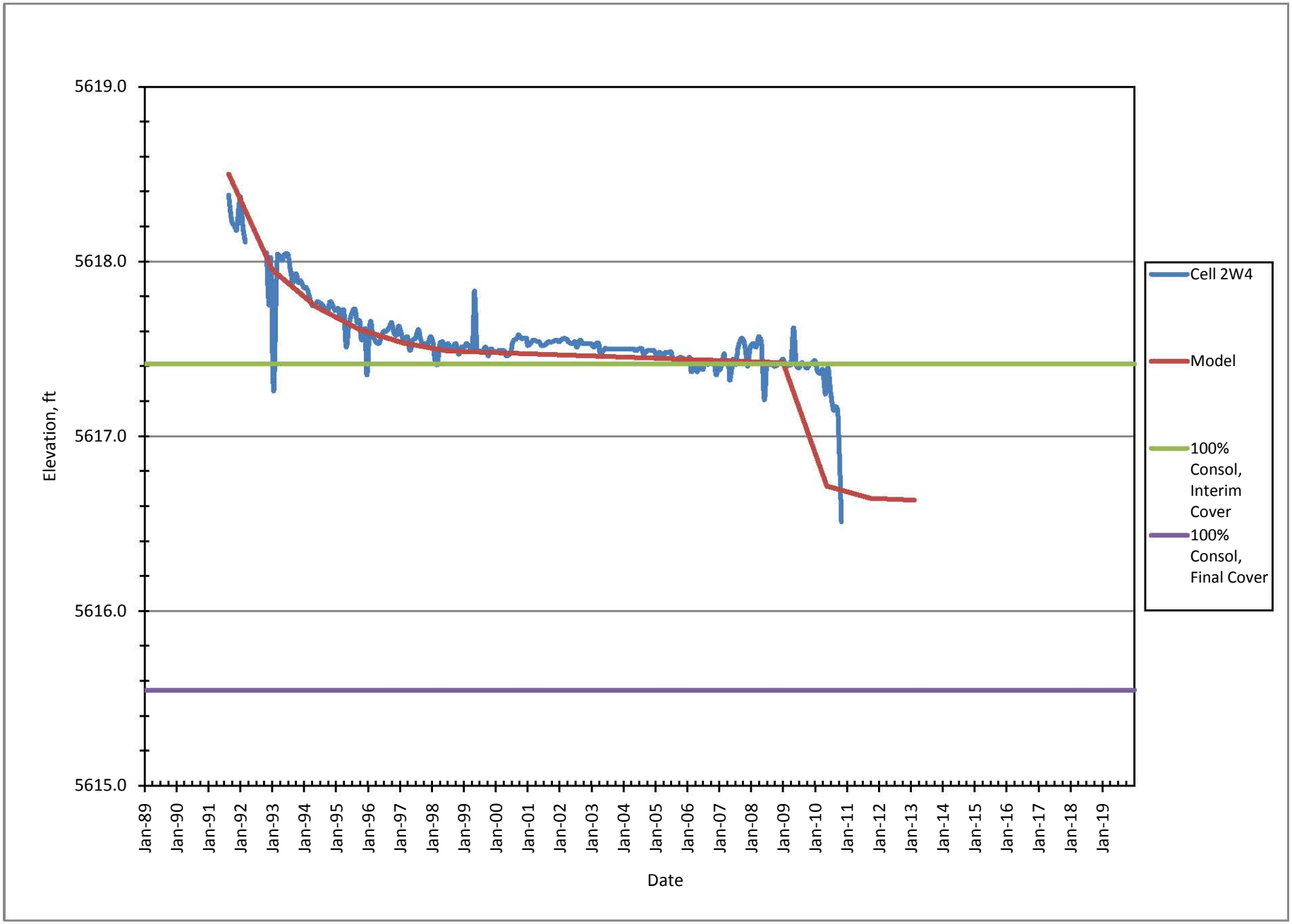
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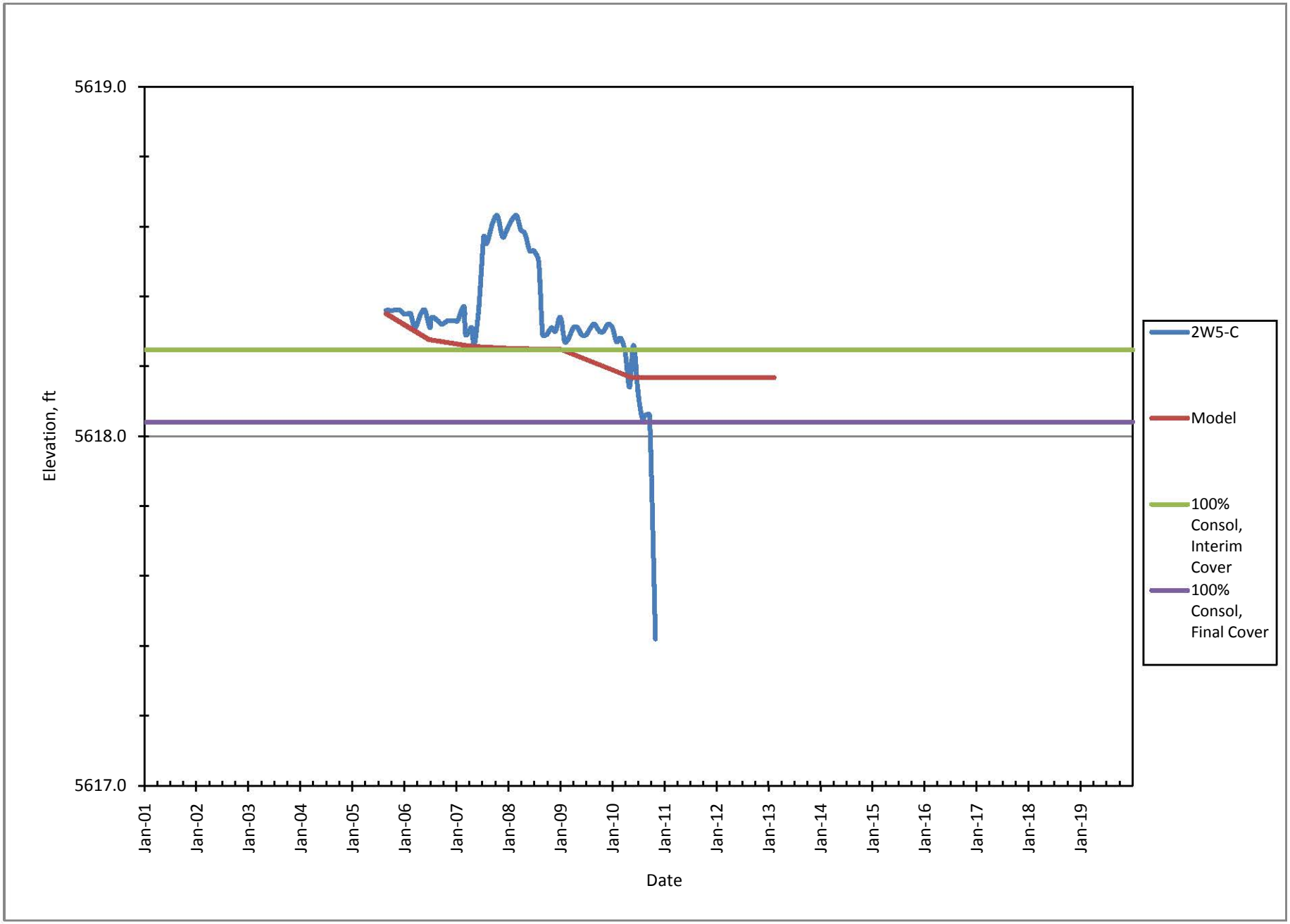
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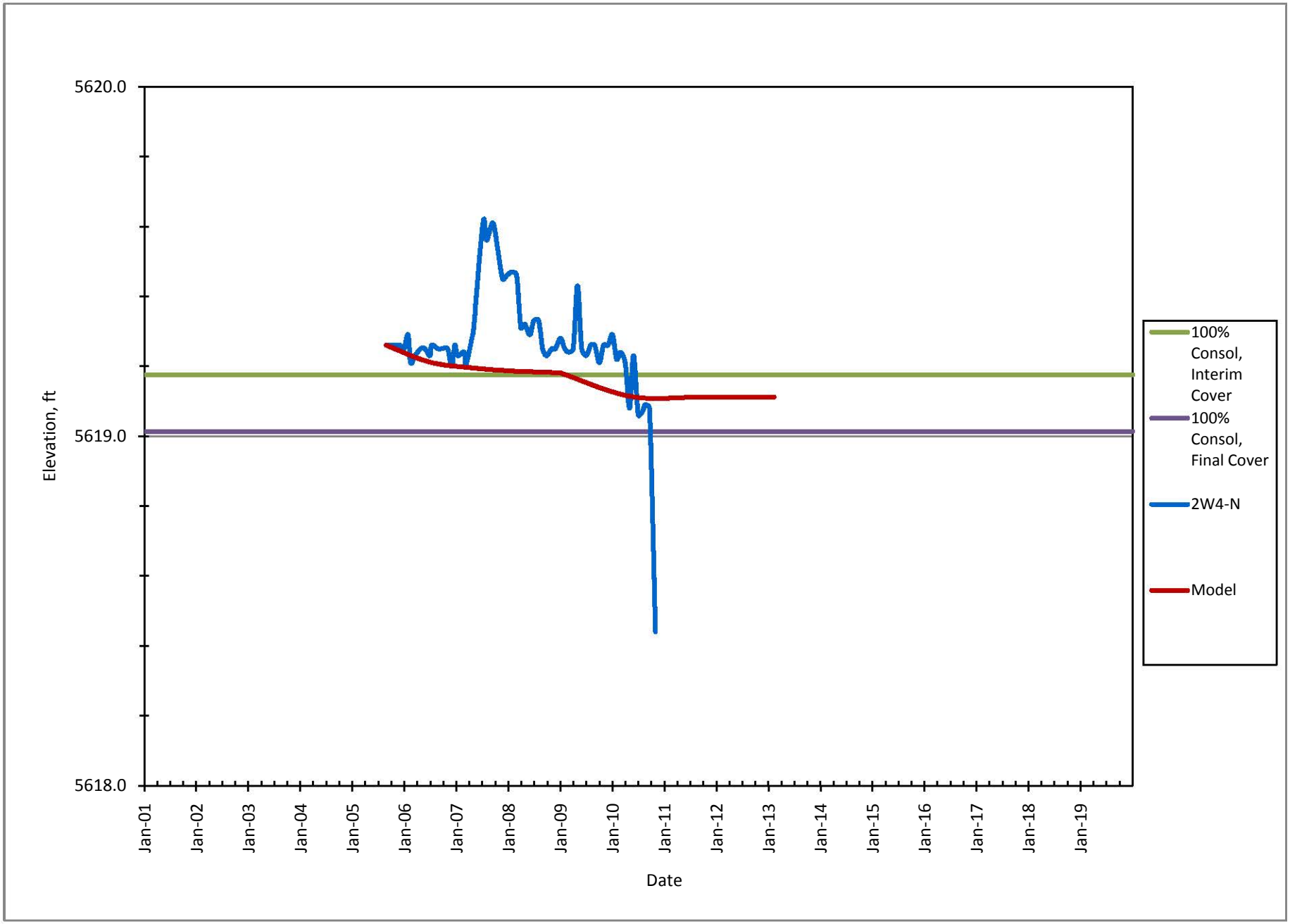
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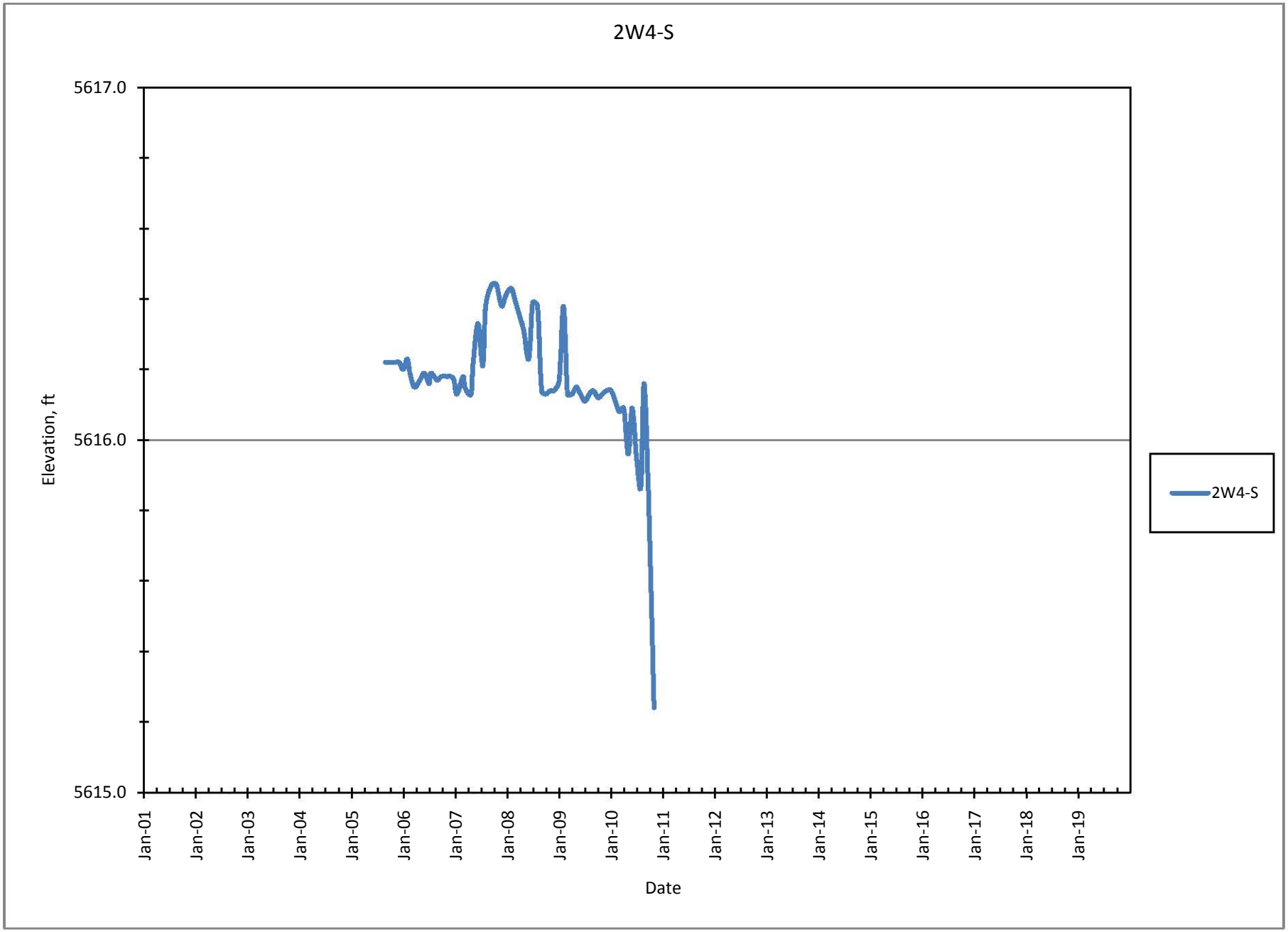
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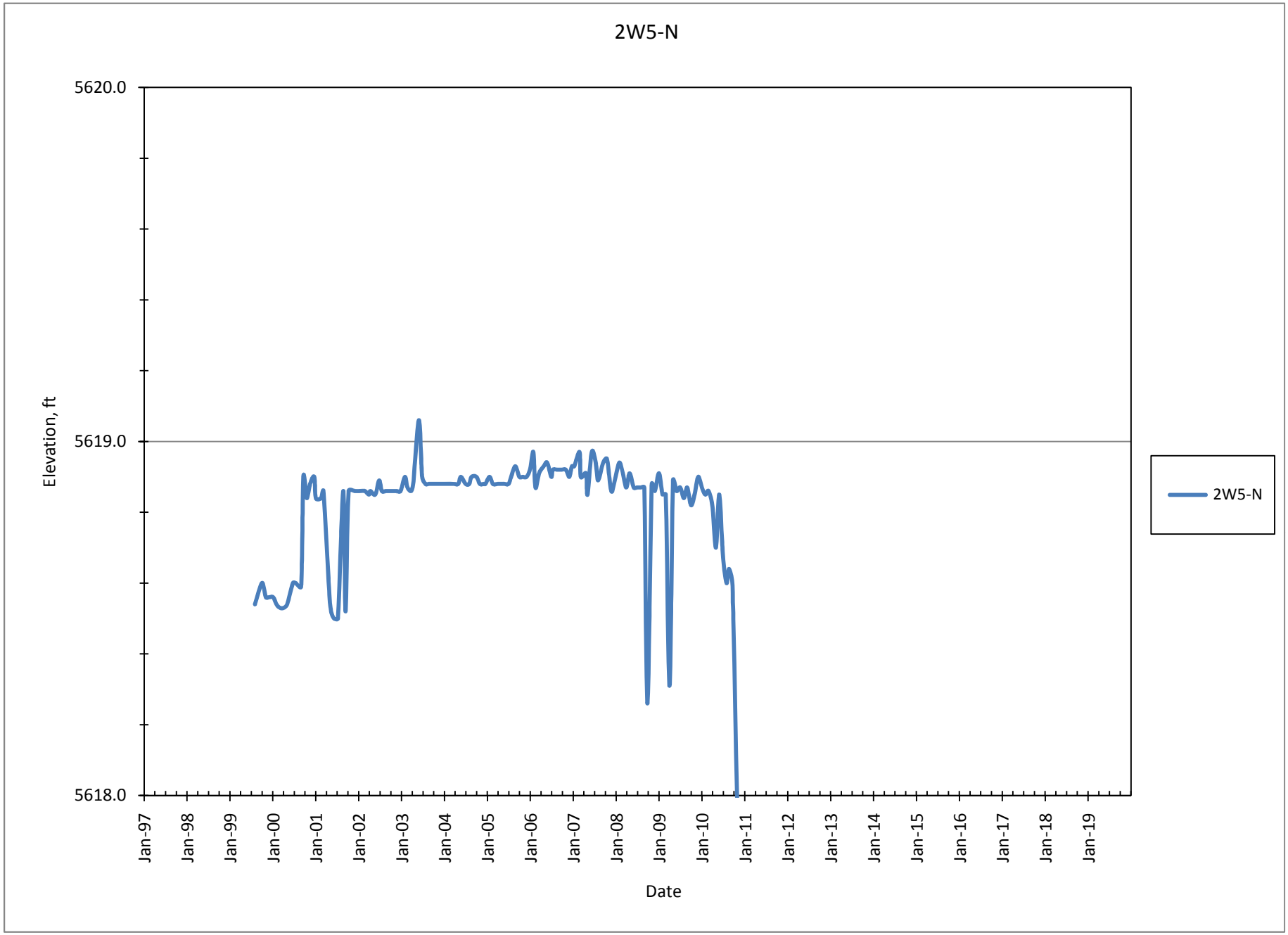
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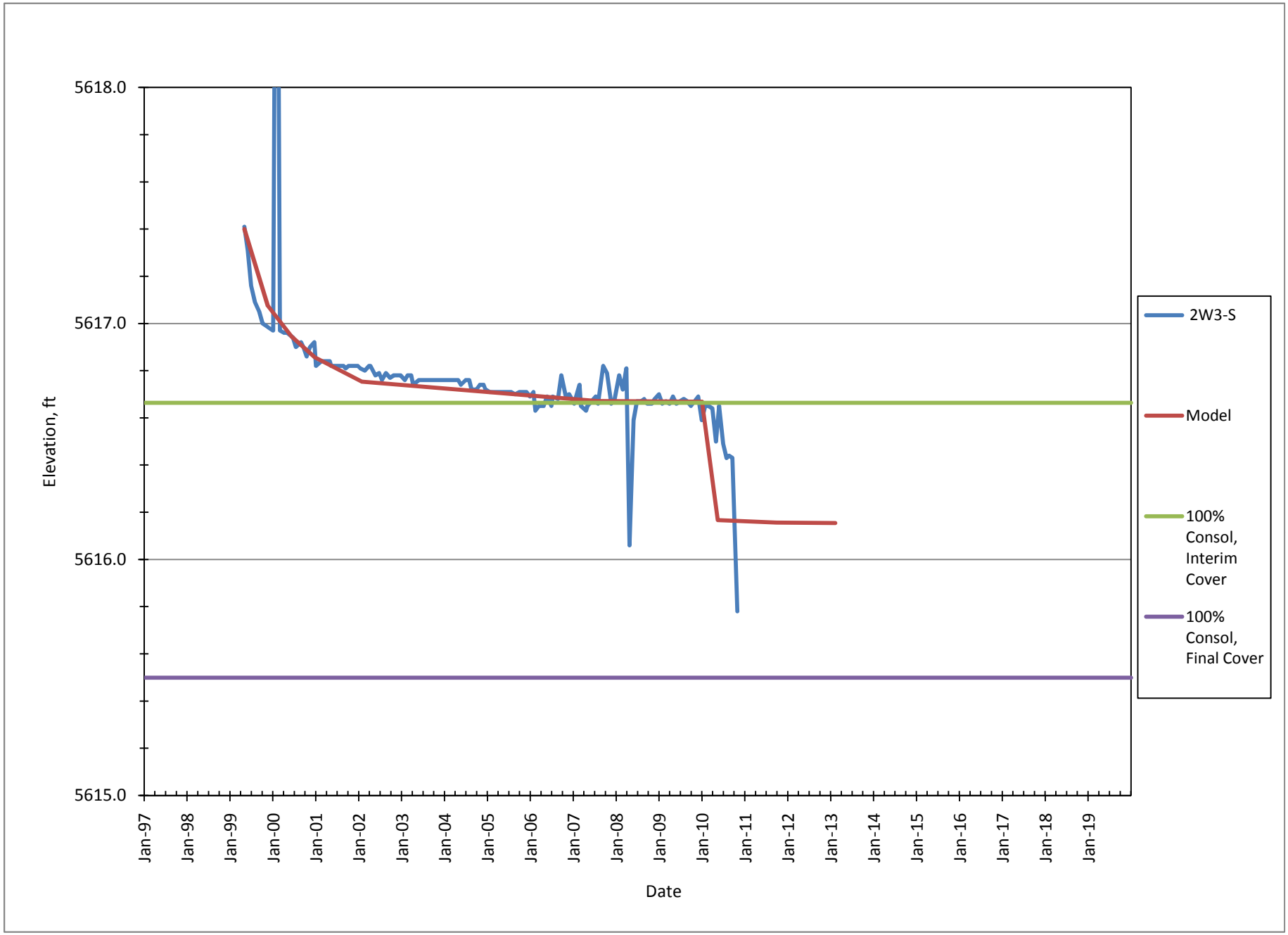
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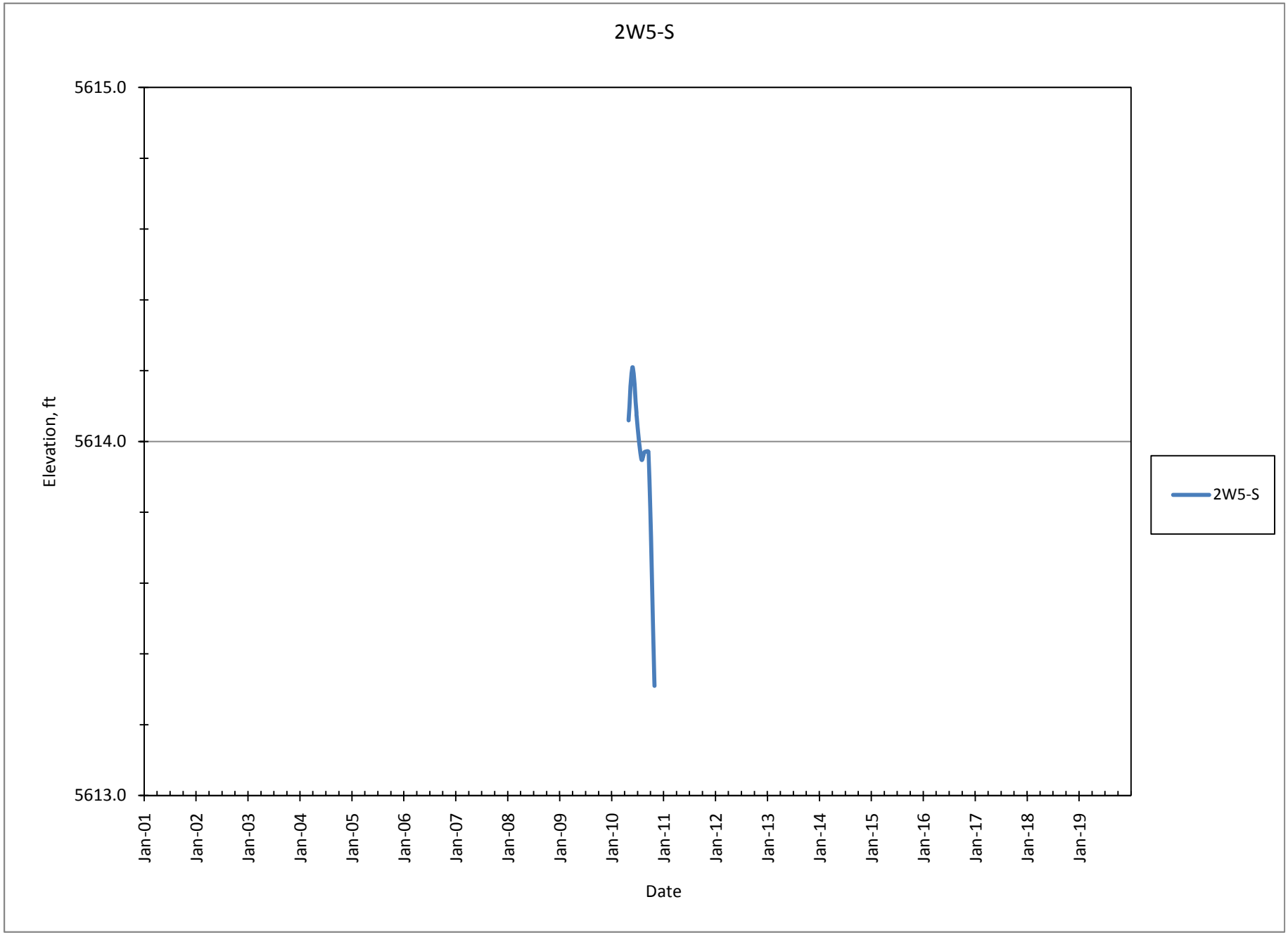
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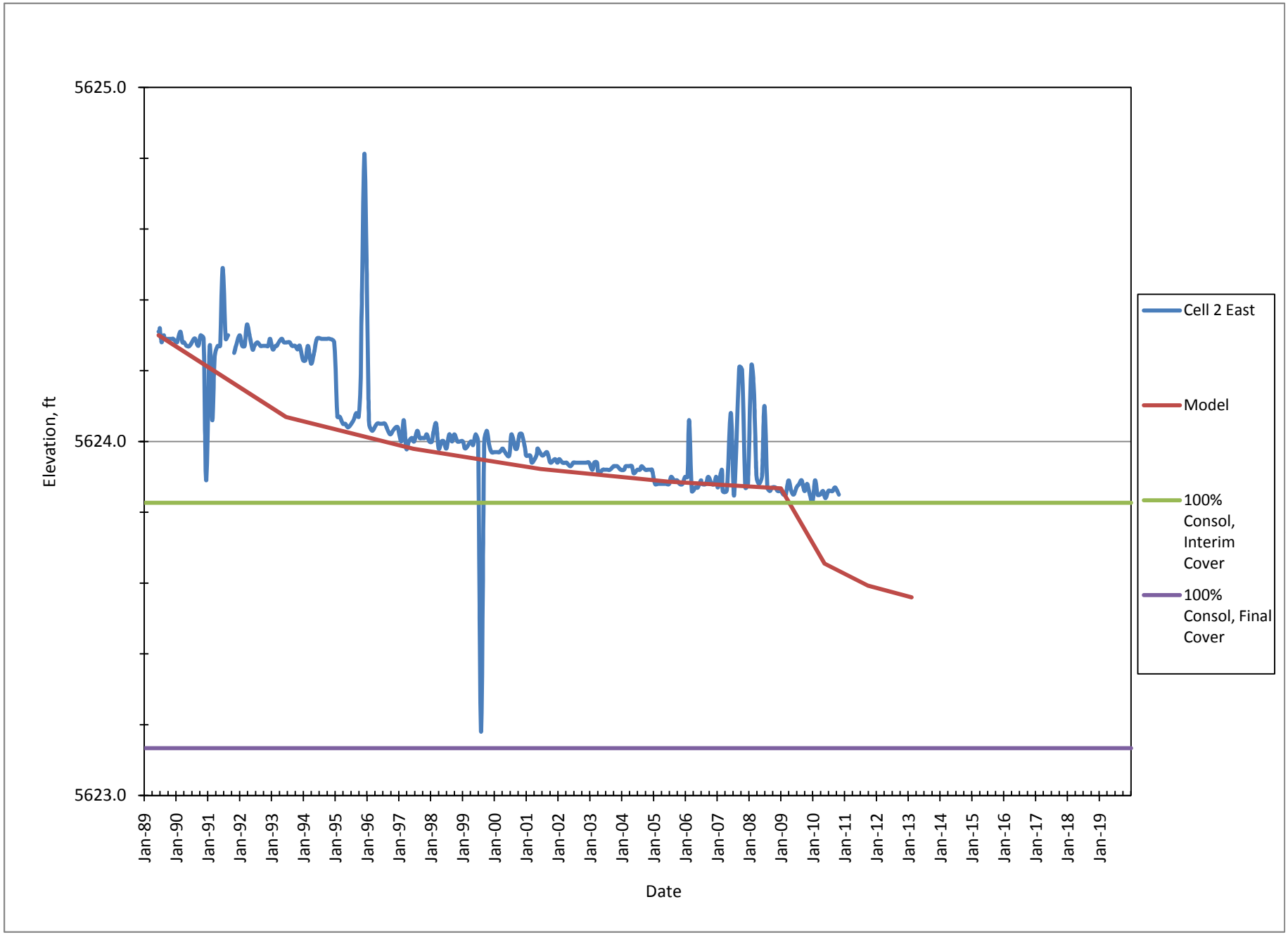
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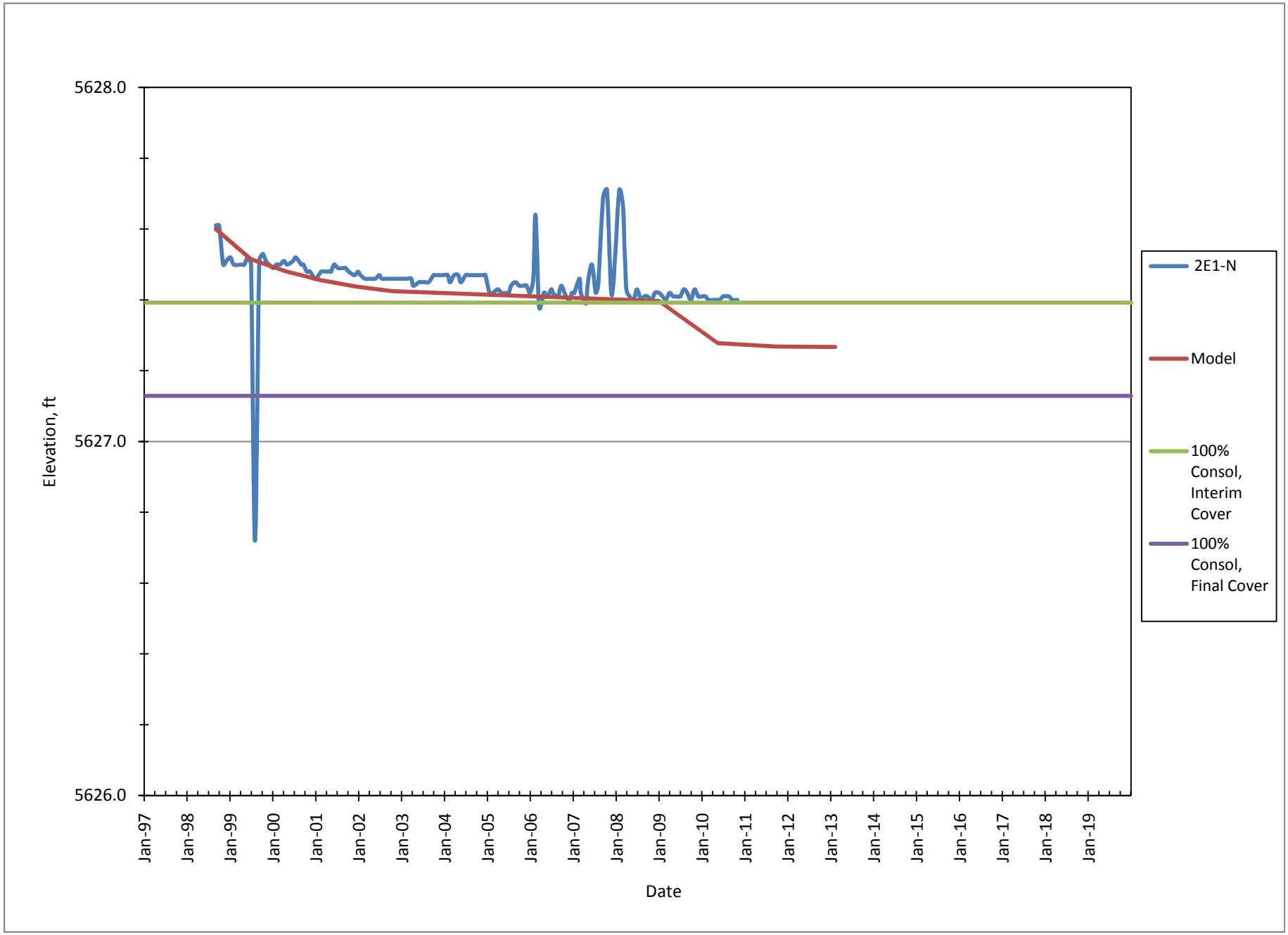
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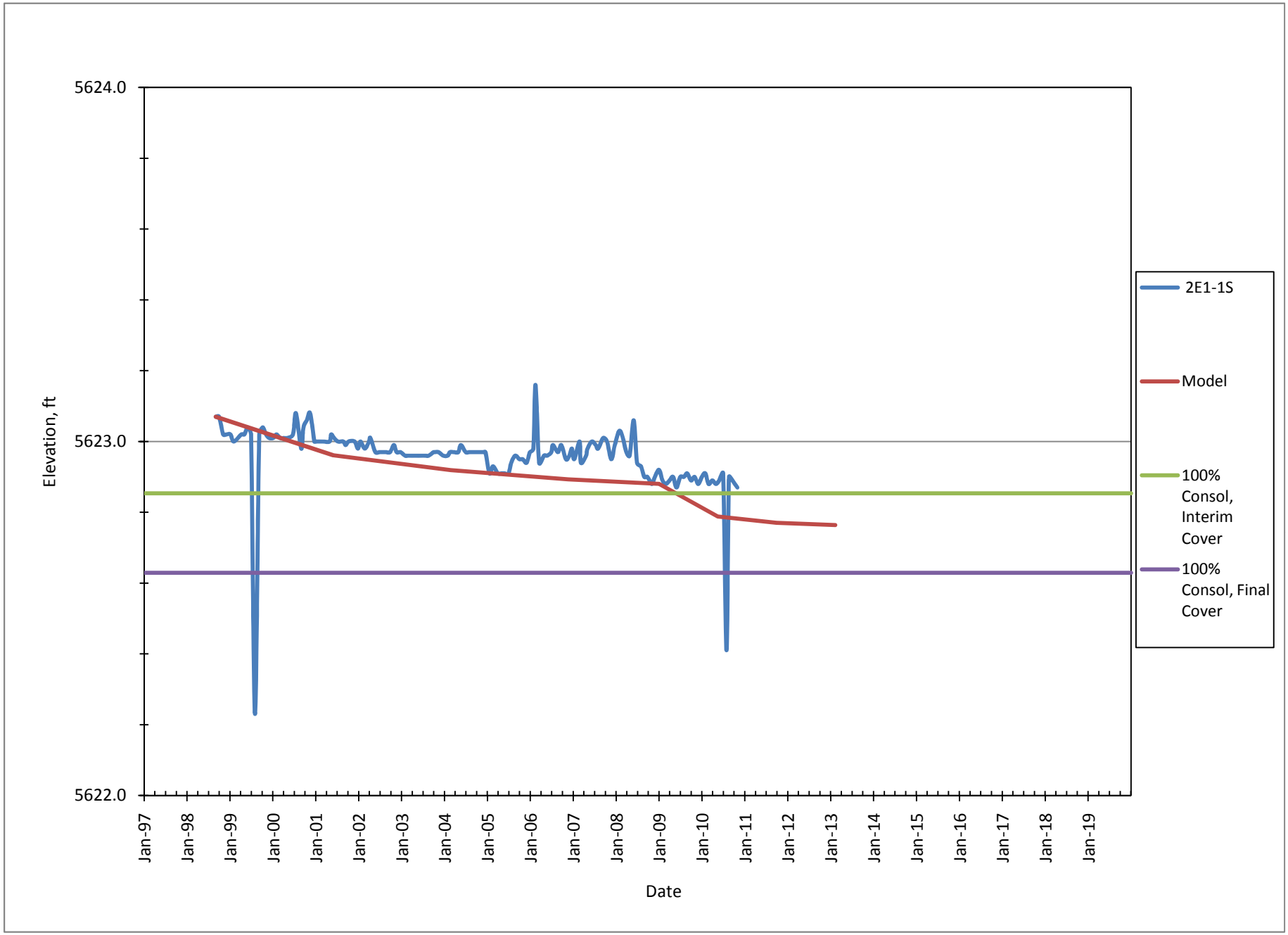
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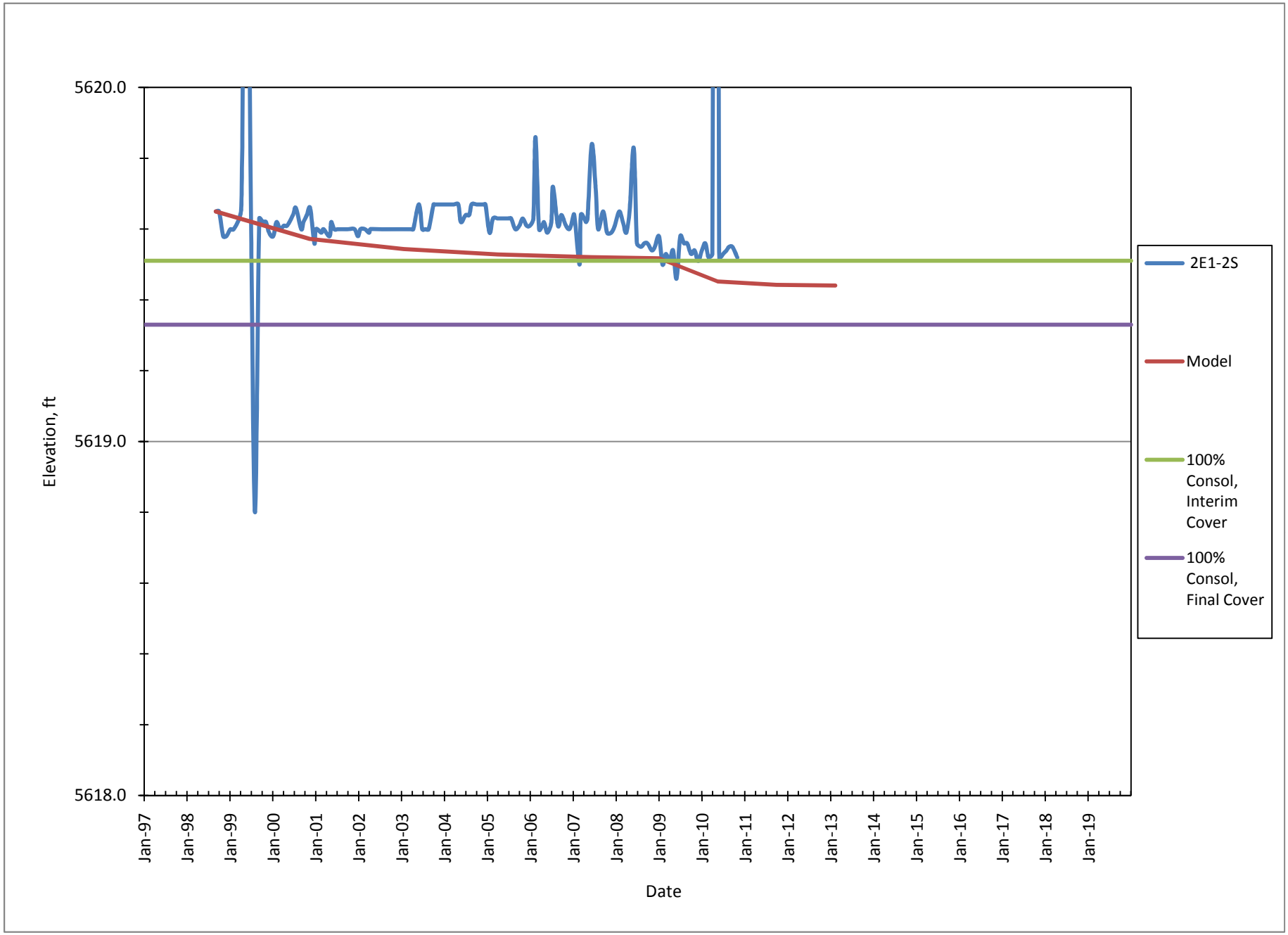
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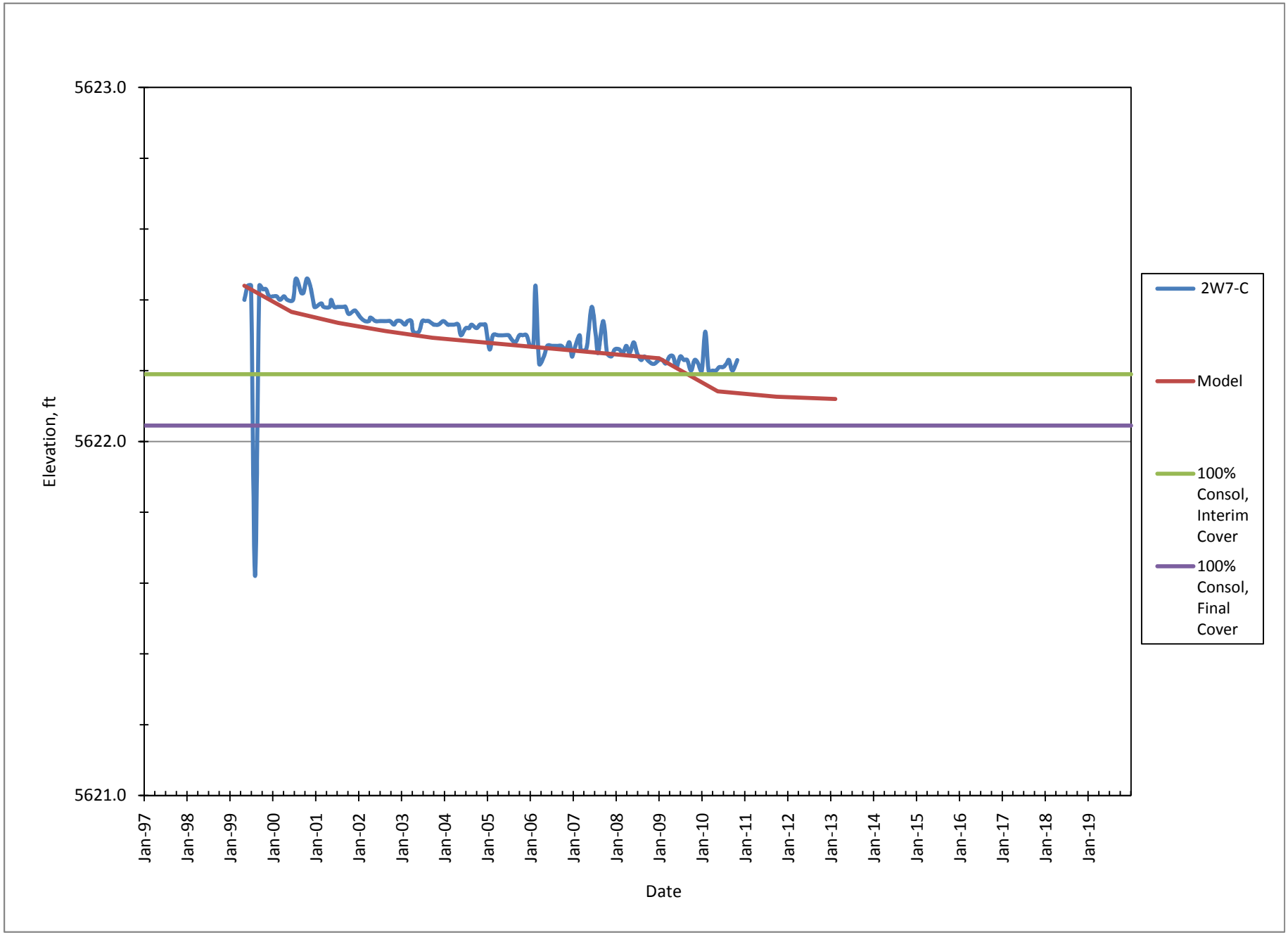
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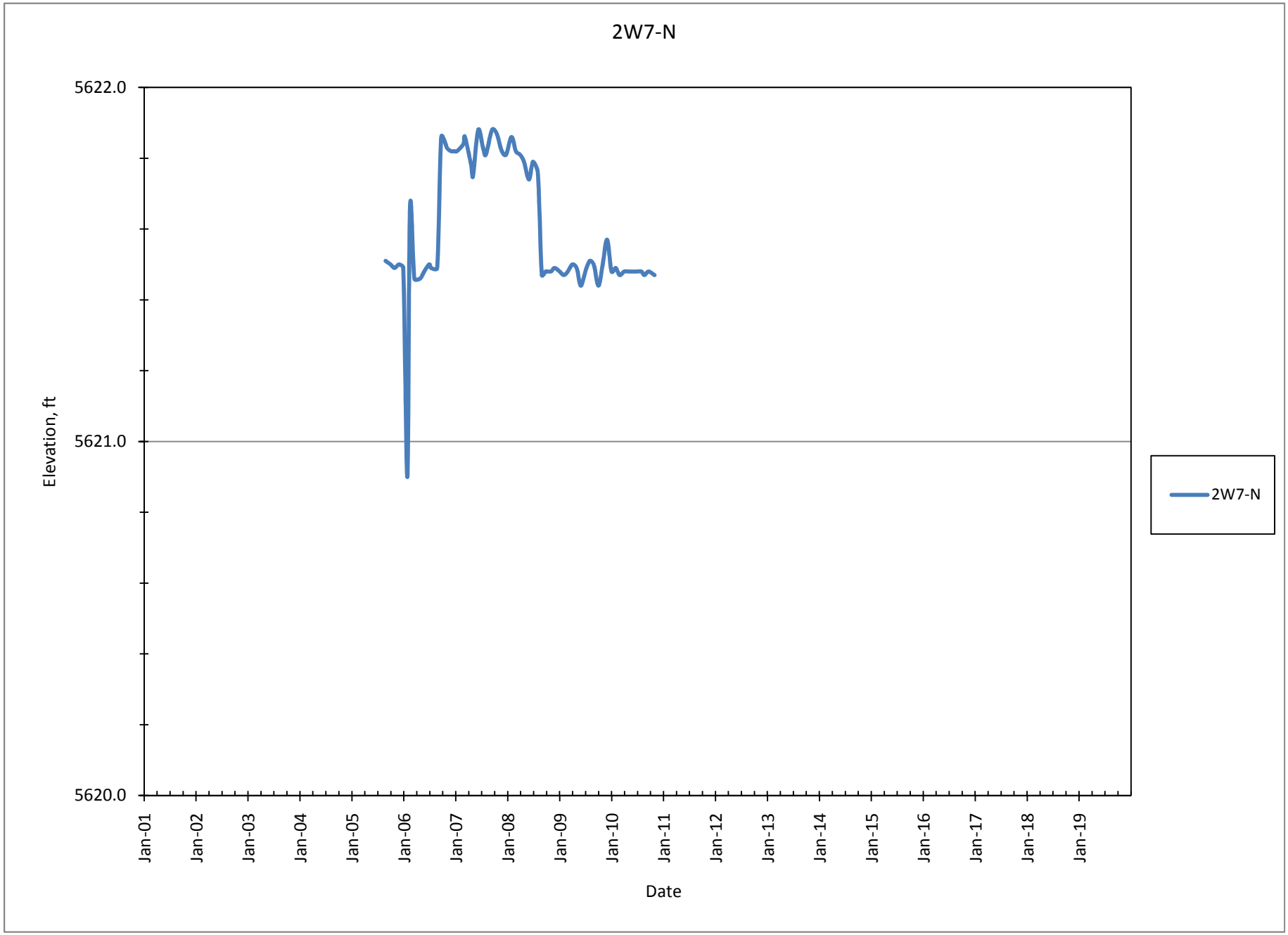
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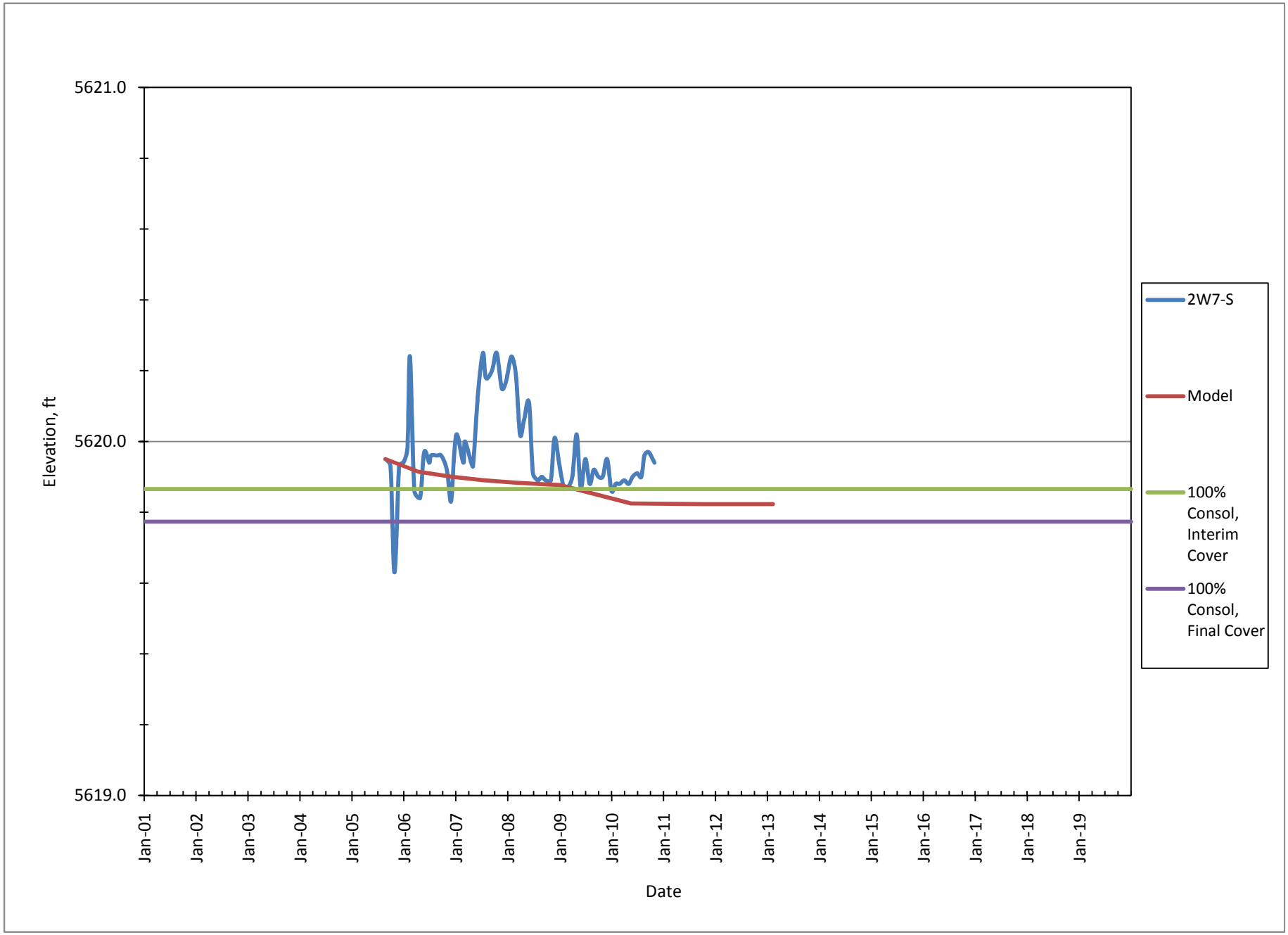
2W7-N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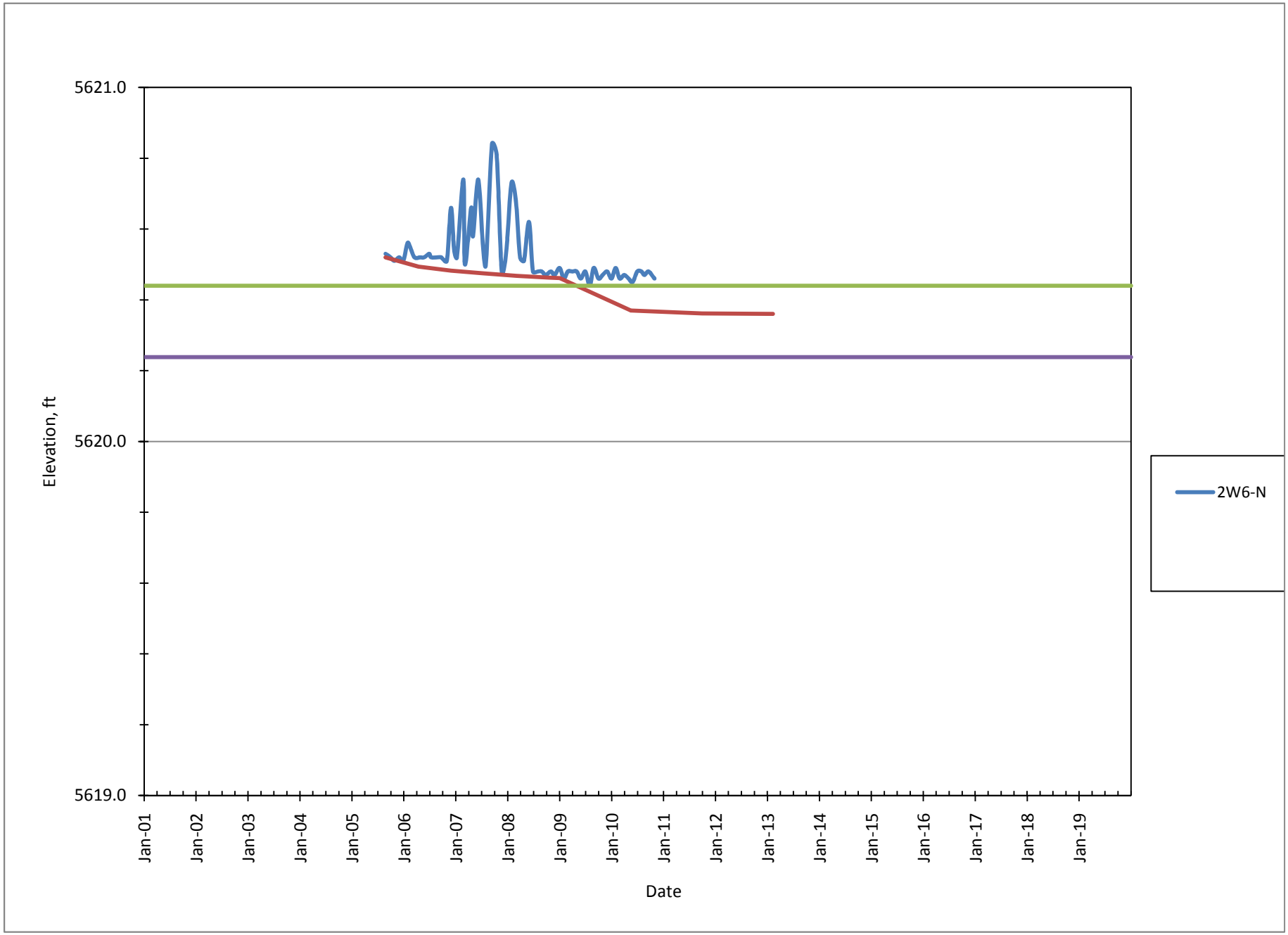
Date
2W7-S
Model
100% Consol, Interim Cover
100% Consol, Final Cover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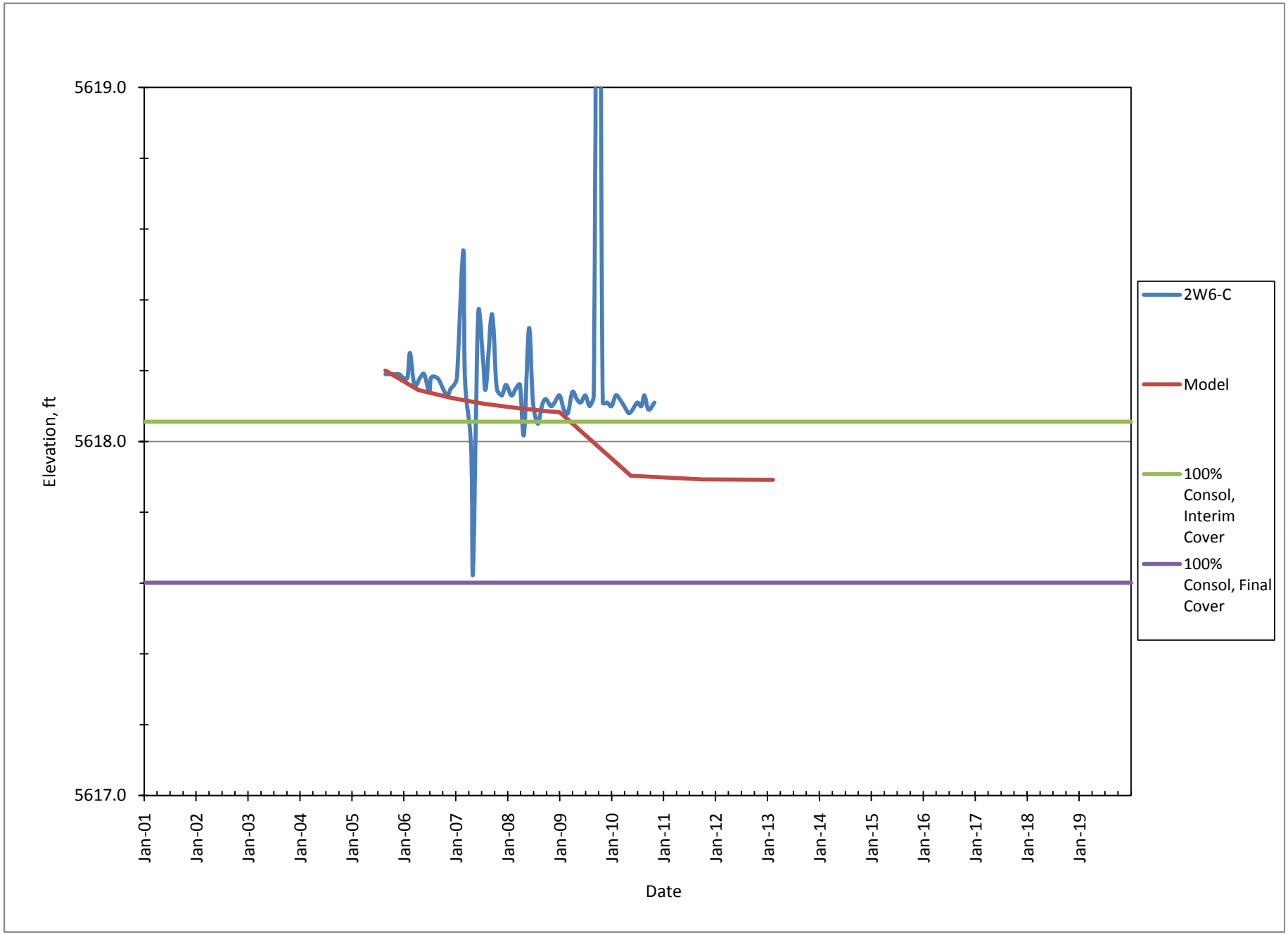
Date
2W6-N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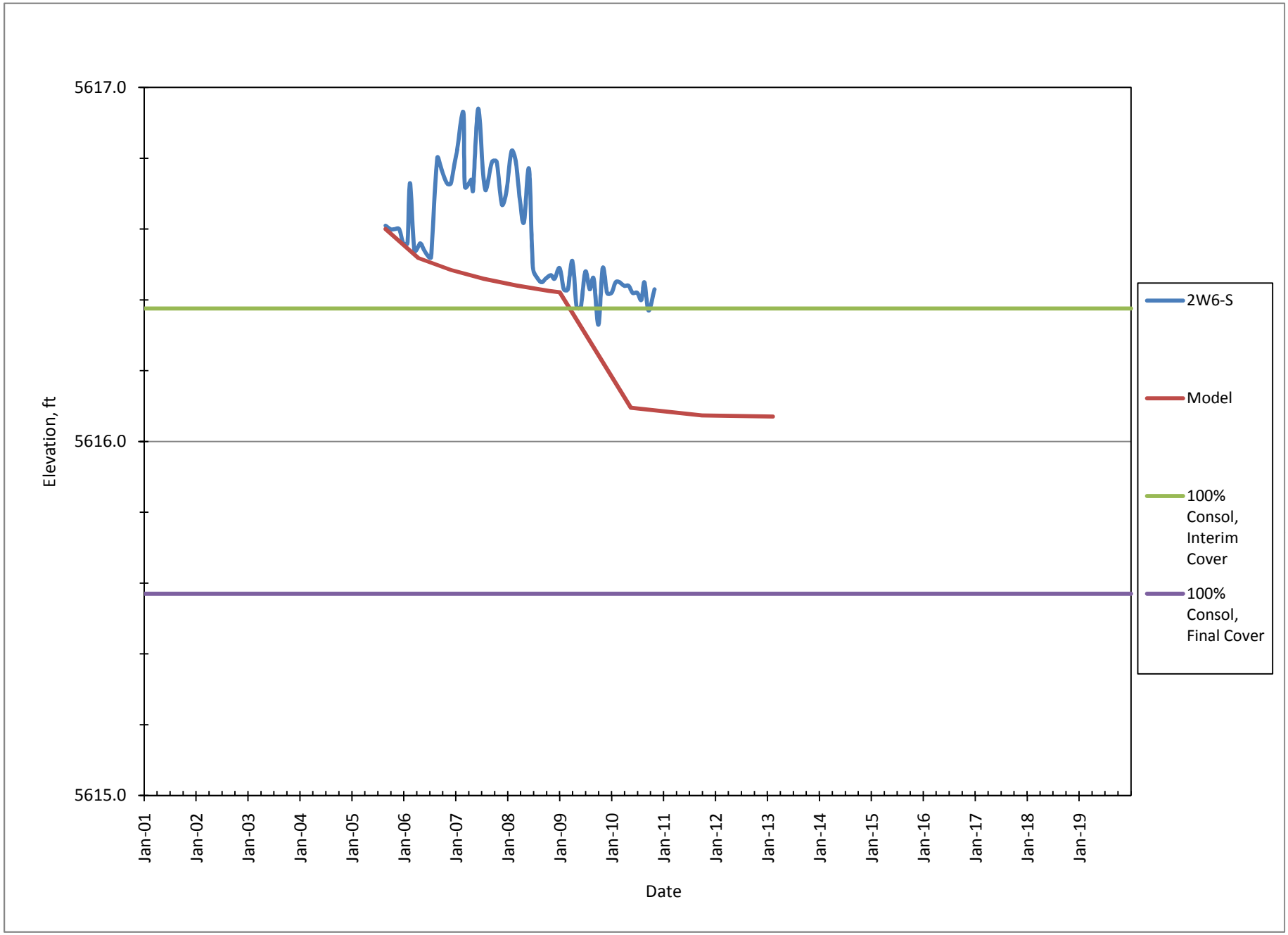
Date
2W6-C
Model
100% Consol, Interim Cover
100% Consol, Final Cover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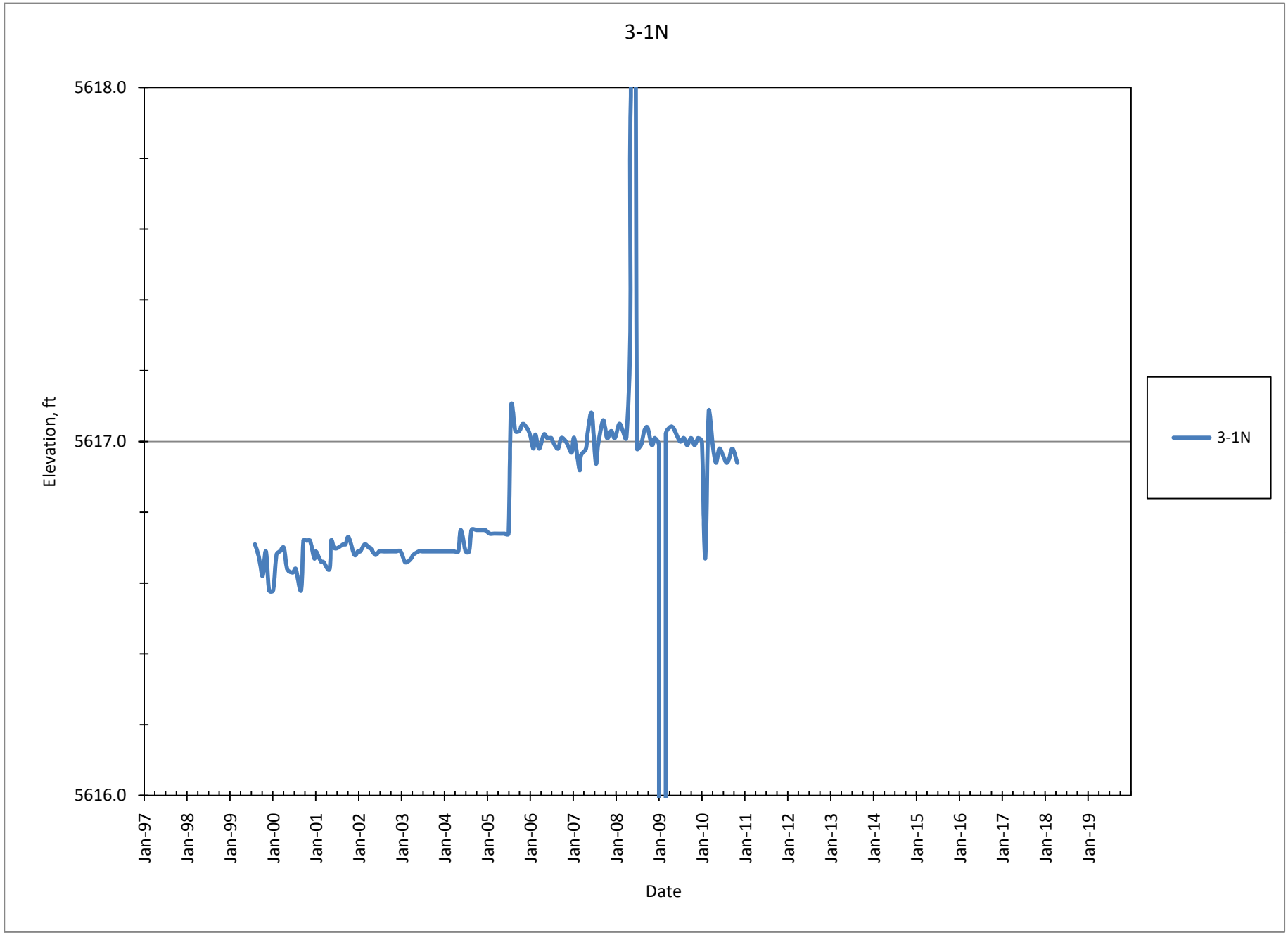
Date
2W6-S
Model
100% Consol, Interim Cover
100% Consol, Final Cover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Jan-02
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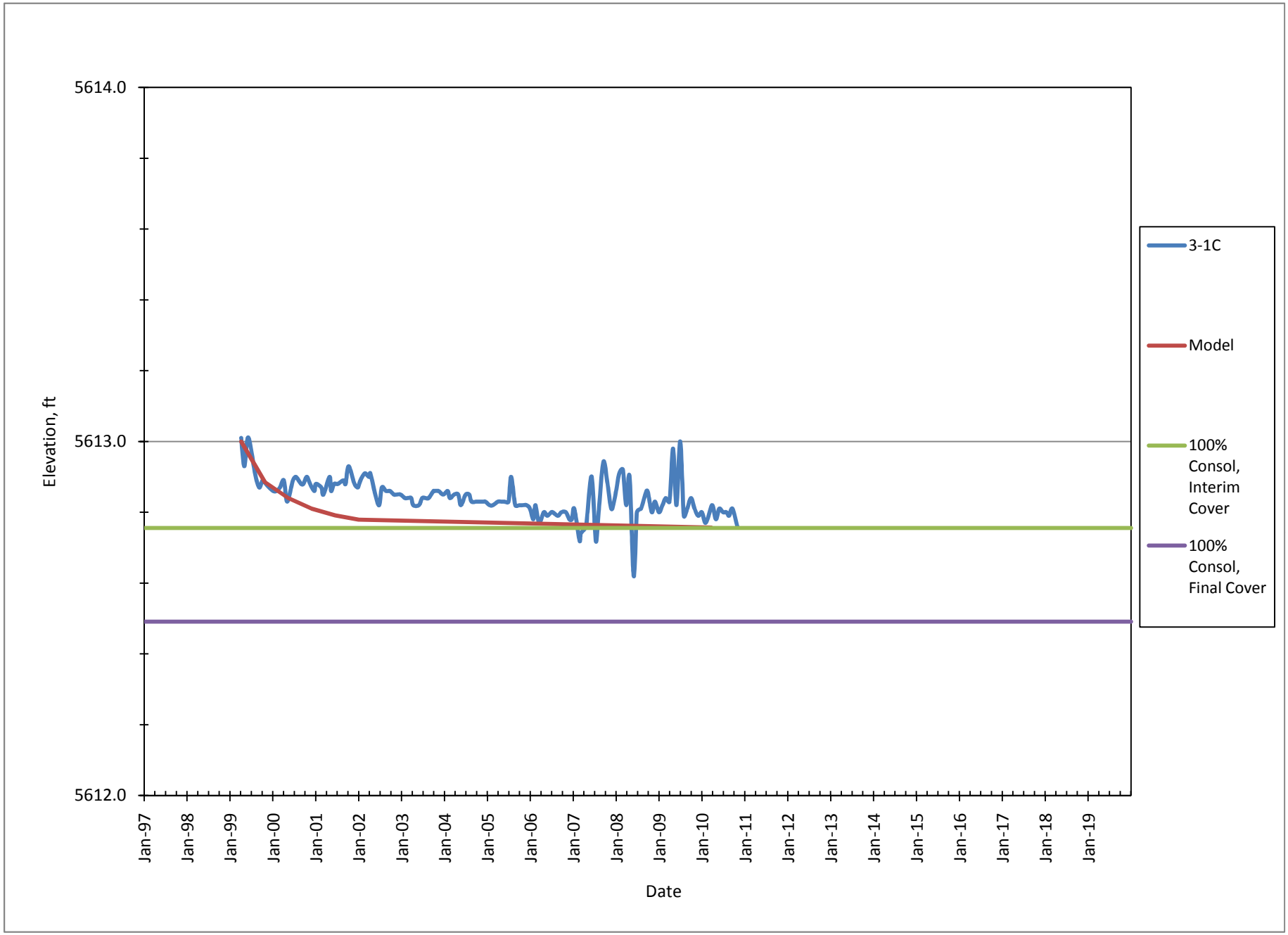
Date
3-1N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Jan-99
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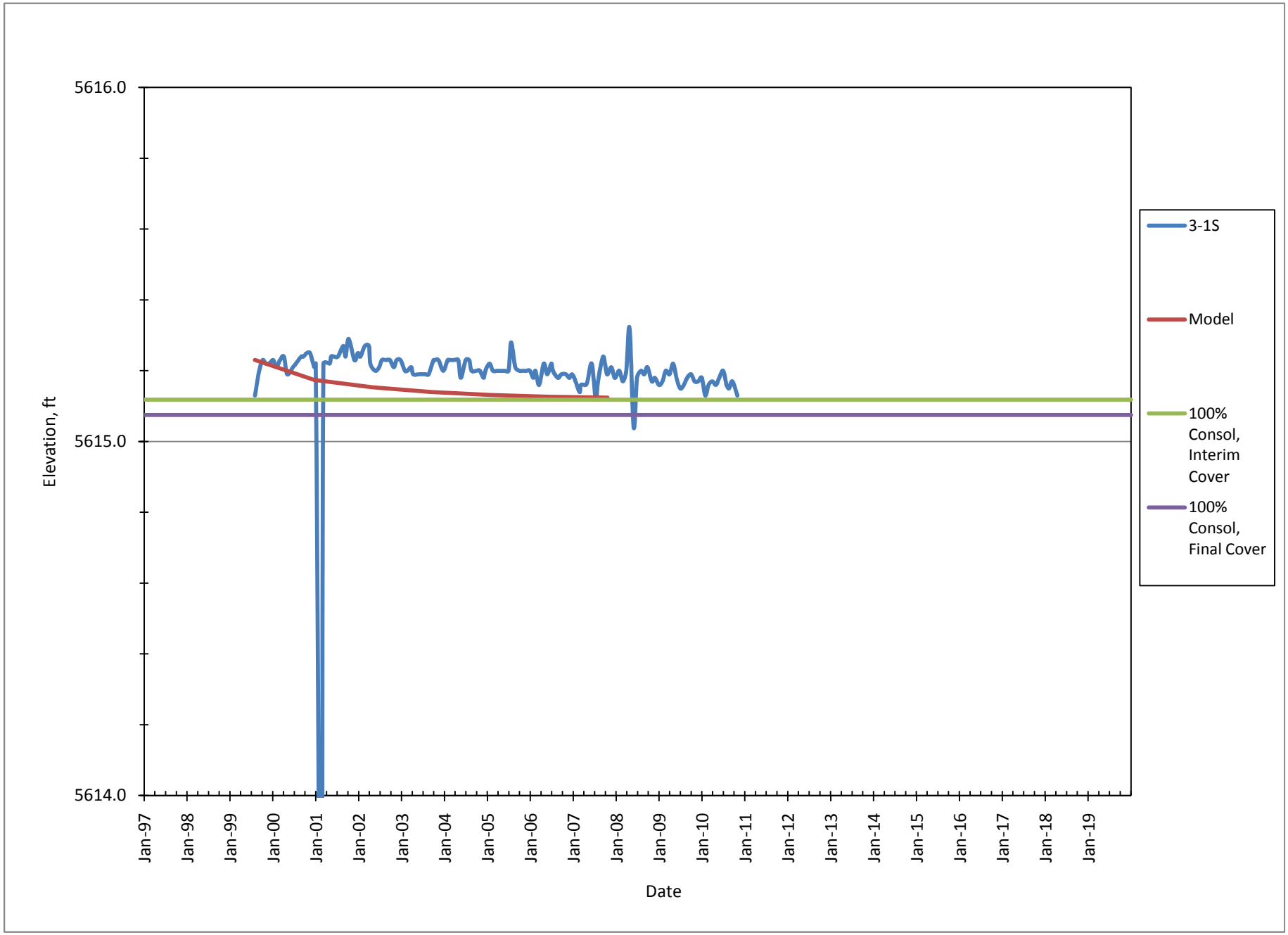
Date
3-1C
Model
100% Consol, Interim Cover
100% Consol, Final Cover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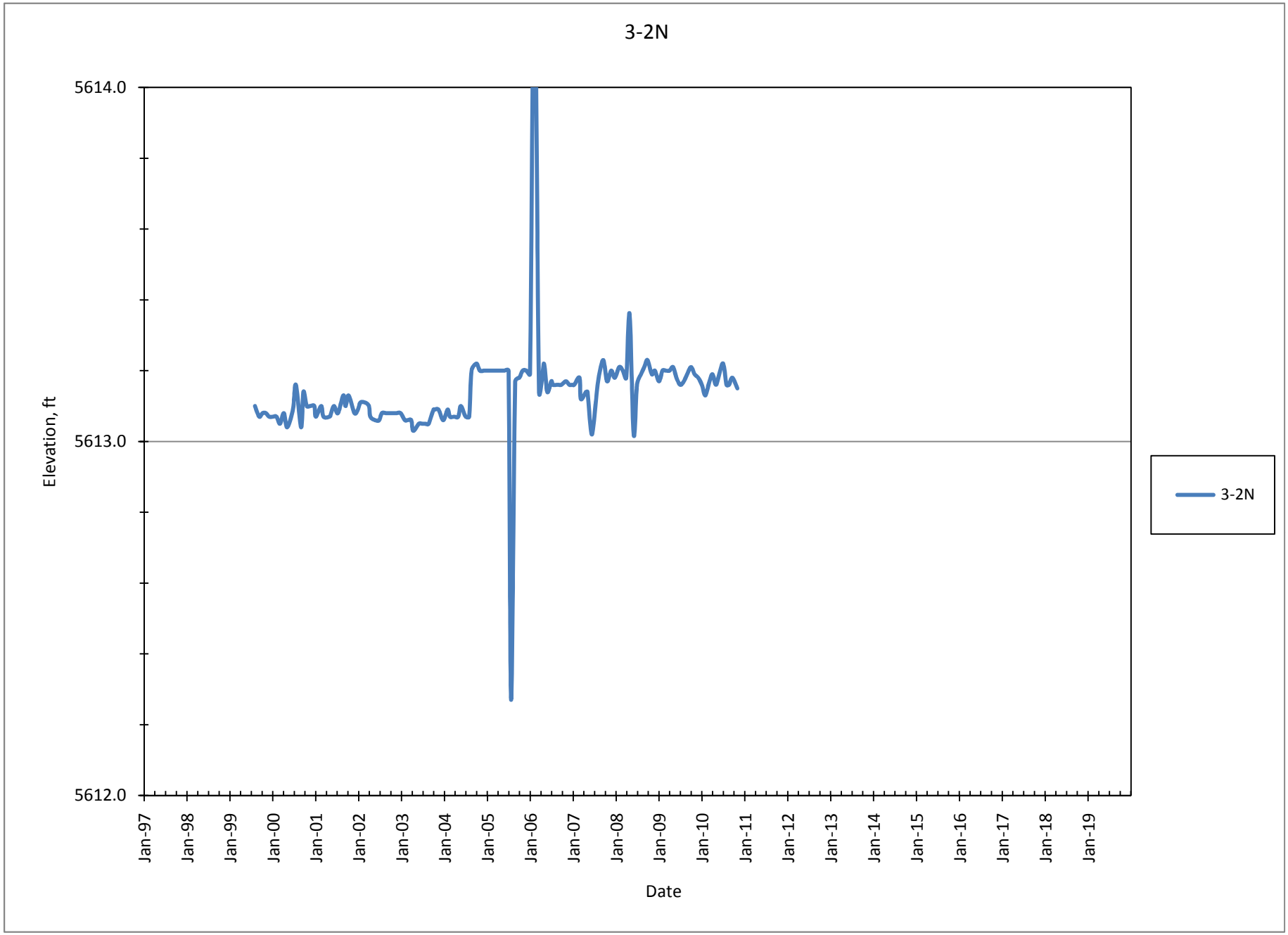
Model
100% Consol, Interim Cover
100% Consol, Final Cover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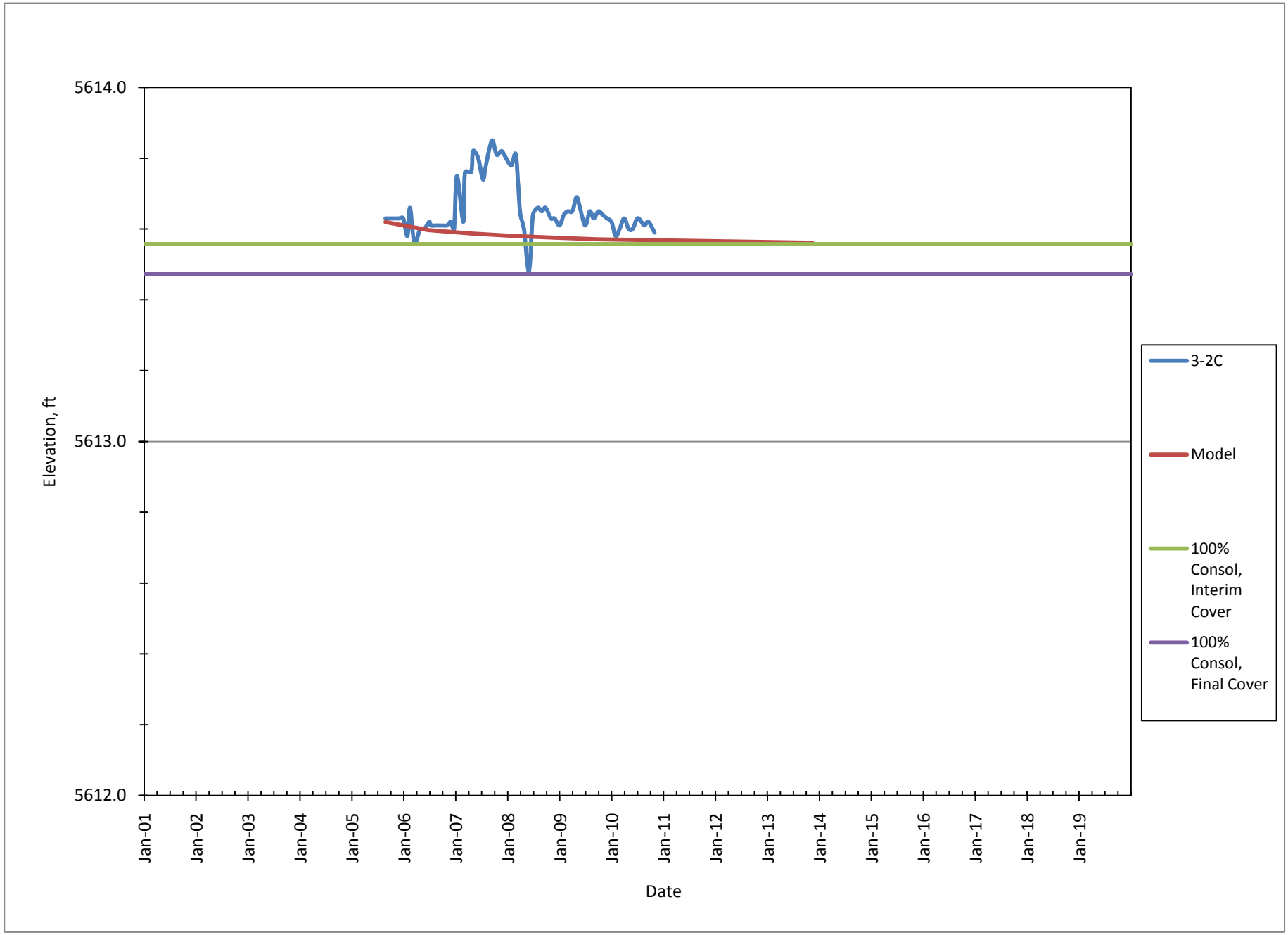
Jan-19
Date
3-2N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Elevation, ft
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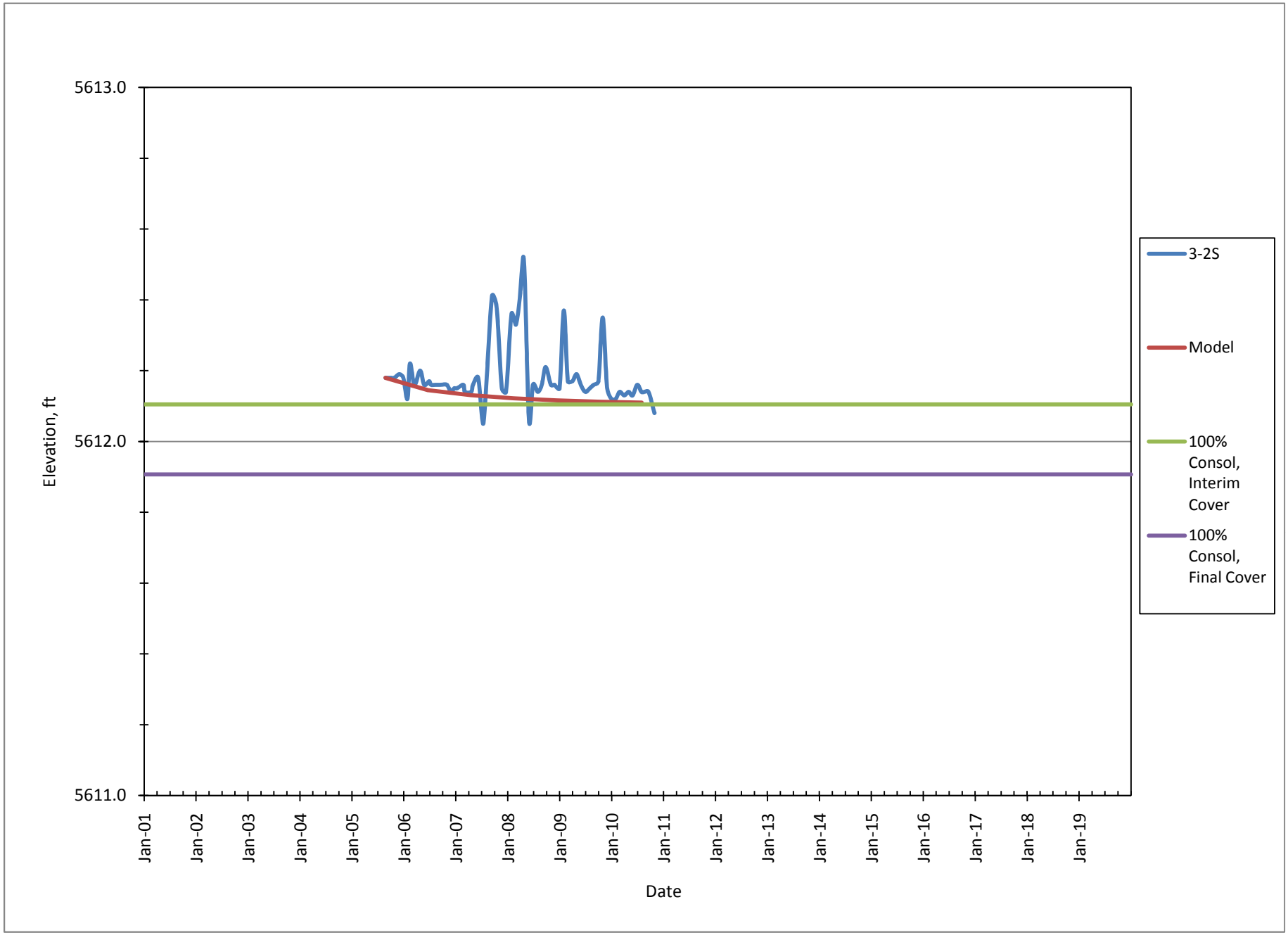
Date
3-2C
Model
100% Consol, Interim Cover
100% Consol, Final Cover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Elevation, ft
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Jan-19
Date
3-2S
Model
100% Consol, Interim Cover
100% Consol, Final Cover

ATTACHMENT F.2

SETTLEMENT CALCULATIONS

Client: Denison Mines
Project: White Mesa Mill Reclamation
Detail: Settlement Analysis of Reclaimed Cells

Job No.: 1009740
Date: 7/24/2011
Computed By: RTS

	Cell 4A Toe	Cell 2W1	Cell 2W2	Cell 2W3	Cell 2W4	2W5-C	2W4-N	2W4-S	2W5-N
Tailings Properties	1	2	3	4	5	6	7	8	9
Compression Index, Cc		0.28	0.57	0.27	0.51	0.047	0.047		
Coeff. Of Consol. Cv (cm^2/s)		0.0012	0.0020	0.0024	0.0024	0.0120	0.0040		
Coeff. Of Consol. Cv (ft^2/day)	0.00	0.11	0.19	0.22	0.22	1.12	0.37	0.00	0.00
Initial Void Ratio	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Specific Gravity	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Tails Sat Density (pcf)	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1
Tails Moist Density (pcf)	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
Tails Dry Density (pcf)	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3
Interim Cover Properties									
Moist Density (pcf)	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7
Final Cover Properties									
Moist Density (pcf)	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7
	Cell 4A Toe	Cell 2W1	Cell 2W2	Cell 2W3	Cell 2W4	2W5-C	2W4-N	2W4-S	2W5-N
Base Elevation		5598.5	5596.0	5594.5	5590.0	5585.5	5592.5	5587.0	5589.0
Tailings Elevation		5613.5	5613.5	5613.5	5613.5	5613.5	5613.5	5613.5	5613.5
Interim Cover Elevation		5618.1	5617.3	5617.5	5617.5	5617.4	5616.9	5612.8	5618.1
Final Cover Elevation		5623.5	5624.0	5624.5	5624.5	5624.5	5624.0	5623.0	5624.0
Thickness of Tailings (ft)		15.0	17.5	19.0	23.5	28.0	21.0	26.5	24.5
Thickness of Interim Cover (ft)		4.6	3.8	4.0	4.0	3.9	3.4	-0.7	4.6
Thickness of Final Cover (ft)		5.4	6.7	7.0	7.0	7.1	7.1	10.2	5.9
Midpoint Elevation of Tailings (ft)		5606.0	5604.8	5604.0	5601.8	5599.5	5603.0	5600.3	5601.3
Initial Elevation of Phreatic Surface (ft)		5610.50	5610.50	5610.50	5610.50	5610.50	5610.50	5610.50	5610.50
Initial Effective Stress (psf)		556.7	625.1	666.1	789.1	912.1	720.8	871.1	816.4
Elevation of Phreatic Surface after Interim Cover Construction (ft)		5610.5	5610.5	5610.5	5610.5	5610.5	5610.5	5610.5	5610.5
Incr. Stress due to Initial Drawdown (psf)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incr. Stress due to Interim Cover (psf)		463.2	382.6	402.7	402.7	392.7	342.3	-70.5	463.2
Total Settlement due to Interim Cover and Initial Drawdown (ft)		0.56	1.05	0.53	1.09	0.10	0.08	0.00	0.00
Incr. Stress due to Final Cover (psf)		613.8	761.5	795.6	795.6	807.0	807.0	1159.3	670.6
Incr. Stress due to Final Drawdown (psf)		0.0	0.0	0.0	12.2	122.3	0.0	85.6	36.7
Total Settlement due to Final Cover (ft)		0.37	1.02	0.51	1.07	0.13	0.10	0.00	0.00
Date of Interim Cover Placement		6/16/1989	8/22/1991	8/22/1991	8/22/1991	8/26/2005	8/26/2005	8/26/2005	8/3/1999
Date of Time Step 1		10/29/1990	1/3/1993	1/3/1993	1/3/1993	6/22/2006	6/22/2006	1/1/2009	8/3/2003
Date of Time Step 2		3/12/1992	5/18/1994	5/18/1994	5/18/1994	4/18/2007	4/18/2007	1/1/2009	8/3/2007
Date of Time Step 3		7/25/1993	9/30/1995	9/30/1995	9/30/1995	2/12/2008	2/12/2008	1/1/2009	1/1/2009
Date of Time Step 4		12/7/1994	2/11/1997	2/11/1997	2/11/1997	12/8/2008	12/8/2008	1/1/2009	1/1/2009
Date of Time Step 5		5/29/2000	6/26/1998	6/26/1998	6/26/1998	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Date of Time Step 6		1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Time Step 1: Days since Int Cover Place		500	500	500	500	300	300	1224	1461
Time Step 2: Days since Int Cover Place		1000	1000	1000	1000	600	600	1224	2922
Time Step 3: Days since Int Cover Place		1500	1500	1500	1500	900	900	1224	3439
Time Step 4: Days since Int Cover Place		2000	2000	2000	2000	1200	1200	1224	3439
Time Step 5: Days since Int Cover Place		4000	2500	2500	2500	1224	1224	1224	3439
Time Step 6: Days since Int Cover Place		7139	6342	6342	6342	1224	1224	1224	3439
Time factor Tv, for Interim Cover, TS 0		0	0	0	0	0	0	0	0
Time factor Tv, for Interim Cover, TS 1		0.2	0.3	0.3	0.2	0.4	0.3	0.0	0.0
Time factor Tv, for Interim Cover, TS 2		0.5	0.6	0.6	0.4	0.9	0.5	0.0	0.0
Time factor Tv, for Interim Cover, TS 3		0.7	0.9	0.9	0.6	1.3	0.8	0.0	0.0
Time factor Tv, for Interim Cover, TS 4		1.0	1.2	1.2	0.8	1.7	1.0	0.0	0.0
Time factor Tv, for Interim Cover, TS 5		2.0	1.5	1.5	1.0	1.7	1.0	0.0	0.0
Time factor Tv, for Interim Cover, TS 6		3.5	3.9	3.9	2.6	1.7	1.0	0.0	0.0
Deg. of Consol, Interim Cover, TS 0 (%)		0%	0%	0%	0%	0%	0%	0%	0%
Deg. of Consol, Interim Cover, TS 1 (%)		56%	61%	62%	51%	72%	56%	0%	0%
Deg. of Consol, Interim Cover, TS 2 (%)		76%	82%	82%	70%	90%	77%	0%	0%
Deg. of Consol, Interim Cover, TS 3 (%)		87%	91%	92%	82%	96%	88%	0%	0%
Deg. of Consol, Interim Cover, TS 4 (%)		93%	95%	96%	89%	98%	93%	0%	0%
Deg. of Consol, Interim Cover, TS 5 (%)		99%	97%	97%	93%	98%	93%	0%	0%
Deg. of Consol, Interim Cover, TS 6 (%)		100%	100%	100%	99%	98%	93%	0%	0%
Estimated Consol, Interim Cover, TS 1 (ft)		0.31	0.64	0.33	0.55	0.07	0.05	0.00	0.00
Estimated Consol, Interim Cover, TS 2 (ft)		0.43	0.86	0.44	0.76	0.09	0.06	0.00	0.00
Estimated Consol, Interim Cover, TS 3 (ft)		0.49	0.96	0.49	0.89	0.10	0.07	0.00	0.00
Estimated Consol, Interim Cover, TS 4 (ft)		0.52	1.00	0.51	0.97	0.10	0.08	0.00	0.00
Estimated Consol, Interim Cover, TS 5 (ft)		0.55	1.02	0.52	1.01	0.10	0.08	0.00	0.00
Estimated Consol, Interim Cover, TS 6 (ft)		0.56	1.04	0.53	1.08	0.10	0.08	0.00	0.00
Elevation of Initial Settlement Mon. read		5619.75	5622.12	5618.35	5618.50	5618.35	5619.26	5616.21	5618.90
Elev. Of Int Cover Surface, TS 1		5619.44	5621.48	5618.02	5617.95	5618.28	5619.21	5616.21	5618.90
Elev. Of Int Cover Surface, TS 2		5619.32	5621.26	5617.91	5617.74	5618.26	5619.20	5616.21	5618.90
Elev. Of Int Cover Surface, TS 3		5619.26	5621.16	5617.86	5617.61	5618.25	5619.19	5616.21	5618.90
Elev. Of Int Cover Surface, TS 4		5619.23	5621.12	5617.84	5617.53	5618.25	5619.18	5616.21	5618.90
Elev. Of Int Cover Surface, TS 5		5619.20	5621.10	5617.83	5617.49	5618.25	5619.18	5616.21	5618.90
Elev. Of Int Cover Surface, TS 6		5619.19	5621.08	5617.82	5617.42	5618.25	5619.18	5616.21	5618.90
Elevation of Phreatic Surface 2009 (ft)		5602.00	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00
Incr. Stress due to 2009 Drawdown (psf)		220.1	281.2	317.9	415.7	415.7	366.8	415.7	415.7
Total Settlement due to 2009 Drawdown (ft)		0.18	0.54	0.29	0.79	0.08	0.06	0.00	0.00
Date of 2009 Drawndow		1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Date of Time Step 1b		5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010
Date of Timestep 2b		9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011
Date of Timestep 3b		2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013
Time Step 1b: Days since 2009 Drawdown		500	500	500	500	500	500	500	500
Time Step 2b: Days since 2009 Drawdown		1000	1000	1000	1000	1000	1000	1000	1000
Time Step 3b: Days since 2009 Drawdown		1500	1500	1500	1500	1500	1500	1500	1500
Time Step 1b: Days since Int Cover Place		7639	7639	7639	7639	7639	7639	7639	7639
Time Step 2b: Days since Int Cover Place		8139	8139	8139	8139	8139	8139	8139	8139
Time Step 3b: Days since Int Cover Place		8639	8639	8639	8639	8639	8639	8639	8639
Time factor Tv, for 2009 Drawdown, TS 1b		1.0	1.2	1.2	0.8	2.8	1.7	0.0	0.0
Time factor Tv, for 2009 Drawdown, TS 2b		2.0	2.4	2.5	1.6	5.7	3.4	0.0	0.0
Time factor Tv, for 2009 Drawdown, TS 3b		3.0	3.6	3.7	2.4	8.5	5.1	0.0	0.0
Time factor Tv, for Interim Cover, TS 1b		15.2	18.6	18.9	12.3	43.5	25.8	0.0	0.0
Time factor Tv, for Interim Cover, TS 2b		16.1	19.8	20.1	13.2	46.3	27.5	0.0	0.0
Time factor Tv, for Interim Cover, TS 3b		17.1	21.0	21.4	14.0	49.2	29.1	0.0	0.0
Deg. of Consol, 2009 Drawdown, TS 1b (%)		93%	95%	96%	89%	99%	98%	0%	0%
Deg. of Consol, 2009 Drawdown, TS 2b (%)		99%	99%	99%	98%	100%	100%	0%	0%
Deg. of Consol, 2009 Drawdown, TS 3b (%)		99%	100%	100%	99%	100%	100%	0%	0%
Deg. of Consol, Interim Cover, TS 1b (%)		100%	100%	100%	100%	100%	100%	0%	0%
Deg. of Consol, Interim Cover, TS 2b (%)		100%	100%	100%	100%	100%	100%	0%	0%
Deg. of Consol, Interim Cover, TS 3b (%)		100%	100%	100%	100%	100%	100%	0%	0%
Estimated Consol, TS 1b (ft)		0.73	1.56	0.81	1.79	0.18	0.15	0.00	0.00
Estimated Consol, TS 2b (ft)		0.74	1.58	0.82	1.86	0.18	0.15	0.00	0.00
Estimated Consol, TS 3b (ft)		0.74	1.58	0.82	1.87	0.18	0.15	0.00	0.00
Elev. Of Int Cover Surface, TS 1b		5619.02	5620.56	5617.54	5616.71	5618.17	5619.11	5616.21	5618.90
Elev. Of Int Cover Surface, TS 2b		5619.01	5620.54	5617.53	5616.64	5618.17	5619.11	5616.21	5618.90
Elev. Of Int Cover Surface, TS 3b		5619.01	5620.54	5617.53	5616.63	5618.17	5619.11	5616.21	5618.90
Plot Date 1		1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989
Plot Date 2		1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020
100% Consol, Interim Cover		5619.19	5621.07	5617.82	5617.41	5618.25	5619.18	5616.21	5618.90
100% Consol, Final Cover		5618.64	5619.51	5617.01	5615.55	5618.04	5619.01	5616.21	5618.90

Client: Denison Mines
Project: White Mesa Mill Reclamation
Detail: Settlement Analysis of Reclaimed Cells

	2W3-S	2W5-S	Cell 2 East	2E1-N	2E1-1S	2E1-2S	2W7-C	2W7-N	2W7-S
Tailings Properties	10	11	12	13	14	15	16	17	18
Compression Index, Cc	0.36		0.18	0.09	0.07	0.05	0.07		0.03
Coeff. Of Consol. Cv (cm^2/s)	0.0040		0.0009	0.0024	0.0012	0.0020	0.0009		0.0040
Coeff. Of Consol. Cv (ft^2/day)	0.37	0.00	0.08	0.22	0.11	0.19	0.08	0.00	0.37
Initial Void Ratio	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Specific Gravity	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Tails Sat Density (pcf)	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1
Tails Moist Density (pcf)	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
Tails Dry Density (pcf)	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3
Interim Cover Properties									
Moist Density (pcf)	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7
Final Cover Properties									
Moist Density (pcf)	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7
	2W3-S	2W5-S	Cell 2 East	2E1-N	2E1-1S	2E1-2S	2W7-C	2W7-N	2W7-S
Base Elevation	5591.5	5583.0	5591.5	5599.0	5591.0	5589.0	5591.5	5593.0	5588.5
Tailings Elevation	5613.5	5613.5	5617.0	5621.4	5614.5	5613.5	5613.5	5613.5	5613.5
Interim Cover Elevation	5617.4	5611.4	5622.0	5625.9	5620.9	5619.0	5621.6	5621.7	5619.0
Final Cover Elevation	5623.5	5623.5	5629.5	5631.0	5628.0	5626.5	5625.5	5627.0	5624.0
Thickness of Tailings (ft)	22.0	30.5	25.5	22.4	23.5	24.5	22.0	20.5	25.0
Thickness of Interim Cover (ft)	3.9	-2.1	5.0	4.5	6.4	5.5	8.1	8.2	5.5
Thickness of Final Cover (ft)	6.1	12.1	7.5	5.1	7.1	7.5	3.9	5.3	5.0
Midpoint Elevation of Tailings (ft)	5602.5	5598.3	5604.3	5610.2	5602.8	5601.3	5602.5	5603.3	5601.0
Initial Elevation of Phreatic Surface (ft)	5610.50	5610.50	5614.00	5618.40	5611.50	5610.50	5610.50	5610.50	5610.50
Initial Effective Stress (psf)	748.1	980.4	843.8	759.0	789.1	816.4	748.1	707.1	830.1
Elevation of Phreatic Surface after Interim Cover Construction (ft)	5610.5	5610.5	5614.0	5618.4	5611.5	5610.5	5610.5	5610.5	5610.5
Incr. Stress due to Initial Drawdown (psf)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incr. Stress due to Interim Cover (psf)	392.7	-211.4	503.4	453.1	644.4	553.8	815.6	825.6	553.8
Total Settlement due to Interim Cover and Initial Drawdown (ft)	0.74	0.00	0.47	0.21	0.22	0.14	0.25	0.00	0.08
Incr. Stress due to Final Cover (psf)	693.3	1375.3	852.5	579.7	807.0	852.5	443.3	602.4	568.3
Incr. Stress due to Final Drawdown (psf)	0.0	183.4	0.0	0.0	0.0	36.7	0.0	0.0	48.9
Total Settlement due to Final Cover (ft)	0.65	0.00	0.39	0.14	0.13	0.11	0.07	0.00	0.05
Date of Interim Cover Placement	5/4/1999	4/30/2010	6/16/1989	9/3/1998	9/3/1998	9/3/1998	5/4/1999	8/26/2005	8/26/2005
Date of Time Step 1	11/20/1999	4/30/2014	6/16/1993	6/30/1999	5/30/2001	11/11/2000	6/7/2000	3/14/2006	4/13/2006
Date of Time Step 2	6/7/2000	4/30/2014	6/16/1997	4/25/2000	2/24/2004	1/20/2003	7/12/2001	9/30/2006	11/29/2006
Date of Time Step 3	12/24/2000	4/30/2014	6/16/2001	2/19/2001	11/20/2006	3/30/2005	8/16/2002	4/18/2007	7/17/2007
Date of Time Step 4	1/28/2002	4/30/2014	6/16/2005	12/16/2001	1/1/2009	6/8/2007	9/20/2003	11/4/2007	3/3/2008
Date of Time Step 5	7/21/2007	4/30/2014	1/1/2009	10/12/2002	1/1/2009	1/1/2009	12/2/2008	5/22/2008	10/19/2008
Date of Time Step 6	1/1/2010	4/30/2014	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Time Step 1: Days since Int Cover Place	200	1461	1461	300	1000	800	400	200	230
Time Step 2: Days since Int Cover Place	400	1461	2922	600	2000	1600	800	400	460
Time Step 3: Days since Int Cover Place	600	1461	4383	900	3000	2400	1200	600	690
Time Step 4: Days since Int Cover Place	1000	1461	5844	1200	3773	3200	1600	800	920
Time Step 5: Days since Int Cover Place	3000	1461	7139	1500	3773	3773	3500	1000	1150
Time Step 6: Days since Int Cover Place	3895	1461	7139	3773	3773	3773	3530	1224	1224
Time factor Tv, for Interim Cover, TS 0	0	0	0	0	0	0	0	0	0
Time factor Tv, for Interim Cover, TS 1	0.2	0.0	0.2	0.1	0.2	0.2	0.1	0.0	0.1
Time factor Tv, for Interim Cover, TS 2	0.3	0.0	0.4	0.3	0.4	0.5	0.1	0.0	0.3
Time factor Tv, for Interim Cover, TS 3	0.5	0.0	0.6	0.4	0.6	0.7	0.2	0.0	0.4
Time factor Tv, for Interim Cover, TS 4	0.8	0.0	0.8	0.5	0.8	1.0	0.3	0.0	0.5
Time factor Tv, for Interim Cover, TS 5	2.3	0.0	0.9	0.7	0.8	1.2	0.6	0.0	0.7
Time factor Tv, for Interim Cover, TS 6	3.0	0.0	0.9	1.7	0.8	1.2	0.6	0.0	0.7
Deg. of Consol, Interim Cover, TS 0 (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Deg. of Consol, Interim Cover, TS 1 (%)	44%	0%	49%	41%	51%	56%	30%	0%	42%
Deg. of Consol, Interim Cover, TS 2 (%)	62%	0%	68%	58%	70%	76%	42%	0%	59%
Deg. of Consol, Interim Cover, TS 3 (%)	74%	0%	80%	70%	82%	87%	51%	0%	70%
Deg. of Consol, Interim Cover, TS 4 (%)	88%	0%	87%	78%	88%	93%	59%	0%	79%
Deg. of Consol, Interim Cover, TS 5 (%)	99%	0%	91%	84%	88%	95%	82%	0%	85%
Deg. of Consol, Interim Cover, TS 6 (%)	99%	0%	91%	98%	88%	95%	82%	0%	87%
Estimated Consol, Interim Cover, TS 1 (ft)	0.32	0.00	0.23	0.09	0.11	0.08	0.07	0.00	0.04
Estimated Consol, Interim Cover, TS 2 (ft)	0.45	0.00	0.32	0.12	0.15	0.11	0.10	0.00	0.05
Estimated Consol, Interim Cover, TS 3 (ft)	0.54	0.00	0.38	0.14	0.18	0.12	0.13	0.00	0.06
Estimated Consol, Interim Cover, TS 4 (ft)	0.65	0.00	0.41	0.16	0.19	0.13	0.15	0.00	0.07
Estimated Consol, Interim Cover, TS 5 (ft)	0.73	0.00	0.43	0.18	0.19	0.13	0.20	0.00	0.07
Estimated Consol, Interim Cover, TS 6 (ft)	0.73	0.00	0.43	0.20	0.19	0.13	0.21	0.00	0.07
Elevation of Initial Settlement Mon. read	5617.40	5614.10	5624.30	5627.60	5623.07	5619.65	5622.44	5621.50	5619.95
Elev. Of Int Cover Surface, TS 1	5617.08	5614.10	5624.07	5627.51	5622.96	5619.57	5622.37	5621.50	5619.91
Elev. Of Int Cover Surface, TS 2	5616.95	5614.10	5623.98	5627.48	5622.92	5619.54	5622.34	5621.50	5619.90
Elev. Of Int Cover Surface, TS 3	5616.86	5614.10	5623.92	5627.46	5622.89	5619.53	5622.31	5621.50	5619.89
Elev. Of Int Cover Surface, TS 4	5616.75	5614.10	5623.89	5627.44	5622.88	5619.52	5622.29	5621.50	5619.88
Elev. Of Int Cover Surface, TS 5	5616.67	5614.10	5623.87	5627.42	5622.88	5619.52	5622.24	5621.50	5619.88
Elev. Of Int Cover Surface, TS 6	5616.67	5614.10	5623.87	5627.40	5622.88	5619.52	5622.23	5621.50	5619.88
Elevation of Phreatic Surface 2009 (ft)	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00	5602.00
Incr. Stress due to 2009 Drawdown (psf)	391.2	415.7	476.8	401.0	427.9	415.7	391.2	354.5	415.7
Total Settlement due to 2009 Drawdown (ft)	0.51	0.00	0.31	0.13	0.09	0.07	0.08	0.00	0.04
Date of 2009 Drawndow	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Date of Time Step 1b	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010	5/16/2010
Date of Timestep 2b	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011	9/28/2011
Date of Timestep 3b	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013	2/9/2013
Time Step 1b: Days since 2009 Drawdown	500	500	500	500	500	500	500	500	500
Time Step 2b: Days since 2009 Drawdown	1000	1000	1000	1000	1000	1000	1000	1000	1000
Time Step 3b: Days since 2009 Drawdown	1500	1500	1500	1500	1500	1500	1500	1500	1500
Time Step 1b: Days since Int Cover Place	7639	7639	7639	7639	7639	7639	7639	7639	7639
Time Step 2b: Days since Int Cover Place	8139	8139	8139	8139	8139	8139	8139	8139	8139
Time Step 3b: Days since Int Cover Place	8639	8639	8639	8639	8639	8639	8639	8639	8639
Time factor Tv, for 2009 Drawdown, TS 1b	1.5	0.0	0.3	0.9	0.4	0.6	0.3	0.0	1.2
Time factor Tv, for 2009 Drawdown, TS 2b	3.1	0.0	0.5	1.8	0.8	1.2	0.7	0.0	2.4
Time factor Tv, for 2009 Drawdown, TS 3b	4.6	0.0	0.8	2.7	1.2	1.9	1.0	0.0	3.6
Time factor Tv, for Interim Cover, TS 1b	23.5	0.0	3.9	13.6	6.2	9.5	5.3	0.0	18.2
Time factor Tv, for Interim Cover, TS 2b	25.0	0.0	4.2	14.5	6.6	10.1	5.6	0.0	19.4
Time factor Tv, for Interim Cover, TS 3b	26.6	0.0	4.4	15.4	7.0	10.7	6.0	0.0	20.6
Deg. of Consol, 2009 Drawdown, TS 1b (%)	97%	0%	57%	91%	70%	82%	65%	0%	95%
Deg. of Consol, 2009 Drawdown, TS 2b (%)	99%	0%	77%	98%	89%	96%	85%	0%	99%
Deg. of Consol, 2009 Drawdown, TS 3b (%)	100%	0%	88%	99%	95%	98%	93%	0%	100%
Deg. of Consol, Interim Cover, TS 1b (%)	100%	0%	100%	100%	100%	100%	100%	0%	100%
Deg. of Consol, Interim Cover, TS 2b (%)	100%	0%	100%	100%	100%	100%	100%	0%	100%
Deg. of Consol, Interim Cover, TS 3b (%)	100%	0%	100%	100%	100%	100%	100%	0%	100%
Estimated Consol, TS 1b (ft)	1.23	0.00	0.65	0.32	0.28	0.20	0.30	0.00	0.13
Estimated Consol, TS 2b (ft)	1.24	0.00	0.71	0.33	0.30	0.21	0.31	0.00	0.13
Estimated Consol, TS 3b (ft)	1.25	0.00	0.74	0.33	0.31	0.21	0.32	0.00	0.13
Elev. Of Int Cover Surface, TS 1b	5616.17	5614.10	5623.65	5627.28	5622.79	5619.45	5622.14	5621.50	5619.82
Elev. Of Int Cover Surface, TS 2b	5616.16	5614.10	5623.59	5627.27	5622.77	5619.44	5622.13	5621.50	5619.82
Elev. Of Int Cover Surface, TS 3b	5616.15	5614.10	5623.56	5627.27	5622.76	5619.44	5622.12	5621.50	5619.82
Plot Date 1	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989
Plot Date 2	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020
100% Consol, Interim Cover	5616.66	5614.10	5623.83	5627.39	5622.85	5619.51	5622.19	5621.50	5619.87
100% Consol, Final Cover	5615.50	5614.10	5623.13	5627.13	5622.63	5619.33	5622.04	5621.50	5619.77

Client: **Denison Mines**
Project: **White Mesa Mill Reclamation**
Detail: **Settlement Analysis of Reclaimed Cells**

	2W6-N	2W6-C	2W6-S	3-1N	3-1C	3-1S	3-2N	3-2C	3-2S
Tailings Properties	19	20	21	22	23	24	25	26	27
Compression Index, Cc	0.05	0.09	0.16		0.12	0.04		0.03	0.06
Coeff. Of Consol. Cv (cm^2/s)	0.0020	0.0040	0.0040		0.0032	0.0016		0.0024	0.0040
Coeff. Of Consol. Cv (ft^2/day)	0.19	0.37	0.37	0.00	0.30	0.15	0.00	0.22	0.37
Initial Void Ratio	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Specific Gravity	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Tails Sat Density (pcf)	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1
Tails Moist Density (pcf)	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
Tails Dry Density (pcf)	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3
Interim Cover Properties									
Moist Density (pcf)	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7
Final Cover Properties									
Moist Density (pcf)	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7
	2W6-N	2W6-C	2W6-S	3-1N	3-1C	3-1S	3-2N	3-2C	3-2S
Base Elevation	5591.0	5586.0	5585.0	5591.0	5590.0	5589.0	5584.0	5583.5	5583.0
Tailings Elevation	5613.5	5613.5	5613.5	5608.5	5608.5	5608.5	5608.5	5608.5	5608.5
Interim Cover Elevation	5616.4	5616.2	5615.8	5613.6	5612.7	5614.7	5611.9	5612.3	5610.6
Final Cover Elevation	5624.5	5625.0	5623.5	5621.0	5619.5	5618.0	5621.0	5619.5	5618.0
Thickness of Tailings (ft)	22.5	27.5	28.5	17.5	18.5	19.5	24.5	25.0	25.5
Thickness of Interim Cover (ft)	2.9	2.7	2.3	5.1	4.2	6.2	3.4	3.8	2.1
Thickness of Final Cover (ft)	8.1	8.8	7.7	7.4	6.8	3.3	9.1	7.2	7.4
Midpoint Elevation of Tailings (ft)	5602.3	5599.8	5599.3	5599.8	5599.3	5598.8	5596.3	5596.0	5595.8
Initial Elevation of Phreatic Surface (ft)	5610.50	5610.50	5610.50	5605.50	5605.50	5605.50	5605.50	5605.50	5605.50
Initial Effective Stress (psf)	761.8	898.4	925.8	625.1	652.4	679.7	816.4	830.1	843.8
Elevation of Phreatic Surface after Interim Cover Construction (ft)	5610.5	5610.5	5610.5	5605.5	5605.5	5605.5	5605.5	5605.5	5605.5
Incr. Stress due to Initial Drawdown (psf)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incr. Stress due to Interim Cover (psf)	292.0	271.9	231.6	513.5	422.9	624.2	342.3	382.6	211.4
Total Settlement due to Interim Cover and Initial Drawdown (ft)	0.08	0.14	0.22	0.00	0.24	0.11	0.00	0.06	0.08
Incr. Stress due to Final Cover (psf)	920.7	1000.2	875.2	841.1	772.9	375.1	1034.3	818.4	841.1
Incr. Stress due to Final Drawdown (psf)	0.0	110.0	134.5	0.0					
Total Settlement due to Final Cover (ft)	0.12	0.29	0.50	0.00	0.26	0.04	0.00	0.09	0.20
Date of Interim Cover Placement	8/26/2005	8/26/2005	8/26/2005	8/3/1999	4/8/1999	8/3/1999	8/3/1999	8/26/2005	8/26/2005
Date of Time Step 1	4/13/2006	4/13/2006	4/13/2006	5/29/2000	10/25/1999	12/15/2000	5/29/2000	6/22/2006	6/22/2006
Date of Time Step 2	11/29/2006	11/29/2006	11/29/2006	3/25/2001	5/12/2000	4/29/2002	3/25/2001	4/18/2007	4/18/2007
Date of Time Step 3	7/17/2007	7/17/2007	7/17/2007	1/19/2002	11/28/2000	9/11/2003	1/19/2002	2/12/2008	2/12/2008
Date of Time Step 4	3/3/2008	3/3/2008	3/3/2008	11/15/2002	6/16/2001	1/23/2005	11/15/2002	12/8/2008	12/8/2008
Date of Time Step 5	10/19/2008	10/19/2008	10/19/2008	9/11/2003	1/2/2002	6/7/2006	9/11/2003	10/4/2009	10/4/2009
Date of Time Step 6	1/1/2009	1/1/2009	1/1/2009	7/7/2004	3/21/2010	10/20/2007	7/7/2004	11/12/2013	7/31/2010
Time Step 1: Days since Int Cover Place	230	230	230	300	200	500	300	300	300
Time Step 2: Days since Int Cover Place	460	460	460	600	400	1000	600	600	600
Time Step 3: Days since Int Cover Place	690	690	690	900	600	1500	900	900	900
Time Step 4: Days since Int Cover Place	920	920	920	1200	800	2000	1200	1200	1200
Time Step 5: Days since Int Cover Place	1150	1150	1150	1500	1000	2500	1500	1500	1500
Time Step 6: Days since Int Cover Place	1224	1224	1224	1800	4000	3000	1800	3000	1800
Time factor Tv, for Interim Cover, TS 0	0	0	0	0	0	0	0	0	0
Time factor Tv, for Interim Cover, TS 1	0.1	0.1	0.1	0.0	0.2	0.2	0.0	0.1	0.2
Time factor Tv, for Interim Cover, TS 2	0.2	0.2	0.2	0.0	0.3	0.4	0.0	0.2	0.3
Time factor Tv, for Interim Cover, TS 3	0.3	0.3	0.3	0.0	0.5	0.6	0.0	0.3	0.5
Time factor Tv, for Interim Cover, TS 4	0.3	0.5	0.4	0.0	0.7	0.8	0.0	0.4	0.7
Time factor Tv, for Interim Cover, TS 5	0.4	0.6	0.5	0.0	0.9	1.0	0.0	0.5	0.9
Time factor Tv, for Interim Cover, TS 6	0.4	0.6	0.6	0.0	3.5	1.2	0.0	1.1	1.0
Deg. of Consol, Interim Cover, TS 0 (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Deg. of Consol, Interim Cover, TS 1 (%)	33%	38%	37%	0%	47%	50%	0%	37%	47%
Deg. of Consol, Interim Cover, TS 2 (%)	46%	53%	52%	0%	65%	69%	0%	52%	65%
Deg. of Consol, Interim Cover, TS 3 (%)	56%	65%	63%	0%	78%	81%	0%	63%	77%
Deg. of Consol, Interim Cover, TS 4 (%)	65%	73%	71%	0%	85%	88%	0%	72%	85%
Deg. of Consol, Interim Cover, TS 5 (%)	71%	80%	78%	0%	90%	93%	0%	78%	90%
Deg. of Consol, Interim Cover, TS 6 (%)	73%	82%	80%	0%	100%	95%	0%	94%	93%
Estimated Consol, Interim Cover, TS 1 (ft)	0.03	0.05	0.08	0.00	0.11	0.06	0.00	0.02	0.04
Estimated Consol, Interim Cover, TS 2 (ft)	0.04	0.08	0.12	0.00	0.16	0.08	0.00	0.03	0.05
Estimated Consol, Interim Cover, TS 3 (ft)	0.05	0.09	0.14	0.00	0.19	0.09	0.00	0.04	0.06
Estimated Consol, Interim Cover, TS 4 (ft)	0.05	0.11	0.16	0.00	0.21	0.10	0.00	0.04	0.06
Estimated Consol, Interim Cover, TS 5 (ft)	0.06	0.12	0.17	0.00	0.22	0.10	0.00	0.05	0.07
Estimated Consol, Interim Cover, TS 6 (ft)	0.06	0.12	0.18	0.00	0.24	0.11	0.00	0.06	0.07
Elevation of Initial Settlement Mon. read	5620.52	5618.20	5616.60	5617.20	5613.00	5615.23	5613.10	5613.62	5612.18
Elev. Of Int Cover Surface, TS 1	5620.49	5618.15	5616.52	5617.20	5612.89	5615.17	5613.10	5613.60	5612.14
Elev. Of Int Cover Surface, TS 2	5620.48	5618.12	5616.48	5617.20	5612.84	5615.15	5613.10	5613.59	5612.13
Elev. Of Int Cover Surface, TS 3	5620.47	5618.11	5616.46	5617.20	5612.81	5615.14	5613.10	5613.58	5612.12
Elev. Of Int Cover Surface, TS 4	5620.47	5618.09	5616.44	5617.20	5612.79	5615.13	5613.10	5613.58	5612.12
Elev. Of Int Cover Surface, TS 5	5620.46	5618.08	5616.43	5617.20	5612.78	5615.13	5613.10	5613.57	5612.11
Elev. Of Int Cover Surface, TS 6	5620.46	5618.08	5616.42	5617.20	5612.76	5615.12	5613.10	5613.56	5612.11
Elevation of Phreatic Surface 2009 (ft)	5602.00	5602.00	5602.00						
Incr. Stress due to 2009 Drawdown (psf)	403.4	415.7	415.7						
Total Settlement due to 2009 Drawdown (ft)	0.08	0.17	0.31						
Date of 2009 Drawndow	1/1/2009	1/1/2009	1/1/2009						
Date of Time Step 1b	5/16/2010	5/16/2010	5/16/2010						
Date of Timestep 2b	9/28/2011	9/28/2011	9/28/2011						
Date of Timestep 3b	2/9/2013	2/9/2013	2/9/2013						
Time Step 1b: Days since 2009 Drawdown	500	500	500						
Time Step 2b: Days since 2009 Drawdown	1000	1000	1000						
Time Step 3b: Days since 2009 Drawdown	1500	1500	1500						
Time Step 1b: Days since Int Cover Place	7639	7639	7639						
Time Step 2b: Days since Int Cover Place	8139	8139	8139						
Time Step 3b: Days since Int Cover Place	8639	8639	8639						
Time factor Tv, for 2009 Drawdown, TS 1b	0.7	1.0	0.9						
Time factor Tv, for 2009 Drawdown, TS 2b	1.5	2.0	1.8						
Time factor Tv, for 2009 Drawdown, TS 3b	2.2	3.0	2.7						
Time factor Tv, for Interim Cover, TS 1b	11.2	15.0	14.0						
Time factor Tv, for Interim Cover, TS 2b	12.0	16.0	14.9						
Time factor Tv, for Interim Cover, TS 3b	12.7	17.0	15.8						
Deg. of Consol, 2009 Drawdown, TS 1b (%)	87%	93%	91%						
Deg. of Consol, 2009 Drawdown, TS 2b (%)	97%	99%	98%						
Deg. of Consol, 2009 Drawdown, TS 3b (%)	99%	99%	99%						
Deg. of Consol, Interim Cover, TS 1b (%)	100%	100%	100%						
Deg. of Consol, Interim Cover, TS 2b (%)	100%	100%	100%						
Deg. of Consol, Interim Cover, TS 3b (%)	100%	100%	100%						
Estimated Consol, TS 1b (ft)	0.15	0.30	0.51						
Estimated Consol, TS 2b (ft)	0.16	0.31	0.53						
Estimated Consol, TS 3b (ft)	0.16	0.31	0.53						
Elev. Of Int Cover Surface, TS 1b	5620.37	5617.90	5616.09						
Elev. Of Int Cover Surface, TS 2b	5620.36	5617.89	5616.07						
Elev. Of Int Cover Surface, TS 3b	5620.36	5617.89	5616.07						
Plot Date 1	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989	1/1/1989
Plot Date 2	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020	1/1/2020
100% Consol, Interim Cover	5620.44	5618.06	5616.38	5617.20	5612.76	5615.12	5613.10	5613.56	5612.10
100% Consol, Final Cover	5620.24	5617.60	5615.57	5617.20	5612.49	5615.07	5613.10	5613.47	5611.91

Client: **Denison Mines**
Project: **White Mesa Mill Reclamation**
Detail: **Settlement Analysis of Reclaimed Cells**

	Min Soil Prop			Max Soil Prop			Ave Soil Prop		
	Max Tailings Depth in Cell 2 along inside slope	**Max Tailings Depth in Cell 3 along inside slope**	**Max Tailings Depth in Cell 4A/4B along inside slope**	**Max Tailings Depth in Cell 2 along inside slope**	**Max Tailings Depth in Cell 3 along inside slope**	**Max Tailings Depth in Cell 4A/4B along inside slope**	**Max Tailings Depth in Cell 2 along inside slope**	**Max Tailings Depth in Cell 3 along inside slope**	**Max Tailings Depth in Cell 4A/4B along inside slope**
Tailings Properties									
Compression Index, Cc	0.03	0.03	0.03	0.57	0.57	0.57	0.16	0.16	0.16
Coeff. Of Consol. Cv (cm^2/s)	0.0009	0.0009	0.0009	0.0120	0.0120	0.0120	0.0025	0.0025	0.0025
Coeff. Of Consol. Cv (ft^2/day)	0.08	0.08	0.08	1.12	1.12	1.12	0.23	0.23	0.23
Initial Void Ratio	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Specific Gravity	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Tails Sat Density (pcf)	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1
Tails Moist Density (pcf)	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
Tails Dry Density (pcf)	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3
Interim Cover Properties									
Moist Density (pcf)	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7
Final Cover Properties									
Moist Density (pcf)	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7
	n Consol Propert	n Consol Propert	n Consol Propert	x Consol Propert	x Consol Propert	x Consol Propert	e Consol Propert	e Consol Propert	e Consol Propert
Base Elevation	5581.0	5570.0	5558.0	5581.0	5570.0	5558.0	5581.0	5570.0	5558.0
Tailings Elevation	5613.5	5608.5	5598.5	5613.5	5608.5	5598.5	5613.5	5608.5	5598.5
Interim Cover Elevation	5615.8	5611.0	5601.0	5615.8	5611.0	5601.0	5615.8	5611.0	5601.0
Final Cover Elevation	5623.5	5617.5	5607.5	5623.5	5617.5	5607.5	5623.5	5617.5	5607.5
Thickness of Tailings (ft)	32.5	38.5	40.5	32.5	38.5	40.5	32.5	38.5	40.5
Thickness of Interim Cover (ft)	2.3	2.5	2.5	2.3	2.5	2.5	2.3	2.5	2.5
Thickness of Final Cover (ft)	7.7	6.5	6.5	7.7	6.5	6.5	7.7	6.5	6.5
Midpoint Elevation of Tailings (ft)	5597.3	5589.3	5578.3	5597.3	5589.3	5578.3	5597.3	5589.3	5578.3
Initial Elevation of Phreatic Surface (ft)	5602.00	5605.50	5595.50	5602.00	5605.50	5595.50	5602.00	5605.50	5595.50
Initial Effective Stress (psf)	1682.3	1199.1	1253.8	1682.3	1199.1	1253.8	1682.3	1199.1	1253.8
Elevation of Phreatic Surface after Interim Cover Construction (ft)	5581.0	5570.0	5558.0	5581.0	5570.0	5558.0	5581.0	5570.0	5558.0
Incr. Stress due to Initial Drawdown (psf)	232.3	794.6	843.5	232.3	794.6	843.5	232.3	794.6	843.5
Incr. Stress due to Interim Cover (psf)	0.0	251.7	251.7	0.0	251.7	251.7	0.0	251.7	251.7
Total Settlement due to Interim Cover and Initial Drawdown (ft)	0.03	0.16	0.17	0.53	3.03	3.19	0.14	0.83	0.87
Incr. Stress due to Final Cover (psf)	875.2	738.8	738.8	875.2	738.8	738.8	875.2	738.8	738.8
Incr. Stress due to Final Drawdown (psf)									
Total Settlement due to Final Cover (ft)	0.08	0.07	0.07	1.54	1.37	1.39	0.42	0.38	0.38
Date of Interim Cover Placement	0	0	0	0	0	0	0	0	0
Date of Time Step 1	1.2	1.8	1.9	0.1	0.1	0.1	0.4	0.6	0.7
Date of Time Step 2	2.5	3.5	3.8	0.2	0.3	0.3	0.9	1.3	1.4
Date of Time Step 3	3.7	5.3	5.7	0.3	0.4	0.4	1.3	1.9	2.1
Date of Time Step 4	4.9	7.0	7.7	0.4	0.5	0.6	1.8	2.5	2.7
Date of Time Step 5	6.2	8.8	9.6	0.5	0.6	0.7	2.2	3.1	3.4
Date of Time Step 6	7.4	10.5	11.5	0.6	0.8	0.8	2.6	3.8	4.1
Time Step 1: Days since Int Cover Place	450	640	700	34	46	51	160	230	250
Time Step 2: Days since Int Cover Place	900	1280	1400	68	92	102	320	460	500
Time Step 3: Days since Int Cover Place	1350	1920	2100	102	138	153	480	690	750
Time Step 4: Days since Int Cover Place	1800	2560	2800	136	184	204	640	920	1000
Time Step 5: Days since Int Cover Place	2250	3200	3500	170	230	255	800	1150	1250
Time Step 6: Days since Int Cover Place	2700	3840	4200	204	276	306	960	1380	1500
Time factor Tv, for Interim Cover, TS 0	0	0	0	0	0	0	0	0	0
Time factor Tv, for Interim Cover, TS 1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Time factor Tv, for Interim Cover, TS 2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Time factor Tv, for Interim Cover, TS 3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Time factor Tv, for Interim Cover, TS 4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Time factor Tv, for Interim Cover, TS 5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Time factor Tv, for Interim Cover, TS 6	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.8
Deg. of Consol, Interim Cover, TS 0 (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Deg. of Consol, Interim Cover, TS 1 (%)	43%	43%	43%	43%	42%	42%	42%	43%	42%
Deg. of Consol, Interim Cover, TS 2 (%)	60%	60%	60%	60%	59%	59%	59%	60%	59%
Deg. of Consol, Interim Cover, TS 3 (%)	72%	72%	72%	72%	71%	71%	71%	72%	71%
Deg. of Consol, Interim Cover, TS 4 (%)	80%	81%	80%	80%	79%	79%	80%	80%	80%
Deg. of Consol, Interim Cover, TS 5 (%)	86%	86%	86%	86%	85%	85%	86%	86%	86%
Deg. of Consol, Interim Cover, TS 6 (%)	90%	90%	90%	90%	90%	90%	90%	90%	90%
Estimated Consol, Interim Cover, TS 1 (ft)	0.01	0.07	0.07	0.23	1.27	1.34	0.06	0.35	0.37
Estimated Consol, Interim Cover, TS 2 (ft)	0.02	0.10	0.10	0.32	1.78	1.88	0.09	0.50	0.52
Estimated Consol, Interim Cover, TS 3 (ft)	0.02	0.11	0.12	0.38	2.14	2.26	0.10	0.60	0.62
Estimated Consol, Interim Cover, TS 4 (ft)	0.02	0.13	0.13	0.42	2.40	2.53	0.12	0.67	0.70
Estimated Consol, Interim Cover, TS 5 (ft)	0.02	0.14	0.14	0.46	2.59	2.73	0.12	0.72	0.75
Estimated Consol, Interim Cover, TS 6 (ft)	0.03	0.14	0.15	0.48	2.71	2.86	0.13	0.75	0.79
Elevation of Initial Settlement Mon. read	5623.50	5617.50	5607.50	5623.50	5617.50	5607.50	5623.50	5617.50	5607.50
Elev. Of Int Cover Surface, TS 1	5623.49	5617.43	5607.43	5623.27	5616.23	5606.16	5623.44	5617.15	5607.13
Elev. Of Int Cover Surface, TS 2	5623.48	5617.40	5607.40	5623.18	5615.72	5605.62	5623.41	5617.00	5606.98
Elev. Of Int Cover Surface, TS 3	5623.48	5617.39	5607.38	5623.12	5615.36	5605.24	5623.40	5616.90	5606.88
Elev. Of Int Cover Surface, TS 4	5623.48	5617.37	5607.37	5623.08	5615.10	5604.97	5623.38	5616.83	5606.80
Elev. Of Int Cover Surface, TS 5	5623.48	5617.36	5607.36	5623.04	5614.91	5604.77	5623.38	5616.78	5606.75
Elev. Of Int Cover Surface, TS 6	5623.47	5617.36	5607.35	5623.02	5614.79	5604.64	5623.37	5616.75	5606.71
Elevation of Phreatic Surface 2009 (ft)									
Incr. Stress due to 2009 Drawdown (psf)									
Total Settlement due to 2009 Drawdown (ft)									
Date of 2009 Drawndow									
Date of Time Step 1b									
Date of Timestep 2b									
Date of Timestep 3b									
Time Step 1b: Days since 2009 Drawdown									
Time Step 2b: Days since 2009 Drawdown									
Time Step 3b: Days since 2009 Drawdown									
Time Step 1b: Days since Int Cover Place									
Time Step 2b: Days since Int Cover Place									
Time Step 3b: Days since Int Cover Place									
Time factor Tv, for 2009 Drawdown, TS 1b									
Time factor Tv, for 2009 Drawdown, TS 2b									
Time factor Tv, for 2009 Drawdown, TS 3b									
Time factor Tv, for Interim Cover, TS 1b									
Time factor Tv, for Interim Cover, TS 2b									
Time factor Tv, for Interim Cover, TS 3b									
Deg. of Consol, 2009 Drawdown, TS 1b (%)									
Deg. of Consol, 2009 Drawdown, TS 2b (%)									
Deg. of Consol, 2009 Drawdown, TS 3b (%)									
Deg. of Consol, Interim Cover, TS 1b (%)									
Deg. of Consol, Interim Cover, TS 2b (%)									
Deg. of Consol, Interim Cover, TS 3b (%)									
Estimated Consol, TS 1b (ft)									
Estimated Consol, TS 2b (ft)									
Estimated Consol, TS 3b (ft)									
Elev. Of Int Cover Surface, TS 1b									
Elev. Of Int Cover Surface, TS 2b									
Elev. Of Int Cover Surface, TS 3b									
Plot Date 1	0	0	0	0	0	0	0	0	0
Plot Date 2	100	100	100	100	100	100	100	100	100
100% Consol, Interim Cover	5623.47	5617.34	5607.33	5622.97	5614.47	5604.31	5623.36	5616.67	5606.63
100% Consol, Final Cover	5623.39	5617.27	5607.26	5621.44	5613.09	5602.92	5622.93	5616.29	5606.24

ATTACHMENT F.3

LIQUEFACTION CALCULATIONS

Client: **Denison Mines** **Job No.:** **1009740**
Project: **White Mesa Mill Reclamation** **Date:** **7/24/2011**
Detail: **Liquefaction Analysis of Reclaimed Cells** **Computed By:** **RTS**

Analysis based on Youd, T.L. et al., 2001. Liquefaction Resistance of Soils: Summary report from the 1996 NCEER and 1998 NCEER/NSF Workshops of Evaluation of Liquefaction Resistance of Soils, Journal of Geothecnical and Geoenvironmental Engineering, October.

Cyclic Stress Ratio (CSR)

peak horizontal acceleration, a_{max}

acceleration of gravity, g

a_{max}/g = 0.15

total vertical overburden stress, σ_{vo}

effective vertical overburden stress, σ'_{vo}

depth from top of tailings to water surface (ft) = 3

moist unit weight of tailings (pcf)= 110.5

saturated unit weight of tailings (pcf)= 117.1

depth of interim cover (ft) 2.5

moist unit weight of interim cover (pcf)= 100.7

saturated unit weight of interim cover (pcf)=

depth of final cover (ft) 6.5

moist unit weight of final cover (pcf)= 113.7

saturated unit weight of final cover (pcf)=

stress reduction coefficient, r_d

depth below top of tailings, z (meters)

Cyclic Resistance Ratio (CRR)

measured standard penetration resistance (SPT), N_m

factor to normalize Nm to 100 kPa overburden, C_N

SPT blow count normalized to 100 kPa overburden pressure, $(N_1)_{60}$

equivalent clean sand blow count, $(N_1)_{60CS}$

fines content in tailings= 35

α= 5

β= 1.2

Earthquake Magnitude, Mw= 5.81

z (ft)	z (meters)	σ_{vo}	σ'_{vo}	r_d	CSR	N_m	C_N	$(N1)_{60}$	$(N1)_{60CS}$	$CRR_{7.5}$	MSF	FS
0	0.00	-	-	1.00	#DIV/0!			-		0.05	1.92	
3	0.91	351	164	0.99	0.208	4	1.72	6.9	13.3	0.14	1.92	1.32
6	1.83	703	328	0.99	0.206	4	1.62	6.5	12.8	0.14	1.92	1.29
9	2.74	1,054	492	0.98	0.205	4	1.54	6.1	12.4	0.13	1.92	1.26
12	3.66	1,405	656	0.97	0.203	4	1.46	5.8	12.0	0.13	1.92	1.24
15	4.57	1,757	821	0.97	0.202	4	1.39	5.5	11.7	0.13	1.92	1.22
18	5.49	2,108	985	0.96	0.201	4	1.32	5.3	11.3	0.13	1.92	1.20
21	6.40	2,459	1,149	0.95	0.199	4	1.26	5.0	11.1	0.12	1.92	1.18
24	7.32	2,810	1,313	0.95	0.197	4	1.21	4.8	10.8	0.12	1.92	1.17
27	8.23	3,162	1,477	0.93	0.195	4	1.16	4.6	10.6	0.12	1.92	1.16
30	9.15	3,513	1,641	0.92	0.192	4	1.11	4.5	10.3	0.12	1.92	1.16
33	10.06	3,864	1,805	0.90	0.189	4	1.07	4.3	10.1	0.11	1.92	1.17
36	10.98	4,216	1,969	0.88	0.184	4	1.03	4.1	10.0	0.11	1.92	1.18
39	11.89	4,567	2,133	0.86	0.179	4	1.00	4.0	9.8	0.11	1.92	1.19
42	12.80	4,918	2,297	0.83	0.174	4	0.96	3.9	9.6	0.11	1.92	1.21

APPENDIX G

EROSIONAL STABILITY EVALUATION

G.1 INTRODUCTION

This appendix presents the hydrologic analysis and evaluation of erosion protection for the cover surface of the White Mesa Mill tailings disposal cells and for the discharge channel and sedimentation basin. These analyses have been conducted in a manner consistent with Nuclear Regulatory Commission (NRC) guidelines documented in NRC (1990) and Johnson (2002). The analyses include the tasks listed below.

1. Selection of the Probable Maximum Precipitation (PMP) as the design event for the site.
2. Calculation of the peak discharge (due to the PMP) from the surfaces of Cells 1, 2, 3, 4A and 4B for the cover surface, and for the drainage basin for the discharge channel.
3. Evaluation of reclaimed tailings disposal cell surfaces for erosional stability (the top surfaces and the reclaimed embankment slopes) and evaluation of the discharge channel and sedimentation basin for erosional stability.
4. Evaluation of the need for filter material between erosional protection riprap and underlying soil layers on the transition slopes on the top surface, the reclaimed embankment slopes, and the rock aprons.
5. Evaluation of the need for a rock apron at the toe of the reclaimed embankment slopes to accommodate flow transitioning from embankment slopes to native ground.
6. Evaluation of surface sheet erosion of top surface of cells due to action of surface water and wind.

These tasks are presented in the following sections of this appendix.

G.2 CONCEPTUAL EROSIONAL PROTECTION DESIGN

Erosional protection was evaluated for the proposed monolithic ET cover design based on the following proposed cover surface of the tailings disposal cells:

- Cells 1, 2, and 3 top surfaces graded to 0.5% slope: Erosional protection is provided by 6 inches of topsoil vegetated with a grass mixture providing poor or better vegetated conditions with a minimum of 30 percent plant coverage (representing drought conditions).
- Portions of Cell 2 with top surface at 1% slope and Cells 4A and 4B with top surfaces at 0.8% slope: Erosional protection is provided by 6 inches of topsoil mixed with 25% (by weight) of 1-inch minus (D_{100} = 1 inch) gravel, vegetated with a grass mixture providing poor or better vegetated conditions with a minimum of 30 percent plant coverage.
- External side slopes or internal transition slopes graded to 5 horizontal to 1 vertical (5H:1V): Erosional protection is provided by 12 inches of angular riprap with a minimum D_{50} of 7.4 inches. Filter material will be placed between the erosional protection and the underlying soil layer.
- A rock apron at the toe of 5H:1V slopes: Erosional protection and scour protection on the north, west, and east sides of the cells is provided by a rock apron measuring 2 feet deep and 10 feet in width, with a D_{50} of 7.4 inches. On the south side of cells 4A and

4B, and east side of Cell 4A, the rock apron measures 3.75 ft in depth, 19 feet in width, and has a D_{50} of 15 inches.

G.3 PROBABLE MAXIMUM PRECIPITATION EVENT

As outlined in NRC (1990) and Johnson (2002), the design event for evaluation of long-term erosional stability of the reclaimed tailings disposal cells is the PMP. The selected PMP events used to calculate the peak discharges for evaluation of erosional stability were the six-hour duration PMP (with a precipitation total of 10.0 inches) and the one-hour duration PMP (with a precipitation total of 8.3 inches). These events were determined for the site area using "Hydrometeorological Report (HMR) No. 49: Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages (Hansen et al. 1984) as presented in Denison (2009). Rainfall depth versus duration for short-term events (less than 1 hour) was developed using procedures in HMR 49 and NUREG/CR-4620 (Nelson et al., 1986).

G.4 CALCULATION OF PEAK DISCHARGE

The peak discharge calculations were made using the Rational Method as described in Johnson (2002) and Nelson et al. (1986). The time of concentration was calculated for the longest flow path (see Figure G.1) across the tailings disposal cells using procedures by Kirpich, Soil Conservation Service (SCS) and Brant and Oberman as presented in Nelson et al. (1986) and DOE (1989). Equal weight was given to each of the three methods. A runoff coefficient of 1.0 was used to represent PMP conditions (DOE, 1989). These characteristics represent high runoff quantities and peak flow velocities.

The PMP discharge results across the tailings disposal cells are presented in Table G.1. These discharges represent flow across a unit-width across the slope.

Table G.1. Peak Reclaimed Surface Discharges

Location	Slope Length (feet)	Time of Concentration (min)	Rainfall Intensity (in/hr)	Runoff Coefficient	Peak Unit Discharge (cfs/ft)
Upper reach of Cell 2 at 0.5 % slope	350	7.0	38.1	1.0	0.31
Middle reach of Cell 2 at 1 % slope	600	14.4	25.3	1.0	0.55
Lower reach of Cell 2 at 0.5 % slope	550	23.4	18.0	1.0	0.62
Cell 3 at 0.5 % slope	830	35.0	13.1	1.0	0.70
Cell 4A at 0.8 % slope	1200	47.0	10.2	1.0	0.83
Cell 4A side slopes at 20% slope	210	34.2	13.3	1.0	0.86

Note: Flow accumulates as it flows from Cell 2 to Cell 4A

The unit discharge values in Table G.1 above were used to evaluate the erosional stability of the reclaimed surfaces and size erosion protection materials where necessary. These evaluations are presented in Sections G.5 and G.6.

G.5 EROSIONAL STABILITY OF VEGETATED SLOPES

The surface of the reclaimed tailings disposal cells was evaluated for erosional stability using the methods recommended in NRC (1990) and Johnson (2002).

Temple Method. Temple and others (1987) outlines procedures for grass-lined channel design. These procedures are recommended in Johnson (2002) for areas of vegetated cover and include methods for estimating stresses on channel vegetation as well as the channel surface soils. The evaluation for the tailings disposal cells used the peak discharge values from the PMP (summarized in Table G.1) to conservatively represent the effective stresses from runoff on the cover surface. The stresses on both the vegetation and the soil were evaluated.

The erosional stability of the cover surface for the tailings disposal cells was evaluated by calculating a factor of safety against erosion due to the peak runoff from the PMP. Factor-of-safety values were calculated as the ratio of the allowable stresses (the resisting strength of the cover vegetation or soils) to the effective stresses (the stresses impacted by the runoff flowing over the cover). Two factors of safety were calculated for each analysis to evaluate both the resistance of the vegetation, and the resistance of the silty topsoil layer. The peak unit discharge flow for the tailings disposal cells (from Table G.1) was conservatively multiplied by a concentration factor of 3 to account for channelization of flow.

Allowable stresses. Allowable stresses for the cover soils were calculated using the equations in Temple and others (1987). Material planned for the upper layer of the cover system is the on-site stockpiled topsoil. Laboratory testing of the topsoil conducted in 2010 (see Appendix A) indicates the topsoil classifies as either a silty clay with sand or a sandy silty clay. The D_{75} (diameter of which 75% of the material is finer) is approximately 0.08 mm to 0.1 mm (.003 in to .004 in) with a plasticity index (PI) of approximately 4 to 7. The resistance of a silty soil with a PI less than 10 is estimated to be approximately 0.02 psf (Temple et al., 1987). For noncohesive soils with a D_{75} greater than 0.05 in., the resistance is calculated as follows:

$\tau_a = 0.4D_{75}$, for soils with D_{75}>0.05 in,
$\tau_a = 0.02$, for noncohesive soils with D_{75}≤0.05 in.

Where

τ_a = allowable shear strength (psf), and
D_{75} = particle diameter in which 75 percent of the soil is finer (inch).

For areas where 1-inch gravel is added to the topsoil (25 percent by weight), the D_{75} of the topsoil mixture will increase to approximately 0.2 inches.

As discussed in Appendix J of this report, the cover will be vegetated with a mixture of perennial grasses (primarily wheatgrass, ricegrass, squirreltail, and fescue) and forbs (yarrow and sage). The allowable vegetation shear strength is calculated as:

$$\tau_{va} = 0.75C_I$$

Where

τ_{va} = allowable vegetation shear strength (in psf),
C_I =cover index = 2.5 $[h(M)^{1/2}]^{1/3}$,
h = stem length (ft), and
M = stem density factor (stems per square ft).

Conservatively using poor vegetation conditions, h=1.0, M=67, and C_I=5.03, the resulting vegetation shear strength value is 3.78 psf.

Effective stresses. The effective shear stress on soil due to peak runoff from the PMP was calculated as:

$$\tau_e = \gamma dS\left(1 - C_f\right)(n_s/n)^2$$

Where
τ_e = effective shear stress (psf),
γ = unit weight of water = 62.4 pcf,
d = depth of flow (ft), from Table G-2,
S = slope of cover surface (ft/ft), from Table G-1,
C_f = cover factor (0.375 for poor vegetation),
n_s = soil roughness factor (0.0156 for soils with D_{75}≤0.05 in., or $0.0256(D_{75})^{1/6}$ for D_{75} > 0.05 in), and
n = Manning's roughness coefficient for vegetated surface.

$$n = e^{C_i\left(0.0133[\ln q]^2 - 0.0954 \ln q + 0.297\right) - 4.16}$$

The effective shear stress on vegetation is calculated as:

$$\tau_v = \gamma dS - \tau_e$$

Where
τ_v = effective vegetal stress (psf).

Conservatively using poor vegetation conditions, the effective shear stresses on soil and vegetation on the tailings cover surfaces are summarized in Table G.2.

Table G.2. Effective Shear Stresses on Soil and Vegetation

Location	Description of Erosion Protection	Depth of Flow[1] (ft)	Soil			Vegetation		
			Effective Shear Stress (psf)	Allowable Shear Stress (psf)	Factor of Safety	Effective Shear Stress (psf)	Allowable Shear Stress (psf)	Factor of Safety
Cell 2 at 0.5 % slope	Vegetation (D_{75} = 0.003 in)	0.96	0.016	0.02	1.2	0.284	3.78	13.3
Cell 2 at 1 % slope	Vegetation and gravel (D_{75} = 0.2 in)	0.76	0.035	0.08	2.3	0.439	3.78	8.6
Cell 3 at 0.5 % slope	Vegetation (D_{75} = 0.003 in)	1.01	0.019	0.02	1.1	0.296	3.78	12.8
Cells 4A and 4B at 0.8 % slope	Vegetation and gravel (D_{75} = 0.2 in)	0.96	0.050	0.08	1.6	0.439	3.78	8.6

[1] Calculated using a concentration factor of 3 for peak unit discharge

The calculated factors of safety above show that for poor vegetation conditions, the allowable shear strengths are higher than the effective shear stresses on both the vegetation and the soil during peak discharge from the PMP. When vegetation conditions are good or better, the soil factor of safety improves significantly, while the vegetation factor of safety decreases slightly, but remains well above 1.0. Further details of calculations can be found in Attachment G.1.

These analyses indicate that the cover on the top surface of the tailings disposal cells can be constructed as a vegetated slope. Top slopes at 0.5 percent slopes are adequately stable without the addition of gravel, while the 1 percent slope in Cell 2, and the 0.8 percent slope in Cells 4A and 4B will require the addition of approximately 25% of 1-inch-minus gravel.

G.6 EROSIONAL STABILITY OF ROCK-PROTECTED SIDE-SLOPES

Because of the difficulty in maintaining vegetation on side slopes, the 5:1 side slopes have been designed for erosional protection assuming vegetation is minimal. The maximum unit discharge value from Table G.1 was used to size riprap for the embankment slopes. The Johnson and Abt method referenced in Johnson (2002) was used for the side slopes. The required rock size is calculated as follows:

$$D_{50} = 5.23S^{0.43}q^{0.56}$$

Where

D_{50} = particle diameter in which 75 percent of the soil is finer (inch),
S = slope (ft/ft), and
q = unit discharge (cfs/ft).

Flow Characteristics. The peak unit discharge values from Table G.1 were used to represent flow conditions across the cover surface and down the embankment side slopes south of Cells 4A and 4B. Concentration factors of 3 were used to account for channelization of flow.

Rock Characteristics. A specific gravity of 2.65 was assumed for the riprap. The rock used for the riprap material was assumed to be rounded, therefore rock size was increased by 40% in the design to account for rounded rock characteristics (Abt and Johnson, 1991). The results of the riprap sizing for the embankment slopes are summarized in Table G.3 below.

Table G.3. Results of Riprap Sizing

Location	Design Unit Discharge (cfs/ft)	Slope (ft/ft)	Concentration Factor	Median Rock Size (inches)
Side Slopes	0.86	0.20	3	7.4

Filter Requirements. NUREG-1623 (Johnson, 2002) recommends a filter or bedding layer be placed under the erosion protection if interstitial velocities are greater than 1 ft/s, in order to prevent erosion of the underlying soils. Bedding is not required if interstitial velocities are less than 0.5 ft/s, and are recommended depending on the characteristics of the underlying soil if velocities are between 0.5 and 1.0 ft/s.

Interstitial velocities are calculated by procedures presented by Abt et al. (1991) as given in the following equation:

$$V_i = 0.23(g \times D_{10} \times S)^{0.5}$$

Where

Vi = interstitial velocities (ft/s),
G = acceleration due to gravity (ft/s^2),
D_{10} = stone diameter at which 10 percent is finer (inches), and
S = gradient in decimal form.

The maximum D_{10} of the erosion protection is estimated based on the D_{50} required for erosion protection, assuming the erosion protection will have a coefficient of uniformity (CU) of 6 and a band width of 5. Band width refers to the ratio of the minimum and maximum allowed particle sizes acceptable for any given percent finer designation. USDA (1994) recommends CU to be a maximum of 6 in order to prevent gap-grading of filters. Table G.4 summarizes the results for the side slopes.

Table G.4. Results of Filter Requirements for Side Slopes

Location	Side Slopes
Minimum D_{50} (inches)	7.4
Maximum D_{10} (inches)	2.3
Slope (%)	20
Interstitial Velocity (ft/s)	0.88

Based on the results in Table G.4 and the fine-grained nature of the top soil, it is recommended that a filter be placed between the soil and the rock protection.

Gradation for proposed Filter. The procedure from USDA (1994) for determining the gradation limits for a sand or gravel filter was used to evaluate the type of material needed to satisfy filter requirements between the soil and rock protection for the side slopes. The method details twelve steps to determine an appropriate gradation range for the filter layer. The steps can be found in Chapter 26 of the USDA Handbook and are shown in the Attachment G.1 for supporting calculations. Table G.5 presents the recommended gradation.

Table G.5. Results of Filter Gradation Requirements

Diameter (mm)	Sieve Sizes	Percent Passing
76.2	3"	100
4.75	No. 4	70-100
0.85	No. 20	35-70
0.075	No. 200	5-15

Based on the results of Table G.5, the filter material should be a medium sand that will be placed between the erosion protection and the random fill base layer on the side slopes.

Sheet Erosion. The Modified Universal Soil Loss Equation (MUSLE) as presented in NUREG/CR4620 (Nelson et al., 1986) was used to evaluate the potential for soil loss due to sheet flows across the gravel/topsoil surface layer of the cover.

The MUSLE is defined as: $A = R * K * LS * VW$

Where:

A = soil loss, in tons per acre per year,
R = rainfall factor,
K = soil erodibility factor,
LS = topographic factor, and
VW = dimensionless erosion factor relating to vegetative and mechanical factors

The rainfall factor, R, is 30, as given in NUREG/CR-4620 for the eastern third of Utah. The soil erodibility factor, K, was estimated to be 0.28 for the topsoil and 0.16 for the gravel and topsoil mixture, based on the nomograph (Fig. 5.1) in NUREG/CR-4620.

The topographic factor, LS, is calculated based on the following equation:

$$LS = \frac{650 + 450s + 65s^2}{10{,}000 + s^2} * \left(\frac{L}{72.6}\right)^m$$

Where:

s = slope steepness, in percent (%),
L = slope length in feet,
m = slope steepness dependent exponent

The topographic factor was calculated using a slope of 0.82% and a slope length of 1,300 feet. From the Table 5.2 in NUREG/CR-4620, the slope steepness exponent, m, is 0.2 for slopes less than or equal to 1.0%.

The erosion factor, VW, used was 0.4, from Table 5.3 of NUREG/CR-4620, to represent seedlings of 0 to 60 days, to mimic light vegetation on the cover. Table G.5 summarizes the MUSLE results for the proposed topsoil and the proposed topsoil mixed with 25% gravel, by weight.

Table G.6. Results of MUSLE

Soil Cover	Proposed Topsoil	Proposed Topsoil with 25% Gravel
Rainfall factor, R	30	30
Silt and very fine sand (%)	46.0	34.5
Sand (%)	40.0	30.0
Organic matter (%)	1.5	1.5
Soil structure	Fine granular	Medium or coarse granular
Relative permeability	Moderate	Moderate to rapid
Erodibility factor, K	0.28	0.16
Topographic Factor, LS	0.19	0.19
Erosion factor, VM – low density seedings	0.4	0.4
Soil loss (tons/acre/year)	0.64	0.36
Soil loss (inches/1,000 years)	3.5	1.8

The soil loss equation shows the potential for erosion will be reduced by almost one half, by using 25% gravel in the topsoil mixture. The topsoil loss of 1.8 to 3.5 inches over the life of the cover is less than the minimum design thickness of 6 inches.

G.7 ROCK SIZING FOR APRON

Additional erosion protection will be provided for runoff from the south side slopes of the reclaimed surfaces of Cells 4A and 4B and the east side of Cell 4A with a rock apron. The perimeter apron will: (1) serve as an impact basin and provide for energy dissipation of runoff, (2) provide erosion protection, and (3) transition flow from side slopes to natural ground. The median rock size required in the perimeter apron was calculated using the equations derived by Abt et al. (1998) as outlined in NUREG 1623 (Johnson, 2002) as follows:

$$D_{50\ energy\ dissipation} = 10.46 S^{0.43} q^{0.56}$$

Flow Characteristics. The peak unit discharge values from Table G.1 were used to represent flow conditions down the embankment side slopes south of Cells 4A and 4B. Concentration factors of 3 were used to account for channelization of flow.

Rock Characteristics. A specific gravity of 2.65 was assumed for the riprap. Rock size was increased by 40% to account for rounded rock characteristics per Abt and Johnson (1991).

Based on the above equation, the rock apron along the south toe of Cells 4A and 4B, and along the east toe of Cell 4A should have a median rock size of 15 inches. The width of the apron should be a minimum of 15 times the median rock size (19 ft) and the apron thickness should be a minimum of 3 times the median rock size (3.75 ft). For the remaining transition areas (the toes of the north and west side slopes and east side slope of Cells 2 and 3) the apron can be constructed by extending the 7.4-in D_{50} rock used on the side slopes a minimum of 10 feet over natural ground, at a minimum rock depth of 2 feet.

Filter Requirements. NUREG-1623 (Johnson, 2002), as detailed in section G.6, was used to determined if a bedding layer was required for the rock aprons. The results are presented in Table G.7 below.

Table G.7. Results of Filter Requirements for Rock Aprons

Location	North-West Apron	South-East Apron
Minimum D_{50} (inches)	7.4	15
Maximum D_{10} (inches)	2.3	4.7
Slope (%)	1	1
Interstitial Velocity (ft/s)	0.20	0.28

Based on the results in Table G.7, it is not required to place a bedding layer between the soil and rock protection for the rock aprons.

G.8 DISCHARGE CHANNEL AND SEDIMENTATION BASIN

The PMP event described in section G.3 was used to determine the peak discharge to the channel to be located at the west end of the sedimentation basin. The peak discharge calculations were made using the Rational Method and the time of concentration was calculated for the longest flow path (see Figure G.1) across the mill site and sedimentation basin using the procedures described in section G.4. A runoff coefficient of 1.0 was used to represent PMP conditions (DOE, 1989). These characteristics represent high runoff quantities and peak flow velocities.

The PMP peak discharge calculated across the mill site and sedimentation basin is presented in Table G.8. This discharge represents the peak flow into the channel. Further details of the calculations can be found in Attachment G.1

Table G.8. Peak Discharge Flow to the Discharge Channel

Location	Slope Length (feet)	Time of Concentration (min)	Rainfall Intensity (in/hr)	Runoff Coefficient	Peak Discharge (cfs)
Mill site and sedimentation basin	4,600	26.3	16.4	1.0	2,440

The peak discharge value in Table G.8 above, was used to evaluate the peak flow velocities through the discharge channel excavated into bedrock. The channel dimensions are shown on Drawing REC-3 and include a 150-foot bottom width and 3:1 (H:V) side slopes. The Manning's n-value was estimated and adjusted based on the anticipated type of bedrock and the presumed roughness, along the channel, after excavation. Table G.9 includes peak flow velocities for Manning's n-values of 0.02 and 0.03.

Table G.9. Peak Discharge Channel Flow Velocities

Location	Channel Bottom Width (feet)	Channel Side Slopes (H:V)	Manning Coefficient, n	Flow Depth (ft)	Cross Sectional Area of Flow (ft^2)	Hydraulic Radius (ft)	Peak Velocity (fps)
Discharge channel	150	3:1	0.02	1.67	259	1.61	9.4
Discharge channel	150	3:1	0.03	2.12	332	2.03	7.3

Based on the available bedrock information near the channel location, the rock is expected to consist of a fine to medium-grained sandstone with varying degrees of cementation and

weathering, or a claystone (Dames and Moore, 1978). The shear wave velocities from seismic refraction surveys indicate the bedrock will range from rippable to hard rock, requiring blasting (D'Appolonia, 1979). Because of this variability, an initial Manning's n-value of 0.015 was selected, for a channel in rock and then modifications of 0.005 and 0.015 were added for increasing irregularities in the final excavated rock surface. (USBR, 1987). Maximum suggested permissible peak channel velocities are 10 feet per second for channels excavated in "poor rock" (USACE, 1994).

G.9 REFERENCES

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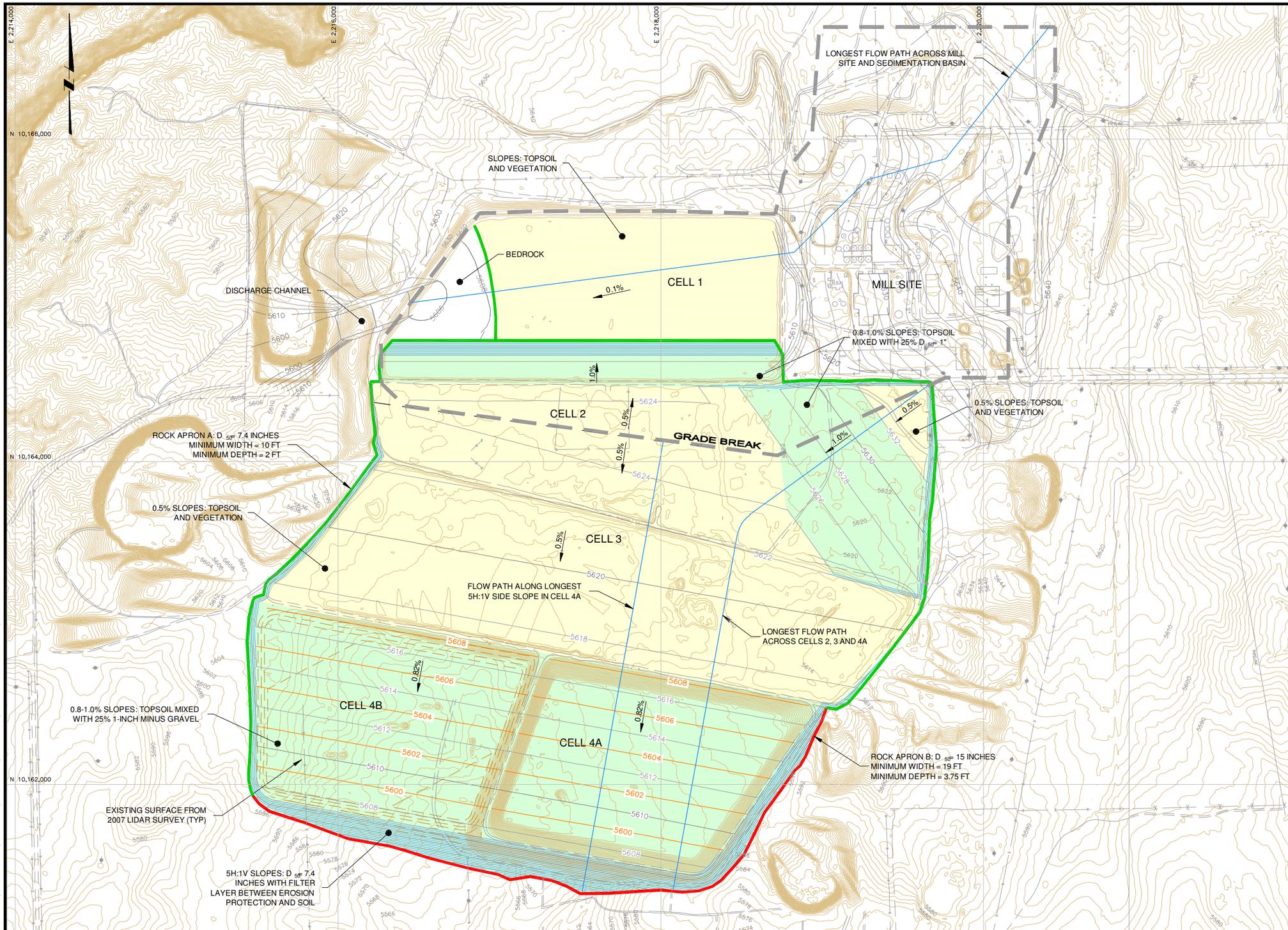

LEGEND:

- 5605 — GROUND SURFACE CONTOUR AND ELEVATION FROM 2007 LIDAR SURVEY, FEET.
- 5605 — FINAL COVER SURFACE ELEVATION (TOP OF EROSION PROTECTION LAYER), FEET
- 5605 — MAXIMUM PERMITTED TAILINGS SURFACE CONTOUR AND ELEVATION, FEET
- DRAINAGE AREA TO DISCHARGE CHANNEL, 148 ACRES

SCALE
300 0 300 600 FT

DENISON MINES
Denison Mines (USA) Corp

PROJECT: WHITE MESA MILL TAILINGS RECLAMATION

TITLE: RECLAMATION COVER EROSION PROTECTION

MWH

DATE: SEP 2011

FIGURE G.1

FILE NAME: 1009740 EROS F

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ATTACHMENT G.1

SUPPORTING CALCULATIONS

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**5/31/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

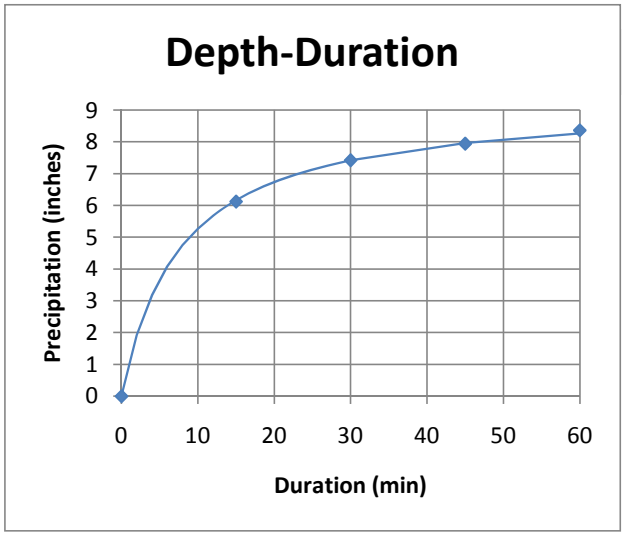
PMP Event

PMP calculation from "Re: Cell 4B Lining System Design Report, Response to DRC Request fo Additional Information - Round 3 Interrogatory, Cell 4B design", September 11,2009.

Procedure: Hydrometeorological Report No. 49: Probable Maximum Precipitation Estimates, Colorado river and Great Basin Drainages (Hansen et al., 1984), corrected for elevation and area.

Table 1. Estimated Precipitation Depths For Local-Storm PMP, White Mesa Mill, Utah Site

Hourly Increments	**First Hour**	**Second Hour**	**Third Hour**				**Fourth Hour**	**Fifth Hour**	**Sixth Hour**
PMP Depths (inches)	0.1	0.4	8.3				0.8	0.2	0.1
Third-Hour Component Depths (inches)			6.1	1.3	0.5	0.4			



Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Time of Concentration

1-hour PMP (in) 8.3

Flow Path 1: flow path across longest 5H:1V side slope in Cell 4A

Description	Slope (feet/feet)	Slope Length (feet)	Time of Concentration (minutes)				% of 1-hour PMP	PD_{PMP} (in)	Intensity (in/hr)
			Kirpich	SCS	Brant and Oberman	Average			
Cell 2 at 0.5%	0.005	530	7.5	7.5	11.5	8.9	60.1	4.99	33.8
Cell 3 top	0.005	870	18.5	18.5	25.2	20.7	81.9	6.80	19.7
Cell 4A top	0.0082	1200	30.2	30.2	38.0	32.8	91.0	7.55	13.8
Cell 4A side slope	0.2	210	31.0	31.1	40.5	34.2	91.7	7.6	13.3

Note: Flow accumulates as it flows from Cell 2 to Cell 4A. Design flow path is longest path across maximum 5H:1V side slope

Flow Path 2: longest flow path across cells with .82% top slope across cells 4A and 4B

Description	Slope (feet/feet)	Slope Length (feet)	Time of Concentration (minutes)				% of 1-hour PMP	PD_{PMP} (in)	Intensity (in/hr)
			Kirpich	SCS	Brant and Oberman	Average			
Cell 2 at 0.5%	0.005	350	5.5	5.5	10.1	7.0	53.4	4.44	38.1
Cell 2 at 1%	0.01	600	11.8	11.8	19.6	14.4	73.2	6.07	25.3
Cell 2 at 0.5%	0.005	550	19.5	19.5	31.3	23.4	84.6	7.02	18.0
Cell 3 top	0.005	830	30.1	30.2	44.7	35.0	92.1	7.64	13.1
Cell 4A top	0.0082	1200	41.8	41.8	57.6	47.0	96.5	8.01	10.2
Cell 4A side slope	0.2	100	42.3	42.3	59.5	48.0	96.8	8.0	10.0

Note: Flow accumulates as it flows from Cell 2 to Cell 4A. Design flow path is longest path across Cell 2, 3, and 4A, and not the longest flow path across each individual cell

Source: Brant and Oberman(1975) as presented in UMTRA TAD (1989)
Formula: tc=C(L/Si^2)^(1/3).
Source:Kirpich (1940) as presented in NUREG 4620
Formula: tc=0.00013*L^0.77/S^0.385 with L in feet, tc in hours
Source: SCS as presented in NUREG 4620
Formula: tc=(11.9L^3/H)^0.385 with L in miles, H in feet, t in hours
% of one-hour PMP=RD/(0.0089*RD+0.0686) for tc<15 min based on Table 4.1 of TAD
Cell geometry based on Figure A-5.1-1 Reclamation Plan Reve 3.2, March, 2010

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Unit discharge of PMP

Flow Path 1: flow path across longest 5H:1V side slope in Cell 4A

Description	Total Drainage Length (ft)	C	Tc (min)	Intensity (in/hr)	unit discharge (cfs/ft)
Cell 2 at 0.5%	530	1	8.9	33.8	0.41
Cell 3 top	1400	1	20.7	19.7	0.63
Cell 4A top	2600	1	32.8	13.8	0.82
Cell 4A side slope	2810	1	34.2	13.3	0.86

Note: Flow accumulates as it flows from Cell 2 to Cell 4A

Flow Path 2: longest flow path across cells with 0.8% top slope across cells 4A and 4B

Description	Total Drainage Length (ft)	C	Tc (min)	Intensity (in/hr)	unit discharge (cfs/ft)
Cell 2 at 0.5%	350	1	7.0	38.1	0.31
Cell 2 at 1%	950	1	14.4	25.3	0.55
Cell 2 at 0.5%	1500	1	23.4	18.0	0.62
Cell 3 top	2330	1	35.0	13.1	0.70
Cell 4A top	3530	1	47.0	10.2	0.83
Cell 4A side slope	3630	1	47.0	10.2	0.85

Note: Flow accumulates as it flows from Cell 2 to Cell 4A

Client:	**Denison Mines**	**Job No.:**	**1009740**
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Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Abt and Johnson method (Abt and Johnson, 1991) applicable for slopes of 50% or less.

Equations assume specific gravity of rock is 2.65 or greater and angular rock.
For rounded rock, increase size by 40%.

ROCK SIZING EQUATION d50 = 5.23*S^0.43q*^0.56

Flow Path 1: flow path across longest 5H:1V side slope in Cell 4A

Area	Cell 4A side slope
Side Slope (ft/ft)	0.2
angle α (rad)	0.197
PMP unit flow (cfs/ft)	0.86
Concentration Factor	3
Coef. Of Movement	1.35
design flow (cfs/ft)	3.49
design flow over rock (cfs/ft)	3.49
D50 (inches) angular	5.27
D50 (inches) rounded	7.38

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Temple Method for Vegetated Slopes - Top Soil

Reference: Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., 1987. Stability Design of Grass-Lined Open Channels, USDA Handbook 667.
And as presented in UMTRA TAD Section 4.3.3 and NUREG 1623, Appendix A

Area	Cell 2 at 0.5%	Cell 3 top	
PMP Design flow (cfs/ft)	0.62	0.70	
Concentration Factor, F	3	3	
PMP Design flow (cfs/ft), q	**1.86**	**2.10**	
Slope, S (ft/ft)	0.005	0.005	
average dry density (pcf)	100	100	(assumed value)
average specific gravity	2.65	2.65	(assumed value)
void ratio, e	0.654	0.654	
unit weight water (pcf)	62.4	62.4	

Topsoil Description	Lean Clay	Lean Clay	
Plasticity Index, PI	<10	<10	(from 2005 RP)
base allowable tractive shear stress (psf) τab=	na	na	
void ratio correction factor, Ce=	na	na	
allowable tractive shear stress (psf), τa=	0.020	0.020	
Long-term, PMP precip			
Repr. stem length (ft) h(ave)			
good veg	2	2	pg 36 and 39 of Temple et al. (1987)
poor veg	1	1	
Repr. stem density (stems/sq ft), M(ave)			
good veg	200	200	Temple Table 3.1, grass mixture
poor veg	67	67	
Retardance curve index, Ci			
good veg	7.62	7.62	
poor veg	5.03	5.03	
Cover factor, Cf			
good veg	0.75	0.75	Temple Table 3.1, grass mixture
poor veg	0.375	0.375	assume min 30% coverage
allowable vegetated shear strength (psf), τva			
good veg	5.71	5.71	
poor veg	3.78	3.78	
Mannings n for soil roughness, ns=	0.0156	0.0156	
Mannings n for vegetal conditions, nr			
good veg	0.0995	0.0924	
poor veg	0.0531	0.0506	
Mannings n for vegetated slopes, nv			
good veg	0.0995	0.0924	
poor veg	0.0531	0.0506	
assumed depth of flow, d (ft)			
good veg	1.402	1.446	
poor veg	0.962	1.007	
calculated q (cfs/ft), with veg			
good veg	1.86	2.10	
poor veg	1.86	2.10	
qcalc - qdesign			
good veg	**0.00**	**0.00**	
poor veg	**0.00**	**0.00**	
Iterate with d until q calc equals q design			
velocity (ft/s), v			
good veg	1.32	1.45	
poor veg	1.93	2.09	
effective shear stress (psf), τe			
good veg	0.0027	0.0032	
poor veg	0.0162	0.0187	
effective veg shear stress (psf) τve			
good veg	0.4348	0.4480	
poor veg	0.2839	0.2955	
shear stress ratio, vegetated slope			
good veg	**13.1**	**12.8**	
poor veg	**13.3**	**12.8**	
shear stress ratio, soil on vegetated slope			
good veg	**7.4**	**6.2**	
poor veg	**1.2**	**1.1**	

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Temple Method for Vegetated Slopes - Top Soil Ammended with 25% Gravel

Reference: Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., 1987. Stability Design of Grass-Lined Open Channels, USDA Handbook 667.
And as presented in UMTRA TAD Section 4.3.3 and NUREG 1623, Appendix A

Area	Cell 2 at 1%	Cell 4A top	
PMP Design flow (cfs/ft)	0.55	0.86	
Concentration Factor, F	3	3	
PMP Design flow (cfs/ft), q	**1.66**	**2.58**	
Slope, S (ft/ft)	0.01	0.0082	
average dry density (pcf)	100	100	(assumed value)
average specific gravity	2.65	2.65	(assumed value)
void ratio, e	0.654	0.654	
unit weight water (pcf)	62.4	62.4	

Topsoil Description	Topsoil with 25% 1"-minus gravel	Topsoil with 25% 1"-minus gravel	
d75 (inches)	0.2	0.2	from preliminary gradation specs
base allowable tractive shear stress (psf) τab=	na	na	
void ratio correction factor, Ce=	na	na	
allowable tractive shear stress (psf), τa=	0.080	0.080	
Long-term, PMP precip			
Repr. stem length (ft) h(ave)			
good veg	2	2	pg 36 and 39 of Temple et al. (1987)
poor veg	1	1	
Repr. stem density (stems/sq ft), M(ave)			
good veg	200	200	Temple Table 3.1, grass mixture
poor veg	67	67	
Retardance curve index, Ci			
good veg	7.62	7.62	
poor veg	5.03	5.03	
Cover factor, Cf			
good veg	0.75	0.75	Temple Table 3.1, grass mixture
poor veg	0.375	0.375	assume min 30% coverage
allowable vegetated shear strength (psf), τva			
good veg	5.71	5.71	
poor veg	3.78	3.78	
Mannings n for soil roughness, ns=	0.0196	0.0196	
Mannings n for vegetal conditions, nr			
good veg	0.1067	0.0824	
poor veg	0.0556	0.0469	
Mannings n for vegetated slopes, nv			
good veg	0.1073	0.0833	
poor veg	0.0568	0.0484	
assumed depth of flow, d (ft)			
good veg	1.114	1.325	
poor veg	0.760	0.956	
calculated q (cfs/ft), with veg			
good veg	1.66	2.58	
poor veg	1.66	2.58	
qcalc - qdesign			
good veg	**0.00**	**0.00**	
poor veg	**0.00**	**0.00**	
Iterate with d until q calc equals q design			
velocity (ft/s), v			
good veg	1.49	1.95	
poor veg	2.18	2.70	
effective shear stress (psf), τe			
good veg	0.0058	0.0094	
poor veg	0.0352	0.0501	
effective veg shear stress (psf) τve			
good veg	0.6891	0.6687	
poor veg	0.4393	0.4392	
shear stress ratio, vegetated slope			
good veg	**8.3**	**8.5**	
poor veg	**8.6**	**8.6**	
shear stress ratio, soil on vegetated slope			
good veg	**13.8**	**8.5**	
poor veg	**2.3**	**1.6**	

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Preliminary Gradations

This spreadsheet calculates preliminary gradations of riprap based on D50
Source: NUREG 4620
Source: USDA, National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters, October 1994.

Area Description	Cell 4A side slope	Comment
Minimum D50 (in)	7.38	Assuming angular rock, Safety factor method for top slope, Abt and Johnson (1991) method for side slopes
Rock thickness (in)	14.75	Based on constructability: 2*D50. May consider 12" as minimum thickness for rock
Maximum D50 (in)	9.84	Based on constructability: Thickness/1.5
Maximum D50 (in)	36.88	Prevent gap-grading: minimum D50*5
Maximum D50 (in)	9.84	Smaller of two above criteria
Maximum D100 (in)	14.75	Based on constructability: 1*Thickness
Maximum D100 (in)	49.18	Based on internal stability?: 5*maximum D50
Maximum D100 (in)	14.75	Smaller of two above criteria
Minimum D100 (in)	14.75	Based on internal stability: 2*minimum D50
Minimum D15 (in)	0.92	Based on internal stability: Maximum D100/16
Maximum D15 (in)	4.61	Prevent gap-grading: Minimum D15*5
Minimum D60 (in)	10.33	Prevent gap-grading: D60/D10<=6
Maximum D60 (in)	13.77	Prevent gap-grading: D60/D10<=6
Minimum D10 (in)	1.72	Prevent gap-grading: D60/D10<=6
Maximum D10 (in)	2.30	Prevent gap-grading: D60/D10<=6

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**7/28/2011**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Interstitial Velocities

Source: NUREG 1623, Section D
Abt, SR, JF Ruff, RJ Wittler (1991). Estimating Flow Through Riprap, Journal of Hydraulic Engineering, Vol. 117, No. 5, May.

Area	Cell 4A	
Description	side slope	
Minimum D50 (inches)	7.38	from Safety Factor Method, or Abt/Johnson Method, assuming angular rock
Minimum D10 (inches)	1.72	from preliminary gradation specs
Maximum D10 (inches)	2.30	from preliminary gradation specs
Slope (ft/ft)	0.2	from preliminary disposal cell layout
Min Velocity (ft/s)	0.77	calculated from Abt et al. (1991) based on Min D10
Max Velocity (ft/s)	0.88	calculated from Abt et al. (1991) based on Max D10
Underlying filter required?	maybe	Per NUREG 1623, Appendix D, section 2.1.1

Client:	**Denison Mines**	**Job No.:**	**1009740**
Project:	**White Mesa Reclamation Plan**	**Date:**	**9/13/2011**
Detail:	**Erosion Protection**	**Computed By:**	**TMS**
		Checked By:	**MMD**

Interstitial Velocities

Source: NUREG 1623, Section D
Abt, SR, JF Ruff, RJ Wittler (1991). Estimating Flow Through Riprap, Journal of Hydraulic Engineering, Vol. 117, No. 5, May.

Area	Cell 4A	Cell 4A	
Description	North-Western Rock Apron	South-Eastern Rock Apron	
Minimum D50 (inches)	7.40	15.00	from Safety Factor Method, or Abt/Johnson Method, assuming angular rock
Minimum D10 (inches)	1.73	3.50	from preliminary gradation specs
Maximum D10 (inches)	2.30	4.67	from preliminary gradation specs
Slope (ft/ft)	0.01	0.01	from preliminary design
Min Velocity (ft/s)	0.17	0.24	calculated from Abt et al. (1991) based on Min D10
Max Velocity (ft/s)	0.20	0.28	calculated from Abt et al. (1991) based on Max D10
Underlying filter required?	no	no	Per NUREG 1623, Appendix D, section 2.1.1

Client: Denison Mines **Job No.:** 1009740
Project: White Mesa Reclamation Plan **Date:** 9/21/2011
Detail: Erosion Protection **Computed By:** TMS
Checked By: MMD

USDA Filter Gradation Calulations

Step 1: Plot Gradation Curve of Base Soil

Stockpile ID	**E4 (Field ID 2)**		**E5 (Field ID 3)**		**E6 (Field ID 4)**		**E7 (Field ID 5)**		**E8 (Field ID 6)**		**W9 (Field ID 7)**		**W7 (Field ID 8)**		**W1 (Field ID 12)**		**W2 (Field ID 13)**	
Description	Sandy Clay Random Fill		Sandy Clay Random Fill		Clay Random Fill		Sandy Clay Random Fill		Sandy Clay Random Fill		Sandy Clay Random Fill		Sandy Clay Random Fill		Sandy Clay Random Fill		Sandy Clay Random Fill	
Sieve Sizes	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer	Diameter (mm)	% Finer
1 1/2"	38.1	100	38.1	100	38.1	100	38.1	100	38.1	100	38.1	100	38.1	100	38.1	100	38.1	100
1"	25.4	100	25.4	100	25.4	100	25.4	100	25.4	100	25.4	100	25.4	100	25.4	100	25.4	100
3/4"	19.1	100	19.1	100	19.1	100	19.1	100	19.1	100	19.1	100	19.1	100	19.1	100	19.1	100
3/8"	9.8	100	9.8	100	9.8	100	9.8	100	9.8	100	9.8	100	9.8	100	9.8	100	9.8	100
Nº 4	4.75	99.9	4.75	100	4.75	99.9	4.75	100	4.75	100	4.75	100	4.75	100	4.75	100	4.75	99.8
Nº 10	2	99.8	2	99.9	2	99.9	2	100	2	100	2	100	2	99.3	2	100	2	99.7
Nº 20	0.85	98.9	0.85	99.2	0.85	99.2	0.85	100	0.85	99	0.85	99.3	0.85	98.8	0.85	99.5	0.85	97.4
Nº 40	0.425	97.7	0.425	97.9	0.425	96.9	0.425	99.7	0.425	97.4	0.425	98.3	0.425	98.1	0.425	98.8	0.425	94.7
Nº 60	0.25	95.1	0.25	93.1	0.25	92.6	0.25	98.8	0.25	91.9	0.25	96.1	0.25	94.4	0.25	97.8	0.25	88.2
Nº 100	0.15	90.8	0.15	80.9	0.15	88.8	0.15	96.7	0.15	74.7	0.15	92.3	0.15	79.4	0.15	95.2	0.15	76.6
Nº 200	0.075	58.8	0.075	64.5	0.075	82.2	0.075	69.8	0.075	53	0.075	62.6	0.075	56.2	0.075	59.4	0.075	58.3

D15 estimated as 0.025

All Steps below are from USDA Ch. 26 Example 26-2A

Step 4. Base Soil Category	2	2	2	2	2	2	2	2	2
Step 5. Filtering Criteria (Max D15) (mm)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Step 6. Min D15	0.076531	0.0698	0.054745	0.06447	0.084906	0.071885	0.080071	0.075758	0.077187
Step 7. Ratio	9.146667	10.0333	12.78667	10.85778	8.244444	9.737778	8.742222	9.24	9.068889
Control Point 1 (D15max)	0.382653	0.3488	0.273723	0.32235	0.424528	0.359425	0.400356	0.378788	0.385935
Control Point 2 (D15min)	0.076531	0.0698	0.054745	0.06447	0.084906	0.071885	0.080071	0.075758	0.077187
Step 8. MaxD10	0.318878	0.2907	0.228102	0.268625	0.353774	0.299521	0.33363	0.315657	0.321612
CP3 Max D60	1.913265	1.7442	1.368613	1.611748	2.122642	1.797125	2.001779	1.893939	1.929674
CP4 Min D60	0.382653	0.3488	0.273723	0.32235	0.424528	0.359425	0.400356	0.378788	0.385935
Step 9. CP5 D5min	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
CP6 D100 max	75	75	75	75	75	75	75	75	75
Step 10. CP7 D10	0.063776	0.0581	0.04562	0.053725	0.070755	0.059904	0.066726	0.063131	0.064322
CP8 D90	20	20	20	20	20	20	20	20	20

Step 11. Connecting Control Points

		E4 (Field ID 2)		**E5 (Field ID 3)**		**E6 (Field ID 4)**		**E7 (Field ID 5)**		**E8 (Field ID 6)**		**W9 (Field ID 7)**		**W7 (Field ID 8)**		**W1 (Field ID 12)**		**W2 (Field ID 13)**	
	CP	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer	D(mm)	% Finer
Fine Design Band	4	0.382653	60	0.348837	60	0.273722628	60	0.32234957	60	0.424528	60	0.359425	60	0.400356	60	0.378787879	60	0.385935	60
	2	0.076531	15	0.069767	15	0.054744526	15	0.064469914	15	0.084906	15	0.071885	15	0.080071	15	0.075757576	15	0.077187	15
	5	0.075	5	0.075	5	0.075	5	0.075	5	0.075	5	0.075	5	0.075	5	0.075	5	0.075	5
	6	75	100	75	100	75	100	75	100	75	100	75	100	75	100	75	100	75	100
Course Design	3	1.913265	60	1.744186	60	1.368613139	60	1.611747851	60	2.122642	60	1.797125	60	2.001779	60	1.893939394	60	1.929674	60
	1	0.382653	15	0.348837	15	0.273722628	15	0.32234957	15	0.424528	15	0.359425	15	0.400356	15	0.378787879	15	0.385935	15
	7	0.063776	10	0.05814	10	0.045620438	10	0.053724928	10	0.070755	10	0.059904	10	0.066726	10	0.063131313	10	0.064322	10

Step 12. Determine Gradation from plot

Client:	**Denison**	**Job No.:**	**1009740**
Project:	**White Mesa Mill**	**Date:**	**9/21/2011**
Detail:	**Discharge Channel**	**Computed By:**	**JMC**

Time of Concentration

1-hour PMP (in) 8.3

Description	Slope (feet/feet)	Path Length (feet)	Time of Concentration (minutes)				% of 1-hour PMP	PD_{PMP} (in)	Intensity (in/hr)
			Kirpich	SCS	Brant and Oberman	Average			
Sed-Channel	**0.010**	**4600**	30.1	30.2	18.7	26.3	86.9	7.21	16.4

Source: Brant and Oberman(1975) as presented in UMTRA TAD (1989)
Formula: tc=C(L/Si^2)^(1/3).
Source:Kirpich (1940) as presented in NUREG 4620
Formula: tc=0.00013*L^0.77/S^0.385 with L in feet, tc in hours
Source: SCS as presented in NUREG 4620
Formula: tc=(11.9L^3/H)^0.385 with L in miles, H in feet, t in hours
% of one-hour PMP=RD/(0.0089*RD+0.0686) for tc<15 min based on Table 4.1 of TAD
Cell geometry and grading based on REC-1 Reclamation Plan Revisions, September, 2011

Client:	**Denison**	**Job No.:**	1009740
Project:	**White Mesa Mill**	**Date:**	9/21/2011
Detail:	**Discharge Channel**	**Computed By:**	JMC

Peak Discharge of PMP precipitation

Description	Total Drainage Area (acres)	C	Tc (min)	Intensity (in/hr)	Q (cfs)
Sed-Channel	**148.40**	1	26.3	16.4	2440.1

Client:	Denison Mines	**Job No.:**	1009740
Project:	White Mesa Mill	**Date:**	21-Sep-11
Detail:	Discharge Channel	**Computed By:**	JMC

Manning's N-value Determination

From US Department of the Interior, Bureau of Reclamation. Design of Small Dams. p. 595. 1987.

Basic N-value for channels in Rock	0.015	
Modifications of N-value	0.005	Minor degree of irregularity
	0.010	Moderate degree of irregularity
	0.020	Severe irregualrity

Based on seismic refraction data, test numbers 1-3, shear wave velocities ranged from 3100 to 7400 feet/sec (see test results from Nielsons, 1978, Appendix A D'Appolonia, 1979). The bedrock in the area of the excavation is anticpated to range from soft and rippable to hard rock requiring blasting. The excavated rock surface will likely exhibit minor ro moderate irregularity.

Assume an N-value ranging from 0.020 0.030

From US Army Corps of Engineers. Hydraulic Design of Flood Control Channels, EM 1110-2-1601. p.2-16. June 1994.
From Table 2-5, Suggested Maximum Permissible Mean Channel Velocities

Poor Rock (usually sedimentary)	10.0	fps
Soft Sandstone	8.0	fps
Soft Shale	3.5	fps
Good Rock (usually igneous or hard metamorphic)	20.0	fps

The bedrock within the channel excavation is anticipated to consist of fine to medium-grained sandstone of varying cementation and weathering, or claystone. (see borings by Dames and Moore, 1978)
Based on the presumed rock type and the referenced table above, permissible mean channel velocities may range up to 8 to 10 fps.

Client:	Denison Mines	**Job No.:**	1009740
Project:	White Mesa Mill	**Date:**	21-Sep-11
Detail:	Discharge Channel	**Computed By:**	JMC

Peak Channel Velocity

Design flow:			2,440	cfs
Trapezoid or triangular channels				
slope (ft/ft)	0.009	ft/ft		
Channel Side Slope 1 (ft/ft)	0.33	ft/ft		
Channel Side Slope 2 (ft/ft)	0.33	ft/ft		
bottom width	150	ft		
Q	2,440	cfs		
n native soils	0.020		bedrock channel with minor irregularities	
Area of flow (A)	258.52	ft^2		
Wetted Perimeter Slope 1 (P1)	5.32	ft		
Wetted Perimeter Slope 2 (P2)	5.32	ft		
Hydraulic Radius (R)	1.61	ft		
Top Width (T)	160.1	ft		
Maximum depth of flow (d)	1.67	ft		
Q calc	2440.0	cfs	**ok**	
average velocity (v)	**9.4**	**fps**	**8-10 fps**	**ok**
unit discharge	**15.74**	**cfs/ft**	take as total Q divided by average flow width	

Client:	Denison Mines	**Job No.:**	1009740
Project:	White Mesa Mill	**Date:**	21-Sep-11
Detail:	Discharge Channel	**Computed By:**	JMC

Peak Channel Velocity

Design flow:		2,440	cfs

Trapezoid or triangular channels			
slope (ft/ft)	0.009	ft/ft	
Channel Side Slope 1 (ft/ft)	0.33	ft/ft	
Channel Side Slope 2 (ft/ft)	0.33	ft/ft	
bottom width	150	ft	
Q	2,440	cfs	
n native soils	0.030		bedrock channel with moderate irregularities
Area of flow (A)	332.10	ft^2	
Wetted Perimeter Slope 1 (P1)	6.77	ft	
Wetted Perimeter Slope 2 (P2)	6.77	ft	
Hydraulic Radius (R)	2.03	ft	
Top Width (T)	162.9	ft	
Maximum depth of flow (d)	2.12	ft	
Q calc	2440.0	cfs	**ok**
average velocity (v)	**7.3**	**fps**	**less than 8-10 fps ok**
unit discharge	**15.60**	**cfs/ft**	take as total Q divided by average flow width

APPENDIX H

TAILINGS DEWATERING

ATTACHMENT H.1

TAILINGS DEWATERING INFORMATION FOR CELLS 2 AND 3

SELECT INFORMATION FROM MWH (2010)

Denison Mines (USA) Corp.

Revised Infiltration and Contaminant Transport Modeling Report, White Mesa Mill Site, Blanding, Utah

March 2010

REVISED
INFILTRATION AND CONTAMINANT TRANSPORT MODELING REPORT
WHITE MESA MILL SITE
BLANDING, UTAH

DENISON MINES (USA) CORP.

March 2010

Prepared for:

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Salt Lake City, Utah
84095

APPENDIX J

TAILINGS CELL DEWATERING MODELING

APPENDIX J

TAILINGS CELL DEWATERING MODELING

This appendix describes the dewatering modeling performed with MODFLOW to estimate the time required to dewater the tailings in Cells 2 & 3 and estimate the residual saturated thickness of tailings. The model-predicted water levels (saturated thickness of tailings) are used in the Giroud-Bonaparte Equation to calculate potential flux rates through the liner into the underlying bedrock vadose zone, as described in Appendix L. A tailings cell dewatering model was not constructed for Cells 4A & 4B because analytical solutions presented by Geosyntec Consultants (2007) were deemed adequate given the uniform distribution of the drain system in those cells.

Tailings Cells 2 & 3 Slimes Drains

To dewater the tailings in Cells 2 & 3, slimes drain networks consisting of perforated PVC pipe are located across the base of the cells which drain to an extraction sump on the southern side of each cell. The drains cover an approximately 400-foot by 600-foot area in the southern part of the cells. The design for the slimes drains is the same for both cells (D'Appolonia Consulting Engineers, 1982). The drain pipes are situated in nine alignments spaced 50 feet apart running in an approximately east-west direction. Each drain is 600 feet long, extending 300 feet in each direction from the central collection pipe that drains to the sump. The drain pipes are covered by an envelope of sand over the drains, rather than a continuous layer across the bottom of the tailing cells ("burrito drains"). Water gravity drains to the sump, whence it is pumped to Cell 1.

METHODOLOGY

Model Code

The computer code MODFLOW was used in this modeling effort with the Department of Defense Groundwater Modeling System (GMS) pre- and post-processor. MODFLOW is

a modular three-dimensional finite-difference flow model developed by the United States Geological Survey (McDonald and Harbaugh, 1988; Harbaugh et al., 2000) to calculate hydraulic-head distribution and determine flow within a simulated aquifer. This model was selected because it can adequately represent and simulate the hydrogeologic conditions necessary and it is well-documented, frequently used, and a versatile program that is widely accepted by the scientific and regulatory communities (Anderson and Woessner, 1992).

Model Domain, Layering, and Grid

The domain for the tailings cell model was approximately 3,500 by 1,200 feet, representing Cells 2 & 3 (see Figure J-1). The finite-difference grid consisted of a constant spacing of 10 feet. The model included two layers to represent the tailings and slimes drains. The bottom layer was 1 foot thick so that the drains could be simulated explicitly (hydraulic conductivity was variable to represent tailings between the drains). The top layer had a variable thickness that represented the tailings. The water level in the top layer was allowed to vary spatially and temporally. The bottom elevations were set based on information presented in the tailings cell construction report (D'Appolonia Consulting Engineers, 1982).

Boundary Conditions

Boundary conditions define hydraulic constraints at the boundaries of the model domain. There are three general types of boundary conditions:

1. Specified head or Dirichlet (e.g., constant head)

2. Specified flux or Neumann (e.g., constant flow, areal recharge, extraction wells, no flow)

3. Head-dependent flux or Cauchy (e.g., drains, evapotranspiration)

No-flow boundaries are a special case of the specified flux boundary in which the flow is set to zero.

For the tailings cell model, no-flow boundaries were assumed to surround the domain. A net flux rate from the cell was assumed across the entire domain. This assumed flux rate represents the combination of potential fluxes from the cell through the liner and potential infiltration into the cell through the cover. The net flux rate was calculated using the average infiltration rate through the cover predicted by the HYDRUS-1D tailings cover model and the potential flux rate through the bottom of Cells 2 & 3 (see Appendix L). The resulting average net flux rate for Cells 2 & 3 was 6.9×10^{-4} cm/day (2.27×10^{-5} ft/day). This assumed net flux rate was applied uniformly across the domain and was simulated with MODFLOW as a negative recharge rate.

The slimes drains were simulated with the Drain package in MODFLOW. Drains are head-dependent boundary conditions in which flow varies based on the difference in hydraulic head in the aquifer and the drain: as head in the aquifer declines (tailings in this case), so does the dewatering rate. Groundwater flow to this array is gravity driven and dependent on the head difference between the surrounding material and the perforated pipe. Operation of the slimes drain extraction pump is only necessary to extract the groundwater driven into this array to maintain a head difference. Essentially, this system acts as a field drain array. The MODFLOW Drain package was developed specifically to simulate this sort of gravity driven, head dependent drain system. A thorough quantitative explanation of the MODFLOW Drain package is presented in *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model: U.S. Geological Survey Techniques of Water-Resources Investigations, book 6, chap. A1* (McDonald and Harbaugh, 1988).

Drain cells were set along nine alignments spaced 50 feet apart. Each drain was 600 feet long. Drains were set in the model as shown on Figure J-1.

Hydraulic Properties

The saturated hydraulic conductivity of the tailings assumed for White Mesa was based on measured values reported for the aquifer testing performed in uranium mill tailings at Cotter Corporation's Canon City Mill tailings impoundment (MFG, Inc., 2005). See Appendix I for details concerning the comparison of tailings grain size for the White Mesa Mill to those of the Canon City Mill. The average hydraulic conductivity of the tailings ranged from 2.1 ft/day (7.4 x 10^{-4} cm/sec) to 8.5 ft/day (3.0 x 10^{-3} cm/sec) with an average value of 4.8 ft/day (1.7 x 10^{-3} cm/sec). A hydraulic conductivity of 4.8 ft/day was assumed for the tailings (in both model layers). A hydraulic conductivity of 25 ft/day was assumed for the sand adjacent to the slimes drain in the bottom layer of the model. This was used only in layer 1 in the cells that represent drains. Hydraulic conductivity values representative of tailings were assumed across the remainder of the bottom layer.

Calibration

The calibration process involves iterating values for model parameters in sequential model simulations to produce estimated values that better match field-measured data. The initial-parameter values were adjusted through calibration until the model produced results that adequately simulated the known data. The tailings cell model was calibrated by varying the drain conductance term until the flow rates approximately matched the 2007 dewatering rates (average rate of 12.5 gpm) and average water levels of 20 feet above the liner.

RESULTS

The MODFLOW dewatering model predicts that the tailings would draindown nonlinearly through time reaching an average saturated thickness of 3.5 feet (1.07 m) after 10 years of dewatering (see Figure J-2). The model also predicts that dewatering rates would decline to approximately 2 gallons per minute (gpm) after 10 years of pumping. This reduction in pumping rates is caused by the reduction in saturated

thickness of tailings. Dewatering rates are also controlled by the saturated hydraulic conductivity of the tailings. If the actual hydraulic conductivity of the tailings is higher than the value assumed in the model, dewatering rates could be higher and water levels could be lowered more rapidly. Conversely, if the actual hydraulic conductivity of the tailings is lower than the value assumed in the model, dewatering rates could be lower and water levels could require more time to dewater. Mass balance errors for the MODFLOW model were less than 1%.

A dewatering model was not constructed for Cells 4A & 4B because dewatering rates were estimated by Geosyntec Consultants (2007). Water levels in Cell 4A were estimated to decline to less than 1 foot after approximately six years of dewatering. Cells 4A & 4B is estimated to be dewatered significantly faster than Cells 2 & 3 due to the more extensive slimes drain network. The dewatering system in Cell 4B is assumed to be designed similarly to Cell 4A, thus dewatering rates were assumed to be similar.

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Figure J-1. MODFLOW tailings cell model domain, grid, and boundary conditions

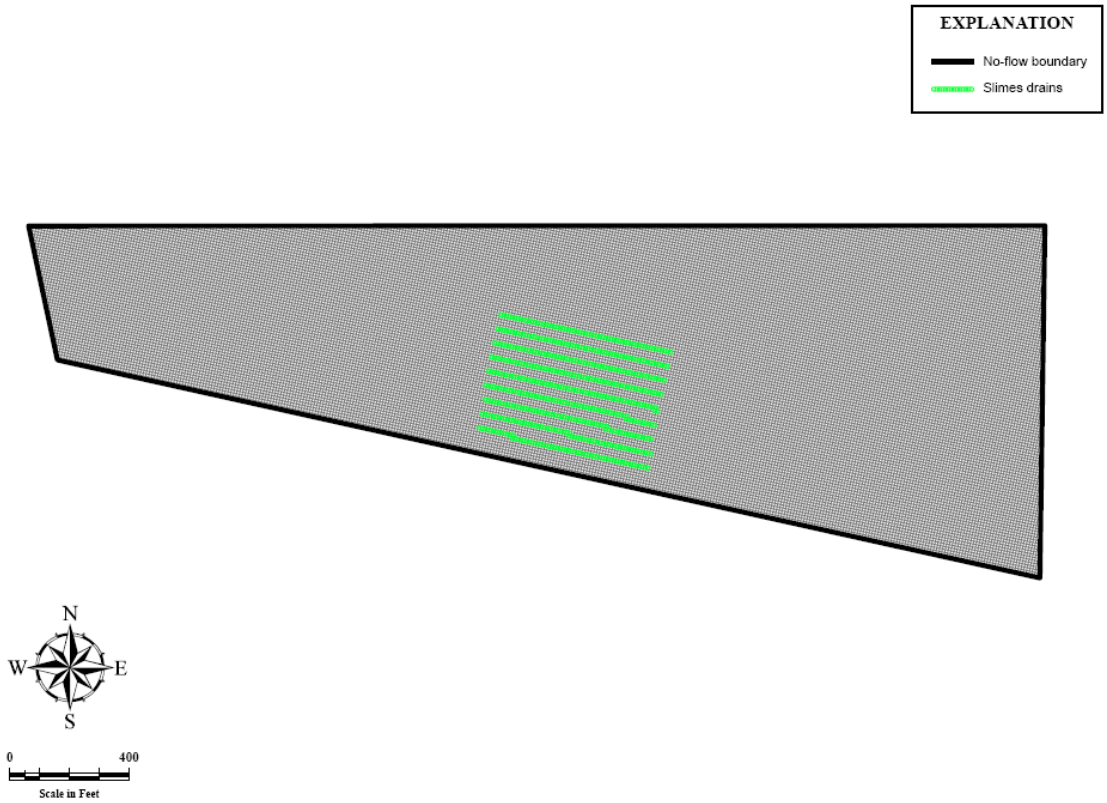
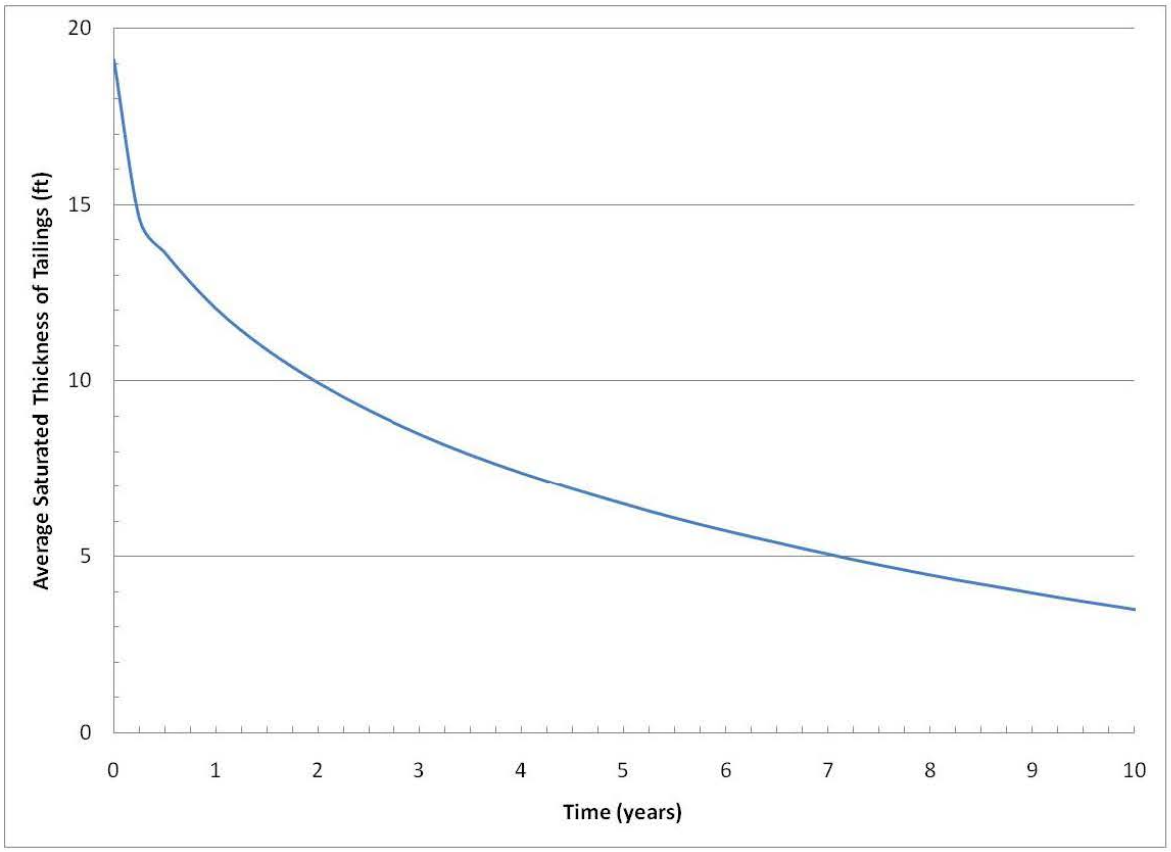


Figure J-2. Model-predicted average saturated thickness of tailings in Cells 2 & 3 with dewatering pumping.



ATTACHMENT H.2

TAILINGS DEWATERING INFORMATION FOR CELLS 4A AND 4B

SELECT INFORMATION FROM GEOSYNTEC (2008a, 2008b) AND DRC (2008)

Geosyntec consultants

COMPUTATION COVER SHEET

Client: **Denison Mines** Project: **White Mesa Mill** Project/ Proposal No.: **SC0349-01** Task No. **04**

Title of Computations **ANALYSIS OF SLIMES DRAIN**

Computations by:	Signature		
	Printed Name	Meghan Lithgow	Date
	Title	Staff Engineer	
Assumptions and Procedures Checked by: (peer reviewer)	Signature		
	Printed Name	Gregory T. Corcoran	Date
	Title	Principal	
Computations Checked by:	Signature		
	Printed Name	Gregory T. Corcoran	Date
	Title	Principal	
Computations backchecked by: (originator)	Signature		
	Printed Name	Meghan Lithgow	Date
	Title	Staff Engineer	
Approved by: (pm or designate)	Signature		
	Printed Name	Gregory T. Corcoran	Date
	Title	Principal	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

PURPOSE AND METHOD OF ANALYSIS

The purpose of this calculation package is to demonstrate that the proposed "slimes drain system" will dewater the tailings at the site within a reasonable time.

Fluid flow rate in porous media will be evaluated using Darcy's law.

ASSUMPTIONS

- This project involves the construction of a 42 acre double lined tailings cell (Cell 4A) that is approximately 42 feet deep at its deepest point and 26 feet deep at the shallowest point with an average depth of 34 feet. The liquids level in the cell will be kept a minimum of 3 feet below the top of the berm (free-board). Therefore, the maximum depth of liquid in the cell will be 39 feet at the start of dewatering.
- The cell will be filled with -28 mesh (US No. 30 sieve) tailings, largely consisting of fine sands and silts, with some clay. Results of grinding test sieve analyses, which are reported based on Tyler Mesh sieve sizes, are presented in Table 1. The grinding test data report is presented in Attachment A. Sieve to Tyler Mesh conversions are presented in Attachment B.
- The tailings will be placed within the cell in a slurry form under the surface of the free liquid contained within the cell. This placement methodology is anticipated to result in a low density (no compaction) soil structure. Therefore, saturated hydraulic conductivity and total porosity are anticipated to be higher than similar soils that are compacted.
- Based on the grinding report (Attachment A), tailings are comprised of approximately 6% medium sand, 49% fine sand, and 45% silt and clay size particles (Table 1).
- Based on the gradation of the tailings (Table 1) from the grinding report (Attachment A), the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the Hydrologic Evaluation of Landfill Performance (HELP) Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit saturated hydraulic conductivities of

between 1.7×10^{-3} cm/sec and 5.2×10^{-4} cm/sec and **low density** silt (ML) and sandy clay (SC) would exhibit saturated hydraulic conductivities of between 3.7×10^{-4} cm/sec and 1.2×10^{-4} cm/sec. The geomean of these two groups of soils, which are gradationally similar to the tailings, is 4.74×10^{-4} cm/sec (Table 2). According to Cedergren (Attachment D), under a normal stress of 2 tons per square foot (approximate normal stress on deeper tailings in the cell), medium sand, fine sand, silt, and silty clay would exhibit a saturated hydraulic conductivities of approximately 2×10^{-2} cm/sec, 1×10^{-2} cm/sec, 1×10^{-4} cm/sec 5×10^{-7} cm/sec, respectively. The geomean of these three soil types, where are gradationally similar to the tailings, is 3.31×10^{-4} cm/sec. The more conservative, lower hydraulic conductivity of 3.31×10^{-4} cm/sec, will be used in this analysis.

- Based on the gradation of the tailings from the grinding report, the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the HELP Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit drainable porosity of between 0.251 and 0.332 and **low density** silt (ML) and sandy clay (SC) would exhibit drainable porosity of between 0.154 and 0.231. The average of these two groups of soils, which are gradationally similar to the tailings, is 0.253 (Table 2). According to the HELP Model Engineering Documentation, medium sand, fine sand, silt, and silty clay would exhibit drainable porosity values of 0.35, 0.29, 0.14, and 0.11, respectively. The average of these three soil types, where are gradationally similar to the tailings, is 0.22. Since the average drainable porosity of 0.22 corresponds to the lower hydraulic conductivity (higher density, lower permeability, lower porosity) selected above, this value will be used in this analysis.
- The permeability of the tailings is isotropic.
- Darcy's law will be used to compute groundwater flow velocities.
- The proposed slimes drain system will consist of a series of strip drains (geotextile wrapped HDPE core, 1" thick, 12" wide, with a transmissivity of 29 (gal/min/ft), which connect to a perforated 4" diameter PVC header pipe that is bedded in drainage aggregate and wrapped in a woven geotextile. The PVC pipe will convey the liquid to the sump for removal.

- The slimes drain spacing will be 50' and will be continuous across the base of the cell (Figure 1).

CALCULATIONS

The flow geometry for the average depth of liquid within the cell is illustrated on Figure 2 and used to compute the emptying time for the proposed slimes drain system.

Calculate the flow into a unit length of strip drain for the various hydraulic gradient conditions.

At the start of cell dewatering, the maximum depth of liquid will vary between 23 feet at the shallow end and 39 feet at the deep end, with an average depth of approximately 31 feet. As the water level drops within the cell, the length of the longest flow path and the associated hydraulic gradient will continually change with time.

The total volume to be drained by a unit length of strip, Q, can be calculated using Darcy's law as follows:

$Q = kiA$

where:

k = hydraulic conductivity of tailings = 3.31×10^{-4} cm/sec = 6.51×10^{-4} ft/min

i = gradient along flowpath = $\frac{dh}{dl} = \frac{31}{39.8} = 0.78$ (see Figure 2)

A = area of strip drain where flow will pass =1.17 ft^2/ft (see Figure 3)

$$Q = (6.51 \times 10^{-4} \frac{ft}{\min})(0.78)(1.17\ ft^2)$$

$$Q = 5.94x10^{-4} \frac{ft^3}{\min} \text{ x } 7.48 \text{ gal/ft}^3 = 4.44\text{x}10^{-3} \text{ gpm}$$

For each one foot incremental drop in fluid elevation within the cell, the total volume to be drained by a unit length of strip drain is as follows:

V = 1 ft unit length x 1ft depth x 50 ft width x .022 (drainable porosity) = 11 CF of free liquid

Therefore, the time to drain the first one foot of liquid within the cell can be estimated as follows:

$t = V/Q = 11\ CF / 5.94x10^{-4}\ CF/min = 18{,}519$ minutes = 12.86 days

Tables 3, 4, and 5 depict the calculations for the maximum (39 feet), average (31 feet), and minimum (23 feet) cell liquid depth, respectively. The results of the maximum depth calculations indicate that the proposed slimes drain system will allow the tailings contained in Cell 4A to drain within approximately 5.5 years.

Calculate the design flow rate of the strip drains.

For this calculation we will assume that the strip drains have a flow rate of 29 gallon per minute per foot (Attachment E, GDE Multi-Flow, 2006), a width of 12" and that flow is occurring under a gradient of 0.01.

Design Flow rate of strip drains:

$$q = \Theta i$$

where:

q = flowrate per unit width

$$i = \frac{dh}{dl} = 0.01$$

Θ = transmissivity = 29 gpm/ft

To account for detrimental effects on the geonet such as chemical clogging, biological clogging, installation defects, and creep, partial factors of safety were used to reduce the strip drain transmissivity. Using recommended partial factor of safety values from Koerner (1999) (Attachment F, 2/4), the reduced transmissivity is calculated as follows:

$$\Theta_{allow} = \Theta_{ult}[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}]$$

where:

Θ_{allow} = allowable flow

$\Theta_{ultimate}$ = calculated value of flow

FS_{IN} = factor of safety for installation, 1.5 (CQA performed during installation)

FS_{CR} = factor of safety for creep, 2.0

FS_{CC} = factor of safety for chemical clogging, 2.0

FS_{BC} = factor of safety for biological clogging, 1.0 (low pH precludes biological activity)

The factors of safety are used to calculate the allowable transmissivity:

$$\Theta_{allow} = 29\frac{gpm}{ft}\left[\frac{1}{1.5 \times 2.0 \times 2.0 \times 1.0}\right] = 4.83\frac{gpm}{ft}$$

Using this transmissivity value, the average factor of safety for flow in the strip composite is estimated to be as follows:

$$FS = \frac{Q_D}{Q_R} = \frac{4.83\ gpm}{0.0044\ gpm} = 1{,}087 \quad \text{(Acceptable)}$$

The average allowable flow rate is much larger than the average maximum flow rate, even with the built-in partial factors of safety. Furthermore, as indicated on Tables 3, 4, and 5, the calculated flow rate within the strip drain decreases with time, which further increases the factor of safety.

<u>Calculate the minimum required AOS and permittivity for filtration geotextile component of strip drain</u>

The geotextile serves as a filter between the strip composite core and the tailings material. The geotextile minimizes fine particles of the tailings material from migrating

into the strip composite, yet allows water to penetrate. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the strip composite layer.

To be conservative in these calculations, the tailings material soil is assumed to consist of more than 20 percent clay.

The retention requirements for geotextiles can be evaluated using the chart entitled "Soil Retention Criteria for Steady-State Flow Conditions" developed by Luettich et al., (1991) (Attachment G, 1/3). This chart uses soil properties to evaluate the required apparent opening size (AOS or O_{95}) of the geotextile. Using the Soil Retention Chart, the AOS of the filter fabrics shall be:

$O_{95} < 0.21$ mm, which corresponds to sieve No. 70.

The permeability of the filter fabric must be evaluated to allow flow through the filter fabric. The following equation can be used to evaluate the minimum allowable geotextile permeability:

$k_g > i_s k_s$ (Luettich et al. (1991), Att. G, 2/3)

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the tailings material (cm/s)

Hydraulic Gradient, i_s: Attachment G, page 3/3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 10 for liquid impoundment applications is recommended.

Soil Permeability, k_s: A permeability of 3.31×10^{-4} cm/s was assumed for the tailings material, as previously defined.

Therefore,

$k_g > i_s k_s = (10)(3.31 \times 10^{-4}$ cm/s)
$k_g > 3.31 \times 10^{-}$ cm/s

Koerner (1999) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations

given in Table 2.12 on p. 150 of Koerner (1999) (Attachment F, 1/4), the following partial safety values were applied:

soil clogging and blinding:	10 (5 – 10)
creep reduction of voids:	2.0 (1.5 – 2.0)
intrusion into voids:	1.2 (1.0 – 1.2)
chemical clogging:	1.5 (1.2 – 1.5)
biological clogging (low pH precludes biological activity):	1.0 (2 – 10)

Therefore,

$k_g >$ $(3.31 \times 10^{-3})(10)(2)(1.2)(1.5)(1)$

$k_g >$ 0.12 cm/s

The thickness of a typical nonwoven needled punched 4 oz/yd^2 (135 g/m^2) geotextile is approximately 40 mils (0.10 cm), see Attachment H. Dividing the permeability by the thickness of the geotextile results in a required minimum permittivity of 1.2 sec^{-1}. The geotextile used in this project has a permittivity of 2.0 sec^{-1}, which is greater than the required permittivity.

Check Pipe Flow Rate

Based on calculations from previous sections, the maximum daily flow rate to the sump is estimated to be 132 gpm (0.29 cfs) (Table 3). The capacity of the pipe is calculated based on Manning's equation for gravity flow as follows:

$$Q = \frac{1.486}{n} R_h^{2/3} S^{1/2} A = 0.35\ cfs$$

Where

n = 0.010 (Koerner (1999), Attachment E, 4/4)

S = Slope of liner (ft/ft) = 1.0 %

R_h = hydraulic radius, ft

Q = flow rate, cubic feet per second, cfs

A = flow area, sf

Assuming 4-inch pipe:

$A = \pi D^2/4$ = 12.6 sq. inches = 0.088 sf

R_h = Area ($\pi D^2/4$)/Wetted Perimeter (πD)

= D/4 = 1 in = 0.083 ft

$$Q = \frac{1.486}{0.010} 0.083^{2/3} 0.01^{1/2} 0.088\, sf = 0.28\, cfs = 112\, gpm$$

Since 112 gpm is less than the maximum required 132 gpm, this calculation shows that the 4-inch diameter slimes drain pipe is the limiting factor for dewatering the tailings in the early phase of dewatering (high flow rates). However, it does not mean that the pipe will be unable to handle this flow, but rather the pipe will require additional time to drain. The additional time needed is computed in the following section.

Effect of Maximum Pipe Capacity on Drainage Time

The maximum capacity of the pipe is 112 gpm, as computed above. Assuming the cell's total lateral length of strip drain is 27,550 feet, the flow rate, per foot of strip drain is calculated to be:

$$\text{Flow Rate} = \frac{112\, gallon}{\min} * \frac{60 \min}{1\, hr} * \frac{24\, hr}{1\, day} * \frac{1 ft^3}{7.48\, gallon} * \frac{1}{27{,}550\, feet} = 0.78 \frac{ft^3}{day}$$

The time needed to de-water first layer is:

$$Time = \frac{Volume}{Drain\ \ length\ \times flow\ rate} = \frac{(50x1x1x0.22)\ ft^3}{1\ ft \times 0.78\ \frac{ft^3}{day}} = 14.1\ days$$

The difference between the maximum daily flow rate drainage time and the maximum daily flow the pipe is able to deliver for the first foot is:

14.1 day – 11.93 day (first row of Table 3) = 2.17 days.

Therefore, the first layer will require an additional 2.17 days to drain. The calculation is repeated until the pipe's allowable flow capacity of 112 gpm is equal to the maximum flow rate from the cell (Table 3). The additional drainage time needed for each layer is added to the original drainage time of 5.5 years. The results of this analysis are shown in Table 3.

The total additional drainage time occurs over the first 9 layers and adds 11 days (0.03 years) to the computed drainage time. Including the effects of the maximum pipe capacity, the cell will take an estimated 5.5 years to drain.

Effect of Precipitation on Drainage Time

To account for the effect of precipitation added to the tailings cell, the HELP Model was used to estimate the average annual leakage through a 3 foot thick (tailings above the liquid) layer of silty sand material (Attachment I). HELP Model default parameters were used along with a maximum 16 inch evaporative zone (conservative for dry climate) and weather data from Grand Junction, Colorado. The model was performed for a 10 year period and included precipitation events ranging from 5.83 to 10.36 inches per year.

The results of this analysis suggest that a maximum average annual percolation through the 3 foot soil layer above the liquid will be approximately 12 ft^3 per acre or 504 ft^3 (3,770 gal.) for the entire Cell 4A area.

The average flow rate during Cell 4A dewatering, as calculated from Table 3 is equal to 71 gpm (102,240 gallon/day).

The time required to drain the additional volume of precipitation in the tailing is computed using the following equation:

$$Time = \frac{Volume}{FlowRate} = \frac{3{,}770\ gal}{102{,}240\ \frac{gal}{day}} = 0.04\ days$$

The additional time that the pond will require to empty due to precipitation is insignificant.

Therefore, the estimated time to dewater Cell 4A will be 5.5 years (baseline) + 0.03 years (pipe limitations) + 0 years (precipitation) = 5.5 years.

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(Attachment D)

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(Attachment F)

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(Attachment G)

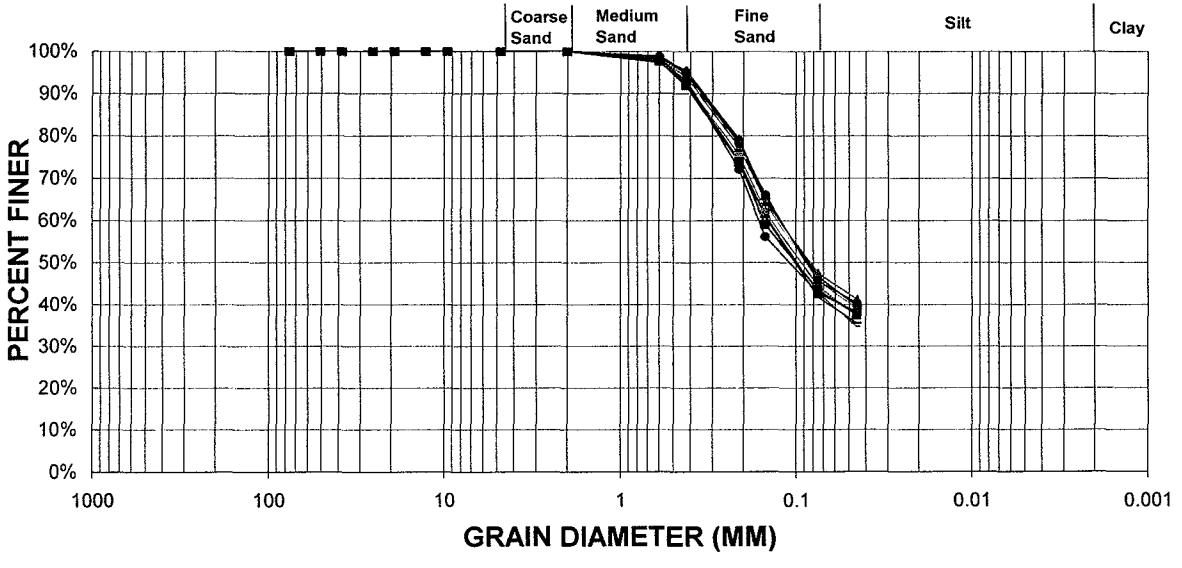
Amoco Fabrics and Fibers Company, (1991), "*Amoco Waste Related Geotextiles.*"
(Attachment H)

Table 1
DSM Screen Undersize Gradation

SIEVE ANALYSIS

		Grinding Test 1			Grinding Test 2A			Grinding Test 2B			Grinding Test 3A			Grinding Test 3B		
Sieve No.	Diameter (mm)	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.2	1.2%	98.8%	2.0	2.0%	98.0%	1.7	1.7%	98.3%	2.4	2.4%	97.6%	1.9	1.9%	98.1%
No. 40	0.425	4.6	4.6%	95.4%	7.3	7.3%	92.7%	6.0	6.0%	94.0%	8.1	8.1%	91.9%	6.9	6.9%	93.1%
No. 70	0.212	20.8	20.8%	79.2%	24.5	24.5%	75.5%	22.6	22.6%	77.4%	26.2	26.2%	73.8%	27.9	27.9%	72.1%
No. 100	0.150	34.8	34.8%	65.2%	38.1	38.1%	61.9%	35.5	35.5%	64.5%	41.0	41.0%	59.0%	43.9	43.9%	56.1%
No. 200	0.075	53.4	53.4%	46.6%	55.7	55.7%	44.3%	52.5	52.5%	47.5%	56.6	56.6%	43.4%	57.4	57.4%	42.6%
No. 325	0.045	60.5	60.5%	39.5%	62.7	62.7%	37.3%	58.8	58.8%	41.2%	62.5	62.5%	37.5%	61.9	61.9%	38.1%
Pan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Grinding Test 6A			Grinding Test 6B			Grinding Test 4A			Grinding Test 4B		
Sieve No.	Diameter (mm)	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.3	1.3%	98.7%	1.0	1.0%	99.0%	2.7	2.7%	97.3%	2.7	2.7%	97.3%
No. 40	0.425	5.2	5.2%	94.8%	4.7	4.7%	95.3%	7.6	7.6%	92.4%	7.3	7.3%	92.7%
No. 70	0.212	21.7	21.7%	78.3%	21.4	21.4%	78.6%	26.2	26.2%	73.8%	25.9	25.9%	74.1%
No. 100	0.150	34.1	34.1%	65.9%	35.9	35.9%	64.1%	38.7	38.7%	61.3%	39.2	39.2%	60.8%
No. 200	0.075	54.4	54.4%	45.6%	54.4	54.4%	45.6%	57.3	57.3%	42.7%	58.3	58.3%	41.7%
No. 325	0.045	59.7	59.7%	40.3%	61.1	61.1%	38.9%	65.4	65.4%	34.6%	64.6	64.6%	35.4%
Pan	-	-	-	-	-	-	-	-	-	-	-	-	-



Average	
Med Sand	6.4%
Fine Sand	49.1%
Silt	44.4%

%FINER = 100 - Σ%RETAINED

5/12/2007

Table 2
Tailings Parameters

Soil	Permeability[1] (cm/sec)	Drainable Porosity[2] (vol./vol.)
med sand	2.00E-02	0.35
fine sand	1.00E-02	0.29
silt	1.00E-04	0.14
silty clay	6.00E-07	0.11
average	7.53E-03	0.22
geomean	3.31E-04	0.20

Soil	Permeability[3] (cm/sec)	Drainable Porosity[3] (vol./vol.)
SM (LS)	1.70E-03	0.332
SM (LFS)	1.00E-03	0.326
SM (SL)	7.20E-04	0.263
SM (FSL)	5.20E-04	0.251
ML (L)	3.70E-04	0.231
ML (SiL)	1.90E-04	0.217
SC (SCL)	1.20E-04	0.154
average	6.60E-04	0.253
geomean	4.74E-04	0.246

Notes:

(1) Source - "Seepage, Drainage, and Flow Nets", Cedergren, H. R., 1989.

(2) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Figure 2 - Soil texture vs. Moisture Retention.

(3) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Table 1 - Low Density Soil Characteristics.

TABLE 3
White Mesa Mill
Cell 4A Slimes Drain
Maximum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)	Pipe Limitation (days)
3.31E-04	6.51E-04	46.3	39	6.40E-04	11	17,185	11.93	131.92	2,266,966	2.17
3.31E-04	6.51E-04	45.8	38	6.31E-04	11	17,446	12.12	129.94	2,266,966	1.98
3.31E-04	6.51E-04	45.4	37	6.19E-04	11	17,761	12.33	127.63	2,266,966	1.77
3.31E-04	6.51E-04	45.0	36	6.08E-04	11	18,094	12.57	125.29	2,266,966	1.53
3.31E-04	6.51E-04	44.6	35	5.96E-04	11	18,446	12.81	122.90	2,266,966	1.29
3.31E-04	6.51E-04	44.2	34	5.85E-04	11	18,818	13.07	120.47	2,266,966	1.03
3.31E-04	6.51E-04	43.8	33	5.73E-04	11	19,213	13.34	117.99	2,266,966	0.76
3.31E-04	6.51E-04	43.5	32	5.59E-04	11	19,677	13.66	115.21	2,266,966	0.44
3.31E-04	6.51E-04	43.2	31	5.45E-04	11	20,172	14.01	112.38	2,266,966	0.09
3.31E-04	6.51E-04	43.0	30	5.30E-04	11	20,748	14.41	109.26	2,266,966	
3.31E-04	6.51E-04	42.8	29	5.15E-04	11	21,363	14.84	106.11	2,266,966	
3.31E-04	6.51E-04	42.6	28	4.99E-04	11	22,023	15.29	102.94	2,266,966	
3.31E-04	6.51E-04	42.4	27	4.84E-04	11	22,731	15.79	99.73	2,266,966	
3.31E-04	6.51E-04	42.3	26	4.67E-04	11	23,550	16.35	96.26	2,266,966	
3.31E-04	6.51E-04	42.2	25	4.50E-04	11	24,434	16.97	92.78	2,266,966	
3.31E-04	6.51E-04	42.1	24	4.33E-04	11	25,392	17.63	89.28	2,266,966	
3.31E-04	6.51E-04	42.1	23	4.15E-04	11	26,496	18.40	85.56	2,266,966	
3.31E-04	6.51E-04	42.1	22	3.97E-04	11	27,700	19.24	81.84	2,266,966	
3.31E-04	6.51E-04	42.1	21	3.79E-04	11	29,019	20.15	78.12	2,266,966	
3.31E-04	6.51E-04	42.2	20	3.60E-04	11	30,543	21.21	74.22	2,266,966	
3.31E-04	6.51E-04	42.3	19	3.41E-04	11	32,226	22.38	70.34	2,266,966	
3.31E-04	6.51E-04	42.5	18	3.22E-04	11	34,178	23.73	66.33	2,266,966	
3.31E-04	6.51E-04	42.6	17	3.03E-04	11	36,273	25.19	62.50	2,266,966	
3.31E-04	6.51E-04	42.8	16	2.84E-04	11	38,721	26.89	58.55	2,266,966	
3.31E-04	6.51E-04	43.1	15	2.64E-04	11	41,592	28.88	54.50	2,266,966	
3.31E-04	6.51E-04	43.3	14	2.46E-04	11	44,770	31.09	50.64	2,266,966	
3.31E-04	6.51E-04	43.6	13	2.27E-04	11	48,548	33.71	46.70	2,266,966	
3.31E-04	6.51E-04	44.0	12	2.07E-04	11	53,076	36.86	42.71	2,266,966	
3.31E-04	6.51E-04	44.3	11	1.89E-04	11	58,296	40.48	38.89	2,266,966	
3.31E-04	6.51E-04	44.7	10	1.70E-04	11	64,704	44.93	35.04	2,266,966	
3.31E-04	6.51E-04	45.1	9	1.52E-04	11	72,537	50.37	31.25	2,266,966	
3.31E-04	6.51E-04	45.6	8	1.33E-04	11	82,509	57.30	27.48	2,266,966	
3.31E-04	6.51E-04	46.0	7	1.16E-04	11	95,123	66.06	23.83	2,266,966	
3.31E-04	6.51E-04	46.5	6	9.81E-05	11	112,183	77.90	20.21	2,266,966	
3.31E-04	6.51E-04	47.1	5	8.07E-05	11	136,357	94.69	16.63	2,266,966	
3.31E-04	6.51E-04	47.6	4	6.39E-05	11	172,255	119.62	13.16	2,266,966	
3.31E-04	6.51E-04	48.2	3	4.73E-05	11	232,569	161.51	9.75	2,266,966	
3.31E-04	6.51E-04	48.8	2	3.11E-05	11	353,196	245.27	6.42	2,266,966	
3.31E-04	6.51E-04	49.4	1	1.54E-05	11	715,076	496.58	3.17	2,266,966	
						days	**1,989.58**		**88,411,655**	**11.06**
						years	**5.45**			

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	39	ft
Length of Strip Drain	27,550	ft

TABLE 4
White Mesa Mill
Cell 4A Slimes Drain
Average Liquid Depth

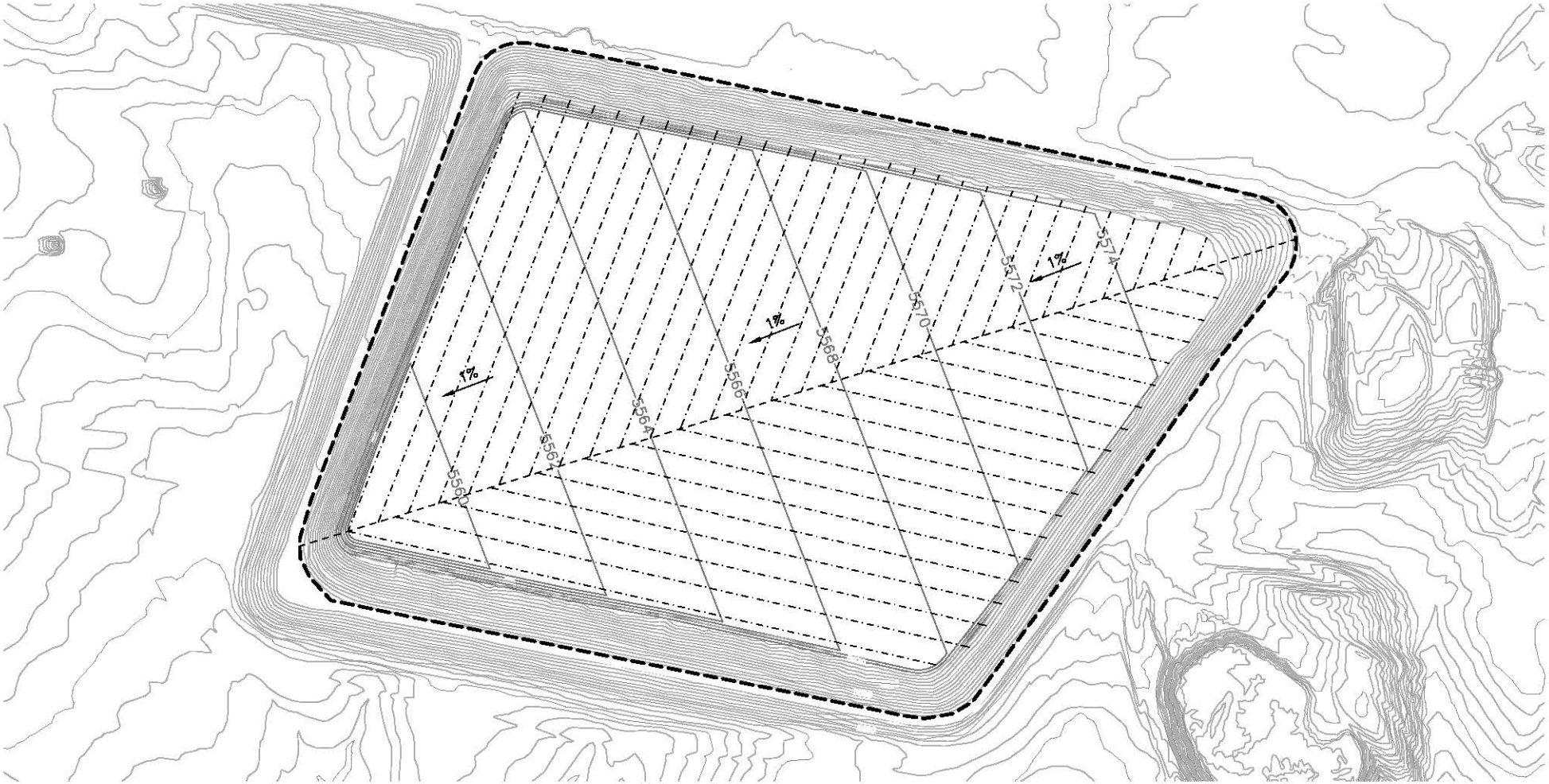
Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	39.8	31	5.92E-04	11	18,584	12.91	121.98	2,266,966
3.31E-04	6.51E-04	39.6	30	5.76E-04	11	19,107	13.27	118.64	2,266,966
3.31E-04	6.51E-04	39.4	29	5.59E-04	11	19,666	13.66	115.27	2,266,966
3.31E-04	6.51E-04	39.2	28	5.43E-04	11	20,265	14.07	111.86	2,266,966
3.31E-04	6.51E-04	39.1	27	5.25E-04	11	20,962	14.56	108.14	2,266,966
3.31E-04	6.51E-04	39.0	26	5.07E-04	11	21,713	15.08	104.41	2,266,966
3.31E-04	6.51E-04	38.9	25	4.88E-04	11	22,523	15.64	100.65	2,266,966
3.31E-04	6.51E-04	38.9	24	4.69E-04	11	23,462	16.29	96.62	2,266,966
3.31E-04	6.51E-04	39.0	23	4.48E-04	11	24,545	17.05	92.36	2,266,966
3.31E-04	6.51E-04	39.0	22	4.29E-04	11	25,661	17.82	88.34	2,266,966
3.31E-04	6.51E-04	39.2	21	4.07E-04	11	27,020	18.76	83.90	2,266,966
3.31E-04	6.51E-04	39.3	20	3.87E-04	11	28,444	19.75	79.70	2,266,966
3.31E-04	6.51E-04	39.5	19	3.66E-04	11	30,093	20.90	75.33	2,266,966
3.31E-04	6.51E-04	39.8	18	3.44E-04	11	32,006	22.23	70.83	2,266,966
3.31E-04	6.51E-04	40.1	17	3.22E-04	11	34,145	23.71	66.39	2,266,966
3.31E-04	6.51E-04	40.4	16	3.01E-04	11	36,550	25.38	62.02	2,266,966
3.31E-04	6.51E-04	40.8	15	2.79E-04	11	39,373	27.34	57.58	2,266,966
3.31E-04	6.51E-04	41.2	14	2.58E-04	11	42,599	29.58	53.22	2,266,966
3.31E-04	6.51E-04	41.6	13	2.37E-04	11	46,321	32.17	48.94	2,266,966
3.31E-04	6.51E-04	42.1	12	2.17E-04	11	50,784	35.27	44.64	2,266,966
3.31E-04	6.51E-04	42.6	11	1.96E-04	11	56,059	38.93	40.44	2,266,966
3.31E-04	6.51E-04	43.1	10	1.76E-04	11	62,388	43.33	36.34	2,266,966
3.31E-04	6.51E-04	43.7	9	1.57E-04	11	70,285	48.81	32.25	2,266,966
3.31E-04	6.51E-04	44.3	8	1.37E-04	11	80,157	55.66	28.28	2,266,966
3.31E-04	6.51E-04	44.9	7	1.18E-04	11	92,848	64.48	24.42	2,266,966
3.31E-04	6.51E-04	45.6	6	1.00E-04	11	110,012	76.40	20.61	2,266,966
3.31E-04	6.51E-04	46.2	5	8.22E-05	11	133,751	92.88	16.95	2,266,966
3.31E-04	6.51E-04	46.9	4	6.48E-05	11	169,722	117.86	13.36	2,266,966
3.31E-04	6.51E-04	47.7	3	4.78E-05	11	230,156	159.83	9.85	2,266,966
3.31E-04	6.51E-04	48.4	2	3.14E-05	11	350,301	243.26	6.47	2,266,966
3.31E-04	6.51E-04	49.2	1	1.54E-05	11	712,181	494.57	3.18	2,266,966
						days	**1,841.45**		**70,275,931**
						years	**5.05**		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	31	ft
Length of Strip Drain	27,550	ft

TABLE 5
White Mesa Mill
Cell 4A Slimes Drain
Minimum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	34.0	23	5.14E-04	11	21,398	14.86	105.94	2,266,966
3.31E-04	6.51E-04	34.1	22	4.90E-04	11	22,437	15.58	101.04	2,266,966
3.31E-04	6.51E-04	34.3	21	4.65E-04	11	23,643	16.42	95.88	2,266,966
3.31E-04	6.51E-04	34.6	20	4.39E-04	11	25,042	17.39	90.53	2,266,966
3.31E-04	6.51E-04	35.0	19	4.13E-04	11	26,665	18.52	85.02	2,266,966
3.31E-04	6.51E-04	35.4	18	3.86E-04	11	28,468	19.77	79.63	2,266,966
3.31E-04	6.51E-04	35.8	17	3.61E-04	11	30,483	21.17	74.37	2,266,966
3.31E-04	6.51E-04	36.3	16	3.35E-04	11	32,841	22.81	69.03	2,266,966
3.31E-04	6.51E-04	36.9	15	3.09E-04	11	35,609	24.73	63.66	2,266,966
3.31E-04	6.51E-04	37.5	14	2.84E-04	11	38,773	26.93	58.47	2,266,966
3.31E-04	6.51E-04	38.2	13	2.59E-04	11	42,535	29.54	53.30	2,266,966
3.31E-04	6.51E-04	38.9	12	2.34E-04	11	46,924	32.59	48.31	2,266,966
3.31E-04	6.51E-04	39.6	11	2.11E-04	11	52,111	36.19	43.50	2,266,966
3.31E-04	6.51E-04	40.4	10	1.88E-04	11	58,480	40.61	38.76	2,266,966
3.31E-04	6.51E-04	41.2	9	1.66E-04	11	66,264	46.02	34.21	2,266,966
3.31E-04	6.51E-04	42.1	8	1.44E-04	11	76,176	52.90	29.76	2,266,966
3.31E-04	6.51E-04	43.0	7	1.24E-04	11	88,919	61.75	25.49	2,266,966
3.31E-04	6.51E-04	43.9	6	1.04E-04	11	105,910	73.55	21.40	2,266,966
3.31E-04	6.51E-04	44.8	5	8.48E-05	11	129,698	90.07	17.48	2,266,966
3.31E-04	6.51E-04	45.8	4	6.64E-05	11	165,741	115.10	13.68	2,266,966
3.31E-04	6.51E-04	46.8	3	4.87E-05	11	225,814	156.81	10.04	2,266,966
3.31E-04	6.51E-04	47.9	2	3.17E-05	11	346,682	240.75	6.54	2,266,966
3.31E-04	6.51E-04	48.9	1	1.55E-05	11	707,839	491.55	3.20	2,266,966
						days	**1,665.59**		**52,140,207**
						years	**4.56**		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	23	ft
Length of Strip Drain	27,550	ft



200 100 0 200

SCALE IN FEET

GEOSYNTEC CONSULTANTS

SLIMES DRAIN LAYOUT CELL 4A BLANDING, UTAH	FIGURE NO. 1
	PROJECT NO. SC0349
	DATE: MARCH 2007

P:\PROJ\SCOord\CADD\SC0349\FIGURES\SC0349-01-04\SC0349_Figure 1_Slimes Drain Layout.dwg 7/10/2006 5:25 PM John Hall

Geosyntec consultants

Written by: G. Corcoran Date: 10/5/07 (DD MM YY) Reviewed by: _____ Date: __/__/__ (DD MM YY)

Client: Dawson Mines Project: Cell 4A. Project/Proposal No. SC0349 Task No. 01/04

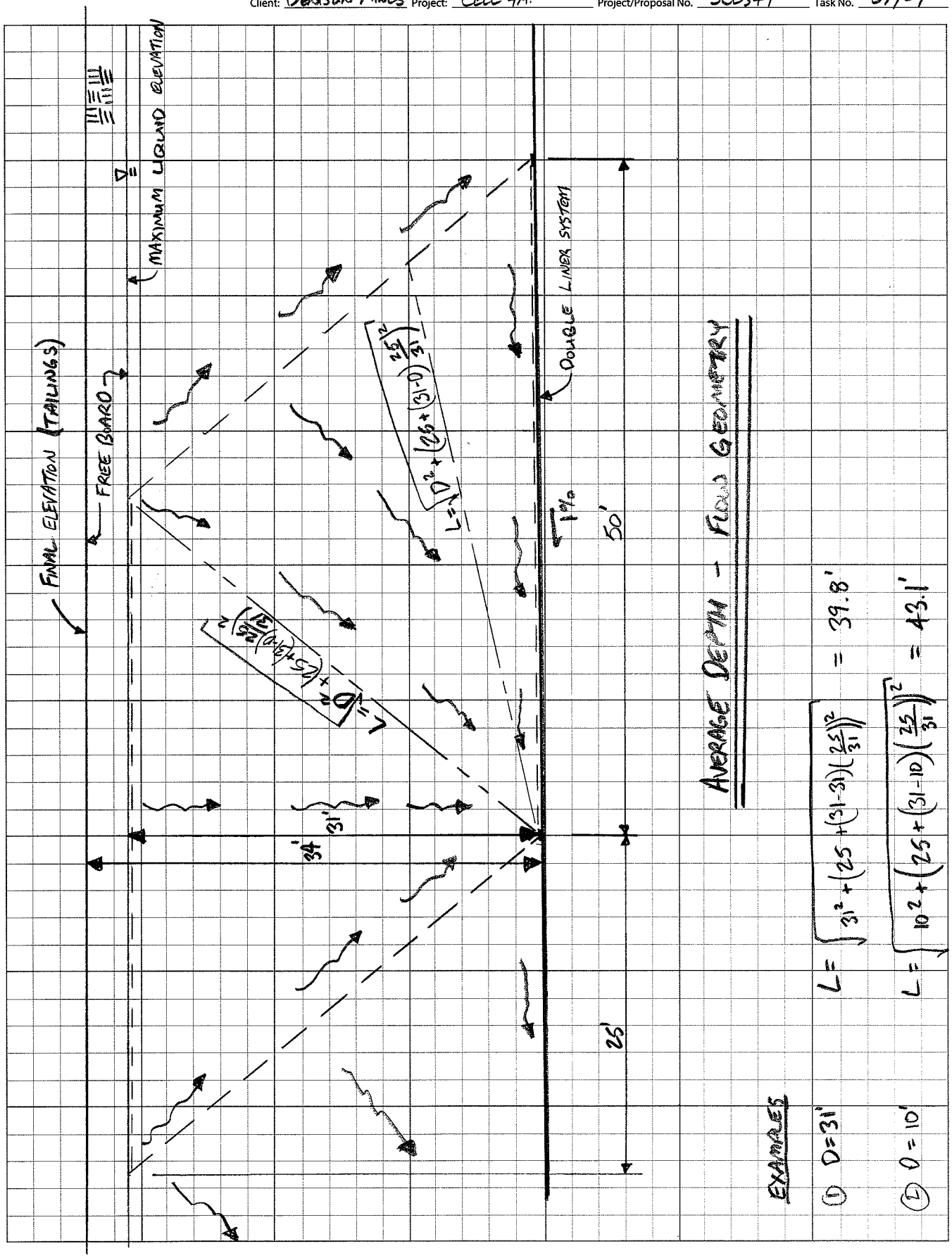
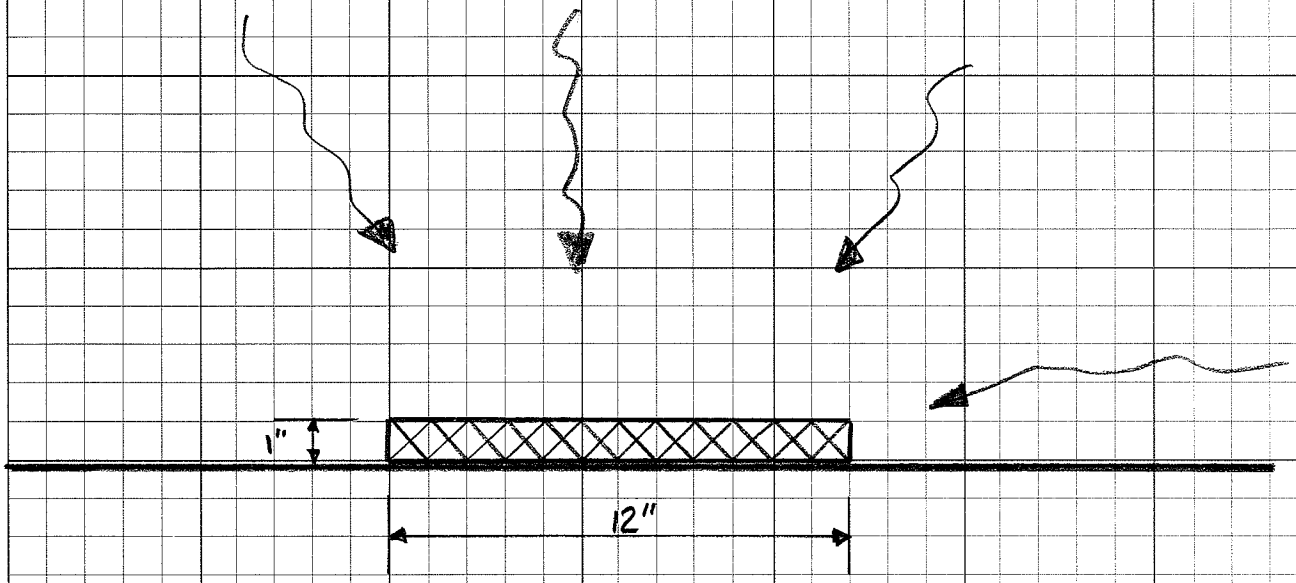


FIGURE 2

Geosyntec consultants

Written by: G. CORCORAN Date: 10/5/07 (DD MM YY) Reviewed by: _____ Date: __/__/__ (DD MM YY)

Client: DENISON MINES Project: CELL 4A Project/Proposal No. SC0349 Task No. 01/04



FLOW AREA - STRIP COMPOSITE

$$A = \frac{14''}{12''/'} = 1.17\ ft^2/ft.$$

FIGURE 3

EXHIBIT 1

SAMPLE DESCRIPTION AND PREPARATION

CSMRI Sample 1

Sponsor's Designation of Sample:	Run-of-mine.
Date Received at Institute:	June 5, 1978.
Sample Weight:	100,520 lb.
Sample Container:	Two truckloads.
Sample Description:	Mine ore -- estimate 5% +10-in. material. Largest boulder -- 48 in. x 24 in. x 14 in. Only two or three rocks were greater than 36 in.
Method of Preparation:	All +10-in. material broken to -10 in. by sledgehammer and jackhammer. The sample was screened at 6 in. and 1-1/2 in. with the +6 in. fraction, put in barrels, and the -1/2 in. fraction piled. The -6 in. +1-1/2 in. material was screened at 4 in. and 1-1/2 in. with the -6 in. +4 in. and -4 in. +1-1/2 in. fractions barreled. The additional -1-1/2 in. fraction was piled with the previous -1-1/2 in. fraction. A screen size analysis of the entire quantity of mill feed material is presented in Exhibit 3. A summary screen size analysis of the ore is as follows:

Screen Product in.		Weight %
Head (calculated)		100.00
-10	+6	2.92
-6	+4	9.48
-4	+1-1/2	15.30
-1-1/2		72.30

Attachment A. 1/14

EXHIBIT 1

CSMRI Sample 2

Sponsor's Designation of Sample:	Crushed ore.
Date Received at Institute:	June 5, 1978.
Sample Weight:	47,380 lb.
Sample Container:	One truckload.
Sample Description:	Ore previously crushed to -3 in., maximum particles approximately 2-1/2 in.
Method of Preparation:	The ore was used as received.

EXHIBIT 2

GRINDING TESTS

Grinding Test 1, Autogenous

Date:	June 13, 1978
Feed Rate, stph:	2
Ore:	Run-of-mine
DSM Screen, in. width:	12
DSM Screen Opening, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0910	0	--	--	104	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
0915	5	12.2	12,964	--	3,150	612	380	116	63	8,335	--	--	--	--	--	--	90	2,858	--	--
1005	55	8.7	--	--	2,880	612	380	116	62	--	90	506	60	3,348	57	2,616(2)	90	2,858	--	--
1030	80	6.8	--	105	2,835	612	380	116	69	--	90	304	70	3,591	58	710(2)	90	2,858	--	--
1100	110	6.5	12,977	106	2,993	612	380	116	66	--	--	--	69	4,223	58	679(2)	80	2,540	--	--
1135	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Mill down, elevator plugged.
1142	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1150	153	6.2	--	109	2,993	612	380	116	69	12,420	90	1,114	70	5,544	56	2,583	--	--	--	--
1230	193	6.0	12,988	111	2,903	612	380	116	64	10,829	90	405	69	6,955	60	4,388	75	2,382	--	--
1300	223	6.2	--	112	3,319	612	380	116	65	11,232	90	365	70	6,048	60	3,861	81	2,572	--	--
1345	238	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Pump plugged. DSM feed.
1400	253	6.4	--	112	3,128	612	380	116	65	11,700	90	122	69	3,229	60	3,996	80	2,540	--	Sample
1415	268	6.3	13,004	112	2,970	612	380	116	65	9,945	90	547	71	3,515	59	2,907	79	2,509	15	Sample.
Average					3,019	612	380	116	65	10,744	90	480	69	4,557	59	3,547	83	2,640		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,934.5 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total, 4,032.2 lb/hr, 2.016 dry stph. Mill volume end of test: 15%.
(2) Excluded from average.

Feed Rate, stph dry:	2.016
Ball Charge:	None
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0910	0	--	--	--	--	--	--	--	--
0915	5	12.2	4.25	2.64	1.31	1.01	--	63	--
1005	55	8.7	5.96	4.25	2.11	1.81	--	62	--
1030	80	6.8	7.62	5.80	2.88	2.58	--	69	--
1100	110	6.5	7.97	6.10	3.03	2.73	--	66	--
1135	145	--	--	--	--	--	--	--	Unplug bucket elevator.
1150	153	6.2	8.36	6.47	3.21	2.91(2)	162.0	69	--
1230	193	6.0	8.64	6.73	3.34	3.04(2)	183.0	64	--
1300	223	6.2	8.36	6.47	3.21	2.91(2)	145.0	65	--
1345	238	--	--	--	--	--	--	--	Unplug DSM feed pump.
1400(3)	253	6.4	8.10	6.23	2.09	2.79(2)	79.0	65	--
1415(3)	268	6.3	8.23	6.35	3.15	2.85(2)	100.0	65	--
Average						2.90	133.8		

(1) Calculated: Sum of Sweco oversize and DSM oversize as percentage of dry mill feed.
(2) Average for power (last five readings): 2.90 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 1 -- continued

Procedure: Sample was wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis DSM Screen Undersize
Sample Time:	1415
Sample Weight, g:	4,630.5
Screen Product (Tyler) Mesh	Weight %
Head (calculated)	100.0
+28	1.2
-28 +35	3.4
-35 +65	16.2
-65 +100	14.0
-100 +200	18.6
-200 +325	7.1
-325	39.5

US SIEVE

GTC 5/10/07

No. 30
No. 40
No. 70
No. 100
No. 200
No. 325

EXHIBIT 2

Grinding Test 2

Date:	June 14, 1978
Feed Rate, stph:	2.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb; 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1040	0	8.7	13,004	102	--	612	380	116	--	--	--	--	--	--	--	--	95	3,017	-	Start mill.
1110	30	5.2	--	104	--	612	380	116	--	--	--	--	--	--	--	--	83	2,636	-	--
1130	50	5.3	--	106	3,060	612	380	116	62	8,147	50	248	74	1,565	54	2,989(2)	84	2,668	-	--
1200	80	5.0	--	108	2,846	612	380	116	63	6,577	67	653	71	1,150	--	--	82	2,604	-	--
1230	110	4.8	13,023	111	3,105	612	380	116	64	8,467	64	605	73	1,281	--	--	82	2,604	-	--
1300	140	4.8	--	112	3,139	612	380	116	63	6,917	62	391	73	2,102	57	3,694	81	2,572	-	--
1330	170	4.8	--	113	3,263	612	380	116	66	8,494	63	595	69	3,571	56	3,881	81	2,572	-	--
1400	200	4.9	--	113	2,981	612	380	116	66	9,029	64	624	71	2,939	58	3,680	81	2,572	-	--
1415	215	5.0	--	113	2,869	612	380	116	66	10,098	64	547	70	3,119	58	3,811	79	2,509	-	Sample.
1430	230	5.0	13,044	113	2,993	612	380	116	65	8,483	64	557	71	3,259	57	3,565	79	2,509	9	Sample. End of test.
Average					3,032	612	380	116	65	8,277	62	528	72	2,373	57	3,726	83	2,626		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,947.0 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total: 4,044.7 lb/hr, 2.022 dry stph. Mill volume end of test: 9%.
(2) Excluded from average.

Feed Rate, stph dry:	2.022
Ball Charge:	301.8 lb, 2% mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwh/st	Power Consumption Net kwh/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %
1040	0	8.7	5.96	4.22	2.09	1.79	--	--
1110	30	5.2	9.97	7.93	3.92	3.63	--	--
1130	50	5.3	9.78	7.78	3.85	3.55	--	62
1200	80	5.0	10.36	8.25	4.08	3.78	--	63
1230	110	4.8	10.80	8.63	4.27	3.97	--	64
1300	140	4.8	10.80	8.63	4.27	3.97	59.0(4)	63
1330	170	4.8	10.80	8.63	4.27	3.97	95.0	66
1400	200	4.9	10.58	8.44	4.17	3.88	87.0	66
1415(3)	215	5.0	10.36	8.25	4.08	3.78(2)	92.0	66
1430(3)	230	5.0	10.36	8.25	4.08	3.78(2)	93.0	65
Average						3.78	91.8	

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last two readings): 3.78 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 2 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis								
	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1415	1430	1415	1430	1415	1430	1415	1430	
Sample Weight, g:	1,058.8	1,206.6	669.3	979.0	915.6	1,106.8	888.1	932.3	
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	23.8	21.6	65.5	71.8	40.4	37.6	2.0	1.7	43.4
-28 +35	6.8	6.4	2.5	1.6	8.4	9.9	5.3	4.3	8.1
-35 +65	13.5	13.3	4.2	3.6	8.8	12.0	17.2	16.6	9.4
-65 +100	9.4	10.2	3.2	3.0	4.7	7.6	13.6	12.9	5.7
-100 +200	11.9	13.4	5.0	5.0	7.3	10.3	17.6	17.0	8.3
-200 +325	4.2	5.9	3.0	2.1	1.6	4.7	7.0	6.3	3.1
-325	30.4	29.2	16.6	12.9	28.8	17.9	37.3	41.2	22.0

EXHIBIT 2

Grinding Test 3

Date:	June 15, 1978
Feed Rate, stph:	3.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(2)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1050	0	5.0	13,045	93	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1135	45	4.5	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	--
1200	70	4.4	--	99	4,350	918	570	174	65	13,631	68	857	70	6,237	58	5,090	105	3,350	--	--
1207	77	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Shutdown, rock jammed in feeder.
1230	77	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1300	107	4.9	--	109	3,435	918	570	174	65	10,530	63	808	73	3,679	55	4,430	106	3,366	--	--
1330	137	4.8	--	108	4,815	918	570	174	66	11,642	64	878	72	5,508	61	5,408	104	3,303	--	--
1400	167	4.9	--	110	4,275	918	570	174	67	11,095	58	639	73	5,059	61	5,545	104	3,303	--	--
1430	197	4.7	--	111	4,590	918	570	174	67	11,156	65	761	72	5,573	61	4,804	103	3,271	--	Sample.
1445	212	4.8	13,085	112	5,040	918	570	174	67	15,135	67	1,010	71	6,646	62	5,692	104	3,303	--	Sample.
1500	242	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	25	Shut down.
Average					4,417	918	570	174	66	12,198	64	826	72	5,450	60	5,162	104	3,316		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%, -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 4,293.8 lb/hr, -4 in. +1-1/2 in., 908.8 lb/hr; -6 in. +4 in., 565.4 lb/hr; -10 in. +6 in., 172.8 lb/hr; total, 5,940.8 lb/hr, 2.970 dry stph. Mill volume end of test: 25%.
(2) Auxilliary water line used -- measured twice, averaged, and added as percentage of regular water meter.

Feed Rate, stph dry:	2.970 stph dry
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1050	0	5.0	10.36	8.26	2.78	2.58	--	--	--
1135	45	4.5	11.52	9.24	3.11	2.91	--	--	--
1200	70	4.4	11.78	9.45	3.18	2.98	118.0(4)	65	--
1207	77	--	--	--	--	--	--	--	Rock jammed in feeder.
1230	77	--	--	--	--	--	--	--	--
1300	107	4.9	10.58	8.43	2.84	2.64	88.0	65	--
1330	137	4.8	10.80	8.62	2.90	2.70(2)	99.0	66	--
1400	167	4.9	10.58	8.43	2.84	2.64(2)	96.0	67	--
1430(3)	197	4.7	11.03	8.82	2.97	2.77(2)	101.0	67	--
1445(3)	212	4.8	10.80	8.62	2.90	2.70(2)	114.0	67	--
1500	242								
Average						2.70	99.6		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last four readings): 2.70 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 3

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Test Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1430	1445	1430	1445	1430	1445	1430	1445	--
Sample Weight, g:	1,174.9	1,310.3	1,365.7	1,223.1	1,183.4	1,245.5	850.1	962.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	27.8	25.1	65.0	67.5	47.4	33.3	2.4	1.9	43.7
-28 +35	6.5	7.1	1.8	2.0	9.1	7.9	5.7	5.0	7.6
-35 +65	12.8	14.6	3.7	4.0	12.4	13.2	18.1	21.0	11.7
-65 +100	9.2	9.0	3.1	3.4	6.5	8.5	14.8	16.0	7.0
-100 +200	11.4	13.5	5.4	5.5	8.9	9.9	15.6	13.5	8.9
-200 +325	4.8	3.4	3.4	3.3	1.6	3.3	5.9	4.5	2.5
-325	27.5	27.3	17.6	14.3	14.1	23.9	37.5	38.1	18.6

EXHIBIT 2

Grinding Test 4

Date:	June 16, 1978
Feed Rate, stph:	2.5
Ore:	Crushed
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(1)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1010	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	Start mill.
1030	20	6.6	13,094	96	--	--	--	--	--	--	--	--	--	90	2,858	--	--
1100	50	6.3	--	97	5,130	63	7,598	67	362	74	1,931	61	5,243	87	2,763	--	--
1130	80	5.9	--	99	5,350	62	8,091	64	418	72	2,398	60	4,482	82	2,604	--	--
1200	110	5.9	--	99	4,995	65	12,519	66	535	70	3,717	61	3,953	80	2,540	--	--
1215	125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Feed off (feed belt jammed).
1218	125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1230	137	6.0	--	100	4,770	62	5,692	62	288	71	2,077	58	3,628	80	2,540	--	--
1300	167	6.0	--	100	5,423	65	6,786	62	326	71	1,885	60	4,428	80	2,540	--	--
1320	187	--	--	--	--	--	--	--	--	--	--	60	4,316(3)	--	--	--	--
1330	197	5.8	--	102	4,826	65	6,728	65	449	69	2,298	59	4,806	79	2,509	--	--
1400	227	5.7	--	104	4,635	64	6,797	62	260	72	1,134	60	4,617	79	2,509	--	Sample.
1415	242	5.7	13,128	104	6,793	63	6,010	64	230	70	819	59	4,328	79	2,509	15	Sample.
1500	257	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Average					5,240	64	7,528	64	359	71	2,032	60	4,422	82	2,597	--	

(1) Moisture: -3 in., 4.3%. Average dry ore feed rate: -3 in., 5,015 lb/hr, 2.508 dry stph. Mill volume end of test: 15%.
(2) Auxilliary water line used -- measured twice, averaged, and added as percentage of regular water meter.
(3) 55-gal drum timed sample.

Feed Rate, stph:	2.508
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1010	0	--	--	--	--	--	--	--	--
1030	20	6.6	7.85	6.00	2.39	2.15	--	--	--
1100	50	6.3	8.23	6.35	2.53	2.29	--	63	--
1130	80	5.9	8.78	6.87	2.74	2.50	50.0(4)	62	--
1200	110	5.9	8.78	6.87	2.74	2.50	81.0(4)	65	--
1215	125	--	--	--	--	--	--	--	Feed belt jammed.
1230	137	6.0	8.64	6.73	2.68	2.44	48.0	62	--
1300	167	6.0	8.64	6.73	2.68	2.44	39.0	65	--
1320	187	--	--	--	--	--	--	--	--
1330	197	5.8	8.93	7.00	2.79	2.55(2)	54.0	65	--
1400(3)	227	5.7	9.09	7.13	2.84	2.60(2)	29.0	64	--
1415(3)	242	5.7	9.09	7.13	2.84	2.60(2)	14.0	63	--
Average						2.58	36.8		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last three readings): 2.58 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 4 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Test Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1140	1415	1400	1415	1400	1415	1400	1415	--
Sample Weight, g:	1,139.4	886.7	715.4	726.2	1,152.9	1,020.0	763.8	769.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	15.3	13.1	86.5	91.8	39.1	43.1	2.7	2.7	55.5
-28 +35	5.8	5.2	0.3	0.3	8.9	7.6	4.9	4.6	5.9
-35 +65	17.8	17.9	0.9	0.5	14.9	12.7	18.6	18.6	9.9
-65 +100	11.1	11.8	0.7	0.3	6.8	6.3	12.5	13.3	4.7
-100 +200	15.8	16.7	1.6	0.7	8.8	8.9	18.6	19.1	6.6
-200 +325	7.7	6.4	0.9	0.4	3.3	4.1	8.1	6.3	2.8
-325	26.5	28.9	9.1	6.0	18.2	17.3	34.6	35.4	14.6

EXHIBIT 2

Grinding Test 5

Date:	June 19, 1978
Feed Rate, stph:	2.0
Ore:	Crushed
Ball Charge:	Total 301.8 lb, 2% mill volume
-1-1/2 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge		Sweco Screen Oversize		DSM Screen Overflow		DSM Screen Underflow		Mill Water		Mill Load Volume %	Remarks
						Solids %	Solids lb/hr	Solids %	Solids lb/hr	Solids %	Solids lb/hr	Solids %	Solids lb/hr	Meter %	Rate lb/hr		
0840	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	Start mill.
0910	30	6.7	13,136	90	3,623	--	--	--	--	--	--	--	--	75	2,382	--	--
0930	50	6.3	--	91	3,960	67	8,744	48	356	67	3,558	60	2,970	71	2,255	--	--
1000	80	6.2	--	92	3,803	66	6,663	45	324	70	2,079	60	4,077	68	2,159	--	--
1030	110	6.5	--	91	--	56	3,578	15	68	70	347	59	3,452	66	2,096	--	Shut down -- out of feed.
1035	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1040	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1100	135	6.5	--	94	4,230	66	4,990	38	182	75	346	62	4,241	68	2,159	--	--
1130	165	6.6	--	96	4,298	66	5,049	42	239	72	729	62	4,101	69	2,191	--	--
1155	190	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--
1200	195	6.7	--	97	4,320	63	3,856	37	200	75	405	61	3,870	69	2,191	--	--
1230	225	6.7	--	100	3,533	62	3,894	27	101	73	394	58	3,445	64	2,032	--	--
1300	255	6.6	--	103	4,016	66	4,693	29	111	70	851	61	3,870	68	2,159	--	--
1330	285	6.3	--	104	4,005	68	9,058	34	173	68	3,672	64	3,744	61	1,937	--	--
1345	300	6.5	--	104	3,645	63	4,139	32	134	71	250	59	3,452	68	2,159	--	Sample.
1400	315	6.1	--	104	4,005	64	4,781	34	143	72	238	57	3,104	69	2,191	--	Sample.
1430	345	6.1	--	105	4,140	63	4,820	33	193	69	598	59	3,505	69	2,191	--	--
1445	360	6.0	--	106	3,713	62	4,018	38	182	71	423	56	2,696	69	2,191	--	Sample.
1500	375	5.7	13,184	107	4,028	63	4,139	36	151	70	1,323	56	2,696	69	2,191	--	Sample.
1510	380	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down.
1513	388	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Collecting mill discharge sample.
1522	397	--	--	--	3,690	--	--	--	--	--	--	--	--	--	--	--	Second barrel.
1529	404	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Third barrel.
1536	411	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Hopper went empty.
1537	412	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down mill.
Average	--	--	--	--	3,934	64	5,173	35	183	71	1,087	59	3,516	68	2,165	--	--

(1) Moisture: -3 in., 2.0%. Average dry ore feed rate: -3 in., 3,855 lb/hr, 1.928 dry stph. Mill volume end of test: 15%.

EXHIBIT 2

Grinding Test 5 -- continued

Feed Rate, stph (dry): 1.928
Ball Charge: 301.8 lb, 2% of mill charge
Corrected Mill Power Tare (empty mill), kw: 0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0840	0	--	--	--	--	--	--	--	--
0910	30	6.7	7.73	5.89	3.05	2.74	--	--	--
0930	50	6.3	8.23	6.35	3.29	2.98	--	67	--
1000	80	6.2	8.36	6.47	3.36	3.04	--	66	--
1030	110	6.5	7.97	6.10	3.16	2.85	--	56	--
1035	115	--	--	--	--	--	--	--	Ran out of ore.
1100	135	6.5	7.97	6.10	3.16	2.85	12.0(4)	66	--
1130	165	6.6	7.85	6.00	3.11	2.80	23.0(4)	66	--
1155	190	--	--	--	--	--	--	--	Check mill volume.
1200	195	6.7	7.73	5.89	3.05	2.74	14.0	63	--
1230	225	6.7	7.73	5.89	3.05	2.74	14.0	62	--
1300	255	6.6	7.85	6.00	3.11	2.80	24.0	66	--
1330	285	6.3	8.23	6.35	3.29	2.98	96.0(4)	68	--
1345(3)	300	6.5	7.97	6.10	3.16	2.85	11.0	63	--
1400(3)	315	6.1	8.50	6.60	3.42	3.11(2)	10.0	64	--
1430	345	6.1	8.50	6.60	3.42	3.11(2)	19.0	63	--
1445(3)	360	6.0	8.64	6.73	3.49	3.18(2)	16.0	62	--
1500(3)	375	5.7	9.09	7.13	3.70	3.37	37.0	63	--
1510	385	--	--	--	--	--	--	--	Check mill load level.
1513	388	--	--	--	--	--	--	--	Start filling No. 1 mill discharge sample barrel.
1522	397	--	--	--	--	--	--	--	Start filling No. 2 mill discharge sample barrel.
1529	404	--	--	--	--	--	--	--	Start filling No. 3 mill discharge sample barrel.
1536	411	--	--	--	--	--	--	--	End filling No. 3 mill discharge sample barrel.
1537	412	--	--	--	--	--	--	--	End of test.
Average						3.13	18.0		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (three readings, omitted reading at 1,500 from average): 3.13 kwhr/st.
(3) Sample run.
(4) Omitted from average.

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Screen Size Analysis

Test Product	Mill Discharge				Sweco Screen Oversize				DSM Screen Oversize				DSM Screen Underflow				Circulating Load
Sample Time	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	--
Sample Weight, g:	1,058.6	1,062.1	911.3	859.1	442.5	300.3	282.2	381.8	1,065.9	713.5	478.8	920.6	817.4	757.0	743.7	787.8	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	12.0	11.5	10.2	10.8	78.4	82.9	81.4	87.5	67.0	54.5	51.9	32.0	1.8	2.0	1.9	1.6	58.1
-28 +35	3.7	3.7	2.7	2.9	1.5	0.8	1.0	0.4	5.0	4.6	4.5	3.9	3.1	3.1	2.8	2.3	3.7
-35 +65	15.3	16.3	12.9	13.4	4.1	1.9	3.0	1.1	6.2	7.4	6.9	10.9	16.8	16.3	15.8	14.2	6.7
-65 +100	12.3	13.4	12.8	12.7	2.4	1.2	1.9	0.8	3.4	5.2	5.2	9.1	14.7	14.6	14.2	14.5	4.8
-100 +200	19.1	18.5	21.3	20.6	4.1	2.7	3.7	1.6	5.3	8.2	9.3	14.2	20.5	20.5	21.7	21.8	8.0
-200 +325	8.0	6.6	9.0	8.6	1.1	1.0	1.1	1.2	1.6	2.8	4.0	5.3	8.1	8.4	7.4	7.4	2.9
-325	29.6	30.0	31.1	31.0	8.4	9.5	7.9	7.4	11.5	17.3	18.2	24.6	35.0	35.1	36.2	38.2	15.8

EXHIBIT 2

Grinding Test 6

Date:	June 20, 1978
Feed Rate, stph:	2.5
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. -6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0820	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--(Grind out)--		Start mill.
0925	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	13,195	82	--	768	474	219	--	--	--	--	--	--	--	--	80	2,540	--	--
1000	35	5.9	--	80	--	768	474	219	66	11,286	60	662	71	4,090	61	5,737	85	2,699	--	--
1030	65	5.3	--	82	3,713	768	474	219	66	9,742	54	535	68	4,896	61	3,486	84	2,668	--	--
1100	95	5.2	--	83	3,825	768	474	219	67	10,492	60	608	68	4,651	61	4,255	85	2,699	--	--
1135	130	5.2	--	84	3,510	768	474	219	66	7,960	59	597	68	3,733	61	4,255	84	2,668	25	--
1200	155	5.2	--	87	3,758	768	474	219	68	10,588	57	487	68	4,651	60	3,699	85	2,699	--	--
1230	185	5.1	--	88	3,420	768	474	219	68	10,037	55	545	69	3,974	60	4,104	89	2,826	--	--
1245	200	5.1	--	88	3,420	768	474	219	67	9,950	52	714	68	4,223	59	4,275	89	2,826	--	Sample.
1300	215	5.0	--	89	3,600	768	474	219	67	11,759	62	781	68	6,487	62	3,627	85	2,699	--	Sample.
1330	245	5.0	12,236	92	--	768	474	219	67	8,924	60	1,337	68	4,039	60	3,780	88	2,795	--	--
1337	252	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	Shut down.
Average					3,607	768	474	219	67	10,082	58	696	68	4,527	61	4,135	85	2,712		

(1) Moisture: -1-1/2 in., 2.3%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 3,524 lb/hr; -4 in. +1-1/2 in., 760.3 lb/hr; -6 in. +4 in., 470.2 lb/hr; -10 in. +6 in., 217.5 lb/hr; Total: 4,972 lb/hr; 2.486 dry stph. Mill volume end of test: 27%.

Feed Rate, stph (dry):	2.486
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0820	--	--	--	--	--	--	--	--	Grind out.
0925	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	7.62	5.80	2.33	2.09	--	--	--
1000	35	5.9	8.78	6.87	2.76	2.52	--	66	--
1030	65	5.3	9.78	7.78	3.13	2.92	105.0	66	--
1100	95	5.2	9.97	7.92	3.18	2.94	99.0	67	--
1135	130	5.2	9.97	7.92	3.18	2.94	87.0	66	--
1200	155	5.2	9.97	7.92	3.18	2.94	98.0	68	--
1230	185	5.1	10.16	8.09	3.25	3.01	93.0	68	--
1245(3)	200	5.1	10.16	8.09	3.25	3.01	101.0	67	--
1300(3)	215	5.0	10.36	8.26	3.32	3.08(2)	144.0	67	--
1330	245	4.0	10.36	8.26	3.32	3.08(2)	--	67	--
1337	252	--	--	--	--				End of test.
Average						3.08	103.9		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (two readings): 3.08 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 6 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Total Product	Screen Size Analysis								
	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1245	1300	1245	1300	1245	1300	1245	1300	
Sample Weight, g:	1,258.8	1,237.7	673.8	642.6	1,361.9	1,079.3	832.1	918.1	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	21.0	18.4	64.8	70.7	32.9	23.1	1.3	1.0	32.9
-28 +35	6.4	6.5	1.9	1.2	9.4	8.5	3.9	3.7	8.1
-35 +65	13.9	15.1	3.8	2.7	12.8	14.3	16.5	16.7	12.2
-65 +100	10.5	11.4	3.2	2.2	8.8	8.6	12.4	14.5	8.0
-100 +200	13.3	14.2	5.4	5.0	11.8	14.2	20.3	18.5	12.0
-200 +325	5.5	5.6	3.1	2.2	4.8	3.7	5.3	6.7	4.1
-325	29.4	28.8	17.8	16.0	19.5	27.6	40.3	38.9	22.7

Sediment Description and Classification Background

U.S. Standard Sieves

Note that the same size mesh can be a differing sieve number depending on the Sieve manufacturer (Tyler vs. ASTM)

Mesh Size (microns)	**TYLER**	**ASTM-E11**	**BS-410**	**DIN-4188**
µm	Mesh	No.	Mesh	mm
5	2500		2500	0.005
10	1250		1250	0.010
15	800		800	0.015
20	625		625	0.020
22				0.022
25	500		500	0.025
28				0.028
32				0.032
36				0.036
38	400	400	400	
40				0.040
45	325	325	350	0.045
50				0.050
53	270	270	300	
56				0.056
63	250	230	240	0.063
71				0.071
75	200	200	200	
80				0.080
90	170	170	170	0.090
100				0.100
106	150	140	150	
112				0.112
125	115	120	120	0.125
140				0.140
150	100	100	100	

Attachment B, 1/10

160				0.160
180	80	80	85	0.180
200				0.200
212	65	70	72	
250	60	60	60	0.250
280				0.280
300	48	50	52	
315				0.315
355	42	45	44	0.355
400				0.400
425	35	40	36	
450				0.450
500	32	35	30	0.500
560				0.560
600	28	30	25	
630				0.630
710	24	25	22	0.710
800				0.800
850	20	20	18	
900				0.900
1000	16	18	16	1.0
1120				1.12
1180	14	16	14	
1250				1.25
1400	12	14	12	1.4
1600				1.6
1700	10	12	10	
1800				1.8
2000	9	10	8	2.0
2240				2.24
2360	8	8	7	
2500				2.5
2800	7	7	6	2.8
3150				3.15
3350	6	6	5	
3550				3.55
4000	5	5	4	4.0
4500				4.5

4750	4	4	3.5	
5000				5.0

Sediment Classification based on Grain Size:

Unified Soil Classification System (USCS)

Sediment Name	**Diameter (mm)**	**Sieve No.**
Cobble	greater than 75 mm	
Gravel	4.75 to 75 mm	4
Sand	0.075 to 4.75 mm	200
Fines (silt and clay)	less than 0.075 mm	

USCS Division of Sands

Sediment Name	Diameter Range (mm)	Passes through Sieve No.	Retained on Sieve No.
Coarse Sand	2.0 - 4.8	4	10
Medium Sand	0.43 - 2.0	10	40
Fine Sand	0.075 - 0.43	40	200

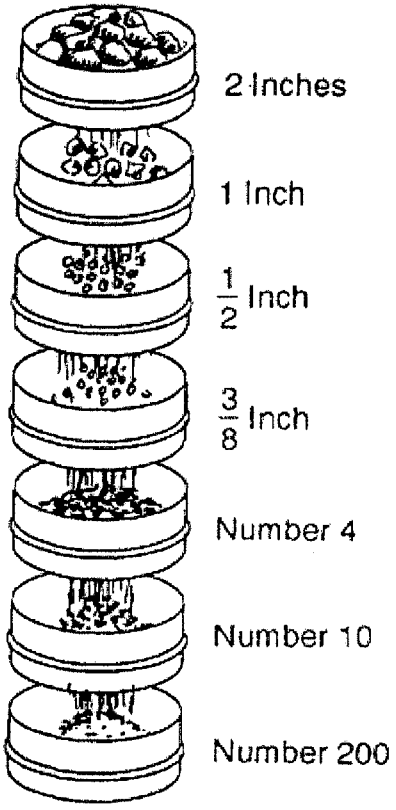


Figure 4-3. Dry sieve analysis.

USCS Classification System

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS More Than Half Retained on 200 Sieve	GRAVELS More Than Half Coarse Fraction Retained on No. 4 Sieve	Clean Gravels (Little or no Fines)	GW	Well Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
			GP	Poorly Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
		Gravels With Fines (Appreciable Fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More Than Half Coarse Fraction Passes a No. 4 Sieve	Clean Sands (Little or no Fines)	SW	Well Graded Sands, Gravelly Sands, Little or no Fines
			SP	Poorly Graded Sands, Gravelly Sands, Little or no Fines
		Sands With Fines (Appreciable Fines)	SM	Silty Sands, Sand - Silt Mixtures
			SC	Clayey Sands, Sand - Clay Mixtures
FINE GRAINED SOILS More Than Half Passes 200 Sieve	SILTS and CLAYS Liquid Limit Less Than 50		ML	Inorganic Silts & Very Fine Sands, Silty or Clayey Fine Sands, Clayey Silts
			CL	Inorganic Clays of Low to Medium Plasticity, Lean Clays
			OL	Organic Silts & Organic Silty Clays of Low Plasticity
	SILTS and CLAYS Liquid Limit Greater Than 50		MH	Inorganic Silts, Fine Sand or Silty Soils, Elastic Silts
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils			PT	Peat and Other Highly Organic Soils

Visual logging of sediments entails estimating percentages of gravels, sands and fines (silt and clays). Practice and the use of the Geotechnical Gage will increase your confidence and ability in visually logging sediments.

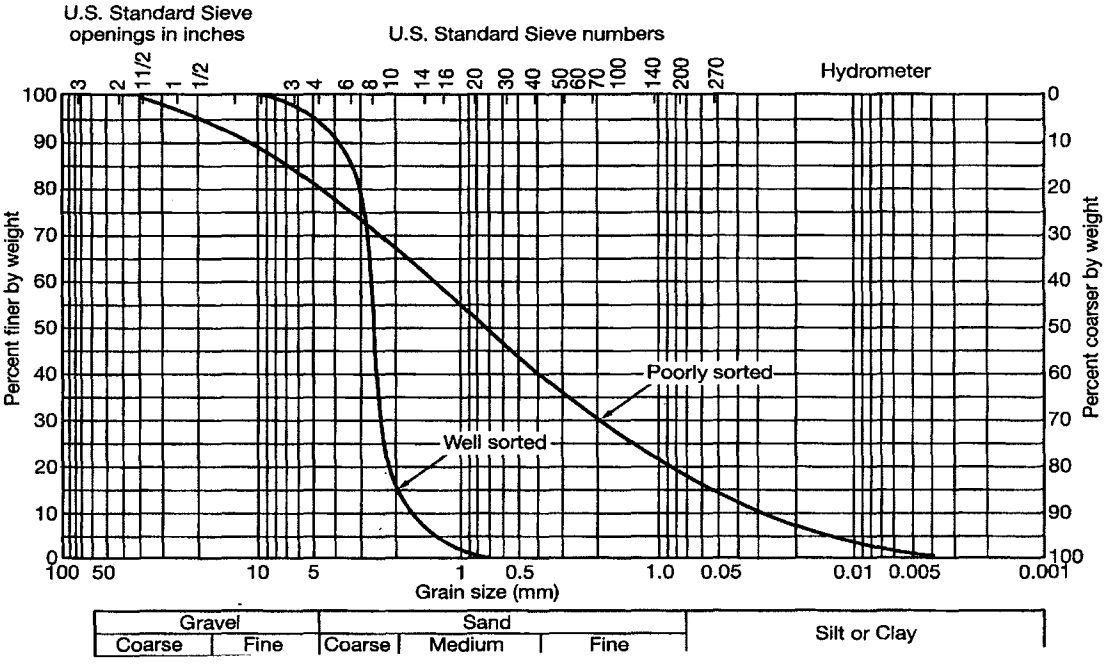
Read: Visual Exam Test

Read: Field Identification Guidelines

Ultimately, sediment samples may undergo grain size analysis through sieves. Graphing the cumulative weight percent retained/passing by sieve no. or grain size will result in the sediment grain-size distribution curve. The grain-size distribution curve is used to quantitatively classify the sediment type (your visual identification is a qualitative classification).

Read: Grain Size Distribution Measurement

Grain Size Distribution Curve



The grain-size distribution curve is used with the USCS classification chart to classify the sediment type. Other measures used to describe the sediment are the sorting or gradation of the sediment. As can be seen in the above chart, a well-sorted sediment has a small range of sediment grain sizes while a poorly sorted sediment has a large range of sediment grain sizes. In the USCS classification scheme, the gradation of the sediment is used instead of the sorting. A well-graded sediment has a large range of grain sizes while a poorly or uniformly graded sediment has a small range of grain sizes.

Figure 4-6. Well-graded soil.

POORLY SORTED SEDIMENT = WELL GRADED SEDIMENT

Figure 4-7. Uniformly graded soil.

WELL-SORTED SEDIMENT = POORLY OR UNIFORMLY GRADED SEDIMENT

Figure 4-8. Gap-graded soil.

After sieve analysis, the data are tabulated showing the weight of sediment retained on each sieve. The cumulative weight retained is calculated starting from the largest sieve size and adding subsequent sediment weights from the smaller size sieves (see table below). The percent retained is calculated from the weight retained and the total weight of the sample. [Don't get confused by the graph - it is individual percent retained in Column 16 and cumulative percent passing in Column 17]. The cumulative percent passing in Column 17 of the table below is calculated by sequentially subtracting percent retained from 100 %. In table below, cumulative percent passing 1/4 inch sieve = 100 - 16 = 84; cumulative percent passing #4 sieve = 84-5.2 = 78.8; etc.

SIEVE ANALYSIS DATA

1. DATE STARTED	22 FEB 91
2. PROJECT	BRAVO AIRFIELD
3. EXCAVATION	1+00
4. DATE COMPLETED	28 FEB 91
5. SAMPLE DESCRIPTION	LIGHT BROWN SANDY SOIL
6. SAMPLE NUMBER	1A
7. PREWASHED (check one)	XX YES / NO
8. ORIGINAL SAMPLE WEIGHT	2459
9. + #200 SAMPLE WEIGHT	2359
10. −#200 SAMPLE WEIGHT	100

11. SIEVE SIZE	12. WEIGHT OF SIEVE	13. WEIGHT OF SIEVE + SAMPLE	14. WEIGHT RETAINED	15. CUMULATIVE WEIGHT RETAINED	16. PERCENT RETAINED	17. PERCENT PASSING
1½	202					
1	231					
½	210	210	0	0	0	100.0
¼	230	624	394	394	16.0	84.0
#4	205	332	127	521	5.2	78.8
#8	225	691	466	987	19.0	59.8
#20	215	612	397	1384	16.2	43.6
#60	235	581	346	1730	14.1	29.5
#100	250	612	362	2092	14.7	14.8
#200	260	515	255	2347	10.4	4.4

18. TOTAL WEIGHT RETAINED IN SIEVES (Sum Column 14)	2347	19. ERROR (8 − 23) 2459-2457 = 2
20. WEIGHT SIEVED THROUGH #200 (Weight in pan) 270-260	10	
21. WASHING LOSS (18 - 19 + 10) 2459-(2359+100)	0	
22. TOTAL WEIGHT PASSING #200 (20 + 10) 10+100	110	
23. TOTAL WEIGHT OF FRACTIONS (18 + 22)	2457	

24. REMARKS

USCS SP
PERCENT-G 21.2
PERCENT-S 74.4
PERCENT-F 4.4

25. ERROR (percent)

$$\frac{\text{ERROR (19)}}{\text{ORIGINAL WT (8)}} \times 100 = \frac{2}{2459} \times 100 = .08$$

26. TECHNICIAN	27. COMPUTED BY (Signature)	28. CHECKED BY (Signature)
Joe Blob PV2	Joe Blob PV2	Fred Jones SSG

DD Form 1206, DEC 86 Previous editions are obsolete

Figure 4-4. Data sheet, example of dry sieve analysis.

The cumulative percent passing is plotted on the grain-size distribution graph. The percentage passing the No. 4 and 200 sieves is used to classify the sediments as gravels (G), sands (S) or fines (must use plasiticity index to differentiate between silts and clays).

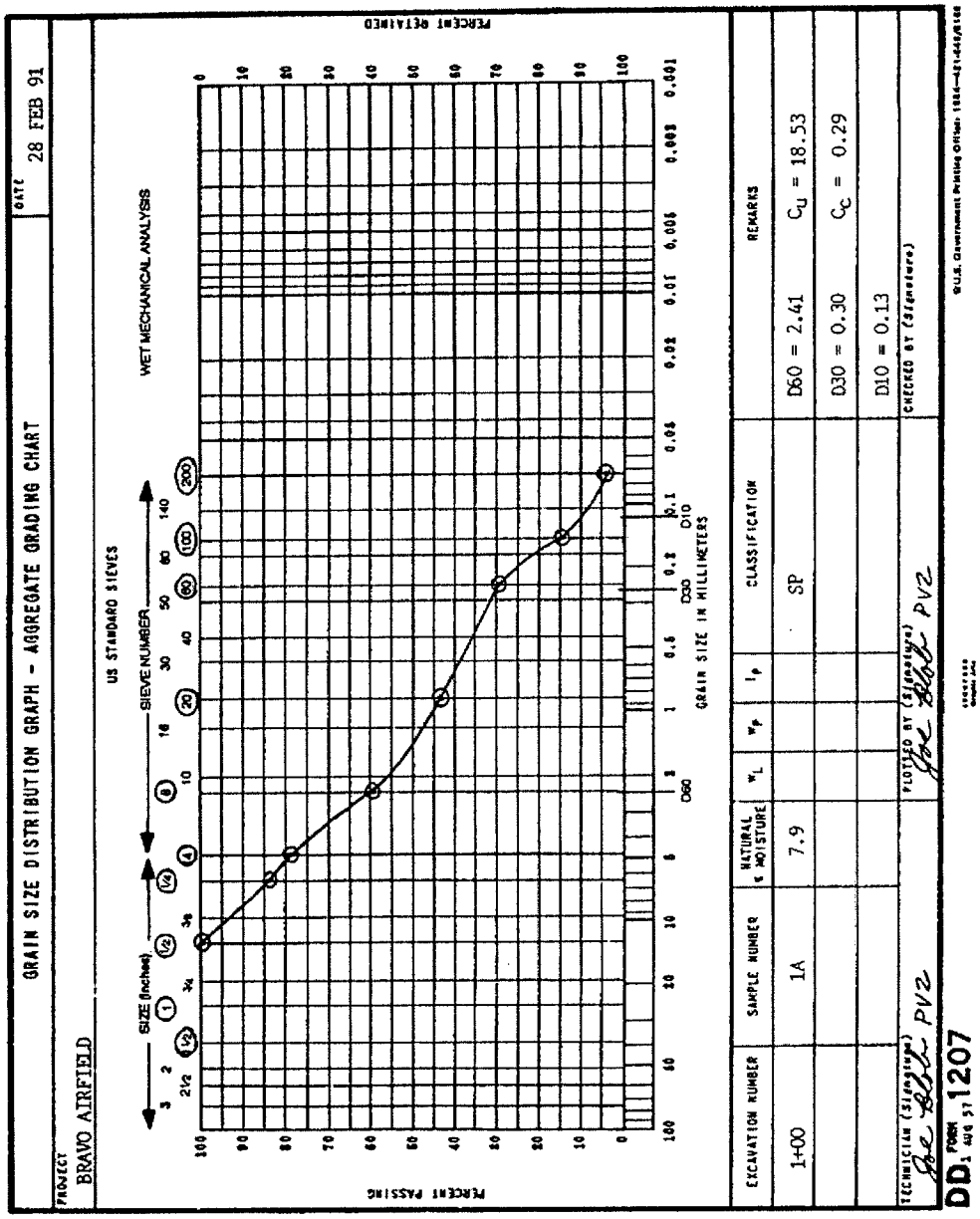


Figure 4-5. Grain-size distribution curve from sieve analysis.

The grain-size distribution graph is used to read off the grain size at which 10% of the sample passed (D_{10}), 30% of the sample passed (D_{30}) and 60% of the sample passed (D_{60}). These numbers are used to calculate several coefficients:

Hazen's effective size, D_{10}, which will be used to estimate permeability

Uniformity Coefficient, C_u = D_{60}/D_{10}

In the above graph,

$$D_{60} = 2.4 \text{ mm and } D_{10} = 0.13 \text{ mm}$$

$$\text{then} \quad C_u = 2.4/0.13 = 18.5$$

The uniformity coefficient is used to judge gradation.

Coefficient of Curvature, C_c

$$C_c = \frac{(D_{30})^2}{(D_{60} \times D_{10})}$$

In the above graph,

$$D_{30} = 0.3 \text{ mm}$$

$$\text{and } C_c = \frac{(0.3)^2}{(2.4)(0.13)} = .29$$

In the graph below, well-graded soils (GW and SW) are long curves spanning a wide range of sizes with a constant or gently varying slope. Uniformly graded soils (SP) are steeply sloping curves spanning a narrow range of sizes. For a gap-graded soil (GP), the curve flattens out in the area of the grain-size deficiency or gap.

The USCS criteria for well-graded gravels (GW) and sands (SW) are:

1. Less than 5% finer than No. 200 sieve
2. Uniformity coefficient greater than 4
3. Coefficient of curvature between 1 and 3

If Criterion 1 is met, but not Criteria 2 and 3, the gravels are gap-graded or uniform gravels (GP) or sands (SP)

If you are interested in more information: Gradation and Bearing Capacity

United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

EPA/600/R-94/168b
September 1994

EPA

The Hydrologic Evaluation of Landfill Performance (HELP) Model

Engineering Documentation for Version 3

ATTACHMENT C. 1/3

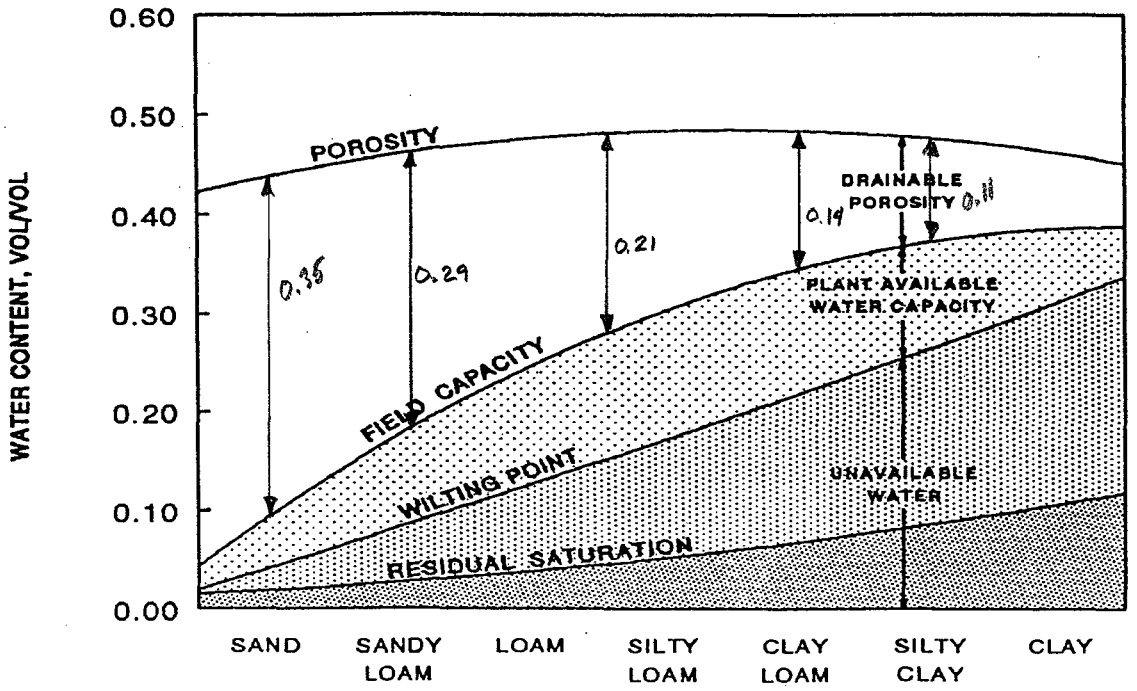


Figure 2. Relation Among Moisture Retention Parameters and Soil Texture Class

are not specified, the program assumes values near the steady-state values (allowing no long-term change in moisture storage) and runs a year of simulation to initialize the moisture contents closer to steady state. The soil water contents at the end of this year are substituted as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results of the volumetric water content initialization period are not reported in the output.

3.3.2 Unsaturated Hydraulic Conductivity

Darcy's constant of proportionality governing flow through porous media is known quantitatively as hydraulic conductivity or coefficient of permeability and qualitatively as permeability. Hydraulic conductivity is a function of media properties, such as particle size, void ratio, composition, fabric, degree of saturation, and the kinematic viscosity of the fluid moving through the media. The HELP program uses the saturated and unsaturated hydraulic conductivities of soil and waste layers to compute vertical drainage, lateral drainage and soil liner percolation. The vapor diffusivity for geomembranes is specified as a saturated hydraulic conductivity to compute leakage through geomembranes by vapor diffusion.

Attachment C, 2/3

TABLE 1. DEFAULT LOW DENSITY SOIL CHARACTERISTICS

Soil Texture Class			A Total Porosity vol/vol	B Field Capacity vol/vol	Wilting Point vol/vol	Saturated Hydraulic Conductivity cm/sec	A-B DRAINABLE POROSITY vol/vol
HELP	USDA	USCS					
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}	
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}	
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}	
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}	0.332
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}	0.326
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}	0.263
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}	0.251
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}	0.231
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}	0.217
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}	0.154
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}	
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}	
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}	
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}	
15	C	CH	0.475	0.378	0.251	2.5×10^{-5}	
21	G	GP	0.397	0.032	0.013	3.0×10^{-1}	

a = constant representing the effects of various fluid constants and gravity, 21 cm^3/sec

ϕ = total porosity, vol/vol

θ_r = residual volumetric water content, vol/vol

ψ_b = bubbling pressure, cm

λ = pore-size distribution index, dimensionless

A more detailed explanation of Equation 11 can be found in Appendix A of the HELP program Version 3 User's Guide and the cited references.

ATTACHMENT C, 3/3

ered that when well-graded mixtures of sand and gravel contained as little as 5% of fines (sizes smaller than a No. 200 sieve) high compactive efforts reduced the effective porosities nearly to zero and the permeabilities to less than 0.01% of those at moderate densities. These tests explain one of the reasons that blends of sand and gravel often used for drains are virtually useless as drainage aggregates if they contain more than insignificant amounts of fines.

In the preceding paragraphs variations in the permeability of remolded materials caused by variable compaction were discussed. Any factor that densifies soils reduces permeability. Studies of the rate of consolidation of clay and peat foundations are sometimes made by using initial coefficients of permeability of compressible formations. While the consolidation process is going on in foundations their permeabilities are becoming less. Generally, decreases in the permeabilities of clay foundations are rather moderate, but they can be large in highly compressible organic silts and clays and in peats. Modified calculation methods utilizing the changing permeability are needed in the analysis of highly compressible foundations. Some typical variations in permeability caused by consolidation are given in Fig. 2.10, a plot of consolidation pressure versus permeability.

$\sigma_n \simeq 31' \times 130$ pcf
$\simeq 4000$ psf
$\simeq 2$ Tsf

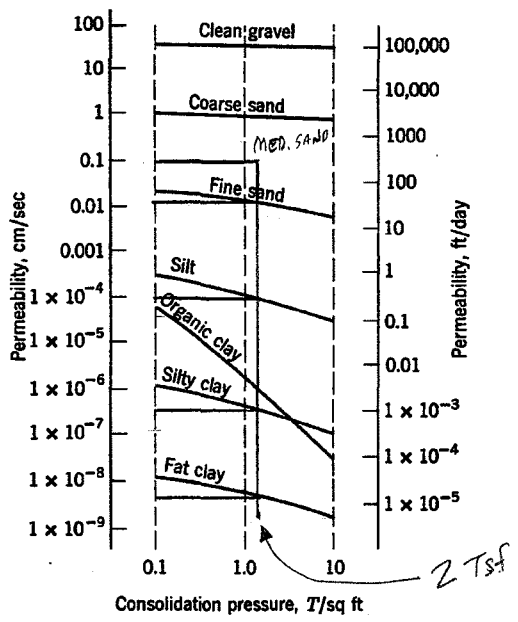


FIG. 2.10 Permeability versus consolidation pressure.

"Seepage, Drainage, and Flow Nets"
3rd Edition, Cedergren, H.R. 1989

Attachment D 1/2

$$k = \frac{Q}{iAt} \tag{2.2}$$

Darcy's *discharge velocity* multiplied by the entire cross-sectional area, including voids e and solids 1, gives the seepage quantity Q under a given hydraulic gradient $i = \Delta h/\Delta l$ or h/L. It is an imaginary velocity that does not exist anywhere. The average *seepage velocity* v_s of a mass of water progressing through the pore spaces of a soil is equal to the discharge velocity $(v_d = ki)$ multiplied by $(1 + e)/e$ or the discharge velocity divided by the effective porosity n_e; hence permeability is related to seepage velocity by the expression

$$k = \frac{v_s n_e}{i} \tag{2.3}$$

For any seepage condition in the laboratory or in the field in which the *seepage quantity,* the area perpendicular to the direction of flow, and the hydraulic gradient are known the coefficient of permeability can be calculated. Likewise, for any situation where the *seepage velocity* is known at a point at which the hydraulic gradient and soil porosity also are known, permeability can be calculated.

Experimentally determined coefficients of permeability can be combined with prescribed hydraulic gradients and discharge areas in solving practical problems involving seepage quantities and velocities. When a coefficient of permeability has been properly determined, it furnishes a very important factor in the analysis of seepage and in the design of drainage features for engineering works.

The coefficient of permeability as used in this book and in soil mechanics in general should be distinguished from the physicists' coefficient of permeability K, which is a more general term than the engineers' coefficient and has units of centimeters squared rather than a velocity; it varies with the porosity of the soil but is independent of the viscosity and density of the fluid. The transmissibility factor T represents the capability of an aquifer to discharge water and is the product of permeability k and aquifer thickness t.

The engineers' coefficient, which is used in practical problems of seepage through masses of earth and other porous media, applies only to the flow of water and is a simplification introduced purely from the standpoint of convenience. It has units of a velocity and is expressed in centimeters per second, feet per minute, feet per day, or feet per year, depending on the habits and personal preferences of individuals using the coefficient. In standard soil mechanics terminology k is expressed in centimeters per second.

Although coefficient of permeability is often considered to be a constant for a given soil or rock, it can vary widely for a given material, depending on a number of factors. Its absolute values depend, first of all, on the properties of water, of which viscosity is the most important. For individual materials

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Cedergren, "Seepage, Drainage, and Flow Nets", 3rd Ed. 1989

GDE Control Products, Inc.

Multi-FLO

Technical Properties

Multi-Flow

Product Information

Applications

Fittings
Accessories

Technical

Backfill

Installation
Drainage Guide
FAQ's

Drainage Core

Property	Test Method	Value
Thickness, inches	ASTM D-1777	1.0
Flow Rate, gpm/ft*	ASTM D-4716	29 *
Compressive Strength	ASTM D-1621	6000

Geotextile Filter

Property	Test Method	Value
Weight, oz/sq yd2	ASTM D-3776	4.0
Tensile Strength, lb.	ASTM D-4632	100
Elongation, %	ASTM D-4632	50
Puncture, lb.	ASTM D-4833	50
Mullen Burst, psi	ASTM D-3786	200
Trapezoidal Tear, lb.	ASTM D-4533	42
Coeffecient of Perm,cm/sec	ASTM D-4491	0.1
Flow Rate, gpm/ft2	ASTM D-4491	100
Permittivity, 1/sec	ASTM D-4491	1.8
A.O.S Max US Std Sieve	ASTM D 4751	70
UV Stability, 500 hrs., %	ASTM D-4355	70
Seam Strength, lb./ft	ASTM D-4595	100
Fungus	ASTM G-21	No Growth

* Horizontal Installation , gradient = 0.01, compressive force = 10 psi for 1(

All values given represent minimum average roll values

GDE Control Products, Inc. Laguna Hills, CA. 949-305-7117

GDE, Multi-Flow
<http: www.gdccontrol.com/Multi-Flow5.html> Attachment E 1/1

TABLE 2.12 RECOMMENDED REDUCTION FACTOR VALUES FOR USE IN EQ. (2.25a)

Application	Range of Reduction Factors				
	Soil Clogging and Blinding*	Creep Reduction of Voids	Intrusion into Voids	Chemical Clogging†	Biological Clogging
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion-control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	5 to 10‡
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	~~1.2 to 1.5~~	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

*If stone riprap or concrete blocks cover the surface of the geotextile, use either the upper values or include an additional reduction factor.

†Values can be higher particularly for high alkalinity groundwater.

‡Values can be higher for turbidity and/or for microorganism contents greater than 5000 mg/l.

$$q_{\text{allow}} = q_{\text{ult}}\left(\frac{1}{\Pi\text{RF}}\right) \tag{2.25b}$$

where

q_{allow} = allowable flow rate,
q_{ult} = ultimate flow rate,
RF_{SCB} = reduction factor for soil clogging and blinding,
RF_{CR} = reduction factor for creep reduction of void space,
RF_{IN} = reduction factor for adjacent materials intruding into geotextile's void space,
RF_{CC} = reduction factor for chemical clogging,
RF_{BC} = reduction factor for biological clogging, and
ΠRF = value of cumulative reduction factors.

As with Eqs. (2.24) for strength reduction, this flow-reduction equation could also have included additional site-specific terms, such as blocking of a portion of the geotextile's surface by riprap or concrete blocks.

2.5 DESIGNING FOR SEPARATION

Application areas for geotextiles used for the separation function were given in Section 1.3.3. There are many specific applications, and it could be said, in a general sense, that geotextiles always serve a separation function. If they do not also serve this function, any other function, including the primary one, will not be served properly. This should not give the impression that the geotextile function of separation always plays a secondary role. Many situations call for separation only, and in such cases the geotextiles serve a significant and worthwhile function.

ATTACHMENT F 1/4

4.1.6 Allowable Flow Rate

As described previously, the very essence of the design-by-function concept is the establishment of an adequate factor of safety. For geonets, where flow rate is the primary function, this takes the following form.

$$\mathrm{FS} = \frac{q_{\mathrm{allow}}}{q_{\mathrm{reqd}}} \tag{4.3}$$

where

FS = factor of safety (to handle unknown loading conditions or uncertainties in the design method, etc.),
q_{allow} = allowable flow rate as obtained from laboratory testing, and
q_{reqd} = required flow rate as obtained from design of the actual system.

Alternatively, we could work from transmissivity to obtain the equivalent relationship.

$$\mathrm{FS} = \frac{\theta_{\mathrm{allow}}}{\theta_{\mathrm{reqd}}} \tag{4.4}$$

where θ is the transmissivity, under definitions as above. As discussed previously, however, it is preferable to design with flow rate rather than with transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable flow rate or transmissivity value, which comes from hydraulic testing of the type described in Section 4.1.3, we must assess the realism of the test setup in contrast to the actual field system. If the test setup does not model site-specific conditions adequately, then adjustments to the laboratory value must be made. This is usually the case. Thus the laboratory-generated value is an ultimate value that must be reduced before use in design; that is,

$$q_{\mathrm{allow}} < q_{\mathrm{ult}}$$

One way of doing this is to ascribe reduction factors on each of the items not adequately assessed in the laboratory test. For example,

$$q_{\mathrm{allow}} = q_{\mathrm{ult}}\left[\frac{1}{\mathrm{RF}_{IN} \times \mathrm{RF}_{CR} \times \mathrm{RF}_{CC} \times \mathrm{RF}_{BC}}\right] \tag{4.5}$$

or if all of the reduction factors are considered together.

$$q_{\mathrm{allow}} = q_{\mathrm{ult}}\left[\frac{1}{\Pi \mathrm{RF}}\right] \tag{4.6}$$

where

q_{ult} = flow rate determined using ASTM D4716 or ISO/DIS 12958 for short-term tests between solid platens using water as the transported liquid under laboratory test temperatures,

ATTACHMENT F 2/

q_{allow} = allowable flow rate to be used in Eq. (4.3) for final design purposes,
RF_{IN} = reduction factor for elastic deformation, or intrusion, of the adjacent geosynthetics into the geonet's core space,
RF_{CR} = reduction factor for creep deformation of the geonet and/or adjacent geosynthetics into the geonet's core space,
RF_{CC} = reduction factor for chemical clogging and/or precipitation of chemicals in the geonet's core space,
RF_{BC} = reduction factor for biological clogging in the geonet's core space, and
ΠRF = product of all reduction factors for the site-specific conditions.

Some guidelines for the various reduction factors to be used in different situations are given in Table 4.2. Please note that some of these values are based on relatively sparse information. Other reduction factors, such as installation damage, temperature effects, and liquid turbidity, could also be included. If needed, they can be included on a site-specific basis. On the other hand, if the actual laboratory test procedure has included the particular item, it would appear in the above formulation as a value of unity. Examples 4.2 and 4.3 illustrate the use of geonets and serve to point out that high reduction factors are warranted in critical situations.

Example 4.2

What is the allowable geonet flow rate to be used in the design of a capillary break beneath a roadway to prevent frost heave? Assume that laboratory testing was done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 2.5×10^{-4} m²/s.

Solution: Since better information is not known, average values from Table 4.2 are used in Eq. (4.5).

TABLE 4.2 RECOMMENDED PRELIMINARY REDUCTION FACTOR VALUES FOR EQ. (4.5) FOR DETERMINING ALLOWABLE FLOW RATE OR TRANSMISSIVITY OF GEONETS

Application Area	RF_{IN}	RF_{CR}*	RF_{CC}	RF_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock, and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill covers	1.3 to 1.5	1.1 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

*These values are sensitive to the density of the resin used in the geonet's manufacture. The higher the density, the lower the reduction factor. Creep of the covering geotextile(s) is a product-specific issue.

ATTACHMENT F, 3/4

The above formula can be readily converted to flow rate, Q, by multiplying the velocity by the cross-sectional area A of the pipe.

For pipelines that are either flowing full or flowing partially full, the *Manning equation* is generally used.

$$V = \frac{1}{n} R_H^{0.66} S^{0.5} \tag{7.10}$$

where

V = velocity of flow (m/s),
R_H = hydraulic radius (m),
S = slope or gradient of pipeline (m/m), and
n = coefficient of roughness (see Table 7.7) (dimensionless).

Note that plastic pipe of the type discussed in this chapter, with a *smooth interior,* has a Manning coefficient from 0.009 to 0.010. Plastic pipe with a *profiled or corrugated interior* has a Manning coefficient ranging from 0.018 to 0.025.

Eqs. (7.9) and (7.10) are generally used in the form of charts or nomographs to determine pipe sizes, flow velocity or discharge flow rates (see Figures 7.6 and 7.7). For each chart we include an example from Hwang [7], illustrated on the respective nomographs by heavy lines. Note that both nomographs are for pipes flowing full.

Example 7.1

A 100 m long pipe with D = 200 mm and C = 120 carries a discharge of 30 l/s. Determine the head loss in the pipe. (See the Hazen-Williams chart in Figure 7.6.)

Solution: Applying the conditions given to the solution chart in Figure 7.6, the energy gradient is obtained.

$$S = 0.0058 \text{ m/m}$$

TABLE 7.7 VALUES OF MANNING ROUGHNESS COEFFICIENT, *N*, FOR REPRESENTATIVE SURFACES

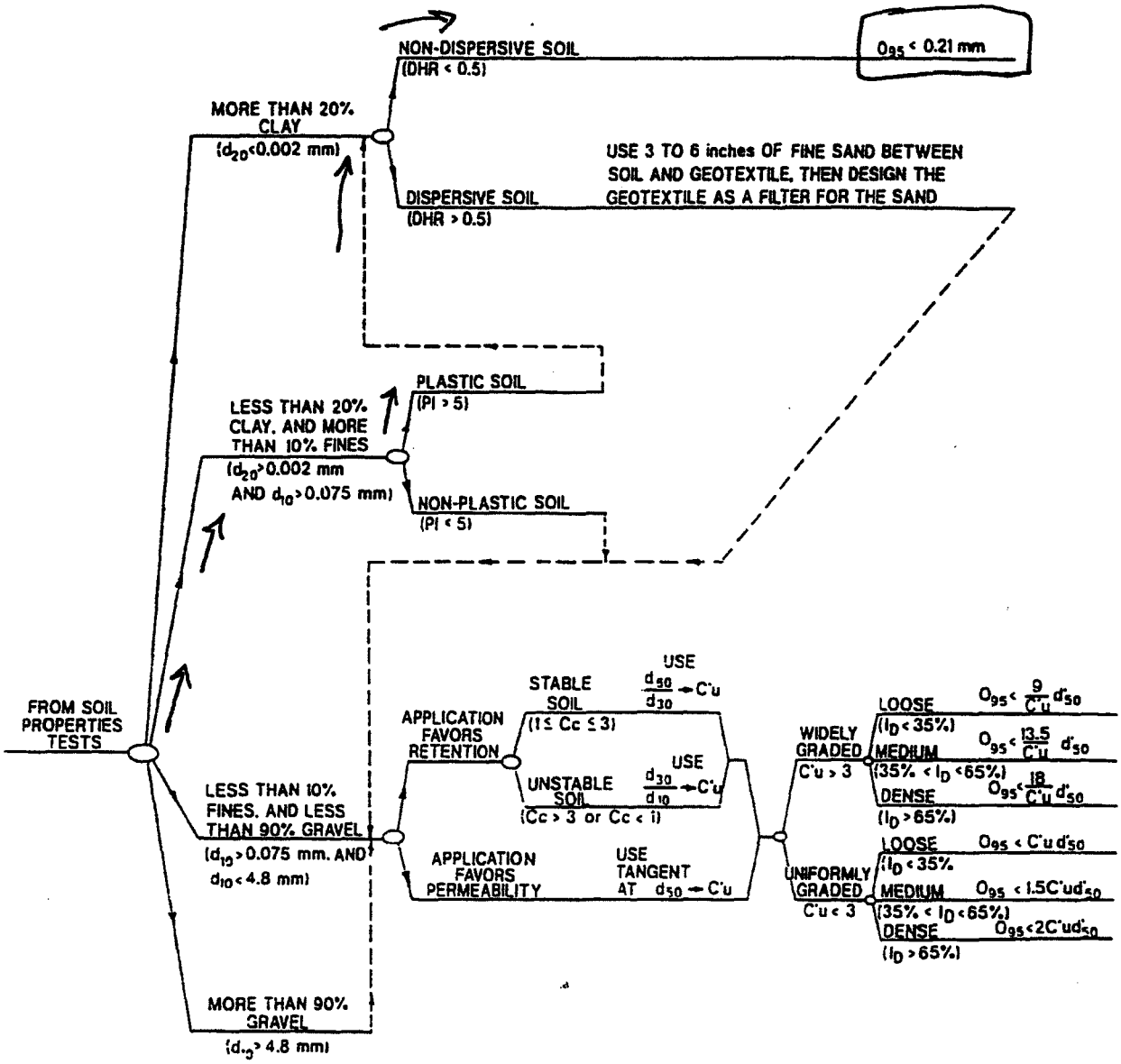
Type of Pipe Surface	Representative *n* value
Lucite, glass, or plastic*	0.010
Wood or finished concrete	[illegible]
Unfinished concrete, well-laid brickwork, concrete or cast iron pipe	[illegible]
Riveted or spiral steel pipe	[illegible]
Smooth, uniform earth channel	[illegible]
Corrugated flumes, typical canals, river free from large stones and heavy weeds	[illegible]
Canals and rivers with many stones and weeds	[illegible]

*The table does not distinguish between different types of plastic, or between smooth wall pipes with perforations.

Source: After Fox and McDonald [9].

Koerner, R.M., "Designing with Geosynthetics," 4th Ed., 1999.
Attachment F 1/4

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{50} \times d_{10}}$

I_D is the relative denisty of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 1/3

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \varphi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 2/3

Table 4-5

Typical Hydraulic Gradients[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
Standard Dewatering Trench	1.0
Vertical Wall Drain	1.5
Pavement Edge Drain	1[b]
Landfill LCDRS	1.5
Landfill LCRS	1.5
Landfill SWCRS	1.5
Inland Channel Protection	1[b]
Shoreline Protection	10[b]
Dams	10[b]
Liquid Impoundments	10[b]

NOTES: [a] Table developed after Giroud [1988].

[b] Critical applications may require designing with higher gradients than those given.

Attachment G
3/3

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.^{2}	4.0 *	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3787	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft^2 sec^{-1}	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40 *	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM-D-4355 2. Percent of minimum grab tensile after conditioning.

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs.	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs.	60/50	100/80	140/120	160/140	185/155	220/180
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft^2 sec^{-1}	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft.	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300
Gross Weight	lbs.	500	550	500	600	550	500
Area	sq. yds.	2000	1500	1000	1000	750	500

Amoco Fabrics and Fibers Company 900 Circle 75 Parkway, Suite 300 Atlanta, Georgi

Amoco Fabrics & Fibers Company, 1991. "Amoco Waste Related Geotextiles" H 1/1

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\IUC\IUC30.D4
TEMPERATURE DATA FILE:       C:\HLP3\IUC\IUC30.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\IUC\IUC30.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\IUC\IUC30.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\IUC\SOIL-8.D10
OUTPUT DATA FILE:            C:\HLP3\IUC\3ft-sm2.OUT


TIME:  11:34     DATE:   5/ 4/2007


******************************************************************************

     TITLE:  IUC 40 feet, 10 year slime drain simulation

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     36.00   INCHES
          POROSITY                     =      0.4730 VOL/VOL
          FIELD CAPACITY               =      0.2220 VOL/VOL
          WILTING POINT                =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
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ATTACHMENT I, 1/4

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2220	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	75.0	FEET

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 75. FEET.

SCS RUNOFF CURVE NUMBER	=	88.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.762	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.664	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.532	INCHES
TOTAL INITIAL WATER	=	8.532	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GRAND JUNCTION COLORADO

STATION LATITUDE	=	39.07	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	293	
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

0.64	0.54	0.75	0.71	0.76	0.44
0.47	0.91	0.70	0.87	0.63	0.58

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
25.50	33.50	41.90	51.70	62.10	72.30
78.90	75.90	67.10	54.90	39.60	28.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO
AND STATION LATITUDE = 39.07 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.42	26934.602	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.873	24947.395	92.62
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.547	1987.206	7.38
SOIL WATER AT START OF YEAR	8.532	30971.395	
SOIL WATER AT END OF YEAR	9.080	32958.598	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.91	35973.301	100.00

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RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.228	40758.055	113.30
PERC./LEAKAGE THROUGH LAYER 2	0.012633	45.857	0.13
CHANGE IN WATER STORAGE	-1.331	-4830.604	-13.43
SOIL WATER AT START OF YEAR	9.080	32958.598	
SOIL WATER AT END OF YEAR	7.619	27656.164	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.130	471.831	1.31
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.74	31726.203	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.431	30605.041	96.47
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.309	1121.151	3.53
SOIL WATER AT START OF YEAR	7.619	27656.164	
SOIL WATER AT END OF YEAR	8.058	29249.146	
SNOW WATER AT START OF YEAR	0.130	471.831	1.49
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.57	31109.109	100.00
RUNOFF	0.000	0.000	0.00

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EVAPOTRANSPIRATION	8.223	29850.770	95.96
PERC./LEAKAGE THROUGH LAYER 2	0.003014	10.940	0.04
CHANGE IN WATER STORAGE	0.344	1247.404	4.01
SOIL WATER AT START OF YEAR	8.058	29249.146	
SOIL WATER AT END OF YEAR	8.401	30496.551	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.004	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.36	37606.805	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.137	36797.102	97.85
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.223	809.710	2.15
SOIL WATER AT START OF YEAR	8.401	30496.551	
SOIL WATER AT END OF YEAR	8.624	31306.262	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.78	28241.400	100.00
RUNOFF	0.000	0.000	0.00

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EVAPOTRANSPIRATION	8.167	29645.734	104.97
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.387	-1404.339	-4.97
SOIL WATER AT START OF YEAR	8.624	31306.262	
SOIL WATER AT END OF YEAR	8.237	29901.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.20	29766.002	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.154	25970.750	87.25
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	1.046	3795.249	12.75
SOIL WATER AT START OF YEAR	8.237	29901.922	
SOIL WATER AT END OF YEAR	9.023	32752.676	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.260	944.495	3.17
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.46	27079.803	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.640	31362.828	115.82

PERC./LEAKAGE THROUGH LAYER 2	0.017125	62.163	0.23
CHANGE IN WATER STORAGE	-1.197	-4345.196	-16.05
SOIL WATER AT START OF YEAR	9.023	32752.676	
SOIL WATER AT END OF YEAR	7.452	27050.932	
SNOW WATER AT START OF YEAR	0.260	944.495	3.49
SNOW WATER AT END OF YEAR	0.634	2301.042	8.50
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	5.83	21162.902	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.171	22400.824	105.85
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.341	-1237.930	-5.85
SOIL WATER AT START OF YEAR	7.452	27050.932	
SOIL WATER AT END OF YEAR	7.582	27522.836	
SNOW WATER AT START OF YEAR	0.634	2301.042	10.87
SNOW WATER AT END OF YEAR	0.163	591.209	2.79
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.35	26680.502	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.669	24209.432	90.74

PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.681	2471.069	9.26
SOIL WATER AT START OF YEAR	7.582	27522.836	
SOIL WATER AT END OF YEAR	8.309	30162.926	
SNOW WATER AT START OF YEAR	0.163	591.209	2.22
SNOW WATER AT END OF YEAR	0.116	422.187	1.58
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

****

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.44	0.44	0.65	0.81	0.75	0.52
	0.39	1.08	0.58	1.00	0.94	0.54
STD. DEVIATIONS	0.23	0.30	0.31	0.44	0.53	0.63
	0.30	0.48	0.44	0.63	0.52	0.31
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.440	0.536	0.624	0.720	0.941	1.161
	0.512	0.979	0.483	0.735	0.587	0.451
STD. DEVIATIONS	0.214	0.265	0.279	0.353	0.546	0.558
	0.398	0.510	0.397	0.632	0.250	0.226
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	0.0001	0.0010	0.0009	0.0008
	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0004	0.0024	0.0020	0.0017
	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000

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*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   10
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET       PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                      8.16    (   1.320)      29628.1     100.00

 RUNOFF                             0.000   (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION                 8.169   (  1.5803)      29654.79    100.090

 PERCOLATION/LEAKAGE THROUGH        0.00328 (  0.00628)        11.896     0.04015
   LAYER  2

 CHANGE IN WATER STORAGE           -0.011   (  0.7880)        -38.63     -0.130
*******************************************************************************


*******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
   ----------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              0.86          3121.800

      RUNOFF                                     0.000            0.0000

      PERCOLATION/LEAKAGE THROUGH LAYER  2       0.002888        10.48416

      SNOW WATER                                 0.72          2615.3926

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2313

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1040
*******************************************************************************


*******************************************************************************

                  FINAL WATER STORAGE AT END OF YEAR   10
    ------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1           6.9773         0.1938

                     2           1.3320         0.2220

                 SNOW WATER      0.116
*******************************************************************************
*******************************************************************************
```


9/4

From: <GCorcoran@Geosyntec.com>
To: <DRUPP@utah.gov>, <hroberts@denisonmines.com>, <Ssnyder@denisonmines.com...
CC: <JCox@Geosyntec.com>, <LMORTON@utah.gov>
Date: 7/2/08 5:42 PM
Subject: RE: DUSA Cell 4A Construction: Two Items noted.
Attachments: Slimes Drain Drainage.070208.pdf

Dave,
I have revised the calculations presented in the Analysis of Slimes Drain included in the Cell 4A Interrogatories. The original calculation was based on an area for flow to pass into the strip composite of 14 inches per foot of length (12 inches across the top and two sides at 1 inch each). This calculation, using the maximum liquid depth resulted in a drainage time of approximately 5.5 years.
The sand bag coverage issue likely only impacts a discreet amount of the sides of the strip composite (probably much less than 10%). However, taking a conservative approach, I assumed that all two inches of the sides of the entire strip composite is not available for flow. Incorporating the 12 inches per foot of length flow area into the maximum liquid level model calculation results in a drainage time of approximately 6.4 years (see attached), an increase of approximately 0.9 years. Given that the relationship is linear, one can interpolate between 5.5 and 6.4 years to estimate the impact of the percentage of strip composite sides that are not covered by sand bags. If this value is 10%, one can estimate that the drainage time would be approximately 5.6 years (0.9 years x 10% + 5.5 years).
We believe that this minor change meets the design intent.
Please let us know if you have additional comments, and confirm that this addresses your concerns.
Regards,
Greg

From: Dave Rupp [mailto:DRUPP@utah.gov]
Sent: Wednesday, July 02, 2008 1:54 PM
To: hroberts@denisonmines.com; Ssnyder@denisonmines.com; Greg Corcoran
Cc: Jim Cox; Jephory McMichen; Loren Morton
Subject: RE: DUSA Cell 4A Construction: Two Items noted.

Greg,
Thanks for your response. As I view section C-5 of the drawings, the sandbags drape over the both edges of the strip-drain, and preclude access to the edge and top of the strip-drain by the tailings. This will be a criterion we will use in inspecting for conformance to the existing plans.
The first photograph DRC sent on 6-25-08 regarding this problem shows six openings through the sandbags to the strip-drain surfaces. It appears that if the existing bags are only centered with respect to the strip-drain, the coverage will not achieve conformance to the drawing section C-5.
The design intent was to fully protect the strip-drain from clogging. Therefore, DUSA needs to make the necessary adjustments to conform to the drawings, or submit an alternative design proposal to accomplish the design intent. - -

David A. Rupp, P.E.
Utah Division of Radiation Control
P. O. Box 144850
Salt Lake City, UT 84114-4850
Telephone (801) 536-4023
Fax (801) 533-4097
Email: drupp@utah.gov

>>> <GCorcoran@Geosyntec.com> 7/1/2008 1:50 PM >>>
Dave,
Over the past few days, the contractor has repositioned sand bags over the slimes drain to address this issue, and bring the installation into compliance with the design drawings and specifications. We believe this fully addresses your earlier concerns.
Please let us know if you have additional comments, and confirm that this addresses your concerns.
Regards,
Greg

From: Dave Rupp [mailto:DRUPP@utah.gov]
Sent: Tuesday, July 01, 2008 6:41 AM
To: hroberts@denisonmines.com; Ssnyder@denisonmines.com; Greg Corcoran
Cc: Jim Cox; Jephory McMichen; Loren Morton
Subject: RE: DUSA Cell 4A Construction: Two Items noted.

Greg,
I am fine with your explanation of the waves in the geomembrane and strip-drain.

However, regarding the overfilled sandbags creating incomplete coverage over the strip-drains, DUSA needs to either:
1). Provide revised calculations showing the new time required for completion of the drainage of the tailings through the slimes drain, at the time of cell closure. This is critical, given the existing configuration which departs from the approved design, in which

portions of the strip-drain would now be compromised by invasion of the strip-drains by slimes material, and the corresponding reduction of flow into the collection pipe, or
2). Provide proposed design or field construction adjustments to prevent this problem, with corresponding calculations as necessary to demonstrate the effectiveness of the adjustments.

We cannot agree with your claim that when the cell is loaded the sandbags will settle and the problem may resolve itself, because there will be no practical means available to verify this claim. Without such verification DUSA has an obligation to prevent the problem now.

Please be advised that the As-built Report cannot be approved without prior resolution of this construction problem. - -

David A. Rupp, P.E.
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>>> <GCorcoran@Geosyntec.com> 6/25/2008 1:30 PM >>>
Dave,
The waves in the geomembrane are a result of expanding geomembrane (thermal expansion due to increasing daytime temperatures) and the "plastic memory" in the underlying geonet. The plastic memory results from the manufacturing process, which uses an extrusion process consisting of extruding molten plastic through counter-rotating, round dies. As the plastic geonet is formed, it exits the die as a round column. As the plastic net cools in the column, the plastic develops a slight "memory" of this shape. After the column is cut and laid flat to form the geonet rolls, the geonet "remembers" that it was once a column or tube shape and when laid flat exhibits some minor curling of the edges. This is not detrimental to the geonet, but just creates minor curling of the edges that are easily laid flat with a small normal load on the surface.
The waves will lay down once the sand bags are put in place between the header pipe and the lateral. The filling of the cell with liquids will provide a relatively uniform liner system temperature, thereby reducing the thermal expansion due to elevated daytime air temperature. The material in the cell, whether liquid or solid, will also provide ballast that will get the waves to lay down, especially the underlying geonet with its "plastic memory". Remember that the slimes drain system will not be operated until the cell is filled with tailings.
The section on the drawings does show that the sand bag drapes over the strip composite. However, some of the sandbags were overfilled and leave a small gap at the sides of the strip composite. We do not believe that this causes any problems with the intent of the slimes drain design. Furthermore, we believe that the sand bags will settle in a bit more once the liquid loading is in the cell. The sand bags were designed to provide a sand layer that would act as a filtration layer in addition to the filter geotextile on the strip composite. The bags themselves were only required as a means to get the sand on top of the strip composite. In addition, the sand in the sand bags will convey liquid to the header pipe as the bags are placed in a continuous line.
Please let us know if you have additional comments, and confirm that this addresses your concerns.
Regards,
Greg

From: Dave Rupp [mailto:DRUPP@utah.gov]
Sent: Wednesday, June 25, 2008 8:08 AM
To: hroberts@denisonmines.com; Ssnyder@denisonmines.com
Cc: Greg Corcoran; Jephory McMichen; Loren Morton
Subject: DUSA Cell 4A Construction: Two Items noted.

Harold/Steve:
On a site visit last Friday, I had two items of concern I wanted to point out for your resolution.
The main one is the covering by the sand bags on the strip drains. Incomplete covering of the drains is seen now, and does not conform to the drawings, which show the bags completely covering the drains. On site I spoke with Messrs. D.Turk of DUSA and J.McMichen of GeoSyntec regarding this.
The other item is the inconsistent grade of the last few feet of some of the strip-drains near their connection to the herring backbone interceptor piping. The is grade waving, which if left would impede the flow from the strip-drain into the piping.
These items are illustrated in the attached photos. These items will need to be resolved prior to DRC final acceptance. Please contact me if you have questions. - -
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TABLE 3
White Mesa Mill
Cell 4A Slimes Drain
Maximum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)	Pipe Limitation (days)
3.31E-04	6.51E-04	46.3	39	5.49E-04	11	20,049	13.92	113.07	2,266,966	0.18
3.31E-04	6.51E-04	45.8	38	5.40E-04	11	20,354	14.13	111.38	2,266,966	
3.31E-04	6.51E-04	45.4	37	5.31E-04	11	20,722	14.39	109.40	2,266,966	
3.31E-04	6.51E-04	45.0	36	5.21E-04	11	21,110	14.66	107.39	2,266,966	
3.31E-04	6.51E-04	44.6	35	5.11E-04	11	21,520	14.94	105.34	2,266,966	
3.31E-04	6.51E-04	44.2	34	5.01E-04	11	21,954	15.25	103.26	2,266,966	
3.31E-04	6.51E-04	43.8	33	4.91E-04	11	22,415	15.57	101.14	2,266,966	
3.31E-04	6.51E-04	43.5	32	4.79E-04	11	22,957	15.94	98.75	2,266,966	
3.31E-04	6.51E-04	43.2	31	4.67E-04	11	23,534	16.34	96.33	2,266,966	
3.31E-04	6.51E-04	43.0	30	4.54E-04	11	24,206	16.81	93.65	2,266,966	
3.31E-04	6.51E-04	42.8	29	4.41E-04	11	24,924	17.31	90.96	2,266,966	
3.31E-04	6.51E-04	42.6	28	4.28E-04	11	25,694	17.84	88.23	2,266,966	
3.31E-04	6.51E-04	42.4	27	4.15E-04	11	26,520	18.42	85.48	2,266,966	
3.31E-04	6.51E-04	42.3	26	4.00E-04	11	27,475	19.08	82.51	2,266,966	
3.31E-04	6.51E-04	42.2	25	3.86E-04	11	28,507	19.80	79.52	2,266,966	
3.31E-04	6.51E-04	42.1	24	3.71E-04	11	29,624	20.57	76.52	2,266,966	
3.31E-04	6.51E-04	42.1	23	3.56E-04	11	30,912	21.47	73.34	2,266,966	
3.31E-04	6.51E-04	42.1	22	3.40E-04	11	32,317	22.44	70.15	2,266,966	
3.31E-04	6.51E-04	42.1	21	3.25E-04	11	33,856	23.51	66.96	2,266,966	
3.31E-04	6.51E-04	42.2	20	3.09E-04	11	35,633	24.75	63.62	2,266,966	
3.31E-04	6.51E-04	42.3	19	2.93E-04	11	37,598	26.11	60.30	2,266,966	
3.31E-04	6.51E-04	42.5	18	2.76E-04	11	39,874	27.69	56.85	2,266,966	
3.31E-04	6.51E-04	42.6	17	2.60E-04	11	42,319	29.39	53.57	2,266,966	
3.31E-04	6.51E-04	42.8	16	2.43E-04	11	45,175	31.37	50.18	2,266,966	
3.31E-04	6.51E-04	43.1	15	2.27E-04	11	48,524	33.70	46.72	2,266,966	
3.31E-04	6.51E-04	43.3	14	2.11E-04	11	52,231	36.27	43.40	2,266,966	
3.31E-04	6.51E-04	43.6	13	1.94E-04	11	56,639	39.33	40.02	2,266,966	
3.31E-04	6.51E-04	44.0	12	1.78E-04	11	61,922	43.00	36.61	2,266,966	
3.31E-04	6.51E-04	44.3	11	1.62E-04	11	68,012	47.23	33.33	2,266,966	
3.31E-04	6.51E-04	44.7	10	1.46E-04	11	75,488	52.42	30.03	2,266,966	
3.31E-04	6.51E-04	45.1	9	1.30E-04	11	84,626	58.77	26.79	2,266,966	
3.31E-04	6.51E-04	45.6	8	1.14E-04	11	96,260	66.85	23.55	2,266,966	
3.31E-04	6.51E-04	46.0	7	9.91E-05	11	110,977	77.07	20.43	2,266,966	
3.31E-04	6.51E-04	46.5	6	8.40E-05	11	130,880	90.89	17.32	2,266,966	
3.31E-04	6.51E-04	47.1	5	6.91E-05	11	159,083	110.47	14.25	2,266,966	
3.31E-04	6.51E-04	47.6	4	5.47E-05	11	200,964	139.56	11.28	2,266,966	
3.31E-04	6.51E-04	48.2	3	4.05E-05	11	271,330	188.42	8.36	2,266,966	
3.31E-04	6.51E-04	48.8	2	2.67E-05	11	412,062	286.15	5.50	2,266,966	
3.31E-04	6.51E-04	49.4	1	1.32E-05	11	834,256	579.34	2.72	2,266,966	
						days	**2,321.18**		**88,411,655**	**0.18**
						years	**6.36**			

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	39	ft
Length of Strip Drain	27,550	ft

Geosyntec consultants

COMPUTATION COVER SHEET

Client: Denison Mines Project: White Mesa Mill – Cell 4B Project/ Proposal No.: SC0349-01 Task No. 04

Title of Computations: **ANALYSIS OF SLIMES DRAIN**

Computations by:	Signature		11/30/07 Date
	Printed Name	Rebecca Flynn	
	Title	Senior Staff Engineer	
Assumptions and Procedures Checked by: (peer reviewer)	Signature		12/3/07 Date
	Printed Name	Gregory T. Corcoran	
	Title	Principal	
Computations Checked by:	Signature		12/3/07 Date
	Printed Name	Gregory T. Corcoran	
	Title	Principal	
Computations backchecked by: (originator)	Signature		11/30/07 Date
	Printed Name	Rebecca Flynn	
	Title	Senior Staff Engineer	
Approved by: (pm or designate)	Signature		12/3/07 Date
	Printed Name	Gregory T. Corcoran	
	Title	Principal	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

PURPOSE AND METHOD OF ANALYSIS

The purpose of this calculation package is to demonstrate that the proposed "slimes drain system" will dewater the tailings at the site within a reasonable time.

Fluid flow rate in porous media will be evaluated using Darcy's law.

ASSUMPTIONS

- This project involves the construction of a 42 acre double lined tailings cell (Cell 4B) that is approximately 42 feet deep at its deepest point and 31 feet deep at the shallowest point with an average depth of 35 feet. The liquids level in the cell will be kept a minimum of 3 feet below the top of the berm (free-board). Therefore, the maximum depth of liquid in the cell will be 39 feet at the start of dewatering.
- The cell will be filled with -28 mesh (US No. 30 sieve) tailings, largely consisting of fine sands and silts, with some clay. Results of grinding test sieve analyses, which are reported based on Tyler Mesh sieve sizes, are presented in Table 1. The grinding test data report is presented in Attachment A. Sieve to Tyler Mesh conversions are presented in Attachment B.
- The tailings will be placed within the cell in a slurry form under the surface of the free liquid contained within the cell. This placement methodology is anticipated to result in a low density (no compaction) soil structure. Therefore, saturated hydraulic conductivity and total porosity are anticipated to be higher than similar soils that are compacted.
- Based on the grinding report (Attachment A), tailings are comprised of approximately 6% medium sand, 49% fine sand, and 45% silt and clay size particles (Table 1).
- Based on the gradation of the tailings (Table 1) from the grinding report (Attachment A), the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the Hydrologic Evaluation of Landfill Performance (HELP) Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit saturated hydraulic

conductivities of between $1.7x10^{-3}$ cm/sec and $5.2x10^{-4}$ cm/sec and **low density** silt (ML) and sandy clay (SC) would exhibit saturated hydraulic conductivities of between $3.7x10^{-4}$ cm/sec and $1.2x10^{-4}$ cm/sec. The geomean of these two groups of soils, which are gradationally similar to the tailings, is $4.74x10^{-4}$ cm/sec (Table 2). According to Cedergren (Attachment D), under a normal stress of 2 tons per square foot (approximate normal stress on deeper tailings in the cell), medium sand, fine sand, silt, and silty clay would exhibit a saturated hydraulic conductivities of approximately $2x10^{-2}$ cm/sec, $1x10^{-2}$ cm/sec, $1x10^{-4}$ cm/sec $5x10^{-7}$ cm/sec, respectively. The geomean of these three soil types, where are gradationally similar to the tailings, is $3.31x10^{-4}$ cm/sec. The more conservative, lower hydraulic conductivity of $3.31x10^{-4}$ cm/sec, will be used in this analysis.

- Based on the gradation of the tailings from the grinding report, the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the HELP Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit drainable porosity of between 0.251 and 0.332 and **low density** silt (ML) and sandy clay (SC) would exhibit drainable porosity of between 0.154 and 0.231. The average of these two groups of soils, which are gradationally similar to the tailings, is 0.253 (Table 2). According to the HELP Model Engineering Documentation, medium sand, fine sand, silt, and silty clay would exhibit drainable porosity values of 0.35, 0.29, 0.14, and 0.11, respectively. The average of these three soil types, where are gradationally similar to the tailings, is 0.22. Since the average drainable porosity of 0.22 corresponds to the lower hydraulic conductivity (higher density, lower permeability, lower porosity) selected above, this value will be used in this analysis.
- The permeability of the tailings is isotropic.
- Darcy's law will be used to compute groundwater flow velocities.
- The proposed slimes drain system will consist of a series of strip drains (geotextile wrapped HDPE core, 1" thick, 12" wide, with a transmissivity of 29 (gal/min/ft), which connect to a perforated 4" diameter PVC header pipe that

is bedded in drainage aggregate and wrapped in a woven geotextile. The PVC pipe will convey the liquid to the sump for removal.

- The slimes drain spacing will be 50' and will be continuous across the base of the cell (Figure 1).

CALCULATIONS

The flow geometry for the average depth of liquid within the cell is illustrated on Figure 2 and used to compute the emptying time for the proposed slimes drain system.

Calculate the flow into a unit length of strip drain for the various hydraulic gradient conditions.

At the start of cell dewatering, the maximum depth of liquid will vary between 31 feet at the shallow end and 39 feet at the deep end, with an average depth of approximately 35 feet. As the water level drops within the cell, the length of the longest flow path and the associated hydraulic gradient will continually change with time.

The total volume to be drained by a unit length of strip, Q, can be calculated using Darcy's law as follows:

$$Q = kiA$$

where:

k = hydraulic conductivity of tailings = 3.31×10^{-4} cm/sec = 6.51×10^{-4} ft/min

i = gradient along flowpath = $\frac{dh}{dl} = \frac{35}{40.6} = 0.86$ (see Figure 2)

A = area of strip drain where flow will pass = 1.17 ft^2/ft (see Figure 3)

$$Q = (6.51 \times 10^{-4} \frac{ft}{\min})(0.86)(1.17\ ft^2)$$

$$Q = 6.55x10^{-4} \frac{ft^3}{\min} \times 7.48 \frac{gal}{ft^3} = 4.9x10^{-3} \frac{gal}{\min}$$

For each one foot incremental drop in fluid elevation within the cell, the total volume to be drained by a unit length of strip drain is as follows:

V = 1 ft unit length x 1ft depth x 50 ft width x 0.022 (drainable porosity) = 11 ft^3 of free liquid

Therefore, the time to drain the first one foot of liquid within the cell can be estimated as follows:

$t = V/Q = 11\ ft^3 / 6.55 \times 10^{-4}\ ft^3/min = 16{,}793$ minutes = 11.66 days

Tables 3, 4, and 5 depict the calculations for the maximum (39 feet), average (35 feet), and minimum (31 feet) cell liquid depth, respectively. The results of the maximum depth calculations indicate that the proposed slimes drain system will allow the tailings contained in Cell 4B to drain within approximately 5.45 years.

<u>Calculate the design flow rate of the strip drains.</u>

For this calculation we will assume that the strip drains have a flow rate of 29 gallon per minute per foot (Attachment E, GDE Multi-Flow, 2006), a width of 12" and that flow is occurring under a gradient of 0.01.

Design Flow rate of strip drains:

$q = \Theta i$

where:

q = flowrate per unit width

$i = \frac{dh}{dl} = 0.01$

Θ = transmissivity = 29 gpm/ft

To account for detrimental effects on the geonet such as chemical clogging, biological clogging, installation defects, and creep, partial factors of safety were used to reduce the strip drain transmissivity. Using recommended partial factor of safety values from Koerner (1999) (Attachment F, 2/4), the reduced transmissivity is calculated as follows:

$$\Theta_{allow} = \Theta_{ult}[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}]$$

where:

Θ_{allow} = allowable flow

$\Theta_{ultimate}$ = calculated value of flow

FS_{IN} = factor of safety for installation, 1.5 (CQA performed during installation)

FS_{CR} = factor of safety for creep, 2.0

FS_{CC} = factor of safety for chemical clogging, 2.0

FS_{BC} = factor of safety for biological clogging, 1.0 (low pH precludes biological activity)

The factors of safety are used to calculate the allowable transmissivity:

$$\Theta_{allow} = 29\,\frac{gpm}{ft}[\frac{1}{1.5 \times 2.0 \times 2.0 \times 1.0}] = 4.83\,\frac{gpm}{ft}$$

Using this transmissivity value, the average factor of safety for flow in the strip composite is estimated to be as follows:

$$FS = \frac{Q_D}{Q_R} = \frac{4.83\ gpm}{0.0049\ gpm} = 986 \quad \text{(Acceptable)}$$

The average allowable flow rate is much larger than the average maximum flow rate, even with the built-in partial factors of safety. Furthermore, as indicated on Tables 3, 4, and 5, the calculated flow rate within the strip drain decreases with time, which further increases the factor of safety.

Written by:	R. Flynn	Date:	08/30/07	Reviewed by:	G. Corcoran	Date:	12/3/07
Client:	Denison Mines	Project:	White Mesa Mill – Cell 4B	Project/ Proposal No.:	SC0349-01	Task No.:	04

Calculate the minimum required AOS and permittivity for filtration geotextile component of strip drain

The geotextile serves as a filter between the strip composite core and the tailings material. The geotextile minimizes fine particles of the tailings material from migrating into the strip composite, yet allows water to penetrate. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the strip composite layer.

To be conservative in these calculations, the tailings material soil is assumed to consist of more than 20 percent clay.

The retention requirements for geotextiles can be evaluated using the chart entitled "Soil Retention Criteria for Steady-State Flow Conditions" developed by Luettich et al., (1991) (Attachment G, 1/3). This chart uses soil properties to evaluate the required apparent opening size (AOS or O_{95}) of the geotextile. Using the Soil Retention Chart, the AOS of the filter fabrics shall be:

$O_{95} < 0.21$ mm, which corresponds to sieve No. 70.

The permeability of the filter fabric must be evaluated to allow flow through the filter fabric. The following equation can be used to evaluate the minimum allowable geotextile permeability:

$k_g > i_s k_s$ (Luettich et al. (1991), Att. G, 2/3)

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the tailings material (cm/s)

Hydraulic Gradient, i: Attachment G, page 3/3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 10 for liquid impoundment applications is recommended.

Soil Permeability, k_s: A permeability of 3.31×10^{-4} cm/s was assumed for the tailings material, as previously defined.

Therefore,

$k_g > \quad i_s k_s = (10)(3.31\text{x}10^{-4}\ \text{cm/s})$
$k_g > \quad 3.31 \text{ x } 10^{-3}\ \text{cm/s}$

Koerner (1999) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations given in Table 2.12 on p. 150 of Koerner (1999) (Attachment F, 1/4), the following partial safety values were applied:

soil clogging and blinding:	10 (5 – 10)
creep reduction of voids:	2.0 (1.5 – 2.0)
intrusion into voids:	1.2 (1.0 – 1.2)
chemical clogging:	1.5 (1.2 – 1.5)
biological clogging (low pH precludes biological activity):	1.0 (2 – 10)

Therefore,

$k_g > \quad (3.31 \text{ x } 10^{-3})(10)(2)(1.2)(1.5)(1)$
$k_g > \quad 0.12\ \text{cm/s}$

The thickness of a typical nonwoven needled punched 4 oz/yd^2 (135 g/m^2) geotextile is approximately 40 mils (0.10 cm), see Attachment H. Dividing the permeability by the thickness of the geotextile results in a required minimum permittivity of 1.2 sec^{-1}. The geotextile used in this project has a permittivity of 2.0 sec^{-1}, which is greater than the required permittivity.

Check Pipe Flow Rate

Based on calculations from previous sections, the maximum daily flow rate to the sump is estimated to be 144 gpm (0.32 cfs) (Table 3). The capacity of the pipe is calculated based on Manning's equation for gravity flow as follows:

$$Q = \frac{1.486}{n} R_h^{2/3} S^{1/2} A$$

Where

n = 0.010 (Koerner (1999), Attachment F, 4/4)
S = Slope of liner (ft/ft) = 1.0 %

R_h = hydraulic radius, ft
Q = flow rate, cubic feet per second, ft^3/s
A = flow area, ft^2

Assuming 4-inch pipe:

$A = \pi D^2/4 = 12.6$ sq. inches $= 0.088\ ft^2$
R_h = Area ($\pi D^2/4$)/Wetted Perimeter (π D)
$= D/4 = 1$ in $= 0.083$ ft

$$Q = \frac{1.486}{0.010} 0.083^{2/3} 0.01^{1/2} 0.088\ ft^2 = 0.25 \frac{ft^3}{s} = 112\ gpm$$

Since 112 gpm is less than the maximum required 144 gpm, this calculation shows that the 4-inch diameter slimes drain pipe is the limiting factor for dewatering the tailings in the early phase of dewatering (high flow rates). However, it does not mean that the pipe will be unable to handle this flow, but rather the pipe will require additional time to drain. The additional time needed is computed in the following section.

Effect of Maximum Pipe Capacity on Drainage Time

The maximum capacity of the pipe is 112 gpm, as computed above. Assuming the cell's total lateral length of strip drain is 27,550 feet, the flow rate, per foot of strip drain is calculated to be:

$$\text{Flow Rate} = \frac{112\ gallon}{\min} * \frac{60 \min}{1\ hr} * \frac{24\ hr}{1\ day} * \frac{1 ft^3}{7.48\ gallon} * \frac{1}{29{,}977\ feet} = 0.72 \frac{ft^3}{day}$$

The time needed to de-water first layer is:

$$Time = \frac{Volume}{Drain\ \ length\ \times flow\ rate} = \frac{(50\ x\ 1\ x\ 1\ x\ 0.22)\ ft^3}{1\ ft \times 0.72 \frac{ft^3}{day}} = 15.27\ days$$

The difference between the maximum daily flow rate drainage time and the maximum daily flow the pipe is able to deliver for the first foot is:

15.27 day – 11.93 day (first row of Table 3) = 3.34 days.

Therefore, the first layer will require an additional 3.34 days to drain. The calculation is repeated until the pipe's allowable flow capacity of 112 gpm is equal to the maximum flow rate from the cell (Table 3). The additional drainage time needed for each layer is added to the original drainage time of 5.45 years. The results of this analysis are shown in Table 3.

The total additional drainage time occurs over the first 12 layers and adds 23 days (0.06 years) to the computed drainage time. Including the effects of the maximum pipe capacity, the cell will take an estimated 5.51 years to drain.

Effect of Precipitation on Drainage Time

To account for the effect of precipitation added to the tailings cell, the HELP Model was used to estimate the average annual leakage through a 3 foot thick (tailings above the liquid) layer of silty sand material (Attachment I). HELP Model default parameters were used along with a maximum 16 inch evaporative zone (conservative for dry climate) and weather data from Grand Junction, Colorado. The model was performed for a 10 year period and included precipitation events ranging from 5.83 to 10.36 inches per year.

The results of this analysis suggest that a maximum average annual percolation through the 3 foot soil layer above the liquid will be approximately 12 ft^3 per acre or 504 ft^3 (3,770 gal.) for the entire Cell 4B area of 42 acres.

The average flow rate during Cell 4B dewatering, as calculated from Table 3 is equal to 78 gpm (112,320 gallon/day).

The time required to drain the additional volume of precipitation in the tailing is computed using the following equation:

$$Time = \frac{Volume}{FlowRate} = \frac{3{,}770\ gal}{112{,}320\ \frac{gal}{day}} = 0.03\ days$$

The additional time that the pond will require to empty due to precipitation is insignificant.

Therefore, the estimated time to dewater Cell 4B will be 5.45 years (baseline) + 0.06 years (pipe limitations) + 0.03 years (precipitation) = 5.54 years.

REFERENCES

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Luettich, S.M., Giroud, J.P., and Bachus, R.C., (1991), "Geotextile Filter Design Manual, report prepared for Nicolon Corporation, Norcross, GA.
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Amoco Fabrics and Fibers Company, (1991), "*Amoco Waste Related Geotextiles.*"
(Attachment H)

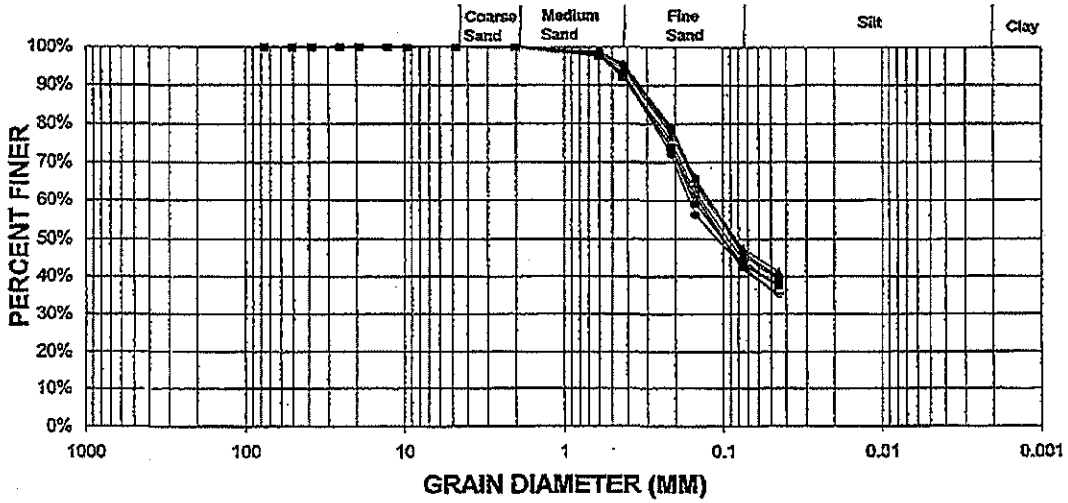
Table 1
DSM Screen Undersize Gradation

SIEVE ANALYSIS

		Grinding Test 1			Grinding Test 2A			Grinding Test 2B			Grinding Test 3A			Grinding Test 3B		
Sieve No.	Diameter (mm)	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.2	1.2%	98.8%	2.0	2.0%	98.0%	1.7	1.7%	98.3%	2.4	2.4%	97.6%	1.9	1.9%	98.1%
No. 40	0.425	4.6	4.6%	95.4%	7.3	7.3%	92.7%	6.0	6.0%	94.0%	8.1	8.1%	91.9%	6.9	6.9%	93.1%
No. 70	0.212	20.8	20.8%	79.2%	24.5	24.5%	75.5%	22.6	22.6%	77.4%	26.2	26.2%	73.8%	27.9	27.9%	72.1%
No. 100	0.150	34.8	34.8%	65.2%	38.1	38.1%	61.9%	35.5	35.5%	64.5%	41.0	41.0%	59.0%	43.9	43.9%	56.1%
No. 200	0.075	53.4	53.4%	46.6%	55.7	55.7%	44.3%	52.5	52.5%	47.5%	56.6	56.6%	43.4%	57.4	57.4%	42.6%
No. 325	0.045	60.5	60.5%	39.5%	62.7	62.7%	37.3%	58.8	58.8%	41.2%	62.5	62.5%	37.5%	61.9	61.9%	38.1%
Pan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Grinding Test 6A			Grinding Test 6B		
Sieve No.	Diameter (mm)	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.3	1.3%	98.7%	1.0	1.0%	99.0%
No. 40	0.425	5.2	5.2%	94.8%	4.7	4.7%	95.3%
No. 70	0.212	21.7	21.7%	78.3%	21.4	21.4%	78.6%
No. 100	0.150	34.1	34.1%	65.9%	35.9	35.9%	64.1%
No. 200	0.075	54.4	54.4%	45.6%	54.4	54.4%	45.6%
No. 325	0.045	59.7	59.7%	40.3%	61.1	61.1%	38.9%
Pan	-	-	-	-	-	-	-

		Grinding Test 4A			Grinding Test 4B		
Sieve No.	Diameter (mm)	Wt. Retained (grams)	% Retained	% Finer	Wt. Retained (grams)	% Retained	% Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	2.7	2.7%	97.3%	2.7	2.7%	97.3%
No. 40	0.425	7.6	7.6%	92.4%	7.3	7.3%	92.7%
No. 70	0.212	26.2	26.2%	73.8%	25.9	25.9%	74.1%
No. 100	0.150	38.7	38.7%	61.3%	39.2	39.2%	60.8%
No. 200	0.075	57.3	57.3%	42.7%	58.3	58.3%	41.7%
No. 325	0.045	65.4	65.4%	34.6%	64.6	64.6%	35.4%
Pan	-	-	-	-	-	-	-



Average	
Med Sand	6.4%
Fine Sand	49.1%
Silt	44.4%

%FINER = 100 - Σ%RETAINED

5/12/2007

Table 2
Tailings Parameters

Soil	Permeability[1] (cm/sec)	Drainable Porosity[2] (vol./vol.)
med sand	2.00E-02	0.35
fine sand	1.00E-02	0.29
silt	1.00E-04	0.14
silty clay	6.00E-07	0.11
average	7.53E-03	0.22
geomean	3.31E-04	0.20

Soil	Permeability[3] (cm/sec)	Drainable Porosity[3] (vol./vol.)
SM (LS)	1.70E-03	0.332
SM (LFS)	1.00E-03	0.326
SM (SL)	7.20E-04	0.263
SM (FSL)	5.20E-04	0.251
ML (L)	3.70E-04	0.231
ML (SiL)	1.90E-04	0.217
SC (SCL)	1.20E-04	0.154
average	6.60E-04	0.253
geomean	4.74E-04	0.246

Notes:
(1) Source - "Seepage, Drainage, and Flow Nets", Cedergren, H. R., 1989.
(2) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Figure 2 - Soil texture vs. Moisture Retention.
(3) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Table 1 - Low Density Soil Characteristics.

TABLE 3
White Mesa Mill
Cell 4B Slimes Drain
Maximum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)	Pipe Limitation (days)
3.31E-04	6.51E-04	46.3	39	6.40E-04	11	17,185	11.93	143.54	2,466,685	3.34
3.31E-04	6.51E-04	45.8	38	6.31E-04	11	17,446	12.12	141.39	2,466,685	3.15
3.31E-04	6.51E-04	45.4	37	6.19E-04	11	17,761	12.33	138.88	2,466,685	2.94
3.31E-04	6.51E-04	45.0	36	6.08E-04	11	18,094	12.57	136.33	2,466,685	2.70
3.31E-04	6.51E-04	44.6	35	5.96E-04	11	18,446	12.81	133.73	2,466,685	2.46
3.31E-04	6.51E-04	44.2	34	5.85E-04	11	18,818	13.07	131.08	2,466,685	2.20
3.31E-04	6.51E-04	43.8	33	5.73E-04	11	19,213	13.34	128.39	2,466,685	1.93
3.31E-04	6.51E-04	43.5	32	5.59E-04	11	19,677	13.66	125.36	2,466,685	1.61
3.31E-04	6.51E-04	43.2	31	5.45E-04	11	20,172	14.01	122.28	2,466,685	1.26
3.31E-04	6.51E-04	43.0	30	5.30E-04	11	20,748	14.41	118.89	2,466,685	0.86
3.31E-04	6.51E-04	42.8	29	5.15E-04	11	21,363	14.84	115.46	2,466,685	0.43
3.31E-04	6.51E-04	42.6	28	4.99E-04	11	22,023	15.29	112.00	2,466,685	(0.02)
3.31E-04	6.51E-04	42.4	27	4.84E-04	11	22,731	15.79	108.51	2,466,685	
3.31E-04	6.51E-04	42.3	26	4.67E-04	11	23,550	16.35	104.74	2,466,685	
3.31E-04	6.51E-04	42.2	25	4.50E-04	11	24,434	16.97	100.95	2,466,685	
3.31E-04	6.51E-04	42.1	24	4.33E-04	11	25,392	17.63	97.14	2,466,685	
3.31E-04	6.51E-04	42.1	23	4.15E-04	11	26,496	18.40	93.10	2,466,685	
3.31E-04	6.51E-04	42.1	22	3.97E-04	11	27,700	19.24	89.05	2,466,685	
3.31E-04	6.51E-04	42.1	21	3.79E-04	11	29,019	20.15	85.00	2,466,685	
3.31E-04	6.51E-04	42.2	20	3.60E-04	11	30,543	21.21	80.76	2,466,685	
3.31E-04	6.51E-04	42.3	19	3.41E-04	11	32,226	22.38	76.54	2,466,685	
3.31E-04	6.51E-04	42.5	18	3.22E-04	11	34,178	23.73	72.17	2,466,685	
3.31E-04	6.51E-04	42.6	17	3.03E-04	11	36,273	25.19	68.00	2,466,685	
3.31E-04	6.51E-04	42.8	16	2.84E-04	11	38,721	26.89	63.70	2,466,685	
3.31E-04	6.51E-04	43.1	15	2.64E-04	11	41,592	28.88	59.31	2,466,685	
3.31E-04	6.51E-04	43.3	14	2.46E-04	11	44,770	31.09	55.10	2,466,685	
3.31E-04	6.51E-04	43.6	13	2.27E-04	11	48,548	33.71	50.81	2,466,685	
3.31E-04	6.51E-04	44.0	12	2.07E-04	11	53,076	36.86	46.47	2,466,685	
3.31E-04	6.51E-04	44.3	11	1.89E-04	11	58,296	40.48	42.31	2,466,685	
3.31E-04	6.51E-04	44.7	10	1.70E-04	11	64,704	44.93	38.12	2,466,685	
3.31E-04	6.51E-04	45.1	9	1.52E-04	11	72,537	50.37	34.01	2,466,685	
3.31E-04	6.51E-04	45.6	8	1.33E-04	11	82,509	57.30	29.90	2,466,685	
3.31E-04	6.51E-04	46.0	7	1.16E-04	11	95,123	66.06	25.93	2,466,685	
3.31E-04	6.51E-04	46.5	6	9.81E-05	11	112,183	77.90	21.99	2,466,685	
3.31E-04	6.51E-04	47.1	5	8.07E-05	11	136,357	94.69	18.09	2,466,685	
3.31E-04	6.51E-04	47.6	4	6.39E-05	11	172,255	119.62	14.32	2,466,685	
3.31E-04	6.51E-04	48.2	3	4.73E-05	11	232,569	161.51	10.61	2,466,685	
3.31E-04	6.51E-04	48.8	2	3.11E-05	11	353,196	245.27	6.98	2,466,685	
3.31E-04	6.51E-04	49.4	1	1.54E-05	11	715,076	496.58	3.45	2,466,685	
						days	1,989.58		96,200,703	22.86
						years	5.45			

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	39	ft
Length of Strip Drain	29,977	ft

TABLE 4
White Mesa Mill
Cell 4B Slimes Drain
Average Liquid Depth

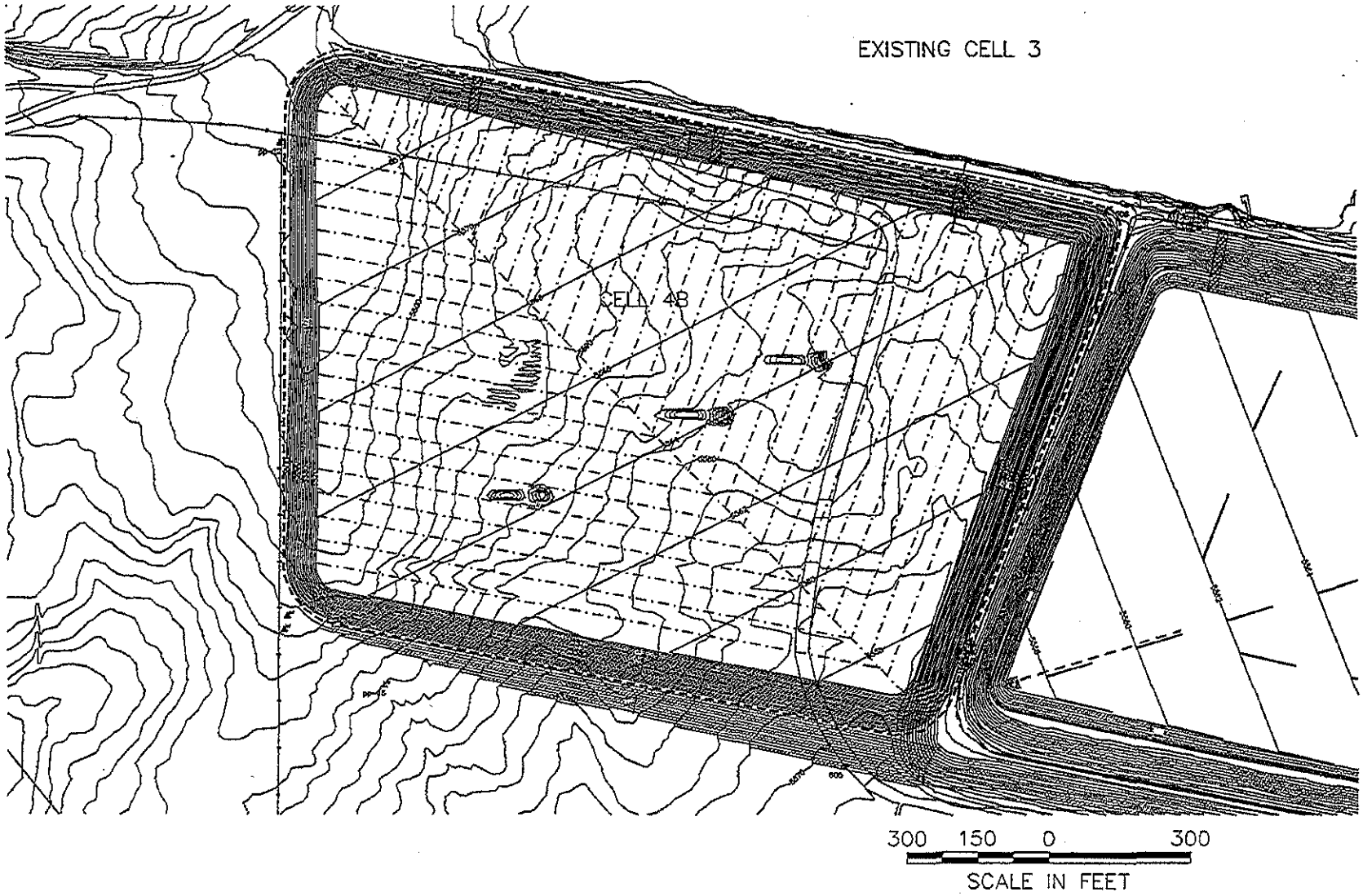
Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	43.0	35	6.19E-04	11	17,784	12.35	138.70	2,466,685
3.31E-04	6.51E-04	42.6	34	6.07E-04	11	18,137	12.59	136.01	2,466,685
3.31E-04	6.51E-04	42.3	33	5.93E-04	11	18,555	12.89	132.94	2,466,685
3.31E-04	6.51E-04	42.0	32	5.79E-04	11	18,999	13.19	129.83	2,466,685
3.31E-04	6.51E-04	41.7	31	5.65E-04	11	19,472	13.52	126.68	2,466,685
3.31E-04	6.51E-04	41.4	30	5.51E-04	11	19,976	13.87	123.48	2,466,685
3.31E-04	6.51E-04	41.2	29	5.35E-04	11	20,565	14.28	119.95	2,466,685
3.31E-04	6.51E-04	41.0	28	5.19E-04	11	21,196	14.72	116.38	2,466,685
3.31E-04	6.51E-04	40.9	27	5.02E-04	11	21,927	15.23	112.49	2,466,685
3.31E-04	6.51E-04	40.8	26	4.84E-04	11	22,715	15.77	108.59	2,466,685
3.31E-04	6.51E-04	40.7	25	4.67E-04	11	23,566	16.37	104.67	2,466,685
3.31E-04	6.51E-04	40.7	24	4.48E-04	11	24,548	17.05	100.49	2,466,685
3.31E-04	6.51E-04	40.7	23	4.29E-04	11	25,615	17.79	96.30	2,466,685
3.31E-04	6.51E-04	40.7	22	4.11E-04	11	26,779	18.60	92.11	2,466,685
3.31E-04	6.51E-04	40.8	21	3.91E-04	11	28,123	19.53	87.71	2,466,685
3.31E-04	6.51E-04	40.9	20	3.72E-04	11	29,602	20.56	83.33	2,466,685
3.31E-04	6.51E-04	41.1	19	3.51E-04	11	31,312	21.74	78.78	2,466,685
3.31E-04	6.51E-04	41.3	18	3.31E-04	11	33,213	23.06	74.27	2,466,685
3.31E-04	6.51E-04	41.5	17	3.11E-04	11	35,337	24.54	69.81	2,466,685
3.31E-04	6.51E-04	41.8	16	2.91E-04	11	37,817	26.26	65.23	2,466,685
3.31E-04	6.51E-04	42.1	15	2.71E-04	11	40,627	28.21	60.72	2,466,685
3.31E-04	6.51E-04	42.4	14	2.51E-04	11	43,839	30.44	56.27	2,466,685
3.31E-04	6.51E-04	42.7	13	2.31E-04	11	47,546	33.02	51.88	2,466,685
3.31E-04	6.51E-04	43.1	12	2.12E-04	11	51,990	36.10	47.45	2,466,685
3.31E-04	6.51E-04	43.6	11	1.92E-04	11	57,375	39.84	42.99	2,466,685
3.31E-04	6.51E-04	44.0	10	1.73E-04	11	63,691	44.23	38.73	2,466,685
3.31E-04	6.51E-04	44.5	9	1.54E-04	11	71,572	49.70	34.46	2,466,685
3.31E-04	6.51E-04	45.0	8	1.35E-04	11	81,423	56.54	30.29	2,466,685
3.31E-04	6.51E-04	45.5	7	1.17E-04	11	94,089	65.34	26.22	2,466,685
3.31E-04	6.51E-04	46.1	6	9.89E-05	11	111,218	77.23	22.18	2,466,685
3.31E-04	6.51E-04	46.7	5	8.14E-05	11	135,199	93.89	18.24	2,466,685
						days	898.47		76,467,226
						years	2.46		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Average Depth	35	ft
Length of Strip Drain	29,977	ft

TABLE 5
White Mesa Mill
Cell 4B Slimes Drain
Minimum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	39.8	31	5.92E-04	11	18,584	12.91	132.73	2,466,685
3.31E-04	6.51E-04	39.6	30	5.76E-04	11	19,107	13.27	129.10	2,466,685
3.31E-04	6.51E-04	39.4	29	5.59E-04	11	19,666	13.66	125.43	2,466,685
3.31E-04	6.51E-04	39.2	28	5.43E-04	11	20,265	14.07	121.72	2,466,685
3.31E-04	6.51E-04	39.1	27	5.25E-04	11	20,962	14.56	117.67	2,466,685
3.31E-04	6.51E-04	39.0	26	5.07E-04	11	21,713	15.08	113.60	2,466,685
3.31E-04	6.51E-04	38.9	25	4.88E-04	11	22,523	15.64	109.52	2,466,685
3.31E-04	6.51E-04	38.9	24	4.69E-04	11	23,462	16.29	105.14	2,466,685
3.31E-04	6.51E-04	39.0	23	4.48E-04	11	24,545	17.05	100.50	2,466,685
3.31E-04	6.51E-04	39.0	22	4.29E-04	11	25,661	17.82	96.13	2,466,685
3.31E-04	6.51E-04	39.2	21	4.07E-04	11	27,020	18.76	91.29	2,466,685
3.31E-04	6.51E-04	39.3	20	3.87E-04	11	28,444	19.75	86.72	2,466,685
3.31E-04	6.51E-04	39.5	19	3.66E-04	11	30,093	20.90	81.97	2,466,685
3.31E-04	6.51E-04	39.8	18	3.44E-04	11	32,006	22.23	77.07	2,466,685
3.31E-04	6.51E-04	40.1	17	3.22E-04	11	34,145	23.71	72.24	2,466,685
3.31E-04	6.51E-04	40.4	16	3.01E-04	11	36,550	25.38	67.49	2,466,685
3.31E-04	6.51E-04	40.8	15	2.79E-04	11	39,373	27.34	62.65	2,466,685
3.31E-04	6.51E-04	41.2	14	2.58E-04	11	42,599	29.58	57.91	2,466,685
3.31E-04	6.51E-04	41.6	13	2.37E-04	11	46,321	32.17	53.25	2,466,685
3.31E-04	6.51E-04	42.1	12	2.17E-04	11	50,784	35.27	48.57	2,466,685
3.31E-04	6.51E-04	42.6	11	1.96E-04	11	56,059	38.93	44.00	2,466,685
3.31E-04	6.51E-04	43.1	10	1.76E-04	11	62,388	43.33	39.54	2,466,685
3.31E-04	6.51E-04	43.7	9	1.57E-04	11	70,285	48.81	35.10	2,466,685
						days	536.50		56,733,748
						years	1.47		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	31	ft
Length of Strip Drain	29,977	ft



SLIMES DRAIN LAYOUT
CELL 4B
BLANDING, UTAH

Geosyntec consultants

DATE: SEPTEMBER 2007

PROJECT NO. SC0349

FIGURE 1

P:\PRJ\SDCadd\CADD\SC0349\PlanSet_Cell 4b\0349C004.dwg

Geosyntec consultants

Written by: ___ Date: DD / MM / YY Reviewed by: ___ Date: DD / MM / YY

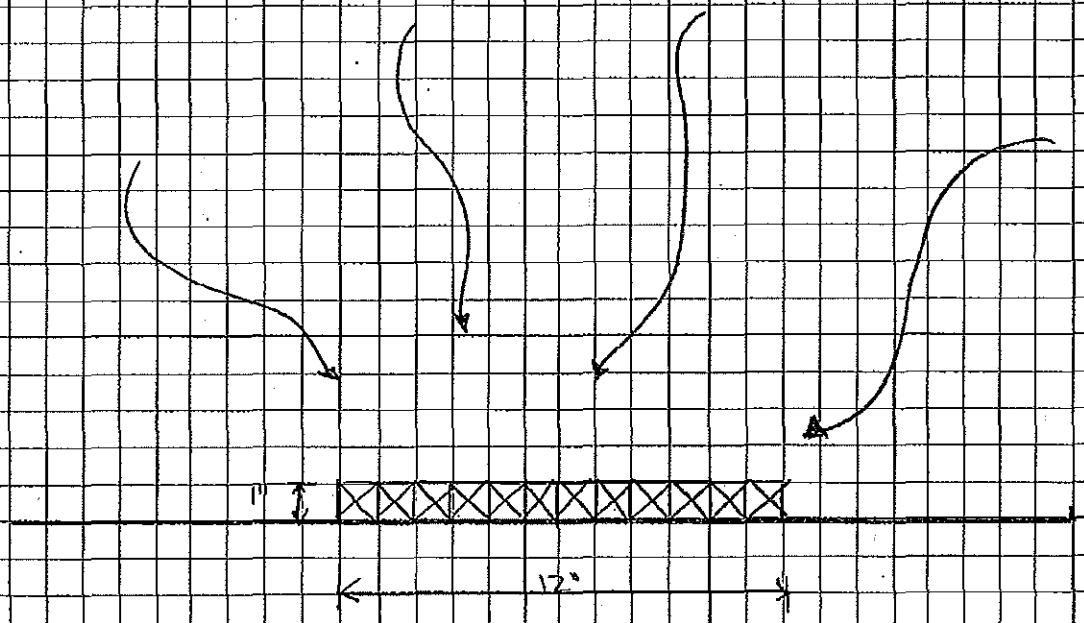
Client: ___ Project: ___ Project/Proposal No. ___ Task No. ___

FIGURE 2

Geosyntec consultants

Written by: RF Date: 30/08/07 (DD MM YY) Reviewed by: _____ Date: __/__/__ (DD MM YY)

Client: DMC Project: WMM-C114B Project/Proposal No. SC0349 Task No. _____



FLOW AREA - STRIP COMPOSITE

$A = \frac{14''}{12''/_1} = 1.17\ ft^2/ft$

FIGURE 3

EXHIBIT 1

SAMPLE DESCRIPTION AND PREPARATION

CSMRI Sample 1

Sponsor's Designation of Sample: Run-of-mine.

Date Received at Institute: June 5, 1978.

Sample Weight: 100,520 lb.

Sample Container: Two truckloads.

Sample Description: Mine ore -- estimate 5% +10-in. material. Largest boulder -- 48 in. x 24 in. x 14 in. Only two or three rocks were greater than 36 in.

Method of Preparation: All +10-in. material broken to -10 in. by sledgehammer and jackhammer. The sample was screened at 6 in. and 1-1/2 in. with the +6 in. fraction, put in barrels, and the -1/2 in. fraction piled. The -6 in. +1-1/2 in. material was screened at 4 in. and 1-1/2 in. with the -6 in. +4 in. and -4 in. +1-1/2 in. fractions barreled. The additional -1-1/2 in. fraction was piled with the previous -1-1/2 in. fraction. A screen size analysis of the entire quantity of mill feed material is presented in Exhibit 3. A summary screen size analysis of the ore is as follows:

Screen Product in.		Weight %
Head (calculated)		100.00
-10	+6	2.92
-6	+4	9.48
-4	+1-1/2	15.30
-1-1/2		72.30

EXHIBIT 1

CSMRI Sample 2

Sponsor's Designation of Sample:	Crushed ore.
Date Received at Institute:	June 5, 1978.
Sample Weight:	47,380 lb.
Sample Container:	One truckload.
Sample Description:	Ore previously crushed to -3 in., maximum particles approximately 2-1/2 in.
Method of Preparation:	The ore was used as received.

EXHIBIT 2

GRINDING TESTS

Grinding Test I, Autogenous

Date:	June 13, 1978
Feed Rate, stph:	2
Ore:	Run-of-mine
DSM Screen, in. width:	12
DSM Screen Opening, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Motor Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0910	0	--	--	104	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
0915	5	12.2	12,964	--	3,150	612	380	116	63	8,335	--	--	--	--	--	--	90	2,858	--	--
1005	55	8.7	--	--	2,880	612	380	116	62	--	90	506	60	3,348	57	2,616(2)	90	2,858	--	--
1030	80	6.8	--	105	2,835	612	380	116	69	--	90	304	70	3,591	58	710(2)	90	2,858	--	--
1100	110	6.5	12,977	106	2,993	612	380	116	66	--	--	--	69	4,223	58	679(2)	80	2,540	--	--
1135	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Mill down, elevator plugged.
1142	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1150	153	6.2	--	109	2,993	612	380	116	69	12,420	90	1,114	70	5,544	56	2,583	--	--	--	--
1230	193	6.0	12,988	111	2,903	612	380	116	64	10,829	90	405	69	6,955	60	4,398	75	2,382	--	--
1300	223	6.2	--	112	3,319	612	380	116	65	11,232	90	365	70	6,048	60	3,861	81	2,572	--	--
1345	238	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Pump plugged. DSM feed.
1400	253	6.4	--	112	3,128	612	380	116	65	11,700	90	122	69	3,229	60	3,996	80	2,540	--	Sample
1415	268	6.3	13,004	112	2,970	612	380	116	65	9,945	90	547	71	3,515	59	2,907	79	2,509	15	Sample.
Average					3,019	612	380	116	65	10,744	90	480	69	4,557	59	3,547	83	2,640		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,934.5 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total, 4,032.2 lb/hr, 2.016 dry stph. Mill volume end of test: 15%.
(2) Excluded from average.

Feed Rate, stph dry:	2.016
Ball Charge:	None
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0910	0	--	--	--	--	--	--	--	--
0915	5	12.2	4.25	2.64	1.31	1.01	--	63	--
1005	55	8.7	5.96	4.25	2.11	1.81	--	62	--
1030	80	6.8	7.62	5.80	2.88	2.58	--	69	--
1100	110	6.5	7.97	6.10	3.03	2.73	--	66	--
1135	145	--	--	--	--	--	--	--	Unplug bucket elevator.
1150	153	6.2	8.36	6.47	3.21	2.91(2)	162.0	69	--
1230	193	6.0	8.64	6.73	3.34	3.04(2)	183.0	64	--
1300	223	6.2	8.36	6.47	3.21	2.91(2)	145.0	65	--
1345	238	--	--	--	--	--	--	--	Unplug DSM feed pump.
1400(3)	253	6.4	8.10	6.23	2.09	2.79(2)	79.0	65	--
1415(3)	268	6.3	8.23	6.35	3.15	2.85(2)	100.0	65	--
Average						2.90	133.8		

(1) Calculated: Sum of Sweco oversize and DSM oversize as percentage of dry mill feed.
(2) Average for power (last five readings): 2.90 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 1 -- continued

Procedure: Sample was wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis DSM Screen Undersize
Sample Time:	1415
Sample Weight, g:	4,630.5
Screen Product (Tyler) Mesh	**Weight %**
Head (calculated)	100.0
+28	1.2
-28 +35	3.4
-35 +65	16.2
-65 +100	14.0
-100 +200	18.6
-200 +325	7.1
-325	39.5

US SIEVE GTC 5/10/07

No. 30
No. 40
No. 70
No. 100
No. 200
No. 325

EXHIBIT 2

Grinding Test 2

Date:	June 14, 1978
Feed Rate, stph:	2.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb; 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Motor Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1040	0	8.7	13,004	102	--	612	380	116	--	--	--	--	--	--	--	--	95	3,017	-	Start mill.
1110	30	5.2	--	104	--	612	380	116	--	--	--	--	--	--	--	--	83	2,636	-	--
1130	50	5.3	--	106	3,060	612	380	116	62	8,147	50	248	74	1,565	54	2,989(2)	84	2,668	-	--
1200	80	5.0	--	108	2,846	612	380	116	63	6,577	67	653	71	1,150	--	--	82	2,604	-	--
1230	110	4.8	13,023	111	3,105	612	380	116	64	8,467	64	605	73	1,281	--	--	82	2,604	-	--
1300	140	4.8	--	112	3,139	612	380	116	63	6,917	62	391	73	2,102	57	3,694	81	2,572	-	--
1330	170	4.8	--	113	3,263	612	380	116	66	8,494	63	595	69	3,571	56	3,881	81	2,572	-	--
1400	200	4.9	--	113	2,981	612	380	116	66	9,029	64	624	71	2,939	58	3,680	81	2,572	-	--
1415	215	5.0	--	113	2,869	612	380	116	66	10,098	64	547	70	3,119	58	3,811	79	2,509	-	Sample.
1430	230	5.0	13,044	113	2,993	612	380	116	65	8,483	64	557	71	3,259	57	3,565	79	2,509	9	Sample. End of test.
Average					3,032	612	380	116	65	8,277	62	528	72	2,373	57	3,726	83	2,626		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,947.0 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total: 4,044.7 lb/hr, 2.022 dry stph. Mill volume end of test: 9%.
(2) Excluded from average.

Feed Rate, stph dry:	2.022
Ball Charge:	301.8 lb, 2% mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwh/st	Power Consumption Net kwh/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %
1040	0	8.7	5.96	4.22	2.09	1.79	--	--
1110	30	5.2	9.97	7.93	3.92	3.63	--	--
1130	50	5.3	9.78	7.78	3.85	3.55	--	62
1200	80	5.0	10.36	8.25	4.08	3.78	--	63
1230	110	4.8	10.80	8.63	4.27	3.97	--	64
1300	140	4.8	10.80	8.63	4.27	3.97	59.0(4)	63
1330	170	4.8	10.80	8.63	4.27	3.97	95.0	66
1400	200	4.9	10.58	8.44	4.17	3.88	87.0	66
1415(3)	215	5.0	10.36	8.25	4.08	3.78(2)	92.0	66
1430(3)	230	5.0	10.36	8.25	4.08	3.78(2)	93.0	65
Average						3.78	91.3	

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last two readings): 3.78 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 2 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis								
	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1415	1430	1415	1430	1415	1430	1415	1430	
Sample Weight, g:	1,058.8	1,206.6	669.3	979.0	915.6	1,106.8	888.1	932.3	
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	23.8	21.6	65.5	71.8	40.4	37.6	2.0	1.7	43.4
-28 +35	6.8	6.4	2.5	1.6	8.4	9.9	5.3	4.3	8.1
-35 +65	13.5	13.3	4.2	3.6	8.8	12.0	17.2	16.6	9.4
-65 +100	9.4	10.2	3.2	3.0	4.7	7.6	13.6	12.9	5.7
-100 +200	11.9	13.4	5.0	5.0	7.3	10.3	17.6	17.0	8.3
-200 +325	4.2	5.9	3.0	2.1	1.6	4.7	7.0	6.3	3.1
-325	30.4	29.2	16.6	12.9	28.8	17.9	37.3	41.2	22.0

EXHIBIT 2

Grinding Test 3

Date:	June 15, 1978
Feed Rate, stph:	3.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(2)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1050	0	5.0	13,045	93	—	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1135	45	4.5	--	--	—	918	570	174	--	--	--	--	--	--	--	--	--	--	--	--
1200	70	4.4	--	99	4,350	918	570	174	65	13,631	68	857	70	6,237	58	5,090	105	3,350	--	--
1207	77	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Shutdown, rock jammed in feeder.
1230	77	--	--	--	—	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1300	107	4.9	--	109	3,435	918	570	174	65	10,530	63	808	73	3,679	55	4,430	106	3,366	--	--
1330	137	4.8	--	108	4,815	918	570	174	66	11,642	64	878	72	5,508	61	5,408	104	3,303	--	--
1400	167	4.9	--	110	4,275	918	570	174	67	11,095	58	639	73	5,059	61	5,545	104	3,303	--	--
1430	197	4.7	--	111	4,590	918	570	174	67	11,156	65	761	72	5,573	61	4,804	103	3,271	--	Sample.
1445	212	4.8	13,085	112	5,040	918	570	174	67	15,135	67	1,010	71	6,646	62	5,692	104	3,303	--	Sample.
1500	242	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	25	Shut down.
Average					4,417	918	570	174	66	12,198	64	226	72	5,450	60	5,162	104	3,316		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%, -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 4,293.8 lb/hr, -4 in. +1-1/2 in., 908.8 lb/hr; -6 in. +4 in., 565.4 lb/hr; -10 in. +6 in., 172.8 lb/hr; total, 5,940.8 lb/hr, 2.970 dry stph. Mill volume end of test: 25%.
(2) Auxiliary water line used -- measured twice, averaged, and added as percentage of regular water meter.

Feed Rate, stph dry:	2.970 stph dry
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1050	0	5.0	10.36	8.26	2.78	2.58	--	--	--
1135	45	4.5	11.52	9.24	3.11	2.91	--	--	--
1200	70	4.4	11.78	9.45	3.18	2.98	118.0(4)	65	--
1207	77	--	--	--	--	--	--	--	Rock jammed in feeder.
1230	77	--	--	--	--	--	--	--	--
1300	107	4.9	10.58	8.43	2.84	2.64	88.0	65	--
1330	137	4.8	10.80	8.62	2.90	2.70(2)	99.0	66	--
1400	167	4.9	10.58	8.43	2.84	2.66(2)	96.0	67	--
1430(3)	197	4.7	11.03	8.82	2.97	2.77(2)	101.0	67	--
1445(3)	212	4.8	10.80	8.62	2.90	2.70(2)	114.0	67	--
1500	242								
Average						2.70	99.6		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last four readings): 2.70 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 3

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Test Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1430	1445	1430	1445	1430	1445	1430	1445	--
Sample Weight, g:	1,174.9	1,310.3	1,365.7	1,223.1	1,183.4	1,245.5	850.1	962.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	27.8	25.1	65.0	67.5	47.4	33.3	2.4	1.9	43.7
-28 +35	6.5	7.1	1.8	2.0	9.1	7.9	5.7	5.0	7.6
-35 +65	12.8	14.6	3.7	4.0	12.4	13.2	18.1	21.0	11.7
-65 +100	9.2	9.0	3.1	3.4	6.5	8.5	14.8	16.0	7.0
-100 +200	11.4	13.5	5.4	5.5	8.9	9.9	15.6	13.5	8.9
-200 +325	4.8	3.4	3.4	3.3	1.6	3.3	5.9	4.5	2.5
-325	27.5	27.3	17.6	14.3	14.1	23.9	37.5	38.1	18.6

EXHIBIT 2

Grinding Test 4

Date:	June 16, 1978
Feed Rate, stph:	2.5
Ore:	Crushed
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Motor Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(1)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1010	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	Start mill.
1030	20	6.6	13,094	96	--	--	--	--	--	--	--	--	--	90	2,858	--	--
1100	50	6.3	--	97	5,130	63	7,598	67	362	74	1,931	61	5,243	87	2,763	--	--
1130	80	5.9	--	99	5,350	62	8,091	64	418	72	2,398	60	4,482	82	2,604	--	--
1200	110	5.9	--	99	4,995	65	12,539	66	535	70	3,717	61	3,953	80	2,540	--	--
1215	125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Feed off (feed belt jammed).
1218	128	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1230	137	6.0	--	100	4,770	62	5,692	62	288	71	2,077	58	3,628	80	2,540	--	--
1300	167	6.0	--	100	5,423	65	6,786	62	326	71	1,885	60	4,428	80	2,540	--	--
1320	187	--	--	--	--	--	--	--	--	--	--	60	4,316(3)	--	--	--	--
1330	197	5.8	--	102	4,826	65	6,728	69	449	69	2,298	59	4,806	79	2,509	--	--
1400	227	5.7	--	104	4,635	64	6,797	62	260	72	1,134	60	4,617	79	2,509	--	Sample.
1415	242	5.7	13,128	104	6,793	63	6,010	64	230	70	819	59	4,328	79	2,509	15	Sample.
1500	257	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Average					5,240	64	7,528	64	359	71	2,052	60	4,422	82	2,597	--	

(1) Moisture: -3 in., 4.3%. Average dry ore feed rate: -3 in., 5,015 lb/hr, 2.508 dry stph. Mill volume end of test: 15%.
(2) Auxiliary water line used -- measured twice, averaged, and added as percentage of regular water meter.
(3) 55-gal drum timed sample.

Feed Rate, stph:	2.508
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1010	0	--	--	--	--	--	--	--	--
1030	20	6.6	7.85	6.00	2.39	2.15	--	--	--
1100	50	6.3	8.23	6.35	2.53	2.29	--	63	--
1130	80	5.9	8.78	6.87	2.74	2.50	50.0(4)	62	--
1200	110	5.9	8.78	6.87	2.74	2.50	81.0(4)	65	--
1215	125	--	--	--	--	--	--	--	Feed belt jammed.
1230	137	6.0	8.64	6.73	2.68	2.44	48.0	62	--
1300	167	6.0	8.64	6.73	2.68	2.44	39.0	65	--
1320	187	--	--	--	--	--	--	--	--
1330	197	5.8	8.93	7.00	2.79	2.55(2)	54.0	65	--
1400(3)	227	5.7	9.09	7.13	2.84	2.60(2)	29.0	64	--
1415(3)	242	5.7	9.09	7.13	2.84	2.60(2)	16.0	63	--
Average						2.58	36.8		

(1) Calculated; Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last three readings): 2.58 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 4 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis								
	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1140	1415	1400	1415	1400	1415	1400	1415	--
Sample Weight, g:	1,139.4	886.7	715.4	726.2	1,152.9	1,020.0	763.8	769.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	15.3	13.1	86.5	91.8	39.1	43.1	2.7	2.7	55.5
-28 +35	5.8	5.2	0.3	0.3	8.9	7.6	4.9	4.6	5.9
-35 +65	17.8	17.9	0.9	0.5	14.9	12.7	18.6	18.6	9.9
-65 +100	11.1	11.8	0.7	0.3	6.8	6.3	12.5	13.3	4.7
-100 +200	15.8	16.7	1.6	0.7	8.8	8.9	18.6	19.1	6.6
-200 +325	7.7	6.4	0.9	0.4	3.3	4.1	8.1	6.3	2.8
-325	26.5	28.9	9.1	6.0	18.2	17.3	34.6	35.4	14.6

EXHIBIT 2

Grinding Test 5

Date:	June 19, 1978
Feed Rate, stph:	2.0
Ore:	Crushed
Ball Charge:	Total 301.8 lb. 2% mill volume
-1-1/2 in. Balls, lb:	116.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0840	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	Start mill.
0910	30	6.7	13,136	90	3,623	--	--	--	--	--	--	--	--	75	2,382	--	--
0930	50	6.3	--	91	3,960	67	8,744	48	356	67	3,558	60	2,970	71	2,255	--	--
1000	80	6.2	--	92	3,803	66	6,663	45	324	70	2,079	60	4,077	68	2,159	--	--
1030	110	6.5	--	91	--	56	3,578	15	68	70	347	59	3,452	66	2,096	--	Shut down -- out of feed.
1035	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1040	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1100	135	6.5	--	94	4,230	66	4,990	38	182	75	346	62	4,241	68	2,159	--	--
1130	165	6.6	--	96	4,298	66	5,049	42	239	72	729	62	4,101	69	2,191	--	--
1155	190	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--
1200	195	6.7	--	97	4,320	63	3,856	37	200	75	405	61	3,870	69	2,191	--	--
1230	225	6.7	--	100	3,533	62	3,894	27	101	73	394	58	3,445	64	2,032	--	--
1300	255	6.6	--	103	4,016	66	4,693	29	111	70	851	61	3,870	68	2,159	--	--
1330	285	6.3	--	104	4,005	68	9,058	34	173	68	3,672	64	3,744	61	1,937	--	--
1345	300	6.5	--	104	3,645	63	4,139	32	134	71	250	59	3,452	68	2,159	--	Sample.
1400	315	6.1	--	104	4,005	64	4,781	34	143	72	238	57	3,106	69	2,191	--	Sample.
1430	345	6.1	--	105	4,140	63	4,820	33	193	69	598	59	3,505	69	2,191	--	--
1445	360	6.0	--	106	3,713	62	4,018	38	182	71	423	56	2,696	69	2,191	--	Sample.
1500	375	5.7	13,184	107	4,028	63	4,139	36	151	70	1,323	56	2,696	69	2,191	--	Sample.
1510	380	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down.
1513	388	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Collecting mill discharge sample.
1522	397	--	--	--	3,690	--	--	--	--	--	--	--	--	--	--	--	Second barrel.
1529	404	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Third barrel.
1536	411	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Hopper went empty.
1537	412	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down mill.
Average	--	--	--	--	3,934	64	5,173	35	183	71	1,087	59	3,516	68	2,165	--	--

(1) Moisture: -3 in., 2.0%. Average dry ore feed rate: -3 in., 3,855 lb/hr, 1.928 dry stph. Mill volume end of test: 15%.

EXHIBIT 2

Grinding Test 5 -- continued

Feed Rate, stph (dry): 1.928
Ball Charge: 301.8 lb, 2% of mill charge
Corrected Mill Power Tare (empty mill), kw: 0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0840	0	--	--	--	--	--	--	--	--
0910	30	6.7	7.73	5.89	3.05	2.74	--	--	--
0930	50	6.3	8.23	6.35	3.29	2.98	--	67	--
1000	80	6.2	8.36	6.47	3.36	3.04	--	66	--
1030	110	6.5	7.97	6.10	3.16	2.85	--	56	--
1035	115	--	--	--	--	--	--	--	Ran out of ore.
1100	135	6.5	7.97	6.10	3.16	2.85	12.0(4)	66	--
1130	165	6.6	7.85	6.00	3.11	2.80	23.0(4)	66	--
1155	190	--	--	--	--	--	--	--	Check mill volume.
1200	195	6.7	7.73	5.89	3.05	2.74	14.0	63	--
1230	225	6.7	7.73	5.89	3.05	2.74	14.0	62	--
1300	255	6.6	7.85	6.00	3.11	2.80	24.0	66	--
1330	285	6.3	8.23	6.35	3.29	2.98	96.0(4)	68	--
1345(3)	300	6.5	7.97	6.10	3.16	2.85	11.0	63	--
1400(3)	315	6.1	8.50	6.60	3.42	3.11(2)	10.0	64	--
1430	345	6.1	8.50	6.60	3.42	3.11(2)	19.0	63	--
1445(3)	360	6.0	8.64	6.73	3.49	3.18(2)	16.0	62	--
1500(3)	375	5.7	9.09	7.13	3.70	3.37	37.0	63	--
1510	385	--	--	--	--	--	--	--	Check mill load level.
1513	388	--	--	--	--	--	--	--	Start filling No. 1 mill discharge sample barrel.
1522	397	--	--	--	--	--	--	--	Start filling No. 2 mill discharge sample barrel.
1529	404	--	--	--	--	--	--	--	Start filling No. 3 mill discharge sample barrel.
1536	411	--	--	--	--	--	--	--	End filling No. 3 mill discharge sample barrel.
1537	412	--	--	--	--	--	--	--	End of test.
Average						3.13	18.0		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (three readings, omitted reading at 1,500 from average): 3.13 kwhr/st.
(3) Sample run.
(4) Omitted from average.

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis: Mill Discharge				Sweco Screen Oversize				DSM Screen Oversize				DSM Screen Underflow				Circulating Load
Sample Time	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	--
Sample Weight, g:	1,058.6	1,062.1	911.3	859.1	442.5	300.3	282.2	381.8	1,065.9	713.5	478.8	920.6	817.4	757.0	743.7	787.8	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	12.0	11.5	10.2	10.8	78.4	82.9	81.4	87.5	67.0	54.5	51.9	32.0	1.8	2.0	1.9	1.6	58.1
-28 +35	3.7	3.7	2.7	2.9	1.5	0.8	1.0	0.4	5.0	4.6	4.5	3.9	3.1	3.1	2.8	2.3	3.7
-35 +65	15.3	16.3	12.9	13.4	4.1	1.9	3.0	1.1	6.2	7.4	6.9	10.9	16.8	16.3	15.8	14.2	6.7
-65 +100	12.3	13.4	12.8	12.7	2.4	1.2	1.9	0.8	3.4	5.2	5.2	9.1	14.7	14.6	14.2	14.5	4.8
-100 +200	19.1	18.9	21.3	20.6	4.1	2.7	3.7	1.6	5.3	8.2	9.3	14.2	20.5	20.5	21.7	21.8	8.0
-200 +325	8.0	6.6	9.0	8.6	1.1	1.0	1.1	1.2	1.6	2.8	4.0	5.3	8.1	8.4	7.4	7.4	2.9
-325	29.6	30.0	31.1	31.0	8.4	9.5	7.9	7.4	11.5	17.3	18.2	24.6	35.0	35.1	36.2	38.2	15.8

EXHIBIT 2

Grinding Test 6

Date:	June 20, 1978
Feed Rate, stph:	2.5
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. -6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0820	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--(Grind out)--		Start mill.
0925	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	13,195	82	--	768	474	219	--	--	--	--	--	--	--	--	80	2,540	--	--
1000	35	5.9	--	80	--	768	474	219	66	11,286	60	662	71	4,090	61	5,737	85	2,699	--	--
1030	65	5.3	--	82	3,713	768	474	219	66	9,742	54	535	68	4,896	61	3,486	84	2,668	--	--
1100	95	5.2	--	83	3,825	768	474	219	67	10,492	60	608	68	4,651	61	4,255	85	2,699	--	--
1135	130	5.2	--	84	3,510	768	474	219	66	7,960	59	597	68	3,733	61	4,255	84	2,668	25	--
1200	155	5.2	--	87	3,758	768	474	219	68	10,588	57	487	68	4,651	60	3,699	85	2,699	--	--
1230	185	5.1	--	88	3,420	768	474	219	68	10,037	55	545	69	3,974	60	4,104	89	2,826	--	--
1245	200	5.1	--	88	3,420	768	474	219	67	9,950	52	714	68	4,223	59	4,275	89	2,826	--	Sample.
1300	215	5.0	--	89	3,600	768	474	219	67	11,759	62	781	68	6,487	62	3,627	85	2,699	--	Sample.
1330	245	5.0	12,236	92	--	768	474	219	67	8,924	60	1,337	68	4,039	60	3,780	88	2,795	--	--
1337	252	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	Shut down.
Average					3,607	768	474	219	67	10,082	58	696	68	4,527	61	4,135	85	2,712		

(1) Moisture: -1-1/2 in., 2.3%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 3,524 lb/hr; -4 in. +1-1/2 in., 760.3 lb/hr; -6 in. +4 in., 470.2 lb/hr; -10 in. +6 in., 217.5 lb/hr; Total: 4,972 lb/hr; 2.486 dry stph. Mill volume end of test: 27%.

Feed Rate, stph (dry):	2.486
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0820	--	--	--	--	--	--	--	--	Grind out.
0925	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	7.62	5.80	2.33	2.09	--	--	--
1000	35	5.9	8.78	6.87	2.76	2.52	--	66	--
1030	65	5.3	9.78	7.78	3.13	2.92	105.0	66	--
1100	95	5.2	9.97	7.92	3.18	2.94	99.0	67	--
1135	130	5.2	9.97	7.92	3.18	2.94	87.0	66	--
1200	155	5.2	9.97	7.92	3.18	2.94	98.0	68	--
1230	185	5.1	10.16	8.09	3.25	3.01	93.0	68	--
1245(3)	200	5.1	10.16	8.09	3.25	3.01	101.0	67	--
1300(3)	215	5.0	10.36	8.26	3.32	3.08(2)	144.0	67	--
1330	245	4.0	10.36	8.26	3.32	3.08(2)	--	67	--
1337	252	--	--	--	--				End of test.
Average						3.08	103.9		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (two readings): 3.08 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 6 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Total Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1245	1300	1245	1300	1245	1300	1245	1300	
Sample Weight, g:	1,258.8	1,237.7	673.8	642.6	1,361.9	1,079.3	832.1	918.1	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	21.0	18.4	64.8	70.7	32.9	23.1	1.3	1.0	32.9
-28 +35	6.4	6.5	1.9	1.2	9.4	8.5	3.9	3.7	8.1
-35 +65	13.9	15.1	3.8	2.7	12.8	14.3	16.5	16.7	12.2
-65 +100	10.5	11.4	3.2	2.2	8.8	8.6	12.4	14.5	8.0
-100 +200	13.3	14.2	5.4	5.0	11.8	14.2	20.3	18.5	12.0
-200 +325	5.5	5.6	3.1	2.2	4.8	3.7	5.3	6.7	4.1
-325	29.4	28.8	17.8	16.0	19.5	27.6	40.3	38.9	22.7

Sediment Description and Classification Background

U.S. Standard Sieves

Note that the same size mesh can be a differing sieve number depending on the Sieve manufacturer (Tyler vs. ASTM)

Mesh Size (microns)	TYLER	ASTM-E11	BS-410	DIN-4188
µm	Mesh	No.	Mesh	mm
5	2500		2500	0.005
10	1250		1250	0.010
15	800		800	0.015
20	625		625	0.020
22				0.022
25	500		500	0.025
28				0.028
32				0.032
36				0.036
38	400	400	400	
40				0.040
45	325	325	350	0.045
50				0.050
53	270	270	300	
56				0.056
63	250	230	240	0.063
71				0.071
75	200	200	200	
80				0.080
90	170	170	170	0.090
100				0.100
106	150	140	150	
112				0.112
125	115	120	120	0.125
140				0.140
150	100	100	100	

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160				0.160
180	80	80	85	0.180
200				0.200
212	65	70	72	
250	60	60	60	0.250
280				0.280
300	48	50	52	
315				0.315
355	42	45	44	0.355
400				0.400
425	35	40	36	
450				0.450
500	32	35	30	0.500
560				0.560
600	28	30	25	
630				0.630
710	24	25	22	0.710
800				0.800
850	20	20	18	
900				0.900
1000	16	18	16	1.0
1120				1.12
1180	14	16	14	
1250				1.25
1400	12	14	12	1.4
1600				1.6
1700	10	12	10	
1800				1.8
2000	9	10	8	2.0
2240				2.24
2360	8	8	7	
2500				2.5
2800	7	7	6	2.8
3150				3.15
3350	6	6	5	
3550				3.55
4000	5	5	4	4.0
4500				4.5

4750	4	4	3.5	
5000				5.0

Sediment Classification based on Grain Size:

Unified Soil Classification System (USCS)

Sediment Name	**Diameter (mm)**	**Sieve No.**
Cobble	greater than 75 mm	
Gravel	4.75 to 75 mm	4
Sand	0.075 to 4.75 mm	200
Fines (silt and clay)	less than 0.075 mm	

USCS Division of Sands

Sediment Name	Diameter Range (mm)	Passes through Sieve No.	Retained on Sieve No.
Coarse Sand	2.0 - 4.8	4	10
Medium Sand	0.43 - 2.0	10	40
Fine Sand	0.075 - 0.43	40	200

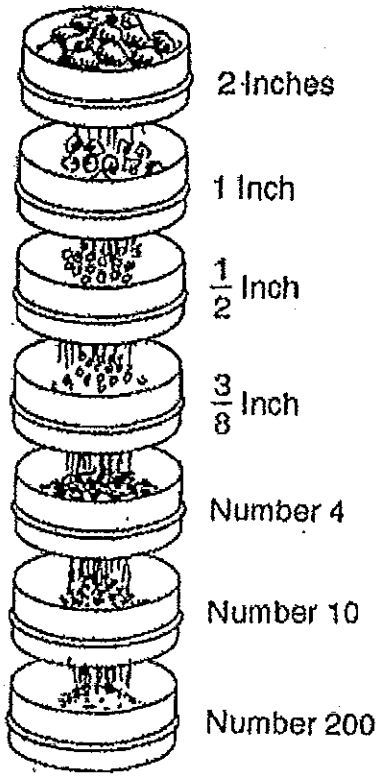


Figure 4-3. Dry sieve analysis.

USCS Classification System

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS More Than Half Retained on 200 Sieve	GRAVELS More Than Half Coarse Fraction Retained on No. 4 Sieve	Clean Gravels (Little or no Fines)	GW	Well Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
			GP	Poorly Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
		Gravels With Fines (Appreciable Fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More Than Half Coarse Fraction Passes a No. 4 Sieve	Clean Sands (Little or no Fines)	SW	Well Graded Sands, Gravelly Sands, Little or no Fines
			SP	Poorly Graded Sands, Gravelly Sands, Little or no Fines
		Sands With Fines (Appreciable Fines)	SM	Silty Sands, Sand - Silt Mixtures
			SC	Clayey Sands, Sand - Clay Mixtures
FINE GRAINED SOILS More Than Half Passes 200 Sieve	SILTS and CLAYS Liquid Limit Less Than 50		ML	Inorganic Silts & Very Fine Sands, Silty or Clayey Fine Sands, Clayey Silts
			CL	Inorganic Clays of Low to Medium Plasticity, Lean Clays
			OL	Organic Silts & Organic Silty Clays of Low Plasticity
	SILTS and CLAYS Liquid Limit Greater Than 50		MH	Inorganic Silts, Fine Sand or Silty Soils, Elastic Silts
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils			PT	Peat and Other Highly Organic Soils

Visual logging of sediments entails estimating percentages of gravels, sands and fines (silt and clays). Practice and the use of the Geotechnical Gage will increase your confidence and ability in visually logging sediments.

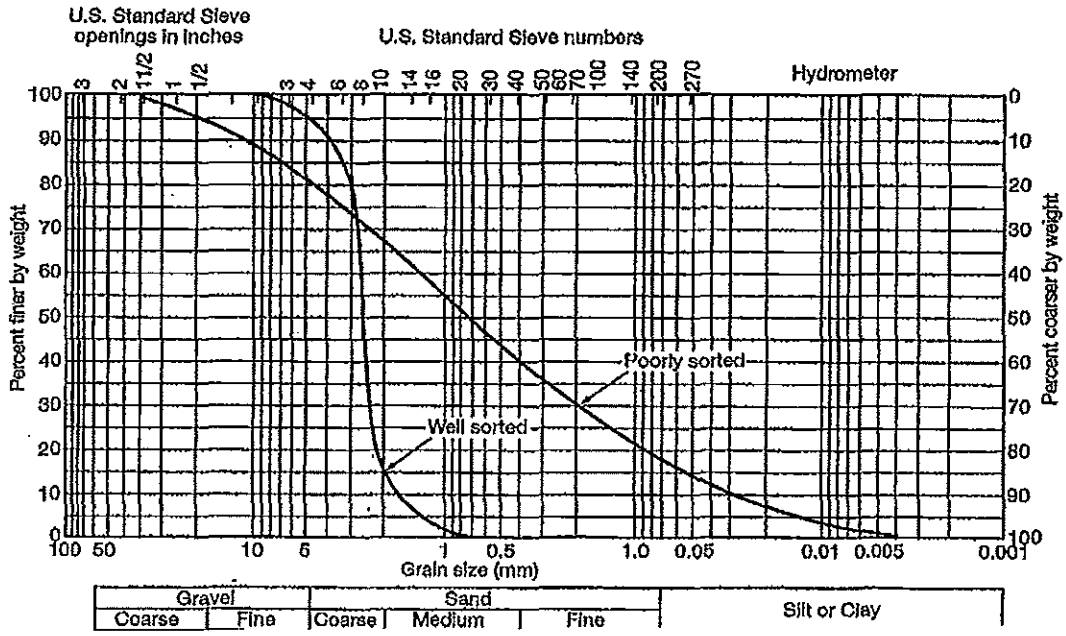
Read: Visual Exam Test

Read: Field Identification Guidelines

Ultimately, sediment samples may undergo grain size analysis through sieves. Graphing the cumulative weight percent retained/passing by sieve no. or grain size will result in the sediment grain-size distribution curve. The grain-size distribution curve is used to quantitatively classify the sediment type (your visual identification is a qualitative classification).

Read: Grain Size Distribution Measurement

Grain Size Distribution Curve



The grain-size distribution curve is used with the USCS classification chart to classify the sediment type. Other measures used to describe the sediment are the sorting or gradation of the sediment. As can be seen in the above chart, a well-sorted sediment has a small range of sediment grain sizes while a poorly sorted sediment has a large range of sediment grain sizes. In the USCS classification scheme, the gradation of the sediment is used instead of the sorting. A well-graded sediment has a large range of grain sizes while a poorly or uniformly graded sediment has a small range of grain sizes.

Figure 4-6. Well-graded soil.

POORLY SORTED SEDIMENT = WELL GRADED SEDIMENT

Figure 4-7. Uniformly graded soil.

WELL-SORTED SEDIMENT = POORLY OR UNIFORMLY GRADED SEDIMENT

Figure 4-8. Gap-graded soil.

After sieve analysis, the data are tabulated showing the weight of sediment retained on each sieve. The cumulative weight retained is calculated starting from the largest sieve size and adding subsequent sediment weights from the smaller size sieves (see table below). The percent retained is calculated from the weight retained and the total weight of the sample. [Don't get confused by the graph - it is individual percent retained in Column 16 and cumulative percent passing in Column 17]. The cumulative percent passing in Column 17 of the table below is calculated by sequentially subtracting percent retained from 100 %. In table below, cumulative percent passing 1/4 inch sieve = 100 - 16 = 84; cumulative percent passing #4 sieve = 84-5.2 = 78.8; etc.

SIEVE ANALYSIS DATA

1. DATE STARTED: 22 FEB 91
2. PROJECT: BRAVO AIRFIELD
3. EXCAVATION: 1+00
4. DATE COMPLETED: 28 FEB 91
5. SAMPLE DESCRIPTION: LIGHT BROWN SANDY SOIL
6. SAMPLE NUMBER: 1A
7. PREWASHED: XX YES / NO
8. ORIGINAL SAMPLE WEIGHT: 2459
9. + #200 SAMPLE WEIGHT: 2359
10. −#200 SAMPLE WEIGHT: 100

11. SIEVE SIZE	12. WEIGHT OF SIEVE	13. WEIGHT OF SIEVE + SAMPLE	14. WEIGHT RETAINED	15. CUMULATIVE WEIGHT RETAINED	16. PERCENT RETAINED	17. PERCENT PASSING
1½	202					
1	231					
½	210	210	0	0	0	100.0
¼	230	624	394	394	16.0	84.0
#4	205	332	127	521	5.2	78.8
#8	225	691	466	987	19.0	59.8
#20	215	612	397	1384	16.2	43.6
#60	235	581	346	1730	14.1	29.5
#100	250	612	362	2092	14.7	14.8
#200	260	515	255	2347	10.4	4.4

18. TOTAL WEIGHT RETAINED IN SIEVES	2347
20. WEIGHT SIEVED THROUGH #200: 270-260	10
21. WASHING LOSS: 2459-(2359+100)	0
22. TOTAL WEIGHT PASSING #200: 10+100	110
23. TOTAL WEIGHT OF FRACTIONS	2457

19. ERROR: 2459-2457 = 2

24. REMARKS
USCS: SP
PERCENT-G: 21.2
PERCENT-S: 74.4
PERCENT-F: 4.4

25. ERROR (%): $\frac{\text{ERROR (19)}}{\text{ORIGINAL WT (8)}} \times 100 = \frac{2}{2459} \times 100 = .08$

26. TECHNICIAN: Joe Blob PV2
27. COMPUTED BY: Joe Blob PV2
28. CHECKED BY: Fred Jones SSG

DD Form 1206, DEC 86 Previous editions are obsolete

Figure 4-4. Data sheet, example of dry sieve analysis.

The cumulative percent passing is plotted on the grain-size distribution graph. The percentage passing the No. 4 and 200 sieves is used to classify the sediments as gravels (G), sands (S) or fines (must use plasiticity index to differentiate between silts and clays).

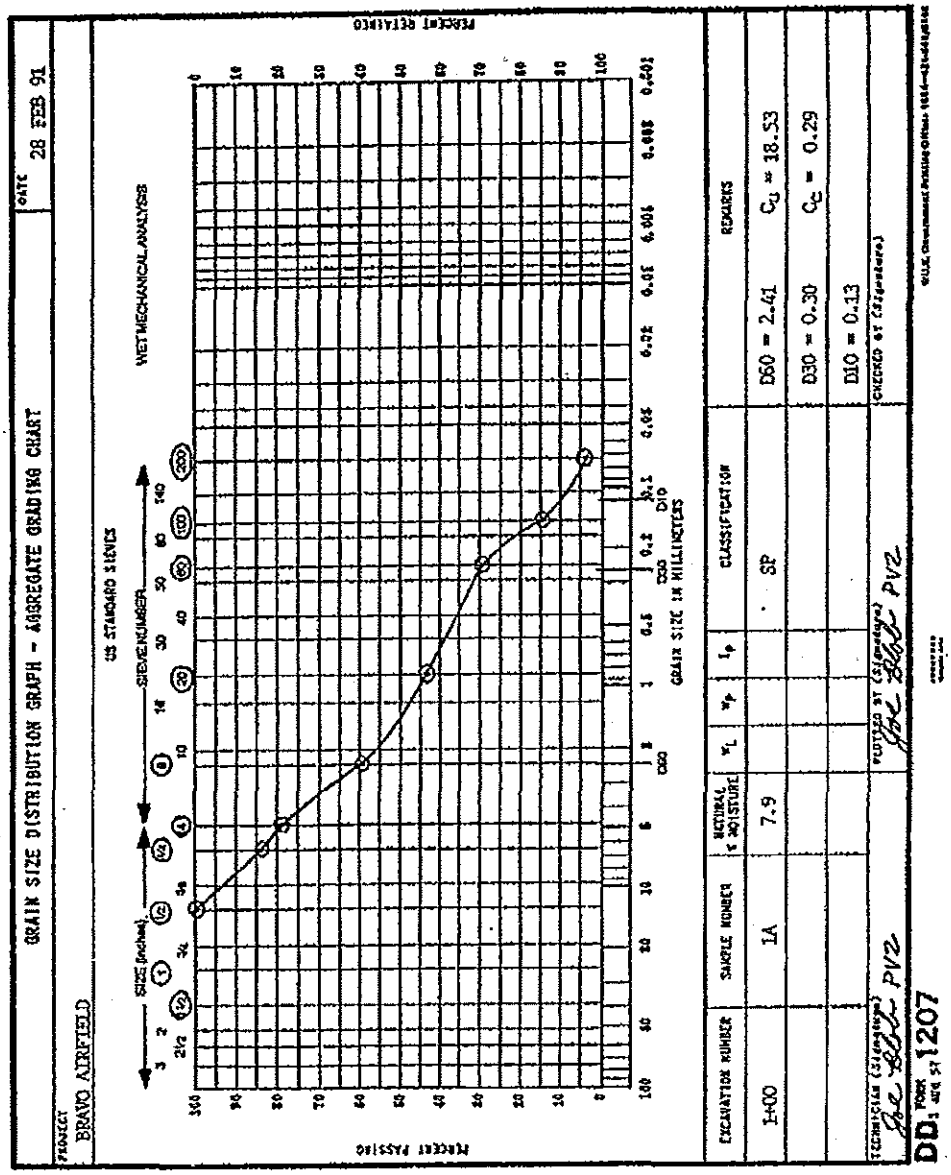


Figure 4-5. Grain-size distribution curve from sieve analysis.

The grain-size distribution graph is used to read off the grain size at which 10% of the sample passed (D_{10}), 30% of the sample passed (D_{30}) and 60% of the sample passed (D_{60}). These numbers are used to calculate several coefficients:

Hazen's effective size, D_{10}, which will be used to estimate permeability

Uniformity Coefficient, $C_u = D_{60}/D_{10}$

In the above graph,

$$D_{60} = 2.4 \text{ mm and } D_{10} = 0.13 \text{ mm}$$

$$\text{then} \quad C_u = 2.4/0.13 = 18.5$$

The uniformity coefficient is used to judge gradation.

Coefficient of Curvature, C_c

$$C_c = \frac{(D_{30})^2}{(D_{60} \times D_{10})}$$

In the above graph,

$$D_{30} = 0.3 \text{ mm}$$

$$\text{and } C_c = \frac{(0.3)^2}{(2.4)(0.13)} = .29$$

In the graph below, well-graded soils (GW and SW) are long curves spanning a wide range of sizes with a constant or gently varying slope. Uniformly graded soils (SP) are steeply sloping curves spanning a narrow range of sizes. For a gap-graded soil (GP), the curve flattens out in the area of the grain-size deficiency or gap.

The USCS criteria for well-graded gravels (GW) and sands (SW) are:

1. Less than 5% finer than No. 200 sieve
2. Uniformity coefficient greater than 4
3. Coefficient of curvature between 1 and 3

If Criterion 1 is met, but not Criteria 2 and 3, the gravels are gap-graded or uniform gravels (GP) or sands (SP)

If you are interested in more information: Gradation and Bearing Capacity

United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

EPA/600/R-94/168b
September 1994

EPA

The Hydrologic Evaluation of Landfill Performance (HELP) Model

Engineering Documentation for Version 3

ATTACHMENT C, 1/3

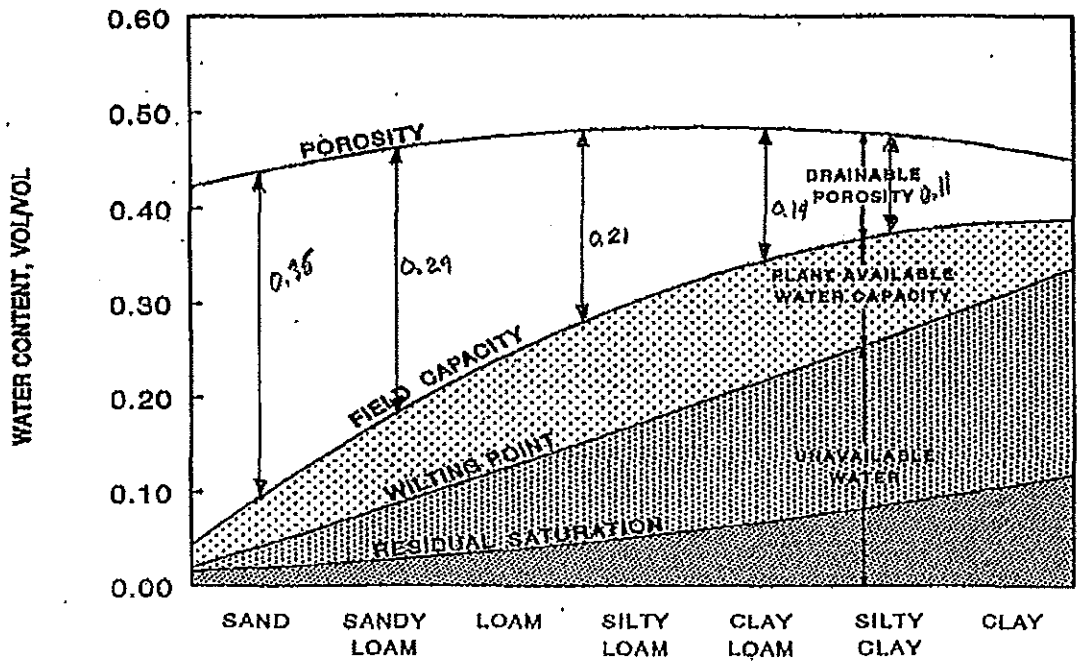


Figure 2. Relation Among Moisture Retention Parameters and Soil Texture Class

are not specified, the program assumes values near the steady-state values (allowing no long-term change in moisture storage) and runs a year of simulation to initialize the moisture contents closer to steady state. The soil water contents at the end of this year are substituted as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results of the volumetric water content initialization period are not reported in the output.

3.3.2 Unsaturated Hydraulic Conductivity

Darcy's constant of proportionality governing flow through porous media is known quantitatively as hydraulic conductivity or coefficient of permeability and qualitatively as permeability. Hydraulic conductivity is a function of media properties, such as particle size, void ratio, composition, fabric, degree of saturation, and the kinematic viscosity of the fluid moving through the media. The HELP program uses the saturated and unsaturated hydraulic conductivities of soil and waste layers to compute vertical drainage, lateral drainage and soil liner percolation. The vapor diffusivity for geomembranes is specified as a saturated hydraulic conductivity to compute leakage through geomembranes by vapor diffusion.

Attachment C 2/3

TABLE 1. DEFAULT LOW DENSITY SOIL CHARACTERISTICS

Soil Texture Class			A Total Porosity vol/vol	B Field Capacity vol/vol	Wilting Point vol/vol	Saturated Hydraulic Conductivity cm/sec	A-B DRAINABLE POROSITY vol/vol
HELP	USDA	USCS					
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}	
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}	
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}	
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}	0.332
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}	0.326
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}	0.263
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}	0.251
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}	0.231
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}	0.217
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}	0.154
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}	
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}	
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}	
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}	
15	C	CH	0.475	0.378	0.251	2.5×10^{-5}	
21	G	GP	0.397	0.032	0.013	3.0×10^{-1}	

a = constant representing the effects of various fluid constants and gravity, 21 cm^3/sec

ϕ = total porosity, vol/vol

θ_r = residual volumetric water content, vol/vol

ψ_b = bubbling pressure, cm

λ = pore-size distribution index, dimensionless

A more detailed explanation of Equation 11 can be found in Appendix A of the HELP program Version 3 User's Guide and the cited references.

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ered that when well-graded mixtures of sand and gravel contained as little as 5% of fines (sizes smaller than a No. 200 sieve) high compactive efforts reduced the effective porosities nearly to zero and the permeabilities to less than 0.01% of those at moderate densities. These tests explain one of the reasons that blends of sand and gravel often used for drains are virtually useless as drainage aggregates if they contain more than insignificant amounts of fines.

In the preceding paragraphs variations in the permeability of remolded materials caused by variable compaction were discussed. Any factor that densifies soils reduces permeability. Studies of the rate of consolidation of clay and peat foundations are sometimes made by using initial coefficients of permeability of compressible formations. While the consolidation process is going on in foundations their permeabilities are becoming less. Generally, decreases in the permeabilities of clay foundations are rather moderate, but they can be large in highly compressible organic silts and clays and in peats. Modified calculation methods utilizing the changing permeability are needed in the analysis of highly compressible foundations. Some typical variations in permeability caused by consolidation are given in Fig. 2.10, a plot of consolidation pressure versus permeability.

$\sigma_n \simeq 31' \times 130$ pcf.
$\simeq 4000$ psf
$\simeq 2$ Tsf

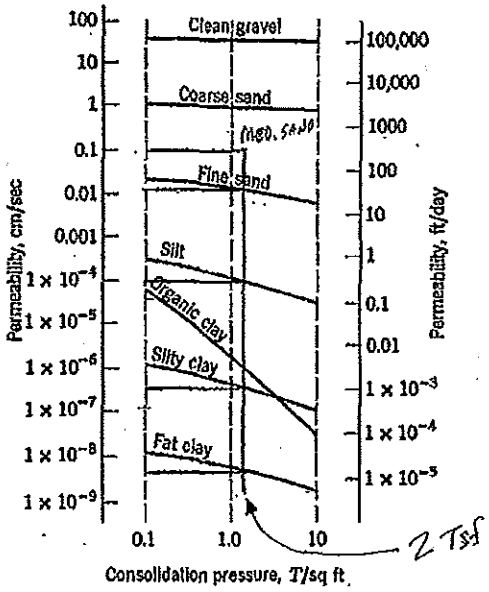

FIG. 2.10 Permeability versus consolidation pressure.

"Seepage, Drainage, and Flow Nets" 3rd Edition, Cedergren, H.R. 1989

Attachment D 1/2

$$k = \frac{Q}{IAt} \tag{2.2}$$

Darcy's *discharge velocity* multiplied by the entire cross-sectional area, including voids e and solids 1, gives the seepage quantity Q under a given hydraulic gradient $i = \Delta h/\Delta l$ or h/L. It is an imaginary velocity that does not exist anywhere. The average *seepage velocity* v_s of a mass of water progressing through the pore spaces of a soil is equal to the discharge velocity $(v_d = ki)$ multiplied by $(1 + e)/e$ or the discharge velocity divided by the effective porosity n_e; hence permeability is related to seepage velocity by the expression

$$k = \frac{v_s n_e}{i} \tag{2.3}$$

For any seepage condition in the laboratory or in the field in which the *seepage quantity*, the area perpendicular to the direction of flow, and the hydraulic gradient are known the coefficient of permeability can be calculated. Likewise, for any situation where the *seepage velocity* is known at a point at which the hydraulic gradient and soil porosity also are known, permeability can be calculated.

Experimentally determined coefficients of permeability can be combined with prescribed hydraulic gradients and discharge areas in solving practical problems involving seepage quantities and velocities. When a coefficient of permeability has been properly determined, it furnishes a very important factor in the analysis of seepage and in the design of drainage features for engineering works.

The coefficient of permeability as used in this book and in soil mechanics in general should be distinguished from the physicists' coefficient of permeability K, which is a more general term than the engineers' coefficient and has units of centimeters squared rather than a velocity; it varies with the porosity of the soil but is independent of the viscosity and density of the fluid. The transmissibility factor T represents the capability of an aquifer to discharge water and is the product of permeability k and aquifer thickness t.

The engineers' coefficient, which is used in practical problems of seepage through masses of earth and other porous media, applies only to the flow of water and is a simplification introduced purely from the standpoint of convenience. It has units of a velocity and is expressed in centimeters per second, feet per minute, feet per day, or feet per year; depending on the habits and personal preferences of individuals using the coefficient. In standard soil mechanics terminology k is expressed in centimeters per second.

Although coefficient of permeability is often considered to be a constant for a given soil or rock, it can vary widely for a given material, depending on a number of factors. Its absolute values depend, first of all, on the properties of water, of which viscosity is the most important. For individual materials

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Cedergren, "Seepage, Drainage, and Flow Nets", 3rd Ed. 1989

GDE Control Products, Inc.

Multi-FLO

Technical Properties

Multi-Flow
Product Information
Applications
Fittings
Accessories
Technical
Backfill
Installation
Drainage Guide
FAQ's

Drainage Core

Property	Test Method	Value
Thickness, inches	ASTM D-1777	1.0
Flow Rate, gpm/ft*	ASTM D-4716	29 *
Compressive Strength	ASTM D-1621	6000

Geotextile Filter

Property	Test Method	Value
Weight, oz/sq yd2	ASTM D-3776	4.0
Tensile Strength, lb.	ASTM D-4632	100
Elongation, %	ASTM D-4632	50
Puncture, lb.	ASTM D-4833	50
Mullen Burst, psi	ASTM D-3786	200
Trapezoidal Tear, lb.	ASTM D-4533	42
Coeffecient of Perm,cm/sec	ASTM D-4491	0.1
Flow Rate, gpm/ft2	ASTM D-4491	100
Permittivity, 1/sec	ASTM D-4491	1.8
A.O.S Max US Std Sieve	ASTM D 4751	70
UV Stability, 500 hrs., %	ASTM D-4355	70
Seam Strength, lb./ft	ASTM D-4595	100
Fungus	ASTM G-21	No Growth

* Horizontal Installation, gradient = 0.01, compressive force = 10 psi for 1t

All values given represent minimum average roll values

GDE Control Products, Inc. Laguna Hills, CA. 949-305-7117

GDE, Multi-Flow
<http: www.gdecontrol.com/Multi-Flow5.html> Attachment E 1/1

TABLE 2.12 RECOMMENDED REDUCTION FACTOR VALUES FOR USE IN EQ. (2.25a)

Application	Range of Reduction Factors				
	Soil Clogging and Blinding*	Creep Reduction of Voids	Intrusion into Voids	Chemical Clogging†	Biological Clogging
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion-control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	5 to 10‡
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

*If stone riprap or concrete blocks cover the surface of the geotextile, use either the upper values or include an additional reduction factor.

†Values can be higher particularly for high alkalinity groundwater.

‡Values can be higher for turbidity and/or for microorganism contents greater than 5000 mg/l.

$$q_{allow} = q_{ult}\left(\frac{1}{\Pi RF}\right) \tag{2.25b}$$

where

q_{allow} = allowable flow rate,
q_{ult} = ultimate flow rate,
RF_{SCB} = reduction factor for soil clogging and blinding,
RF_{CR} = reduction factor for creep reduction of void space,
RF_{IN} = reduction factor for adjacent materials intruding into geotextile's void space,
RF_{CC} = reduction factor for chemical clogging,
RF_{BC} = reduction factor for biological clogging, and
ΠRF = value of cumulative reduction factors.

As with Eqs. (2.24) for strength reduction, this flow-reduction equation could also have included additional site-specific terms, such as blocking of a portion of the geotextile's surface by riprap or concrete blocks.

2.5 DESIGNING FOR SEPARATION

Application areas for geotextiles used for the separation function were given in Section 1.3.3. There are many specific applications, and it could be said, in a general sense, that geotextiles always serve a separation function. If they do not also serve this function, any other function, including the primary one, will not be served properly. This should not give the impression that the geotextile function of separation always plays a secondary role. Many situations call for separation only, and in such cases the geotextiles serve a significant and worthwhile function.

ATTACHMENT F 1/4

4.1.6 Allowable Flow Rate

As described previously, the very essence of the design-by-function concept is the establishment of an adequate factor of safety. For geonets, where flow rate is the primary function, this takes the following form.

$$FS = \frac{q_{allow}}{q_{reqd}} \tag{4.3}$$

where

FS = factor of safety (to handle unknown loading conditions or uncertainties in the design method, etc.),
q_{allow} = allowable flow rate as obtained from laboratory testing, and
q_{reqd} = required flow rate as obtained from design of the actual system.

Alternatively, we could work from transmissivity to obtain the equivalent relationship.

$$FS = \frac{\theta_{allow}}{\theta_{reqd}} \tag{4.4}$$

where θ is the transmissivity, under definitions as above. As discussed previously, however, it is preferable to design with flow rate rather than with transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable flow rate or transmissivity value, which comes from hydraulic testing of the type described in Section 4.1.3, we must assess the realism of the test setup in contrast to the actual field system. If the test setup does not model site-specific conditions adequately, then adjustments to the laboratory value must be made. This is usually the case. Thus the laboratory-generated value is an ultimate value that must be reduced before use in design; that is,

$$q_{allow} < q_{ult}$$

One way of doing this is to ascribe reduction factors on each of the items not adequately assessed in the laboratory test. For example,

$$q_{allow} = q_{ult}\left[\frac{1}{RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}}\right] \tag{4.5}$$

or if all of the reduction factors are considered together.

$$q_{allow} = q_{ult}\left[\frac{1}{IIRF}\right] \tag{4.6}$$

where

q_{ult} = flow rate determined using ASTM D4716 or ISO/DIS 12958 for short-term tests between solid platens using water as the transported liquid under laboratory test temperatures,

ATTACHMENT

q_{allow} = allowable flow rate to be used in Eq. (4.3) for final design purposes,
RF_{IN} = reduction factor for elastic deformation, or intrusion, of the adjacent geosynthetics into the geonet's core space,
RF_{CR} = reduction factor for creep deformation of the geonet and/or adjacent geosynthetics into the geonet's core space,
RF_{CC} = reduction factor for chemical clogging and/or precipitation of chemicals in the geonet's core space,
RF_{BC} = reduction factor for biological clogging in the geonet's core space, and
IIRF = product of all reduction factors for the site-specific conditions.

Some guidelines for the various reduction factors to be used in different situations are given in Table 4.2. Please note that some of these values are based on relatively sparse information. Other reduction factors, such as installation damage, temperature effects, and liquid turbidity, could also be included. If needed, they can be included on a site-specific basis. On the other hand, if the actual laboratory test procedure has included the particular item, it would appear in the above formulation as a value of unity. Examples 4.2 and 4.3 illustrate the use of geonets and serve to point out that high reduction factors are warranted in critical situations.

Example 4.2

What is the allowable geonet flow rate to be used in the design of a capillary break beneath a roadway to prevent frost heave? Assume that laboratory testing was done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 2.5×10^{-4} m²/s.

Solution: Since better information is not known, average values from Table 4.2 are used in Eq. (4.5).

TABLE 4.2 RECOMMENDED PRELIMINARY REDUCTION FACTOR VALUES FOR EQ. (4.5) FOR DETERMINING ALLOWABLE FLOW RATE OR TRANSMISSIVITY OF GEONETS

Application Area	RF_{IN}	RF_{CR}*	RF_{CC}	RF_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock, and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill covers	1.3 to 1.5	1.1 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

*These values are sensitive to the density of the resin used in the geonet's manufacture. The higher the density, the lower the reduction factor. Creep of the covering geotextile(s) is a product-specific issue.

ATTACHMENT F, 3/4

The above formula can be readily converted to flow rate, Q, by multiplying the velocity by the cross-sectional area A of the pipe.

For pipelines that are either flowing full or flowing partially full, the *Manning equation* is generally used.

$$V = \frac{1}{n} R_H^{0.66} S^{0.5} \tag{7.10}$$

where

V = velocity of flow (m/s),
R_H = hydraulic radius (m),
S = slope or gradient of pipeline (m/m), and
n = coefficient of roughness (see Table 7.7) (dimensionless).

Note that plastic pipe of the type discussed in this chapter, with a *smooth interior*, has a Manning coefficient from 0.009 to 0.010. Plastic pipe with a *profiled or corrugated interior* has a Manning coefficient ranging from 0.018 to 0.025.

Eqs. (7.9) and (7.10) are generally used in the form of charts or nomographs to determine pipe sizes, flow velocity or discharge flow rates (see Figures 7.6 and 7.7). For each chart we include an example from Hwang [7], illustrated on the respective nomographs by heavy lines. Note that both nomographs are for pipes flowing full.

Example 7.1

A 100 m long pipe with D = 200 mm and C = 120 carries a discharge of 30 l/s. Determine the head loss in the pipe. (See the Hazen-Williams chart in Figure 7.6.)

Solution: Applying the conditions given to the solution chart in Figure 7.6, the energy gradient is obtained.

$$S = 0.0058 \text{ m/m}$$

TABLE 7.7 VALUES OF MANNING ROUGHNESS COEFFICIENT, *N*, FOR REPRESENTATIVE SURFACES

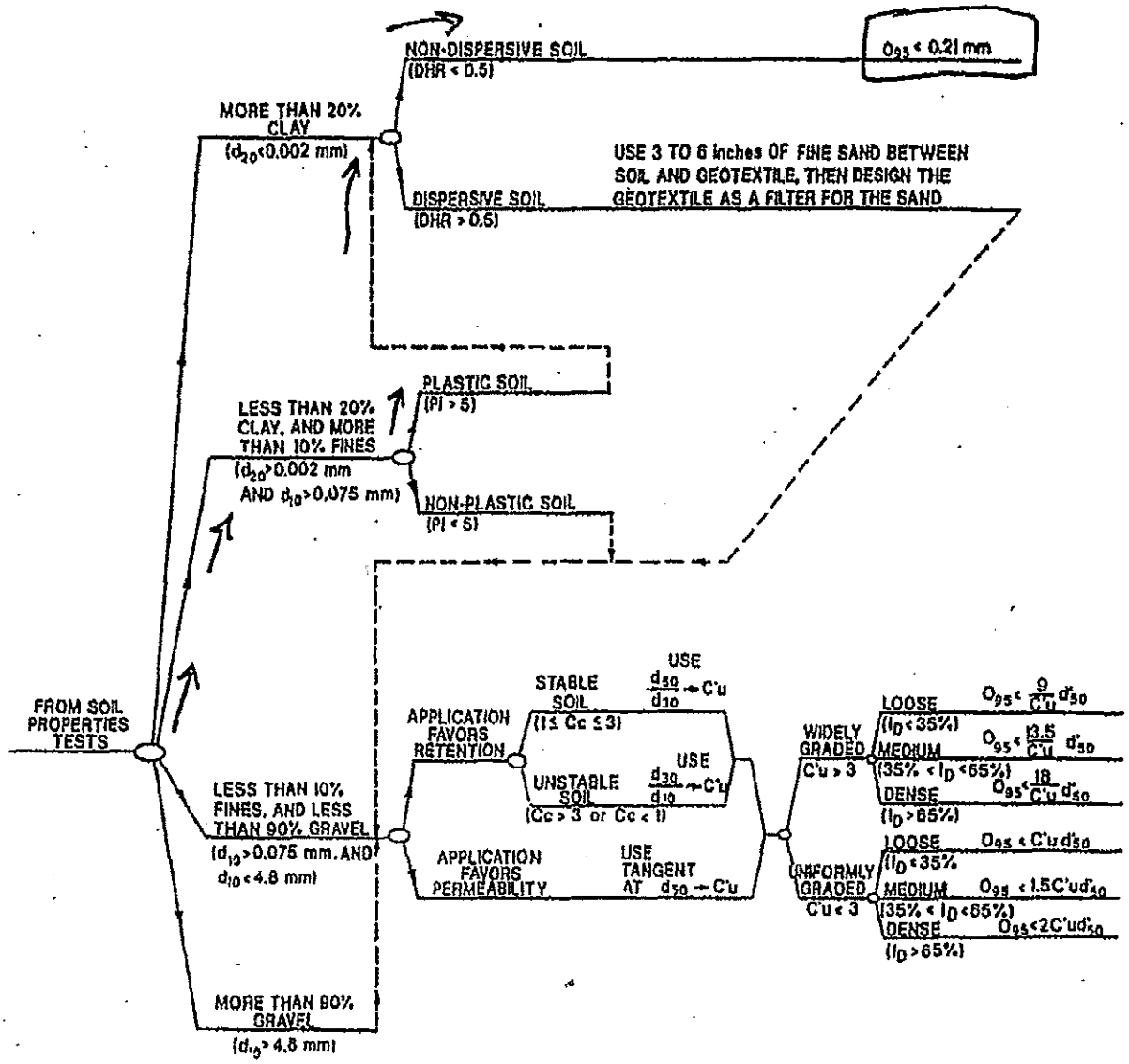
Type of Pipe Surface	Representative Value
Lucite, glass, or plastic*	0.010
Wood or finished concrete	[illegible]
Unfinished concrete, well-laid brickwork, concrete or cast iron pipe	[illegible]
Riveted or spiral steel pipe	[illegible]
Smooth, uniform earth channel	[illegible]
Corrugated flumes, typical canals, river free from large stones and heavy weeds	[illegible]
Canals and rivers with many stones and weeds	[illegible]

*The table does not distinguish between different types of plastic, or between smooth wall [illegible] pipes with perforations.

Source: After Fox and McDonald [9].

Koerner, R.M., "Designing with Geosynthetics," 4th Ed., 1999
Attachment F4

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative denisty of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 1/3

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \varphi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 2/3

Table 4-5

Typical Hydraulic Gradients[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
Standard Dewatering Trench	1.0
Vertical Wall Drain	1.5
Pavement Edge Drain	1[b]
Landfill LCDRS	1.5
Landfill LCRS	1.5
Landfill SWCRS	1.5
Inland Channel Protection	1[b]
Shoreline Protection	10[b]
Dams	10[b]
Liquid Impoundments	10[b]

NOTES: [a] Table developed after Giroud [1988].

[b] Critical applications may require designing with higher gradients than those given.

Attachment G
3/3

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0 *	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3787	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40 *	65	90	110	130	175
UV. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning.

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3788	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs.	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs.	50/50	100/80	140/120	160/140	185/155	220/180
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	160	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft.	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300
Gross Weight	lbs.	600	550	500	600	550	500
Area	sq. yds.	2000	1500	1000	1000	750	500

Amoco Fabrics and Fibers Company 900 Circle 75 Parkway, Suite 300 Atlanta, Georgi

Amoco Fabrics & Fibers Company, 1991. "Amoco Waste Related Geotextiles" H 1/1

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HLP3\IUC\IUC30.D4
TEMPERATURE DATA FILE:        C:\HLP3\IUC\IUC30.D7
SOLAR RADIATION DATA FILE:    C:\HLP3\IUC\IUC30.D13
EVAPOTRANSPIRATION DATA:      C:\HLP3\IUC\IUC30.D11
SOIL AND DESIGN DATA FILE:    C:\HLP3\IUC\Cell4B.D10
OUTPUT DATA FILE:             C:\HLP3\IUC\Cell4B.OUT


TIME:  12:18      DATE:    8/30/2007


******************************************************************************

     TITLE:  IUC Slimes Drain Analysis Cell 4B

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     36.00   INCHES
          POROSITY                     =      0.4700 VOL/VOL
          FIELD CAPACITY               =      0.2220 VOL/VOL
          WILTING POINT                =      0.1000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1980 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

CELL4B.OUT

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4700	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2220	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	75.0	FEET

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 75. FEET.

SCS RUNOFF CURVE NUMBER	=	88.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.689	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.520	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.600	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.458	INCHES
TOTAL INITIAL WATER	=	8.458	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GRAND JUNCTION COLORADO

STATION LATITUDE	=	39.07	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	293	
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

0.64	0.54	0.75	0.71	0.76	0.44
0.47	0.91	0.70	0.87	0.63	0.58

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
25.50	33.50	41.90	51.70	62.10	72.30
78.90	75.90	67.10	54.90	39.60	28.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO
AND STATION LATITUDE = 39.07 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.44	0.44	0.65	0.81	0.75	0.52
	0.39	1.08	0.58	1.00	0.94	0.54
STD. DEVIATIONS	0.23	0.30	0.31	0.44	0.53	0.63
	0.30	0.48	0.44	0.63	0.52	0.31
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.441	0.542	0.627	0.714	0.941	1.152
	0.511	0.980	0.481	0.737	0.589	0.454
STD. DEVIATIONS	0.213	0.272	0.280	0.352	0.544	0.560
	0.398	0.510	0.395	0.637	0.250	0.224
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	0.0009	0.0011	0.0002	0.0008
	0.0003	0.0000	0.0000	0.0000	0.0010	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0020	0.0027	0.0008	0.0019

0.0009 0.0000 0.0000 0.0000 0.0032 0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES		CU. FEET	PERCENT
PRECIPITATION	8.16	(1.320)	29628.1	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	8.168	(1.5732)	29651.33	100.079
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.00442	(0.00727)	16.060	0.05420
CHANGE IN WATER STORAGE	-0.011	(0.7860)	-39.33	-0.133

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0
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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	0.86	3121.800
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003089	11.21440
SNOW WATER	0.72	2615.3926

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2271

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1000

****

0
****

FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	6.9017	0.1917
2	1.3320	0.2220

SNOW WATER 0.116

****
****

APPENDIX I

SETTLEMENT MONITORING PLAN

I.1 INTRODUCTION

This appendix outlines the settlement monitoring plan for tailings Cells 1, 2, 3, 4A, and 4B. Monitoring of tailings impoundment surface settlement will be conducted after placement of the interim cover to measure rates and locations of settlement prior to final cover construction. After construction of the final cover system, settlement monitoring will be conducted as part of post-reclamation performance monitoring.

I.2 PLAN OBJECTIVES

There are two objectives for monitoring settlement associated with the tailings cells: (1) assurance that the materials in the tailings cells have stabilized prior to construction of the final cover system, and (2) after final cover construction, verification that the final cover surface is not experiencing significant settlement (i.e., greater than 0.1 feet (30 mm) of cumulative settlement over a 12 month period). These objectives are assessed by measurement of the elevations of monitoring points at selected locations across the cell surfaces.

The mill tailings have been discharged into the cells as slurry, resulting in saturated tailings materials of low density. As a result of covering and dewatering, these tailings will consolidate and settle. The Nuclear Regulatory Commission staff policy requires that the subgrade surface achieve 90 percent of anticipated consolidation prior to placement of the final cover system, in order to minimize differential settlement of the final cover system.

Settlement in the area of Cell 2 and the eastern portion of Cell 3 is expected to be minimal, as an interim cover has already been constructed in these areas. Settlement of the thickest profile of tailings in Cells 2, 3, 4A and 4B is anticipated to range from 0.1 to 0.9 ft after placement of interim cover and dewatering (see Appendix F). Additional settlement due to construction of the final cover is estimated to be approximately 0.4 feet in Cells 2, 3, 4A and 4B, as discussed in Appendix F.

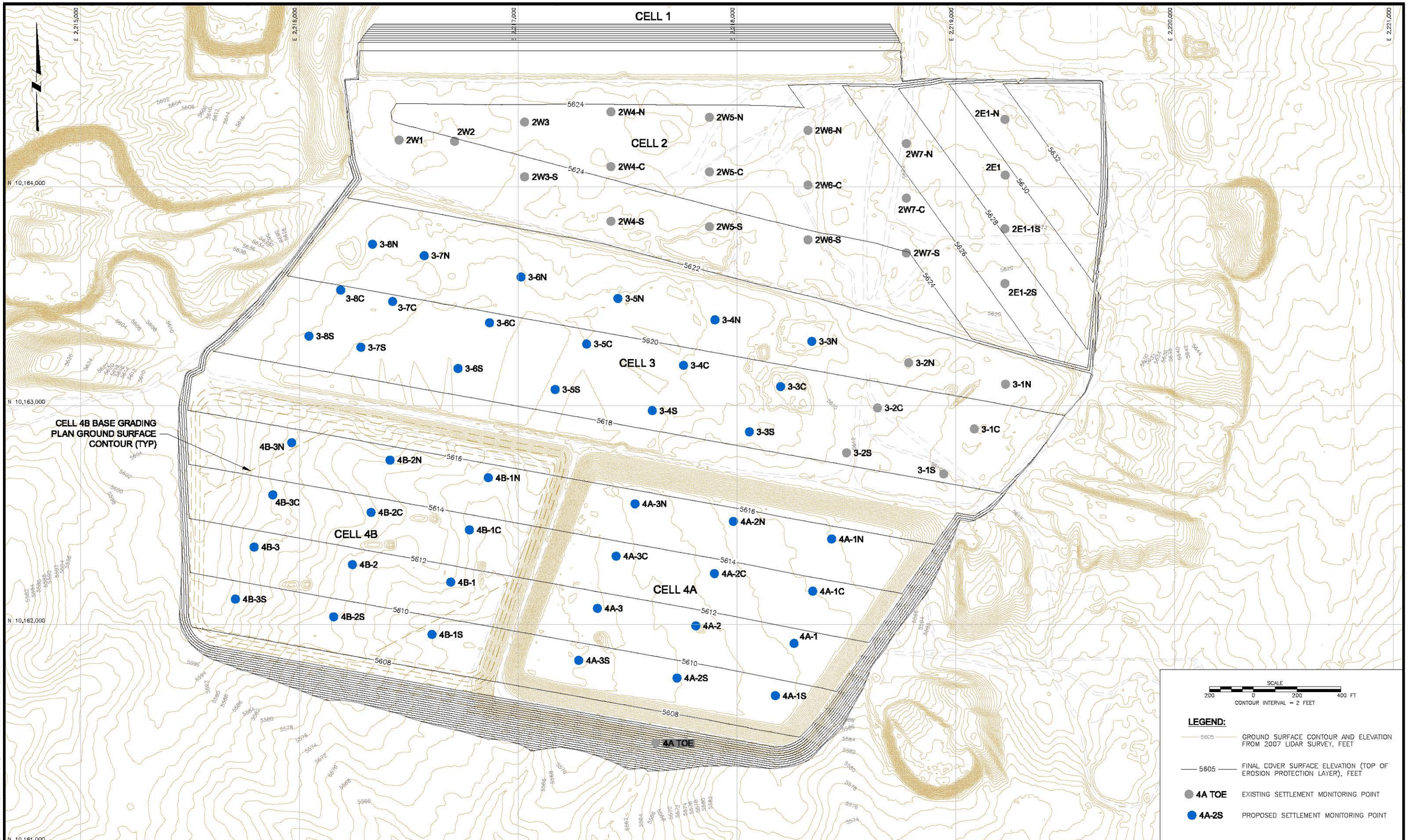
I.3 MONITORING PLAN

The settlement monitoring plan will consist of two phases: (1) monitoring the interim cover surface prior to final cover system construction, and (2) monitoring the top-of-cover surface after final cover system construction. Monitoring of both phases will be done at the approximate location of monitoring points shown on Figure I.1. These points are located on an approximate grid spacing of 225 feet by 425 feet (north-south by east-west). The elevations of the monitoring points will be surveyed on a monthly basis. Survey accuracy would typically be to the nearest 0.01 foot (3 mm).

The settlement monitoring points used prior to final cover construction will be wooden stakes, rebar, or similar driven a minimum of 12 inches into the interim cover. These points will be adequately located and marked with flagging to facilitate location for surveying and to avoid contact with construction equipment. In the areas of Cells 2 and 3 where monitoring points already exist, these points will likely be extended upward during placement of additional random fill. The monitoring points for the remainder of Cell 3, as well as for Cells 4A and 4B will be installed after interim cover placement. These monitoring points may require replacement in areas of active interim fill placement and compaction. A monitoring period of four years prior to final cover system construction is anticipated, based on the estimated time required to reach 90 percent consolidation (see Appendix F). The objective for the phase of monitoring following

interim cover placement is to demonstrate that approximately 90 percent of anticipated consolidation of the materials beneath the subgrade surface has occurred prior to final cover system construction.

The settlement monitoring points used after final cover construction would be of a more permanent construction, consisting of rebar or other metal rod driven a minimum of 24 inches below the cover surface. These points would be adequately located and marked with PVC pipe or other markers to facilitate location for surveying and to avoid contact with maintenance equipment. A monitoring period of two to five years after final cover system construction is anticipated. The objective for the phase of monitoring following final cover construction is to verify that no significant cover surface settlement takes place. Typically less than 0.1 feet (30 mm) of cumulative settlement over a 12 month period is acceptable.



DENISON MINES
Denison Mines (USA) Corp

PROJECT
WHITE MESA MILL TAILINGS RECLAMATION

TITLE
SETTLEMENT MONITORING POINTS

MWH

DATE AUG 2011

FIGURE I.1

FILE NAME 1009740 SETLMON

L:\Design-Drafting\Clients-A-H\DENISON MINES\013-Sheet Set\2011-08-26 COVR DSGN REF\1009740 SETLMON

APPENDIX J

REVEGETATION PLAN

J.1 INTRODUCTION

Revegetation of the tailing cells at the White Mesa Mill Site will be completed following construction of the cover system. The revegetation process will establish a grass-forb community consisting primarily of native, long-lived perennial grasses and forbs that are highly adapted to the climatic and edaphic conditions of the site. Revegetation methods will follow state-of-the-art techniques for soil amendments, seedbed preparation, seeding and mulching. In addition, quality assurance and quality control procedures will be followed to ensure that revegetation methods are implemented correctly and the results of the process meet expectations.

J.2 PLANT SPECIES AND SEEDING RATES

The following 12 species (10 grasses and 2 forbs) are proposed for the ET cover system. These species are selected for their adaptability to site conditions, compatibility, and long-term sustainability. The proposed species are:

Grasses

- Western wheatgrass, variety Arriba (*Pascopyrum smithii*)
- Bluebunch wheatgrass, variety Goldar (*Pseudoroegneria spicata*)
- Slender wheatgrass, variety San Luis (*Elymus trachycaulus*)
- Streambank wheatgrass, variety Sodar (*Elymus lanceolatus* ssp. *psammophilus*)
- Pubescent wheatgrass, variety Luna (*Thinopyrum intermedium* ssp. *barbulatum*)
- Indian ricegrass, variety Paloma (*Achnatherum hymenoides*)
- Sandberg bluegrass, variety Canbar (*Poa secunda*)
- Sheep fescue, variety Covar (*Festuca ovina*)
- Squirreltail, variety Toe Jam Creek (*Elymus elymoides*)
- Blue grama, variety Hachita (*Bouteloua gracilis*)

Forbs

- Common yarrow, no variety (*Achillea millefolium*)
- White sage, no variety (*Artemisia ludoviciana*).

The ecological characteristics of these species are described in detail in Appendix D.

Table J.1 presents broadcast seeding rates for each species. Seeding rates were developed based on the objective of establishing a permanent cover of grasses and forbs in a mixture that would promote compatibility among species and minimize competitive exclusion or loss of species over time. Seeding rates were developed on the basis of number of seeds per unit area (e.g. number of seeds per square foot) and then converted to weight per unit area (e.g. pounds per acre).

Table J.1. Species and seeding rates proposed for ET cover at the White Mesa Mill Site.

Scientific Name	Common Name	Native/ Introduced	Seeding Rate (# PLS seeds/ft^2) †	Seeding Rate (lbs PLS/acre)†
Grasses				
Pascopyrum smithii	Western wheatgrass	Native	6.0	3.0
Pseudoroegneria spicata	Bluebunch wheatgrass	Native	8.0	3.0
Elymus trachycaulus	Slender wheatgrass	Native	5.0	2.0
Elymus lanceolatus	Streambank wheatgrass	Native	5.5	2.0
Elymus elymoides	Squirreltail	Native	7.0	2.0
Thinopyrum intermedium	Pubescent wheatgrass	Introduced‡	1.5	1.0
Achnatherum hymenoides	Indian ricegrass	Native	8.0	4.0
Poa secunda	Sandberg bluegrass	Native	9.0	0.5
Festuca ovina	Sheep fescue	Native	9.0	1.0
Bouteloua gracilis	Blue grama	Native	13.0	1.0
Forbs				
Achillea millefolium	Common yarrow	Native	23.0	0.5
Artemisia ludoviciana	White sage	Native	23.0	0.5
Total			118.0	21.0

†Seeding rate is for broadcast seed and presented as number of pure live seeds per ft^2 and pounds of pure live seed per acre.
‡Introduced refers to species that have been 'introduced' from another geographic region, typically outside of North America. Also referred to as 'exotic' species.

Seeding rates are calculated from an expected field emergence for each species and the desired number of plants per unit area. For purposes of calculation, field emergence for small seeded grasses and forbs is assumed to be around 50% if germination is greater than 80%. Field emergence is assumed to be around 30% if germination is between 60 and 80%. The Natural Resource Conservation Service recommends a seeding rate of 20 to 30 pure live seeds per square foot as a minimum number of seeds when drill seeding in areas with an annual precipitation between 6 and 18 inches. Twenty pure live seeds per square foot, with an expected field emergence of 50% should produce an adequate number of plants on the seeded area to control erosion and suppress annual invasion. This seeding rate is primarily for favorable growing conditions, soils that are not extreme in texture, gentle slopes, north or east facing aspect, good moisture, and adequate soil nutrients. When conditions are less favorable or when the seed is broadcast, seeding rates are increased up to a level that is two to four times the drill rate for favorable conditions. A multiplier of 4x was used in establishing the proposed seeding rate.

The quality assurance and quality control plan for seed application rates and procedures for confirming that specified application rates are achieved is as follows. The first step begins with a seed order. Seed will be purchased as pounds of pure live seed and will be certified for percent purity and percent germination. When certified, a container of seed must be labeled by the seed supplier as to origin, germination percentage, date of the germination test, percentage of pure seed (by weight), other crop and weed seeds, and inert material. Certification is our best guarantee that the seed being purchased meets minimum standards and the quality specified. Once the seed is obtained, seed labels will be checked to determine the percent PLS and the date that the seed was tested for percent purity and percent germination. If the test date is greater than 6 months old, the seed will be tested again before being accepted.

J.3 SOIL FERTILIZATION AND ORGANIC MATTER AMENDMENT

The physical and chemical characteristics of the soil that will be used for the cover system are presented in Appendix D. Based on this analysis, there are three soil properties that appear to be deficient for sustained plant growth and will need to be treated prior to seeding and to ensure that the soil provides adequate carbon and plant essential nutrients for initial plant establishment and long-term sustainability. The soil properties that will need treatment include percent organic matter, total nitrogen, and plant available potassium (Appendix D). The upper 30 cm of the water storage layer will be treated with a commercial organic matter amendment to alleviate the existing deficiencies. This treatment will be applied after the water storage layer is in place and before placement of the topsoil-gravel erosion protection layer. Further chemical analysis will be conducted prior to placement of the water storage layer to verify the chemical properties of this material and to finalize the proposed treatment. The current amendment proposal is to add 1.5 tons/acre of Biosol®. Biosol® is an organic matter amendment that also provides a balanced nutrient ratio that supplies plants with micro- and macro-nutrients for sustained plant growth. In addition to providing a source of humus to alleviate the organic matter deficiency, Biosol® also has a nitrogen content of 6% and a potassium (K_2O) content of 3% that will effectively alleviate the nitrogen and potassium deficiency. Biosol® will be uniformly spread over the surface of the water storage layer and mixed to a depth of 30 cm. The proposed application rate will be adjusted up or down based on soil chemical analysis that is conducted prior to placement of the water storage layer.

The topsoil-gravel erosion control layer will not be amended for organic matter or nutrients to avoid the stimulation of undesirable weedy species. The addition of nutrients, especially nitrogen, during revegetation is known to stimulate the growth of annual weeds at the potential detriment of seeded perennial species. Withholding nutrient additions from the topsoil-gravel cover will allow the seeded species to establish without the unwanted competition from undesirable weedy species.

J.4 SEEDBED PREPARATION

Following placement of the topsoil-gravel erosion protection layer, the area will be harrowed to reduce any compaction that may have occurred during placement of the cover and to create an uneven surface for optimum seedbed conditions. Since seeding will be conducted with a broadcast method it is critical for the soil surface to be loose and uneven, but also have a firmness below the soil surface to allow proper seeding depth and to promote optimum seed-soil contact for germination and initial plant establishment.

J.5 SEEDING

Seed will be applied using a broadcasting method as soon as practicable following seedbed preparation. This procedure will use a centrifugal type broadcaster, also called an end-gate seeder. These broadcasters operate with an electric motor and are usually mounted on the back of a small tractor and generally have an effective spreading width of about 20 feet or more. Prior to seeding, a known area will be covered with a tarp and seed will be distributed using the broadcaster and simulating conditions that would exist under actual seeding conditions. Seed will then be collected and weighed to determine actual seeding rate in terms of pounds per acre. This process will be repeated until the specified seeding rate is obtained. During the seeding process, the seeding rate will be verified at least once by comparing pounds of seed applied to the size of the area seeded. In addition, seed will be applied in two separate passes. One-half

of the seed will be spread in one direction and the other half of seed will be spread in a perpendicular direction. This will ensure that seed distribution across the site is highly uniform and also provide the opportunity to adjust the seeding rate if the specified rate is not being achieved. Seeding will not occur if wind speeds exceed 10 mph.

Immediately following seeding, the area will be lightly harrowed to provide seed coverage and to maximize seed-soil contact. This step in the revegetation process will ensure that the seed is placed at an optimum seeding depth and in good soil contact for proper germination conditions.

Seeding will take place as soon as practical after the cover system is in place. Successful seeding in southeastern Utah can occur either in late fall (e.g. October) as a dormant seeding, with germination and establishment occurring the following spring or can be conducted in June, prior to the summer monsoon season. The timing for seeding will be dependent upon the construction schedule for the cover system.

J.6 MULCHING

A mulch will be applied immediately following seeding to conserve soil moisture for seed germination and initial plant establishment. Mulching will also provide additional soil erosion protection from both wind and water until a plant cover is established. A weed-free, wood-fiber mulch will be applied to the seeded area at a rate of 1.0 ton/acre. Wood fiber mulch will consist of specially prepared wood fibers and will not be produced from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants. The fibers will be dyed an appropriate color, non-toxic, water-soluble dye to facilitate visual metering during application. Wood fiber mulch will be supplied in packages and each package will be marked by the manufacturer to show the air-dry weight.

The wood fiber mulch will be applied by means of hydraulic equipment that utilizes water as the carrying agent. The mulch will be applied in a uniform manner at a minimum rate of 1.0 ton/acre. A continuous agitator action, that keeps the mulching material and approved additives in uniform suspension, will be maintained throughout the distribution cycle. The pump pressure will be capable of maintaining a continuous non-fluctuating stream of slurry. The slurry distribution lines will be large enough to prevent stoppage and the discharge line will be equipped with a set of hydraulic spray nozzles that will provide an even distribution of the mulch slurry to the seedbed. Mulching will not be done in the presence of free surface water resulting from rains, melting snow, or other causes.

A tackifier will be used with the wood fiber mulch to improve adhesion. The tackifier will be a biodegradable organic formulation processed specifically for the adhesive binding of mulch. In addition, the tackifier will uniformly disperse when mixed with water and will not be detrimental to the homogeneous properties of the mulch slurry. Tackifier may be added either during the manufacturing of the mulch or incorporated during mulch application. Tackifier will have characteristics of hydrating and dispersing in circulating water to form a homogeneous slurry and remain in such a state in the hydraulic mulching unit when mixed with the wood fiber mulch. When applied, the tackifier will form a loose chain-like protective film, but not a plant inhibiting membrane, which will allow moisture to percolate into the underlying soil, while helping bind seeds to the soil surface during germination and initial seedling growth, after which the tackifier will break down through natural processes.

APPENDIX K

DURABILITY

ATTACHMENT H

ROCK TEST RESULTS

BLANDING AREA GRAVEL PITS

PREPARED BY

INTERNATIONAL URANIUM (USA) CORP.

INDEPENDENCE PLAZA

1050 17TH STREET, SUITE 950

DENVER, CO 80265

TO: Harold R. Roberts cc: William N. Deal

FROM: Robert A. Hembree

DATE: November 20, 1998

SUBJECT: Rock Test Results – Blanding Area Gravel Pits

Attached you will find the results for lab tests that were performed on rock samples obtained from three gravel sources around the White Mesa Mill. These samples were taken from the Cow Canyon pit located just north of Bluff (15 miles south of the mill), the Brown Canyon pit located on the east side of Recapture Canyon four miles northeast of the mill, and the North Pit located one mile northeast of Blanding. A 75 pound sample of material was collected from each site, each sample was crushed and screened to a +1/2 –1 ½ inch size. Testing was performed by Western Colorado Testing in Grand Junction, Colorado. All samples were tested for specific gravity, absorption, sulfate soundness and L.A. Abrasion.

Test results indicate that all three sites score high enough to be used as rip rap sources for the reclamation cover at the mill (see attached scoring calculations). The Cow Canyon site scores high enough that there would be no over-sizing required; it is suitable for use in channels as well as on side and top slopes. The Brown Canyon site requires the most over-sizing at nineteen percent (19%). The North Pit material would require over-sizing of 9.35%. These test results prove that there are sources of rip rap material within a reasonable distance of the mill site. The average over-sizing factor for the three sites is 9.5%, which is well below the 25% number used in the 1996 reclamation cost estimate. The over-sizing factor used in the Titan Design Study was also 25%.

Based on the results of the testing IUC could use any of these three sites. The North Pit would be the most reasonable choice of material sites since it has a lower over-sizing factor than the Brown Canyon site and is closer to the mill than the Cow Canyon site. The North Pit also has the advantage of being an established public pit on BLM administered land.

RAH/rah

International Uranium (USA) Corp.
WHITE MESA MILL RECLAMATION

NRC Rip Rap Scoring Calculations

Weighting Factors for Igneous Rocks
Oversizing for side slopes, top slopes, and well drained toes and aprons
Rock Scoring less than 50% is rejected, rock scoring over 80% does not require oversizing

Cow Canyon Pit (Bluff)

Lab Test	Lab Results	Score	Weight	Score x Weight	Max. Score
Specific Gravity	2.63	7.5	9	67.5	90
Absorption, %	0.47	8.25	2	16.5	20
Sodium Sulfate Sound., %	0.2	10	11	110	110
L.A. Abrasion, %	6.4	7.5	1	7.5	10
Totals				201.5	230

Overall Score 87.61 %

Oversizing none %

Brown Canyon Site

Lab Test	Lab Results	Score	Weight	Score x Weight	Max. Score
Specific Gravity	2.525	5.5	9	49.5	90
Absorption, %	2.61	1.75	2	3.5	20
Sodium Sulfate Sound., %	5.5	7.5	11	82.5	110
L.A. Abrasion, %	10.3	4.75	1	4.75	10
Totals				140.25	230

Overall Score 60.98 %

Oversizing 19.02 %

North Pit (N. Blanding)

Lab Test	Lab Results	Score	Weight	Score x Weight	Max. Score
Specific Gravity	2.557	6.25	9	56.25	90
Absorption, %	2.84	1.25	2	2.5	20
Sodium Sulfate Sound., %	3.2	8.75	11	96.25	110
L.A. Abrasion, %	6.3	7.5	1	7.5	10
Totals				162.5	230

Overall Score 70.65 %

Oversizing 9.35 %

WESTERN COLORADO TESTING, INC.

529 25 1/2 Road, Suite B-101
Grand Junction, Colorado 81505
(970) 241-7700 • Fax (970) 241-7783

November 16, 1998
WCT #811898

International Uranium USA Corporation
Independence Plaza
1050 17th Street
Denver, Colorado 80265

Attention: Mr. Bob Hembree

Reference: Rock Durability Testing

As requested, three (3) potential sources of riprap for use in reclamation of tailings ponds in Blanding, Utah were tested for rock durability. The riprap material was obtained, crushed to testing size, and delivered to Western Colorado Testing, Inc. by the client. The three sources of material were tested for specific gravity and absorption (ASTM C127), Sodium Sulfate Soundness (ASTM C88), and Los Angeles Abrasion (ASTM C131). The results of the testing are provided below.

Material Source: Cow Canyon	
Test	**Result**
Bulk Specific Gravity, g/cc	2.630
SSD Specific Gravity, g/cc	2.642
Apparent Specific Gravity, g/cc	2.663
Water Absorption, %	0.47
Sodium Sulfate Soundness, Avg. % Loss	0.2
L.A. Abrasion, % Loss @ 100 Rev.	6.4

International Uranium USA Corporation
WCT #811898
November 16, 1998

Material Source: Brown Canyon	
Test	**Result**
Bulk Specific Gravity, g/cc	2.460
SSD Specific Gravity, g/cc	2.525
Apparent Specific Gravity, g/cc	2.629
Water Absorption, %	2.61
Sodium Sulfate Soundness, Avg. % Loss	5.5
L.A. Abrasion, % Loss @ 100 Rev.	10.3

Material Source: North Pit	
Test	**Result**
Bulk Specific Gravity, g/cc	2.485
SSD Specific Gravity, g/cc	2.557
Apparent Specific Gravity, g/cc	2.674
Water Absorption, %	2.84
Sodium Sulfate Soundness, Avg. % Loss	3.2
L.A. Abrasion, % Loss @ 100 Rev.	6.3

If there are any questions or if additional testing is needed, please feel free to contact our office.

Respectfully Submitted:
WESTERN COLORADO TESTING, INC.

Kyle Alpha
Construction Services Manager

KA/mh
Meb:jobs\811811118