RECLAMATION PLAN

FINAL DESIGN, PLANS AND SPECIFICATIONS

FOR THE

MAYBELL HEAP LEACH FACILITY

APRIL 1995

Prepared By:

Umetco Minerals Corporation
Grand Junction, Colorado

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado

FINAL PLANS AND SPECIFICATIONS
FOR
CLOSURE ACTIVITIES

MAYBELL HEAP LEACH FACILITY

UMETCO MINERALS CORPORATION
GRAND JUNCTION, COLORADO

REV. NO.	DATE OF ISSUE	PURPOSE OF ISSUE	ISSUE APPROVED BY
0	1/23/89	For Submittal to State	
1	1/27/95	For Submittal to State	
2	3/15/95	For Submittal to State	
3	3/28/95	For Submittal to State	R E Gieck

State Approval Gregory N. Brown P.E. Date: April 7, 1995
Colorado Dept of Public Health & Environ
Radiation Control Division

FINAL PLANS AND SPECIFICATIONS
FOR
CLOSURE ACTIVITIES

MAYBELL HEAP LEACH FACILITY

UMETCO MINERALS CORPORATION
GRAND JUNCTION, COLORADO

REV. NO.	DATE OF ISSUE	PURPOSE OF ISSUE	ISSUE APPROVED BY
0	1/23/89	For Submittal to State	
1	1/27/95	For Submittal to State	
2	3/15/95	For Submittal to State	
3	3/28/95	For Submittal to State	[signature]

State Approval ______ See attached CDPHE correspondence ______ Date: __________________

STATE OF COLORADO

Roy Romer, Governor
Patti Shwayder, Acting Executive Director

Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
Denver, Colorado 80222-1530
Phone (303) 692-2000

Laboratory Building
4210 E. 11th Avenue
Denver, Colorado 80220-3716
(303) 691-4700

Colorado Department of Public Health and Environment

Post-it® Fax Note 7671	Date 4/10/95	# of pages ▶ 2
To Rahe Junge	From D. Simpson	
Co./Dept. Umetco Minerals	Co. CDPHE	
Phone #	Phone # 692-3066	
Fax # 245-7543	Fax #	

April 7, 1995

Curtis O. Sealy
Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506

Re: Final Plans and Specifications
Colorado Radioactive Materials License #660-01
Umetco-Maybell, Moffat County, Colorado

Dear Mr. Sealy:

The Radiation Control Division ("Division") and the Colorado Geological Survey have received and reviewed Umetco's submittal package entitled "Final Plans and Specifications for Closure Activities, Maybell Heap Leach Facility, Umetco Minerals Corporation, Grand Junction, Colorado, Revision Number 3, dated March 28, 1995".

The Division believes that Umetco's Final Plans and Specifications for the Umetco-Maybell Title II Uranium Heap Leach Site are competent and warrant approval for the purpose of taking full advantage of the 1995 construction season. The Division approves the start of reclamation activities at the Umetco-Maybell Title II Site which shall be in accordance with:

> Final Plans and Specifications for Closure Activities, Maybell Heap Leach Facility, Umetco Minerals Corporation, Grand Junction, Colorado, Revision Number 3, dated March 28, 1995; and
>
> Soils Cleanup Plan, Maybell Heap Leach Facility, March 1995, prepared by Umetco Minerals Corporation, Grand Junction, Colorado, Revision Number 3, dated March 14, 1995; and
>
> Liquid Waste Management Plan, Maybell Heap Leach Facilities, prepared by Umetco Minerals Corporation, Grand Junction, Colorado, Revision Number 2, dated May 13, 1994.

Curtis O. Sealy
Umetco Minerals Corporation
April 7, 1995

The Division and the Colorado Geological Survey will work with Umetco to finalize designs and closure plans for the "Final Phase Reclamation" in the areas just south of the existing Heap Leach pile. Please be aware that the Division's approval to start reclamation activities is made with the understanding that design changes may be necessary as construction proceeds to accommodate such things as final volumes of materials from soils cleanup.

The Division hereby designates:

> Gregory N. Brand, Professional Engineer, Colorado Department of Public Health and Environment, Radiation Control Division, Uranium & Special Projects Unit to be the "State Maybell Coordinator"; and
>
> Jeffrey L. Hynes, Senior Engineering Geologist, Colorado Department of Natural Resources, Colorado Geological Survey, to be the "Alternate State Maybell Coordinator".

If you have any questions regarding this matter, please call me at (303) 692-3066.

Sincerely,

Donald H. Simpson

Donald H. Simpson
Uranium & Special Projects Unit Leader
Radiation Control Division

cc: Robert M. Quillin, CDPHE-RCD
Gregory Brand, CDPHE-RCD
Jeff Hynes, CDNR-CGS
Rahe Junge, Umetco
Tom Gieck, Umetco

CONFIDENTIALITY

The Final Plans and Specifications for Closure Activities at the Maybell Heap Leach Facility, Specification No. MAY-1, are considered to be proprietary information developed by Umetco Minerals Corporation.

TABLE OF CONTENTS

FINAL PLANS AND SPECIFICATIONS

TABLE OF CONTENTS (cont.)

FINAL PLANS AND SPECIFICATIONS

Page No.

TABLE OF CONTENTS (cont.)

FINAL PLANS AND SPECIFICATIONS

Page No.

APPENDIX A

CALCULATIONS - SUMMARY

A. Hydrology and Rock Protection Design

A-1 Probable Maximum Precipitation - Design Storm

A-2 Erosion Protection for Top of Reclaimed Heap

A-3 Erosion Protection for 5:1 Side Slopes of Reclaimed Heap

A-4 Hydrology, Sizing and Design of Erosion Protection for Channels

A-5 Channel Sizing and Riprap Design

A-6 Riprap Durability

B. Infiltration

B-1 HELP Model

B-2 Dilution Calculations

C. Radon Flux Calculations

C-1 Radon Flux - Top of Heaps

C-2 Radon Flux - Side Slopes

D. Slope Stability Analysis

E. Drawings

M-120 Cover Sheet and Vicinity Map
M-121 Pre-reclamation Site Plan
M-122 Post-reclamation Drainage Plan
M-123 Final Cover and Grading Plan
M-124 Heap Cross Sections
M-125 Channel Sections
M-126 Details
M-127 Soil Excavation Map

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
5H:1V	5 horizontal to 1 vertical
AEC	Atomic Energy Commission
ALARA	As low as reasonably achievable
BLM	Bureau of Land Management
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
CFS	Cubic feet/second
D_{50}	Mean rock size
Division	Radiation Control Division
DOE	U.S. Department of Energy
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
FBDU	Ford, Bacon & Davis Utah, Inc.
g	Acceleration of gravity
MCL	Maximum concentration limit
ME	Maximum earthquake
µR/hr	Microroentgens per hour
NA	Not available
NEPA	National Environmental Policy Act
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
$pCi/m^2/s$	Picocuries per square meter per second
PMF	Probable maximum flood
PMP	Probable maximum precipitation
POC	Point of compliance
ppm	Parts per million
RCD	Radiation Control Division
TAD	Technical Approach Document
t_c	Time of concentration
TDS	Total dissolved solids

1.0 GENERAL

1.1 Intent of Specifications

The Final Plans and Specifications (hereinafter referred to as the Specifications) presented in this document cover the construction required to implement the Closure Plan for the Maybell Heap Leach Facility. These Final Plans and Specifications were prepared in accordance with the requirements set forth in Radioactive Materials License No. 660-01.

1.2 Scope of Specifications

The Specifications cover the following major items of work:

1. Liquid Management Facilities
2. Soil Cleanup
3. Plant Decommissioning
4. Heap Configuration
5. Reclamation Cover
6. Surface Water Runoff Control Facilities
7. Monitoring Devices

1.3 Drawing List

The following drawings are attached and are made a part of the Specifications:

Drawing No.	Revision No.	Title
M-120	1	Cover Sheet and Vicinity Map
M-121	0	Pre-reclamation Site Plan
M-122	0	Post-reclamation Drainage Plan
M-123	1	Final Cover and Grading Plan
M-124	1	Heap Cross Sections
M-125	1	Channel Sections
M-126	1	Details
M-127	1	Soil Excavation Map

1.4 Field and Design Changes

The designs and attendant drawings are based on available topographical data. It is expected that actual field conditions may vary from those shown on the Drawings. Changes in alignments, grades and elevations that do not affect the design concept may be required during construction.

These necessary changes will be approved and documented by the Quality Control Officer with the agreement of the Design Engineer and State Maybell Coordinator in accordance with the Quality Plan and Construction Verification Program.

All the designs are based on industry standards and accepted state-of-the-art practices. Changes in design concepts will be approved and documented by the Design Engineer and will be submitted to the State for approval.

All changes will be recorded on the "as-built" Drawings for the work.

1.5 Environmental Quality Protection

The work will be carried out in compliance with applicable Federal, State and local statutes, rules and regulations, licenses and permits and the Radioactive Materials License No. 660-01 and will be monitored in accordance with procedures approved by the Colorado Department of Public Health and Environment.

1.5.1 Land

During construction, care will be exercised to preserve the natural landscape and to prevent any unnecessary destruction, scarring or defacing of the natural surroundings in the vicinity of the work.

1.5.2 Water

Construction activities will be performed in accordance with stormwater permit requirements to prevent off-site migration of contaminated sediments.

1.5.3 Air

Construction activities will be carried out under an Air Pollution Emission Notice. Reasonable and practical efforts will be made to operate construction equipment to minimize emission of air contaminants. Fugitive dust from unpaved haul roads and other areas of heavy vehicle use will be minimized by sprinkling, by vehicles speeds, by dust suppression agents, or combination as appropriate.

Storage and handling of flammable and combustible liquids and provisions for fire prevention will be in accordance with local and State regulations and the facility Spill Control and Countermeasures Plan.

1.6 Quality Control/Quality Assurance

Quality control/quality assurance activities for the work described in the Specifications will be performed in accordance with the Quality Plan and Construction Verification Program.

1.7 Boundary Surveys

Surveys of property lines, restricted areas, etc. will be performed by a registered land surveyor as required.

2.0 DESIGN BASIS AND TECHNICAL DATA

The design for final decontamination, decommissioning and reclamation of the Maybell Heap Leach Site conforms to the requirements set forth in Colorado's *Rules and Regulations Pertaining to Radiation Control*, 6 CCR 1007-1-1 et seq. Specifically, the design meets the Colorado Department of Public Health and Environment's criteria in Appendix A of Part 18 of the regulations and conditions set forth in Radioactive Materials License No. 660-01. Additionally, the Colorado Department of Public Health and Environment, Radiation Control Division's *Policy on Soil Contamination Cleanup Pursuant to 40 CFR 192 Cleanup Requirements* has been followed in the design and specifications. The reclamation design, plans, and specifications also uphold the ALARA principle by reducing potential radiation exposures to workers and the general public to levels below regulatory standards. Maybell reclamation activities meet or are more protective than specific standards regarding worker and public protection against radiation, the control of radon emanations, long-term isolation of waste materials, groundwater protection and soils cleanup. The design basis for these standards are described in Section 2.1 and the technical details regarding the design basis are presented in Section 2.2.

2.1 Design Basis

2.1.1 Radon Attenuation

The waste material repository must be designed to provide reasonable assurance that releases of radon-222 do not exceed a release rate of 20 $pCi/m^2/s$ when averaged over the disposal area in accordance with the generally applicable EPA regulations in 40 CFR §192.02(b). Radon flux is calculated using the RADON computer code (Birchard, 1986). This code mathematically analyzes one-dimensional steady-state radon diffusion through a two-phase multi-layer system of porous media, representing the waste pile and its cover.

Multiple layers of tailings and cover are represented in the model with differences in physical, radiological and diffusional properties represented by seven layer-specific input parameters. Radon concentrations in both soil-air and soil-water phases are treated, as well as the exchange between phases. Boundary conditions are the radon flux into the bottom of the cover and the air concentration of radon at the surface of the pile. In addition, interface conditions are applied, requiring continuity of both flux and concentration in both phases at layer interfaces. The exact simultaneous solution to the coupled radon mass balance and flush equations for the two phases is performed using matrix algebra for the general n-layer case.

2.1.2 Long Term Control

The control of residual radioactive materials are to be designed to be effective for up to one thousand years, to the extent reasonably achievable and, in any case, for at least two hundred years. Design of the disposal repository to assure compliance with this criterion is dependent upon controlling wind and water erosion and assuring repository stability. Erosion control features and repository stability are designed to withstand the effects of a probable maximum precipitation (PMP) event and the effects of a maximum credible earthquake (MCE).

The probable maximum precipitation event is used to design the erosion protection layer of the multi-layered cover and to design permanent, long-term diversion ditches and channels. The PMP used in the design calculations for riprap sizing is a one-hour localized event that produces 7.05 inches of rainfall. This event was determined from the probable maximum precipitation estimate for the Colorado River and Great Basin Drainages contained in Hydrometeorological Report Number 49 (National Oceanic and Atmospheric Administration, 1977).

The maximum credible earthquake is used to assess the long-term stability of the waste repository under earthquake loading conditions. Evaluation of the maximum credible earthquake considered the historical earthquake record, the regional tectonic setting and the presence of potentially active faults in the vicinity.

The maximum credible earthquake for the Uinta-Elkhead Seismotectonic Provinces is a Richter magnitude of 6.5 event, estimated by Kirkham and Rogers (1981). This event at its closest approach to the site on Fault 3 described by Kirkham and Rogers (1981) was attenuated to the Maybell Heap Leach site according to the relationships established by Campbell (1981). Maximum peak horizontal ground acceleration is estimated to be 0.30 g from the MCE at a distance of eight miles. The NRC in the *Final Standard Review Plan* dated October, 1992, indicates that two-thirds of the peak acceleration should be used to define the seismic coefficient used in the pseudostatic analysis. The calculated seismic coefficient is 0.20; however, a 0.25 pseudostatic coefficient has been conservatively used in the analysis of the heap leach pile stability.

2.1.3 <u>Groundwater Protection</u>

Groundwater protection Criterion 5 in the State of Colorado *Rules and Regulations Pertaining to Radiation Control* requires that in no case shall hazardous constituents entering the groundwater from a licensed site exceed the specified concentration limits in the uppermost aquifer beyond the point of compliance during the compliance period. Protection of groundwater resources beneath the repository is dependent upon minimizing infiltration through the cover and seepage through the liner. Infiltration through the cover is evaluated by the HELP computer code developed by the Army Corps of Engineers. This computer code is a quasi-two-dimensional hydrologic model of water movement across, into, through and out of waste repositories. The model uses climatologic, soil and design data to provide a solution for the effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage and lateral drainage. The analysis of infiltration through the cover and underlying liner is used to assess potential impacts to groundwater resources. Actual affects on groundwater quality are determined by analysis of data obtained from the groundwater monitoring program.

2.1.4 <u>Soils Cleanup</u>

Soils cleanup criteria are provided in EPA's 40 CFR 192, Subpart B. Section 192.12 requires that the concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface. The design basis for soils cleanup activities is to provide a soils cleanup methodology that properly identifies areas to be remediated, methods to accomplish the remediation and appropriate verification surveys. Details of soil cleanup activities are presented in the Soils Cleanup Plan for the Maybell Heap Leach Facility.

2.2 Technical Data

2.2.1 Radon Attenuation Analysis

Radon attenuation analysis to assess the cover design was conducted using the computer program RADON developed by the Nuclear Regulatory Commission, authored by G. F. Birchard, April 1, 1986. Guidance for the analysis of radon attenuation was also obtained from the *Radon Attenuation Handbook for Uranium Mill Tailings Cover Design* as set forth in NUREG/CR-3533 (Rogers and others, 1984). The RADON program utilized radon-generating source parameters such as radium activity, porosity, emanation coefficient, diffusion coefficient and heap thickness to calculate the bare (uncovered) source radon flux. The equation for estimating this flux is presented in the NUREG/CR-3533.

The program also uses a diffusion equation to quantify the attenuation or reduction of the radon exit flux from a soil cover. Cover soil parameters include thickness, porosity, emanation and diffusion coefficients and source flux for one or more cover layers. The RADON computer program was used to calculate the exit flux from the reclaimed heaps.

Input parameters were developed from radiological measurements and geotechnical soil tests. The radium content of heap materials was measured on six composite samples obtained from the reshaped heap. Each composite sample consisted of samples taken from the upper two feet at four or five locations on each of the original cells. The radium activity of the upper 500 centimeters of the reshaped heaps will be verified after final grading and placement of off-site soils in accordance with Section 6.4. Diffusion and emanation coefficients for waste and cover soils were determined by laboratory measurements. Geotechnical testing of cover soils were performed to establish molded densities and long-term moisture contents. Table 2.2.1 summarizes the input data utilized in the RADON model.

A 500 centimeter thickness was used for the waste material which represents an infinite thickness in the computer code. Cover material thickness was based on the design plans. Porosities were calculated by the RADON program based on layer density and moisture content data input. Results of the RADON model indicate an exit flux of 8.9 pCi/m^2/s. A detailed section of the reclamation cover design utilized for the Radon Attenuation model is shown on Figure 2.2.1-1.

TABLE 2.2.1

PARAMETER	HEAP MATERIAL	CLAY SOIL LAYER	RANDOM FILL
Layer Thickness (cm)	500	45.72	121.92
Layer Density (gm/cm^3)	1.68	1.75	1.78
Radium Activity (pCi/g)	53	2.32	3.06
Emanation Coefficient	0.265	0.193	0.106
Moisture Content (%)	9	10.49	6
Diffusion Coefficient	0.0172	0.014	0.022

2.2.2 Frost Penetration

An analysis of frost penetration into the reclamation cover was performed using the *Digital Solution of Modified Buggren Equation to Calculate Depths of Freeze or Thaw in Multi-layered Systems* computer program developed by the U. S. Army Cold Regions Research and Engineering Laboratory. To provide a conservative data base for this analysis, default climatic data for Casper, Wyoming, was used in the model due to similar climatic conditions. The mean annual temperature at the facility is 42.3 °F compared to 45.3 °F at Casper. The mean annual temperature for Maybell was input.

Soil density values used in the model are minimum specified values based on laboratory testing of the proposed borrow areas. To be conservative in the analysis, a water content of six percent was assumed for the random fill layer of the reclamation cover. An n-factor of 0.7 was input as recommended by DOE for graded topslopes and cobble and gravel sideslopes (DOE Technical Approach Document, Revision II, December, 1989). Values for heat capacity, thermal conductivity and latent heat of fusion were generated by the program based upon density and moisture content values input. Table 2.2.2-1 provides a summary of input parameters used for this analysis.

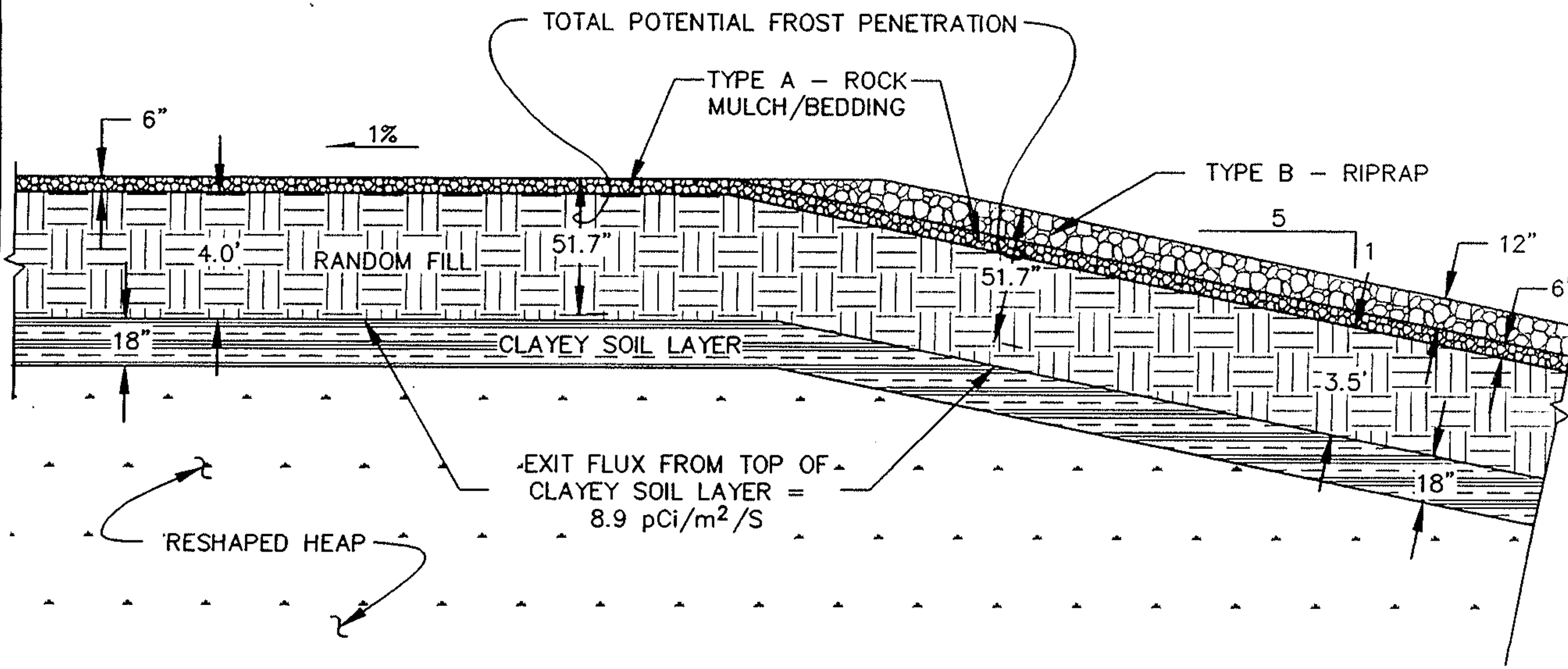
The resulting total frost penetration determined by this analysis is 51.7 inches. This compares to a frost penetration depth of 48 inches used by the Moffat County Building Department for the Maybell area. Since the cover design provides for a minimum 54 inches over the top of the radon barrier, frost penetration will cause no adverse effects to the radon barrier.

2.2.3 Stability Analysis

Slope stability of the reclaimed heap was analyzed using the UTEXAS2 (University of Texas Analysis of Slopes - Version 2) computer program for slope stability calculations. This program allows the use of several methods of analysis including input of seismic coefficients for use in pseudostatic slope stability computations. Spencer's procedure of slices for computing the factor of safety was selected for this analysis.

The slope stability analysis was performed for the maximum slope elevation located on the southern side of the reshaped heap. Input parameters for the analysis were developed from laboratory testing as reported in Appendix A of the Site Characterization Report (Chen, 1988) and the CDPHE approved Liquid Waste Management Plan (Umetco, May 13, 1994). To provide a conservative analysis, the cohesive strengths of random fill soils, heap materials, mine spoil and foundation soils were neglected. Additionally, a phreatic surface was assumed to exist above the clay liner. As dewatering of the heap leach material occurs, this phreatic level will decrease and, ultimately, disappear.

Seismicity evaluation of the Maybell site is summarized in Section 2.1.2. The maximum peak horizontal ground acceleration is estimated at 0.3 g with a corresponding pseudo-static coefficient of 0.20. The stability analysis performed for the reclaimed heap utilizes a conservative seismic coefficient of 0.25 for analysis under pseudostatic conditions.



SCALE: 1" = 5'

Umetco Minerals Corporation

MAYBELL HEAP
RECLAMATION COVER
RADON ATTENUATION

JAN 1995 FIGURE 2.2.1–1

Table 2.2.2-1
Frost Penetration Input Parameters

Design Freezing Index (Air) = 1258 F-days
Design Freezing Index (Surface) = 944 F-days
Mean Annual Temperature = 42.3 Degrees F
Length of Freezing Season = 115 Days

Layer No. & Type	Layer Thickness (Inches)	Water Content (%)	Dry Density (pcf)	Heat Capacity (btu/foot hour °F)	Thermal Conductivity (btu/foot hour °F)
Course grain soil	6	3	135	25.99	1.24
Course grain soil	48	6	109.2	23.48	0.88
Fine grain soil	18	10	108.6	---	---

The unsaturated sand and sandstone of the heaps and foundation of the heaps are not susceptible to liquification under earthquake conditions. Accordingly, dynamic analysis is not applicable to this structure.

Table 2.2.3-1 summarizes material types and strength parameters input for this analysis.

Figure 2.2.3-1 illustrates the representative cross-section and circular slip surfaces as well as material properties resulting from the analysis. NRC requirements for minimum factor of safety are established by NRC 3.11 Regulatory Guide, Table 3.2. The resulting factors of safety for the slope stability analysis are shown in Table 2.2.3-2.

The minimum factors of safety resulting from this slope stability analysis exceed established NRC minimum requirements.

2.2.4 Settlement

The waste material consists of cohesionless to low-cohesion, silty sand. The materials were placed by dumping and spreading at relatively low moisture contents as opposed to being placed as a very high moisture slurry such as tailings. Other than transportation, placement and extraction, the ore was not treated by a physical process such as crushing, screening or grinding. Hauling and spreading equipment applied some degree of compaction during initial placement. Preconsolidation of the granular waste material has occurred from self-weight loading over a 14-year period. Flooding of the heaps during the leaching process as well as annual infiltration of snowmelt has contributed to the settlement of the heaps. Additional consolidation of the heaps has resulted over a five-year period since surcharging loading of the heaps during the reshaping operation. The reshaping operation involved reduction of the original slopes to a 5:1 (H:V) gradient. Excavated material from reshaping operation was placed and compacted on top of the heap.

Some settlement is anticipated due to the weight of materials added during placement of cover materials. Because the heap materials are granular, the maximum amount of settlement of the heap will occur during the construction period. Cover materials will be placed and compacted to assure that settlement of the cover is negligible. Post-construction settlement of the heap materials and cover will not cause significant deformation of the top surface, perimeter slopes, or channels because of the preconsolidation of the heap materials, the natural properties of these materials and the construction methods used during regrading and cover placement. Settlement will be monitored after construction to assure that the cover is not adversely affected by consolidation of the waste materials.

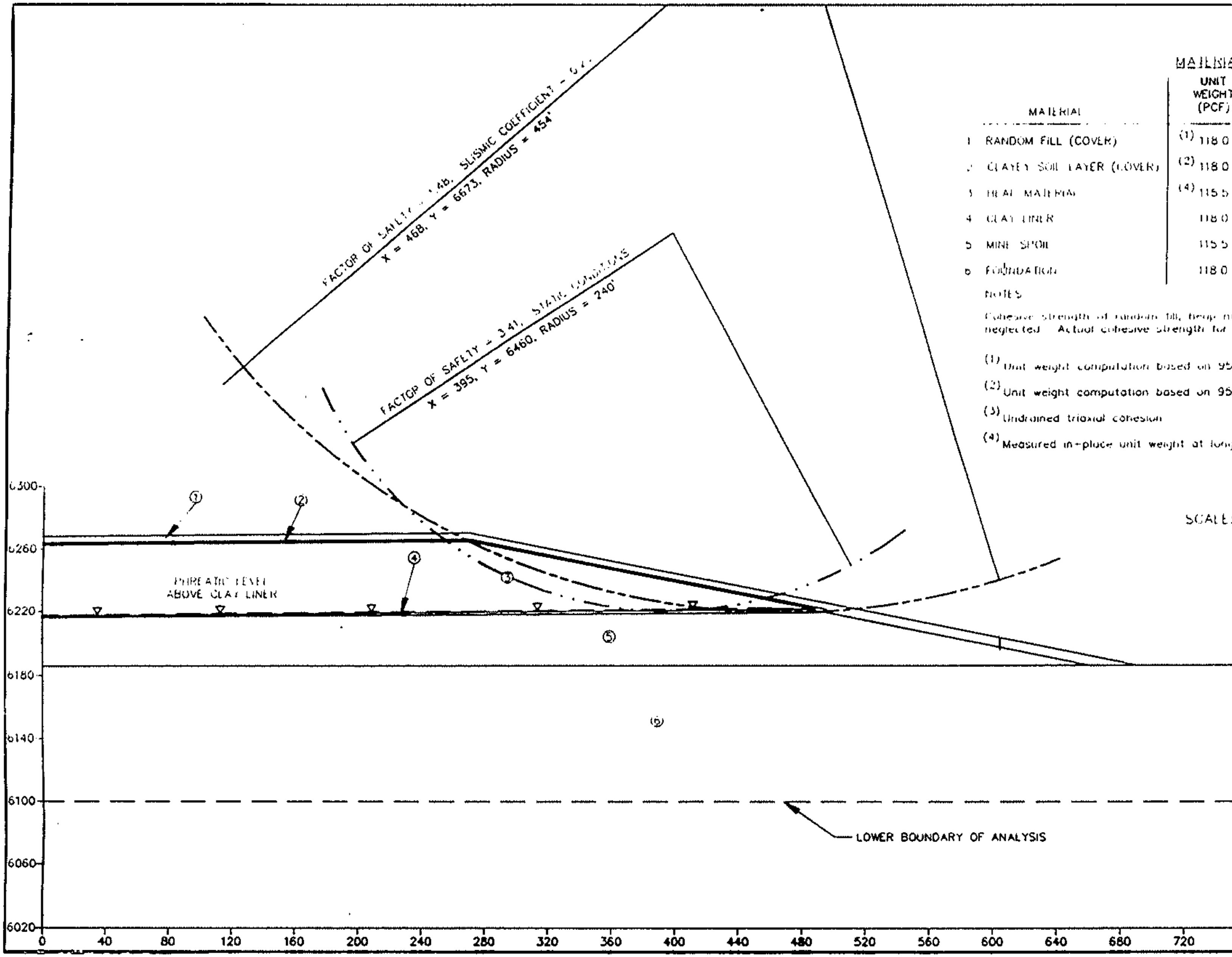
2.2.5 Liquefaction Potential

The liquefaction potential was evaluated with respect to the foundation and heap materials. The foundation varies from silty sands to weakly cemented sandstone. Heap materials are also composed of silty sands. These materials are in a partially saturated condition with low to moderate amounts of moisture which will decrease with time.

Table 2.2.3-1
Slope Stability Input Parameters

Material	Unit Weight (PCF)	Cohesion (PSF)	Internal Angle of Friction (Degrees)
Foundation	118.0	230	33.8
Mine Spoil	115.5	0	33.8
Clay Liner	118.0	(3)1100	0
Heap Material	(4)115.5	0	33.8
Clay Soil Layer (Cover)	(2)118.0	(3)1100	0
Random Fill (Cover)	(1)118.0	0	33.8

Notes:
Cohesive strength of random fill, heap materials and mine spoil were neglected. Actual cohesive strength for these materials is 230 psf.
(1) Unit weight computation based on 95% maximum density (D698) @ 6% moisture.
(2) Unit weight computation based on 95% maximum density (D698) @ 9% moisture.
(3) Undrained triaxial cohesion.
(4) Measured in-place unit weight at long-term moisture content of 10%.



MATERIAL PROPERTIES

	MATERIAL	UNIT WEIGHT (PCF)	COHESION (PSF)	INTERNAL ANGLE OF FRICTION (DEGREES)
1	RANDOM FILL (COVER)	(1) 118.0	0	33.8
2	CLAYEY SOIL LAYER (COVER)	(2) 118.0	(3) 1100	0
3	HEAP MATERIAL	(4) 115.5	0	33.8
4	CLAY LINER	118.0	(3) 1100	0
5	MINE SPOIL	115.5	0	33.8
6	FOUNDATION	118.0	250	33.8

NOTES

Cohesive strength of random fill, heap materials and mine spoil were neglected. Actual cohesive strength for these materials is 250 psf

(1) Unit weight computation based on 95% maximum density (D698) @ 6% moisture

(2) Unit weight computation based on 95% maximum density (D698) @ 9% moisture

(3) Undrained triaxial cohesion

(4) Measured in-place unit weight at long term moisture content of 10%

SCALE: 1" = 60'

Umetco Minerals Corporation

MAYBELL HEAP
STABILITY ANALYSIS

JANUARY 1995

FIG. 2.2.3-1

Table 2.2.3-2
Stability Analysis

Condition	Minimum Factor of Safety	NRC Minimum Factor of Safety
Static	3.41	1.5
Pseudostatic (seismic coeff. = 0.25)	1.48	1.0

Liquefaction and/or cyclic mobility can occur in saturated, cohesionless soils (sands and silts) or low plasticity, clayey soils due to the cyclic loading usually caused by earthquake-induced ground motions. Liquefaction occurs when the effective stress in the soil is reduced to zero by the earthquake-induced buildup of pore water pressure. When this occurs, the shear strength of the soil decreases and the soil becomes essentially a viscous fluid (Technical Approach Document, Revision II, UMTRA-DOE, December, 1989).

For liquefaction to occur, several site and soil conditions must be satisfied, such as the presence of loose cohesionless soils in saturated condition, presence of groundwater and level of earthquake shaking. These conditions have not been identified at the Maybell site.

As described in Section 2.2.4, consolidation of the granular waste material has occurred from self-weight loading over a 14-year period. In October of 1993, a geotechnical investigation was conducted on the reshaped heap to identify the quantity of free liquids stored in the heap and to acquire accurate geotechnical data to establish input parameters for modeling of liquid movement in the heap. The geotechnical investigation, described in the Liquid Waste Management Plan, indicates no significant volume of saturated material existing within the heap. Furthermore, the (saturated) hydraulic conductivity of the radon barrier will have to be in the range of 10^{-7} cm/sec in order to satisfy the NRC criteria for groundwater compliance. Therefore, once the radon barrier is placed on top of the embankment, the influx from precipitation through the radon barrier will be near zero and heap materials will remain unsaturated for the design life of the embankment. Accordingly, the unsaturated sand and sandstone of the heaps and foundation of the heaps are not susceptible to liquefaction.

2.3 Hydrological Analysis

2.3.1 Design Storm

The major long-term risk to stability of the reclaimed facility is from erosion forces due to flood events. The occurrence of a Probable Maximum Precipitation (PMP) event over a watershed produces a Probable Maximum Flood (PMF), which is the most critical case for designing the reclamation cover.

The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local storm results in a much higher peak flow than the general PMP storm and in a more conservative reclamation design. The 1-hour, local PMP storm for the Maybell site was determined with the data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches.

Peak discharges for the top and sideslopes of the reclaimed heap and the sub-basin surrounding the site were calculated by the Rational Formula. The supporting calculations are presented in Appendix A.

2.4 Erosion Protection

2.4.1 Riprap Size

Erosion protection for the top surface of the heap, 5:1 (H:V) sideslopes and channels were designed utilizing methodologies established in Appendix D, *Final Staff Technical Position (STP), Design of Erosion Protection Cover for Stabilization of Uranium Mill Tailings Sites*, U. S. Nuclear Regulatory Commission, August 1990 (NRC/STP).

As recommended in the STP, the Safety Factors Method was utilized for design of erosion protection for the top cover and the Stevenson Method for design of riprap on 5:1 cover slopes. To be conservative in these designs, a runoff coefficient of 1 and flow concentration factor of 3 were assumed. Design of erosion protection for the channels was performed using the Safety Factors Method. A total of fourteen separate median stone size values were determined for the various hydraulic conditions at the site. To maintain a minimum number of riprap types to be processed, four separate riprap gradations were selected. The selection of riprap types was based on volume required and filter bed compatabilities. The type of riprap used for each application was based on selection of the riprap type with the greater D_{50} design value determined for that specific application.

Table 2.4.1-1 provides a summary of peak discharges, median stone design values, specified erosion protection and specified erosion protection thicknesses. Table 2.4.1-2 lists the four types of erosion protection and grain size distribution for the specified materials.

Design of riprap toe protection is based on methodologies established in NUREG/CR-4480. The design of channel outlets is based on recommendations contained in Appendix D, NRC/STP. Design procedures for both of these applications are dependent on estimation of the depth of scour at the toe of the slope or channel outlet. Depth of scour calculations utilized the equation:

$$S = \frac{2.89q^{0.82}}{D_{85}^{\ 0.23}}\left(\frac{h_d}{q^{2/3}}\right)^{0.93} - h_d$$

S = depth of scour hole (m)
q = water discharge per unit of width ($m^3/s/m$)
h_d = downstream water depth
D_{85} = particle size for which 85 percent of the material is finer
Sediment Transport Technology, Table 10.8, Simons & Sentürk (1992)

The estimated maximum scour depth that will occur at the toe of the repository is 1.2 feet. From this estimated value the width and depth of the horizontal toe protection was determined and is shown in Detail 4 on Drawing M-126.

Table 2.4.1-1
Erosion Protection Design Summary

Application	Peak Discharge (CFS)	Design D_{50} (inches)	Specified Erosion Protection	Specified Thickness (inches)
Top of Reclamation Cover	1.3 cfs/ft	0.6	Type A	6
5:1 Reclamation Cover Slopes	2.19 cfs/ft (maximum)	6.55	Type B Type A-Bedding	12 6
CHANNEL 1				
STA 0+00 to 14+61.1	625.6	2.5	Type C Type A-Bedding	12 6
STA 14+61.1 to END (18+00)	625.6	22.5	Type D Type A-Bedding	30 6
CHANNEL 2				
STA 0+00 to 3+63.07	515	3.36	Type B	9
STA 3+63.07 to 4+93.07	515	15.6	Type D Type A-Bedding	30 6
STA 4+93.07 to 7+55.08	1055	2.5	Type D Type A-Bedding	30 6
STA 7+55.08 to 17+55.08	1775	15.7	Type D Type A-Bedding	30 6
CHANNEL 3				
STA 0+00 to 8+00	635	6.3	Type B Type A-Bedding	12 6
STA 8+00 to 11+40	635	17.8	Type D Type A-Bedding	30 6
CHANNEL 4				
STA 0+00 to 10+00	620	6.2	Type B Type A-Bedding	12 6
STA 10+00 to 18+00	620	13.4	Type D Type A-Bedding	30 6
CHANNEL 5				
STA 0+00 to 8+92.34	610	1.9	Type B Type A-Bedding	12 6

Table 2.4.1-2
Erosion Protection Materials

Type	Design D_{50} (inches)	Grain Size Distribution: Maximum Size (inches)	D_{50} (inches)	D_{15} (inches)
Type A	0.6	3	3/8 to 1½	#4 to ¾
Type B	6.5	9	5 to 8	3 to 6
Type C	2.5	6	2 to 5	¾ to 3
Type D	22.5	30	18 to 24	5 to 10

The maximum scour depth was calculated for each individual channel outlet. The results were compared and the maximum value of 6.5 feet was selected to design the typical channel outlet as shown in Detail 5 on Drawing M-126.

Supporting calculations for riprap designs are presented in Appendix A. The required placement specifications for erosion protection materials are provided in Sections 7 and 8 of the Specifications as well as Drawing M-126.

2.4.2 Riprap Durability

Riprap durability was evaluated in accordance with rock quality rating procedures established in Appendix D, NRC/STP. Durability tests were performed on samples of processed riprap material from the Steele Quarry. Results of these tests are shown below on Table 2.4.2-1.

Limestone, a sedimentary rock, will be used as riprap material. This material will be processed and supplied by the Steele Quarry. Durability was evaluated in accordance with rock quality rating procedures established in Appendix D, NRC/STP. Durability tests were performed on samples processed from the quarry and the results are shown below in Table 2.4.2-1.

The test results indicate that the limestone is of good quality for use as erosion protection. The resulting rock quality rating is 89.6 percent which exceeds the minimum rating for oversizing of erosion protection materials for both critical and non-critical areas.

The results of these tests indicate that rock is of good quality for use as erosion protection. The resulting rock quality rating is 89.6 percent requiring no oversizing of erosion protection materials for both critical and non-critical areas.

The durability of erosion protection materials will be tested in accordance with Section 7.5.2 and evaluated based on criteria established in the NRC/STP *Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, Appendix D* (August, 1990). The "rating" or "scoring" resulting from this evaluation must exceed 80 for acceptance of the rock material. Erosion protection materials scoring below 80 will be rejected or evaluated with applicable oversizing criteria prior to acceptance.

2.5 Ground Water Protection

2.5.1 Infiltration Analysis

An analysis of the potential deep infiltration of surface water through the cover into the heaps was conducted to assess potential seepage from the repository. The computer program entitled Hydrologic Evaluation of Landfill Performance Version 3.01 (HELP) was used to estimate the quantity of deep infiltration. The model uses climatologic, soil and design data in a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage and lateral drainage. The program facilitates estimation of the amounts of runoff, drainage and seepage that may be expected at the Maybell site.

Table 2.4.2-1
Riprap Durability Testing

Sample Size	3/8"-1.5"	2.5"-3.5"	3.5"-4.5"	4.5"-5.5"	5.5" +
Soundness (Percent Loss)		0.65	0.41	0.03	
L A Abrasion (Percent Loss) 100 Revolutions 200 Revolutions	 7.6 28.8				
Specific Gravity			2.68	2.71	
Absorption (Percent)			0.28	0.31	
Indirect Tensile (lbs/sq. in.)					1,186.3
Schmidt Rebound					65.2

Climatological data for Lander, Wyoming, were used in the simulation of infiltration. Rainfall for the 5-year period chosen is 12.3 inches where Maybell has an average annual rainfall of 12.6 inches. Solar radiation and monthly mean average temperatures for the Maybell area were input to the model. Considering the above, the analysis performed is a reasonable approximation of the infiltration to be expected at the Maybell site.

Modeling results show that approximately 0.3344 inches or 0.0279 cubic feet per square foot of infiltration area occurs annually. The results confirm a very low infiltration at the repository and indicate that a perched water table condition will not develop on the clay liner after closure is completed. Supporting computer input data and calculations associated with this analysis are provided in the Liquid Waste Management Plan, Maybell Heap Leach Facilities, Umetco Minerals Corporation (May 12, 1994).

2.5.2 Dilution Analysis

Seepage analysis indicated that infiltration into the repository and subsequent downward migration of liquids will occur at an extremely low volume. Significant dilution will occur for the small amount of liquid that reaches the Brown's Park aquifer. Using an infiltration volume of 0.0279 cubic foot per square foot from the HELP model, a dilution ratio in excess of about 250 to 1 is calculated using a simple mixing model. Thus, any potential seepage that could possibly reach the Brown's Park aquifer would be diluted to extremely low levels and not have a significant effect on the groundwater resources.

2.6 Soils Cleanup Methodology

The cleanup of contaminated soils in the area of the Maybell Heap Leach Pile are fully described in the Soil Cleanup Plan. Background conditions for the unmined and mined areas were defined from soil investigations and gamma surveys conducted in 1989 and 1991. Data from these surveys provided the basis for identifying contaminated soil cleanup areas and developing the soil cleanup program.

The Soil Cleanup Plan was developed to meet License Conditions 17.3.1.3, 28.7, 32.1, and 32.2 of Radioactive Materials License 660-01 and to meet the regulatory requirements set forth in Appendix A, Part 18 of Colorado's *Rules and Regulations Pertaining to Radiation Control.* These regulations require the cleanup of contaminated soil in accordance with concentration limits established for radium by the U. S. EPA in 40 CFR 192. In addition, several guidance documents were used in developing the Soil Cleanup Plan and attendant verification survey. Specifically, the Colorado Department of Public Health and Environment's document titled *Policy on Soil Contamination Cleanup within the State of Colorado Pursuant to 40 CFR 192 Cleanup Requirement*; the EPA's publication titled *Methods for Evaluating the Attainment of Cleanup Standard, Volume 1: Soil and Solid Media*; and the NRC's report titled *Manual for Conducting Radiological Survey's in Support of License Termination* were all used in developing the soil cleanup program for Maybell. The program is designed to reduce the concentration, averaged over 100 square meters, of radium in soils to levels that do not exceed background by 5 pCi/g averaged over the first 15 cm and 15 pCi/g averaged over 15 cm layers more than 15 cm below the surface.

3.0 LIQUID MANAGEMENT FACILITIES

Drainage of free liquids from the heap is expected to occur for a number of years following construction of the reclamation cover. When post-reclamation monitoring of the drainage discharge rate indicates flows have become sufficiently low or ceased, the drainage collection system will be sealed as described in Section 6.5. License Condition 24.5 establishes criteria for obtaining Division approval for sealing of the drainage collection system. CDPHE/RCD-approved sealing may occur when one of the following conditions have been met:

1. Plugging of the drainage/collection system will be allowed if monitoring indicates zero (0) flow for a period of two years, or

2. if the licensee can demonstrate that the remaining flow will not exit the side slopes or endanger the stability of the heap leach piles.

The following sections describe the drainage characteristics and anticipated duration of post-reclamation drainage in relation to the time frame for sealing the drainage/collection system in accordance with criteria established by LC 24.5.

3.1 Drainage Characteristics

Drainage of excess free liquids from the heap occurs in a cyclic manner. Increased flows in the spring and summer result from infiltration by snowmelt and operation of the spray evaporation system. Monitoring records indicate that excessive infiltration on the heap result in the rapid development of perched liquids on the clay liner of the heap and increased flow rates through the drainage collection system. Field personnel at the site estimate the lag time from the date of a major precipitation event resulting in excess infiltration to discharge drain reaction at approximately ten days.

3.2 Liquid Waste Management Facilities

Improvements to the site's liquid waste management facilities were completed in 1994 in accordance with the Liquid Waste Management Plan (Umetco, May, 1994). These improvements consisted of construction of a new evaporation pond, discontinued use and dismantling of the spray evaporation system, and modifications to the heap drainage collection system. Detailed drawings of these facilities are provided in the Liquid Waste Management Plan and Final Construction Report for Maybell Liquid Waste Management Facilities.

3.2.1 Heap Drainage Collection System

The heap drainage collection system collects liquids discharging from the original (intact) heap underdrains. Modifications to the drainage collection system included construction of perimeter drains designed to collect potential lateral seepage of liquids from immediately above the clay liner but not through the underdrain system.

3.2.2 New Evaporation Pond

Liquid wastes collected through the heap underdrain system are discharged into an evaporation pond completed in 1994. The evaporation pond has a surface area of two acres at the three-foot freeboard level with an operating capacity of 6.4 million gallons. The evaporation pond's lining system is comprised of (top to bottom):

- 60-mil HDPE (High Density Polyethylene) primary liner,
- Geonet drainage layer,
- 30-mil VLDPE (Very Low Density Polyethylene) geomembrane, and
- Clay soil liner.

The Geonet drainage layer is designed to monitor leakage between the geomembrane liners and drains to the leak detection sump.

3.3 Disposal of Drainage Residues

3.3.1 General

When the liquid discharge rate from the reclaimed heaps becomes sufficiently low or ceases, as determined by criteria set forth in LC 24.0, the collection drains will be sealed by grouting the discharge lines from points at which the discharge pipes exit the reclamation cover as specified in Section 6.5. Remaining liquids will be evaporated in the lined evaporation ponds.

3.3.2 Disposal of Drainage Residues

Once evaporation of liquid waste has been terminated, and collection discharge lines sealed, the evaporation ponds will be reclaimed in-place. All piping, valves, etc., associated with the heap drainage collection system that exist outside of the reclaimed heap will be placed in the evaporation ponds.

When it has been determined that all remnant contaminated materials from the site have been identified and placed in the ponds, the Final Phase Reclamation activities and final reclamation cover designs will be submitted to the Division for approval per LC 24.7. Borrow materials for construction of this cover will be stockpiled in the vicinity during heap reclamation.

3.4 Monitoring and Documentation

Monitoring and documentation of the liquid waste shall be performed in accordance with Environmental Monitoring Procedures D.1-1, Liquid Waste Monitoring.

Existing heap leach piezometer monitoring will be used to establish free-liquid levels perched on the clay liner of the heap. The piezometers will be monitored on a monthly basis to determine liquid levels and fluctuations prior to placement of the reclamation cover on top of the heap in 1996. Piezometers will also be monitored if unusual or unexpected flows occur from the drains. Piezometers will be properly sealed immediately prior to top cover construction but may be reinstalled or saved if insufficient data exists to determine when the drain collection systems are to be sealed.

The existing drainage collection system collects liquids from the underdrain system and the new drain system will collect liquids flowing toward the sideslopes of the heap. These collection systems will be monitored in accordance with LC 24.3. Comparison of discharge rates from the existing drainage collection system and the new drainage collection system will provide information as to the lateral drainage characteristics of the structure. This data will be utilized by Umetco and CDPHE/RCD for determination of the appropriate time frame and methodologies to be employed for sealing of the drainage collection system in accordance with provisions set forth in LC 24.5.

4.0 PLANT DECOMMISSIONING

The majority of the facility's processing equipment has been dismantled and placed in the reshaped heap. Remaining equipment, structures and remnant debris will be dismantled in accordance with the following specifications.

4.1 Work Items

- Dismantle and remove all remaining processing equipment and support facilities associated with the Maybell Heap Leach Facility.
- Place and compact these materials on top of the heaps prior to placement of the cover.

4.2 Equipment and Support Facilities

All equipment and support facilities, including instrumentation, process piping, electrical controls and switchgear, and structures will be removed. Concrete foundations will be demolished and removed as required.

4.3 Evaporation Ponds

The Winter Storage and New Evaporation Pond will be reclaimed in-place at the termination of the Liquid Waste Management Plan. Final Phase Reclamation closure and design will be in accordance with LC 24.7.

4.4 Material Placement

The solid waste debris, scrap and soil materials will be placed in the heap area in accordance with the following requirements.

The scrap will have a maximum linear dimension of 20 feet and a maximum volume of 30 cubic feet. Scrap exceeding these limits will be reduced to within the acceptable limits by breaking, cutting or other approved methods. Empty drums, tanks or other objects having a hollow volume greater than five cubic feet will be reduced in volume by at least 70 percent. If volume reduction is not feasible, openings will be made in the object to allow soils, heap materials or other approved materials to enter the object. The scrap, after having been reduced in dimension and volume, if required, will be placed in the heap area. The requirements for compaction are given in Section 6.2 of the Specifications.

4.5 Final Reclamation

4.5.1 Grading

Areas disturbed by the plant decommissioning and cleanup operations will be graded to blend into the natural areas as much as possible. Grading operations will be conducted to minimize slopes steeper than 3(H):1(V) and to provide a smooth transition into steeper natural slopes.

4.5.2 Seeding

All disturbed and graded areas will be seeded. Prior to applying seed, the area will be inspected and any areas which appear unsuitable for seeding (either too compact or too loose) will be prepared to provide a firm but friable seedbed.

The seed mixture described in Table 4.5.2-1, previously approved by the Department of Natural Resources and concurred with by the U. S. Bureau of Land Management for use in the area, will be used.

Seed will be applied by either Rangeland drill or by broadcasting. The Rangeland drill will have a drill spacing of twelve inches and a seed depth of one-half to three-fourths inch. Areas seeded by broadcasting will be drag covered. If the seed is applied by broadcasting, the application rate stated in Table 4.5.2-1 will be doubled.

5.0 SOIL CLEANUP PLAN

5.1 Work Items

- Soil Removal
- Soil Mixing
- Verification Survey
- Reclamation and Revegetation

5.2 Soil Cleanup Activities

Areas to be remediated under this plan include all land outside of the toe of the heap leach repository and process area as shown on Drawing M-127. The cleanup areas include lands within the restricted and nonrestricted areas as defined in Radioactive Materials License No. 660-01. The terms on-site and off-site used in this report do not change nor alter the definition of "restricted area". Cleanup activities in the mined and unmined areas include mixing and removal of contaminated materials using standard construction equipment. The Soil Excavation Map (Drawing M-127) shows the location of the areas to be remediated.

Table 4.5.2-1
SEED MIXTURE

Species	Drilled Rate* - Pounds/Acre
Arriba Western Wheatgrass	4.0
Nordan Crested Wheatgrass	2.5
Sodar Streambank Wheatgrass	2.5
Criteria Thickspike Wheatgrass	2.0
Nespar Indian Ricegrass	1.0
Rabbitbrush	0.5
	12.5 Pounds/Acre

*Broadcast rate is twice the drilled rate.

Vegetative matter obtained during clearing and grubbing of the soil cleanup areas will be removed and hauled to the South Rob Overburden Pile and will be used as a soil amendment during reclamation of the borrow area. The vegetative matter will be mulched or reduced in size, spread, and mixed in the upper one-foot of the soil layer so that use of organic matter is optimized during reclamation of the South Rob borrow area.

Fences removed during the soil cleanup activities will be replaced with temporary fencing during the weekend or holidays when work activities have been halted. After soil cleanup activities have been completed, the restricted area boundary fence will be installed and surveyed by a registered land surveyor. This final survey will be submitted to the Colorado Department of Public Health and Environment, Radiation Control Division.

5.2.1 Mixing Areas

Areas to the north, south, and southeast of the heap leach facility will be remediated by mixing the windblown materials with the underlying soil. These areas, shown on Drawing M-127, contain a thin veneer, generally less than 0.25 inch, of windblown material. Construction activities include the mulching of the vegetative material using a brush hog or equivalent. After mulching, the area will be disked to a depth of approximately eight inches and revegetated.

5.2.2 Removal Areas

The areal extent and thickness of deposits to be excavated are shown on Drawing M-127. Soils will be excavated in accordance with this drawing and relocated to the heap leach repository. Total volume of material to be removed is estimated to be 47,000 cubic yards. Prior to excavation, the areas will be visually inspected for discrete deposits of waste materials. These waste materials, such as the loading ramp adjacent to the heap, will be removed prior to final excavation. Excavation of the windblown materials will follow the existing ground contours and, thus, the topography after excavation will be very similar to the surface configuration currently present at the site.

Construction activities include the removal of contaminated material using standard construction equipment. Removal equipment will be dependent upon the location, accessibility, and quantity of contaminated material to be removed. The equipment will consist of heavy equipment, such as scrapers, loaders, off-road end dumps and light equipment, such as loaders, backhoes, and trucks. Soil removal activities will use equipment best suited to removing the material in the most economical and feasible manner with the least environmental impact or potential for spreading contamination. After removal of the contaminated material, the areas will be disked and revegetated.

5.2.3 Verification Survey

A verification survey of the mined and unmined areas will be conducted to determine compliance with Colorado's *Rules and Regulations Pertaining to Radiation Control* and with U. S. EPA 40 CFR 192 soil cleanup standards for radium. The verification survey will be conducted in accordance with the Soil Cleanup Plan approved by the Colorado Department of Public Health and Environment.

5.2.4 Reclamation and Revegetation

After contaminated soils have been removed from the mined and unmined areas and a verification survey conducted and approved by the Radiation Control Division, disturbed areas will be graded and revegetated. Grading operations are anticipated to be minimal because the removal activities will follow the pre-existing soil horizon and be similar to pre-mining conditions. The area will be graded to a smooth surface capable of being revegetated.

Revegetation of the disturbed areas will be accomplished by scarifying and seeding the area using a disk or range drill or by broadcasting. The seed mixture will be introduced at a rate of 12.5 lbs of pure live seed per acre. The seed mixture that will be used is presented in Section 4.5.2.

Prior to seeding, the scarified area will be broadcast with fertilizer consisting of 100 lbs P per acre. After the first full growing season, the revegetated areas will be inspected to determine the need, if any, for additional fertilizer, seeding, or soil amendments. The revegetated areas will be visually evaluated to assure revegetation success.

6.0 HEAP CONFIGURATION

The final heap configuration, shown on Drawings M-122 and M-123, will require final grading of the sideslopes and grading the top.

6.1 Work Items

- Placement and compaction of contaminated material.
- Grading the sideslopes and top of the heap.

6.2 Contaminated Materials Placement and Compaction

Materials to be placed and compacted in the heap area include debris and scrap from the processing plant and support facilities and contaminated soil materials. The debris and scrap materials will be placed in excavated trenches on top of the heap at a minimum depth of 500 cm below the final graded elevation of the top of the heap prior to placement of the cover.

Any scrap placed will be spread across the area to avoid nesting and to reduce the volume of voids present in the disposed mass. Stockpiled soils, contaminated soils, heap materials and/or other approved materials will be placed over and into the scrap in sufficient amounts to fill the voids between the large pieces and the volume within the hollow pieces to form a coherent mass. It is recognized that some voids will remain because of practical limitations of these procedures. Reasonable effort will be made to fill the voids.

Placement of contaminated materials will be such that a relative uniform distribution of the various contaminated material types (debris, sludge, contaminated soils, etc.) is obtained over the placement areas.

The contaminated soils, sludge and other cleanup materials will be compacted to at least 90 percent of Standard Proctor maximum density (ASTM D698) at a moisture content of between minus four percent to plus two percent of optimum in lifts no greater than two feet.

6.3 Grading

The final configuration of the heaps is shown on Drawings M-123 and M-124. Principal features include grading the top of the heap to a uniform one percent grade, excavation of discharge channel and final grading of the 5(H):1(V) sideslopes.

Excess materials removed from final grading of heap slopes will be placed and compacted on top of the heap. All heap materials will be placed in compacted lifts not to exceed 12 inches and will be compacted to at least 90 percent of Standard Proctor maximum density (ASTM D698) at a moisture content of between minus four percent to plus two percent of optimum.

The sideslopes will be graded to a slope of 5(H):1(V) to the approximate configuration shown in Drawings M-123 and M-124. The top of the heap will be contoured to a slope of one percent toward a central channel (Channel 1). All areas will be graded to avoid any abrupt change in grade or flow direction. Small dikes and control facilities will be constructed to contain surface runoff during placement of the cover material, if necessary.

6.4 Verification of Design Radium Activity

Once off-site soils have been placed on top of the heap and final grading has been performed, the radium activity of the upper 500 cm of the reshaped heap will be determined to verify cover design. Verification will be accomplished by drilling approximately ten borings or excavating test pits to a depth of 500 cm. Gamma logs will be made of each boring with selective samples taken at various depths to correlate gamma measurements to radium activity. A minimum of fifteen soil samples will be obtained from the borings for laboratory analysis of radium activity.

6.5 Sealing of Drainage Collection System

Once post reclamation monitoring indicates that the liquid discharge rate from the reclaimed heap becomes sufficiently low or ceases, as determined by LC 24.0, the collection drains will be sealed by grouting the discharge lines from points at which they exit the reclamation cover.

Grouting will be accomplished by exposing the discharge pipes selected for sealing. The discharge pipes will be cut and sealed by one of the following methods as approved by the Division:

1. Install 90° elbow and riser pipe to an elevation determined by the Design Engineer as adequate to facilitate sealing of the specific drainage collection pipe. A flowable expansive grout mixture will be poured into the riser pipe to refusal. The

expansive grout mixture will be established by the Design Engineer prior to sealing of the discharge pipe. Once the grout has set the riser pipe will be removed and the excavation backfilled in accordance with these specifications.

2. Pressure grouting equipment may be installed and utilized for sealing of the drainage collection lines. Grouting mixtures and pressures will be established by the Design Engineer for each specific application. Once the grout has set the excavation will be backfilled in accordance with these specifications.

3. Other as yet to be determined method.

7.0 COVER CONSTRUCTION

The reclamation cover will be constructed on the reshaped heap to the lines and grades established on Drawings M-123 and M-126.

7.1 Work Items

- Placement and compaction of clayey soil layer.
- Placement and compaction of random fill layer.
- Placement of bedding and erosion protection materials.

7.2 Clayey Soils Layer

The clayey soils layer of the closure cover will be placed and compacted on the graded heap surface and Final Phase closure cell(s) cover as shown on the drawings. Final grading of the contaminated materials surface will be accomplished in accordance with Sections 6.2 and 6.3 prior to placement of the clayey soil layer.

7.2.1 Material

The clayey soil layer will be constructed from clayey soils excavated from alluvial or alluvial fan materials located along the Yampa River. Brush, roots, sod or other perishable, unsuitable materials will be removed from the alluvial soils as far as practicable.

The materials will have at least 30 percent materials passing the No. 200 sieve (based on minus #4 fraction) and will have a maximum size of six inches. Liquid limit of the material will be at the least 25 percent with a minimum plasticity index of 10. Clayey soils utilized for this layer must exhibit a remolded laboratory hydraulic conductivity of 1E-7 centimeters/second when placed and compacted in accordance with the Plans and Specifications. Clayey materials that do not meet the Atterberg limit criteria may be used provided the material has diffusion coefficients and emanation coefficients that will reduce radon emanation rates to acceptable levels.

7.2.2 Placement and Compaction

The placement areas and thicknesses for the clayey soils layer are shown on Drawing M-126. Distribution and gradations of materials in each layer will be, as far as practicable, free of lenses, pockets, streaks or layers of materials differing substantially in texture, gradation or moisture content from surrounding materials. Clayey soils utilized in construction of this layer will be placed in approximate horizontal lifts not exceeding six inches in thickness when compacted.

Clayey soils for this layer will be compacted to at least 95 percent of the Standard Proctor maximum density at a moisture content of between optimum and four percent above optimum as determined by ASTM D698.

As far as practicable, the soils will be brought to the proper moisture content prior to placement. Each layer of fill will be conditioned so that the moisture is uniform throughout the layer prior to and during compaction.

If the compacted surface of any layer of fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it will be moistened and/or reworked with a harrow, scarifier, or other suitable equipment to a sufficient depth to provide relatively uniform moisture content and a satisfactory bonding surface before the next layer of earthfill is placed. If the compacted surface of any layer of earthfill in place is too wet, due to precipitation, for proper compaction of the earthfill material to be placed thereon, it will be allowed to dry out, or reworked with harrow, scarifier, or other suitable equipment to reduce the moisture content to the required level. It will then be recompacted to the requirements.

No material will be placed in the fill layer when the materials on which the new material is to be placed is frozen or when ambient temperatures do not permit the placement or compaction of the materials to the specified density without developing frost lenses in the fill.

The surface of the clayey soil layer shall be protected from desiccation prior to placement of the random fill layer. Surface protection shall be accomplished by sprinkling or immediate placement of random fill soils.

7.2.3 Frequency of Quality Control Tests

Inspections and testing will be conducted in accordance with the approved Quality Plan and Construction Verification Program. The minimum frequency of quality control testing to be accomplished on the clayey soils layer will be as follows:

1. Field density and moisture tests (nuclear methods, ASTM D2922 and D3017) - one test per 500 cubic yards with a minimum of two tests taken for each day an appreciable amount of fill is placed (in excess of 150 cubic yards).

2. Field density and moisture tests (sand cone, ASTM D2216) - one test for every ten nuclear gauge tests.

3. Laboratory Compaction Characteristics of Soil (ASTM D698) - one test for every ten or fifteen field tests, depending on variability of materials.

4. One Point Proctor - one test for every five field density tests.

5. Gradation and Classification Testing (ASTM D422) - one test per 1000 cubic yards.

6. Atterberg Limits (ASTM D4318) - one test per day of significant material placement (in excess of 150 cubic yards).

7. Verification of layer thickness - performed on a grid of approximately 100 feet.

7.3 Random Fill Layer

The random fill layer of the closure cover will be placed and compacted on the completed clayey soil layer, the 5:1 slope below the heap liner, and over the clayey soil layer of the Final Phase closure cell(s) as shown on the drawings.

7.3.1 Material

Sandy overburden soils stockpiled from previous excavation of the Rob Pit will be used for construction of the random fill layer. Brush, roots, sod or other perishable, unsuitable materials will be removed from the overburden. This material will have a maximum particle size of eight inches. The location of the overburden soils stockpile is shown on Drawing M-121.

7.3.2 Placement and Compaction

The placement areas and thicknesses for the random fill soils layers are shown on Drawing M-126. Distribution and gradations of materials in each layer will be, as far as practicable, free of lenses, pockets, streaks or layers of materials differing substantially in texture, gradation or moisture content from surrounding materials. Soils utilized in construction of this layer will be placed in approximate horizontal lifts not exceeding twelve inches in thickness when compacted. Random fill soils shall be compacted to at least 95 percent of the Standard Proctor maximum density (ASTM D698) at a moisture content of between plus or minus two percent of the optimum moisture content.

If the compacted surface of any layer of fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it will be moistened and/or reworked with a harrow, scarifier, or other suitable equipment to a sufficient depth to provide relatively uniform moisture content and a satisfactory bonding surface before the next layer of earthfill is placed. If the compacted surface of any layer of earthfill in place is too wet, due to precipitation, for proper compaction of the earthfill material to be placed thereon, it will be allowed to dry or reworked with harrow, scarifier, or other suitable equipment to reduce the moisture content to the required level. It will then be recompacted to the requirements.

No material will be placed in the fill layer when the materials on which the new material is to be placed is frozen or when ambient temperatures do not permit the placement or compaction of the materials to the specified density without developing frost lenses in the fill.

7.3.3 Frequency of Quality Control Tests

Inspections and testing will be conducted in accordance with Quality Plan and Construction Verification Program. The minimum frequency of quality control testing to be accomplished on the random fill layer will be as follows:

1. Field density and moisture tests (nuclear methods, ASTM D2922 and D3017) - one test per 500 cubic yards with a minimum of two tests taken for each day an appreciable amount of fill is placed (in excess of 150 cubic yards).
2. Field density and moisture tests (sand cone, ASTM D2216) - one test for every ten nuclear gauge tests.
3. Laboratory Compaction Characteristics of Soil (ASTM D698) - one test for every ten or fifteen field tests, depending on variability of materials.
4. One Point Proctor - one test for every five field density tests.
5. Gradation and Classification Testing (ASTM D422) - one test per 2000 cubic yards.
6. Atterberg Limits (ASTM D4318) - one test per 2000 cubic yards.
7. Verification of layer thickness - performed on a grid of approximately 100 feet.

7.4 Verification of Radon Flux

Once cover construction on the heap has been completed the exit flux will be verified utilizing Large Area Activated Charcoal Canister (LAACC) units to measure the rate of radon release from the heap. This verification procedure will be performed in accordance with National Pollution Standards for Hazardous Air Pollutants 40 CFR Part 61.

7.5 Erosion Protection Materials

The source of rock will be the Steele Quarry located approximately 6 miles southwest of the Maybell Heap Leach Facility. The required gradation for erosion protection materials will be controlled during processing at the quarry site. Testing to verify that specified erosion protection materials are being delivered to the site will be performed upon delivery to the site in accordance with Quality Plan and Construction Verification Program. A summary of erosion protection materials, placement locations and thicknesses, are shown on Table 2.4.1-1 and on Drawing M-126.

The durability of erosion protection materials will be tested in accordance with Section 7.5.2 and evaluated based on criteria established in the NRC/STP *Design of Erosion*

Protection Covers for Stabilization of Uranium Mill Tailings Sites, Appendix D (August, 1990). The "rating" or "scoring" resulting from this evaluation must exceed 80 for acceptance of the rock material. Erosion protection materials scoring below 80 will be rejected or evaluated with applicable oversizing criteria prior to acceptance.

7.5.1 Placement

Erosion protection materials will be placed to the lines and grades established on the drawings. Erosion protection materials will be hauled to the graded slope and end-dumped in a manner to minimize segregation of material. The material will then be placed by dozer or excavator in a single lift. Placement of the rocks will be conducted so as to minimize accumulation of sizes less than the minimum D_{50} size and nesting of the larger sized rock. The erosion protection layer will be constructed starting at the base of the perimeter slope and have at least two passes by a D-7 dozer or equivalent in order to key the rock for stability.

7.5.2 Frequency of Quality Control Tests

Inspections and testing will be conducted in accordance with Quality Plan and Construction Verification Program. The minimum frequency of quality control testing to be performed on erosion protection materials shall be as follows:

1. Rock Durability Tests (specific gravity, absorption, soundness and abrasion) - one test series performed for each type of riprap when approximately one-third and two-thirds of the total volume of each type of riprap have been delivered. For any type of riprap where volume is greater than 30,000 cy, rock durability tests will be performed for each additional 10,000 cy.

2. Rock Gradation - one test series performed for each type of riprap when approximately one-third and two-thirds of the total volume of each type of riprap have been delivered. For any type of riprap where volume is greater than 30,000 cy, a series shall be performed for each additional 10,000 cy.

3. Verification of layer thickness - performed on a grid of approximately 100 feet.

8.0 SURFACE WATER RUNOFF CONTROL FACILITIES

Surface runoff control facilities will be constructed in accordance with the designs presented on Drawings M-123, M-125 and M-126. Surface runoff will be controlled by a central collection channel (Channel No. 1) and perimeter drainage channels (Channel Nos. 2, 3, 4 and 5).

8.1 Work Items

- Construction of Channel No. 1 on the top and sideslopes of the heap.
- Construction of Channel Nos. 2, 3, 4 and 5 on the perimeter of the repository.
- Grading or filling of soils to facilitate site drainage.

8.2 Channel Construction

Channels will be constructed to the location, lines and grades shown on the drawings. Minor modifications to channel alignments may be performed to the extent necessary to facilitate construction in the field.

8.2.1 Clearing, Grubbing and Stripping

The area to be occupied by the perimeter drainage channels will be stripped of topsoil to a sufficient depth to remove all unsuitable materials. All materials that are unsuitable for use in permanent construction of the channels will be removed in so far as practicable. Materials from clearing, grubbing and stripping will be managed as described in Section 5.0.

8.2.2 Excavation

Excavation for the channels will be constructed to the lines, grades and dimensions shown on the Drawings M-123, M-125 and M-126. The alignments and excavation lines on the drawings are subject to minor changes as may be found necessary to adapt the channels to the conditions disclosed by the excavation. Final channel excavation will be cleaned of all loose or soft materials and trimmed to dimensions shown on the drawings prior to placement of erosion protection materials.

8.2.3 Foundation Preparation

Areas along the channel alignments requiring fill placement will be prepared by filling all cavities, depressions and irregularities which extend below or beyond the established lines of the structure. The foundation for the earthfill will be prepared by leveling, moistening, scarifying and compacting so that surface materials of the foundation will be stable and will provide a satisfactory surface for placement of erosion protection materials.

8.2.4 Fill Placement

Fill soils will conform to the Random Fill Material requirements specified in Section 7.3. Fill soils will be placed and compacted to the lines and grades shown on the drawings and in accordance with Section 7.3.2 of the specifications.

8.3 Riprap Placement

Channel Nos. 1, 2, 3, 4 and 5 will all be lined with riprap.

Design sections and riprap specifications for the structure are shown on Drawings M-125 and M-126. Riprap will be processed, placed and tested in accordance with Section 7.4 of the specifications.

9.0 MONITORING DEVICES

9.1 Erosion and Surface Movement Moments

Monitoring devices will be installed on and adjacent to the repository in order to monitor the performance of the reclamation design during the long-term surveillance of the facility.

The approximate location of the erosion and surface movement monuments are as shown on Drawing M-123. The final locations shall be determined in the field based on access and site conditions. The erosion monuments shall be constructed to the size and dimensions shown in Detail 6 on Drawing M-126.

APPENDIX A
TABLE OF CONTENTS

APPENDIX A-1

DESIGN STORM

Umetco Minerals Corporation
Maybell Heap Reclamation Plan
Appendix A-1

Design Storm:

The major long-term risk to stability of the reclaimed facility is from erosive forces due to flood events. the occurrence of a Probable Maximum Precipitation (PMP) event over a watershed will produce a Probable Maximum Flood (PMF) which is the most critical case for designing the reclamation cover.

The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local PMP storm results in high peak flows of very short duration. A general PMP storm results in much lower peak flows than the local storm, but has a higher total volume of runoff. The 1-hour, local PMP storm for the Maybell site was determined with data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches.

Reclamation Plan for the Maybell Heap Leach Facility, Umetco Minerals Corporation, January 23, 1989.

WESTERN ENGINEERS
MAYBELL HEAPS
WO #2248
NOV 1988

8.1.1 PROBABLE MAXIMUM PRECIPITATION *

* Determined from HMR 49

A. SITE LOCATION:

ELEVATION: 6200 FT MSL
LONGITUDE 108° 01' W
LATITUDE 40° 32' 33" N

B. LOCAL STORM PMP

1 hR – 1 mi² 7.05 INCH

TIME INCREMENT	0-15	15-30	30-45	45-60
PRECIP. DEPTH	5.22	1.05	0.43	0.35

C. GENERAL STORM PMP

AUGUST IS CRITICAL MONTH

DEPTH / DURATION FOR AUGUST

HR	6	12	18	24	48	72
DEPTH	5.7	7.1	8.3	9.3	12.0	13.2

LOCAL STORM IS CRITICAL STORM FOR Maybell SITE

WESTERN ENG.
MAYBELL HEAPS
WO 2248
NOV 1983
2 of.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Drainage Umetco Maybell Heap Leach Area 1 mi² (km²)
Latitude 40°32'30"N Longitude 108° 01'W Minimum Elevation 6200 ft (m)

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi² (2.6-km²) PMP for drainage [fig. 4.5]. 7.5 in. (mm)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 94 %

   b. Multiply step 1 by step 2a. 7.05 in. (mm)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.22

	Duration (hr)									
	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	.74	.89	.95	100	110.4	116.2	117.4	120.3	122	%
5. 1-mi² (2.6-km²) PMP for indicated durations [step 2b X step 4].	5.22	6.27	6.70	7.05	7.78	8.19	8.42	8.52	8.60	in. (mm)
6. Areal reduction [fig. 4.9].	100% →									%
7. Areal reduced PMP [steps 5 X 6].										in. (mm)
8. Incremental PMP [successive subtraction in step 7].				3 (4) 7.05	4 (3) .73	2 (5) .41	5 (2) .23	1 (6) .10	6 (1) .08	in. (mm)
	1 5.22	2 1.05	3 .43	.35	} 15-min. increments					

9. Time sequence of incremental PMP according to:

   Hourly increments [table 4.7]. (.08)(.23)(.73)(7.05)(.41)(.10) (U.S. COE)
   .10 .41 7.05 .73 .23 .08 in. (mm) (HMR-5)

   Four largest 15-min. increments [table 4.8]. 5.22 1.05 .43 .35 in. (mm)

WEI
WO 2248
Nov 08
3 of

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage Maybell Hemp Leach Area 1 (mi²) (km²)
Latitude 40° 32' 20" N Longitude 108° 01' W of basin center

Month July

Step		6	12	18	24	48	72	
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	13.3 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18]	45 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	6.0 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		69	86	94	100	115	121	%
5. Convergence PMP for indicated durations [steps 3 X 4]		4.1	5.2	5.6	6.0	6.9	7.3	in. (mm)
6. Incremental 10 mi² (26 km²) PMP [successive subtraction in step 5]		4.1	1.1	.4	.4	.9	.4	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]		100%						%
8. Areally reduced PMP [step 6 X step 7]								in. (mm)
9. Drainage average PMP [accumulated values of step 8]		4.1	5.2	5.6	6.0	6.9	7.3	in. (mm)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d.	3 in. (mm)							
2. Areal reduction [figure 3.20]	100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	103 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	3.1 in. (mm)							
5. Durational variation [table 3.9 3.6]		30	57	80	100	159	187	%
6. Orographic PMP for given durations [steps 4 X 5]		.9	1.8	2.5	3.1	4.9	5.8	in. (mm)
C. Total PMP								
1. Add steps A9 and B6		5.0	7.0	8.1	9.1	11.8	13.1	in. (mm)

2. PMP for other durations from smooth curve fitted to plot of computed data.

3. Comparison with local-storm PMP (see sec. 6.3).

WEI
WO 2248
Nov 88
4of

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage Maybell Head Launch   Area 1 (mi²) (km²)

Latitude 40°32', Longitude 108°00' of basin center

Month Aug

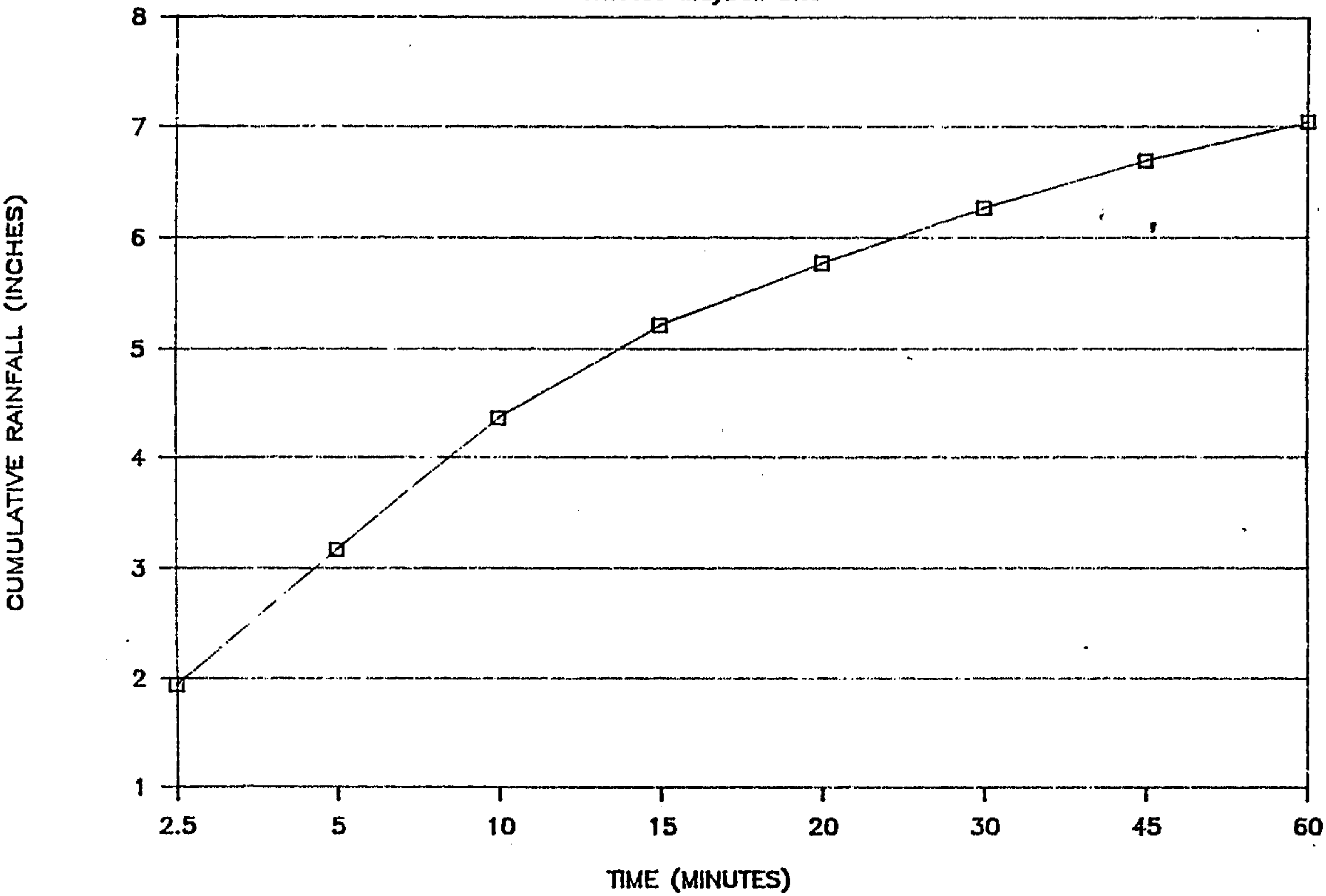
Step		6	12	18	24	48	72	
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	13.9 in. (mm) (13.6 sept)							
2. Reduction for barrier-elevation [fig. 2.18]	45 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	6.3 in. (mm) 6.1 sept							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		69	86	94	100	115	121	% (.69 sept)
5. Convergence PMP for indicated durations [steps 3 X 4]	(4.2)	4.3	5.4	5.9	6.3	7.2	7.6	in. (mm)
6. Incremental 10 mi² (26 km²) PMP [successive subtraction in step 5]		4.3	1.1	.5	.4	.9	.4	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]		100%						%
8. Areally reduced PMP [step 6 X step 7]								in. (mm)
9. Drainage average PMP [accumulated values of step 8]	4.2	4.3	5.4	5.9	6.3	7.2	7.6	in. (mm)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d.	3 in. (mm) 3 sept							
2. Areal reduction [figure 3.20]	100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	102 % (100% sept)							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	3 in. (mm)							
5. Durational variation [table 3.9 3.6]		30	57	80	100	159	187	%
6. Orographic PMP for given durations [steps 4 X 5]		.9	1.7	2.4	3	4.8	5.6	in. (mm)
C. Total PMP								
1. Add steps A9 and B6	(5.1)	5.2	7.1	8.3	9.3	12.0	13.2	in. (mm)

2. PMP for other durations from smooth curve fitted to plot of computed data.

3. Comparison with local-storm PMP (see sec. 6.3).

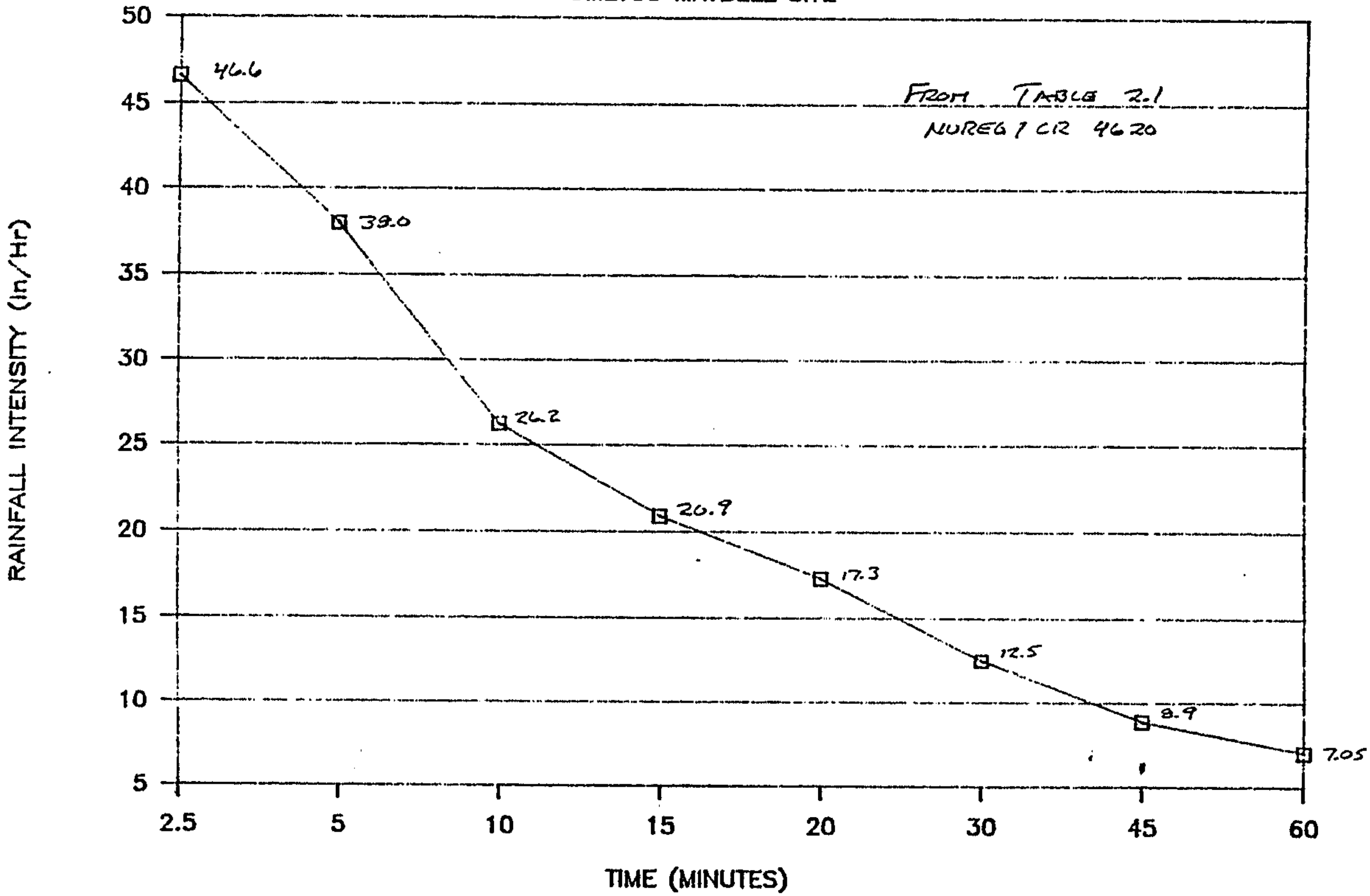
RAINFALL DEPTH/DURATION

Umetco Maybell Site



RAINFALL DURATION/INTENSITY CURVE

UMETCO MAYBELL SITE



APPENDIX A-2

EROSION PROTECTION FOR TOP OF HEAP RECLAMATION COVER

Maybell Reclamation Project - Design of Erosion Protection

- Design Reference: Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, U.S. Nuclear Regulatory Commission, August 1990.

- PMP Determination: "The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local PMP storm results in high peak flows of very short duration. A general PMP storm results in much lower peak flows than the local storm, but has a higher toral volume of runoff. The 1-hour, local PMP storm for the Maybell site was determined with the data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches." (Section 6.6.1, page 17, Reclamation Plan for Maybell Heap Leach Facility, Umetco Minerals Corporation, January 23,1989)

Erosion Protection for Top of Heap:

Rock Mulch Design is based on D_{50} rock sized as determined by procedures given in Appendix D, NRC STP; the designs are similar because ther is no clear-cut distinction between the riprap layer and a layer of rock mulch.

Design Data:

Top Slope of Reclamation Cover = 1%
Maximum Flow Length = 550 ft.
PMP = 7.05 inches
Design Method - Safety Factors Method

Design D_{50} = 0.6 inches

Design Gradation based on methods for determination of Riprap grading recommended by Corps of Engineers and NUREG/CR-4480.

Percent Passing (Finer)	Size Range (inches)
Maximum Size	3"
D_{50}	$^3/_8$" to 1 $^1/_2$"
D_{15}	#4 to $^3/_4$"

RIPRAP DESIGN:
Safety Factors Method for Slopes Less than 10%

Project: **Maybell Heap Reclamation**

Hydrology:

Length of Slope (L)	550	feet	
Elevation Difference (H)	5.5	feet	
PMP	7.05	inches	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	3	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	
Slope	0.01	ft/ft	
Slope (angle from horizontal)	0.57	degrees	
Area (unit-width basis)	0.01	acres	
Time of Concentration (tc)	0.10	hours	(SCS Triangular Hydrograph Theory)
	5.92	minutes	
% of 1-hour PMP	48.14	%	
PMP rainfall depth	3.39	inches	
Rainfall Intensity (i)	34.37	inches/hour	
Peak Flow Rate (q)	1.30	cfs/ft	Rational Formula for unit width analysis)

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	35	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
D_{50} of Riprap	0.6	inches (Input Trial Riprap D_{50})
Cover Slope	0.57	degrees
Mannings Coefficient	0.0240	
Depth of Flow	0.3921	feet
Bed Shear Stress	0.2447	lbs/sq. ft.
Stability Number	0.9802	
Safety Factor =	**1.0055**	

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

Rainfall Duration (min)	% of 1-hour PMP	
2.5	27.5	0.00
5	45	0.00
10	62	48.14
15	74	0.00
20	82	0.00
45	95	0.00
60	100	0.00

48.14

Riprap Gradation - Corps of Engineers Method

Specific Gravity =	2.68	
Design D_{50} =	0.6	inches
Design W_{50} =	.0109	lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	.0219	.0547
W_{50}	.0109	.0365
W_{15}	.0034	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	.7562	1.0262	(layer thickness)	19.21	26.07
D_{50}	.6002	.8965	(layer thickness/1.5)	15.24	22.77
D_{15}	.4073	*		10.35	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

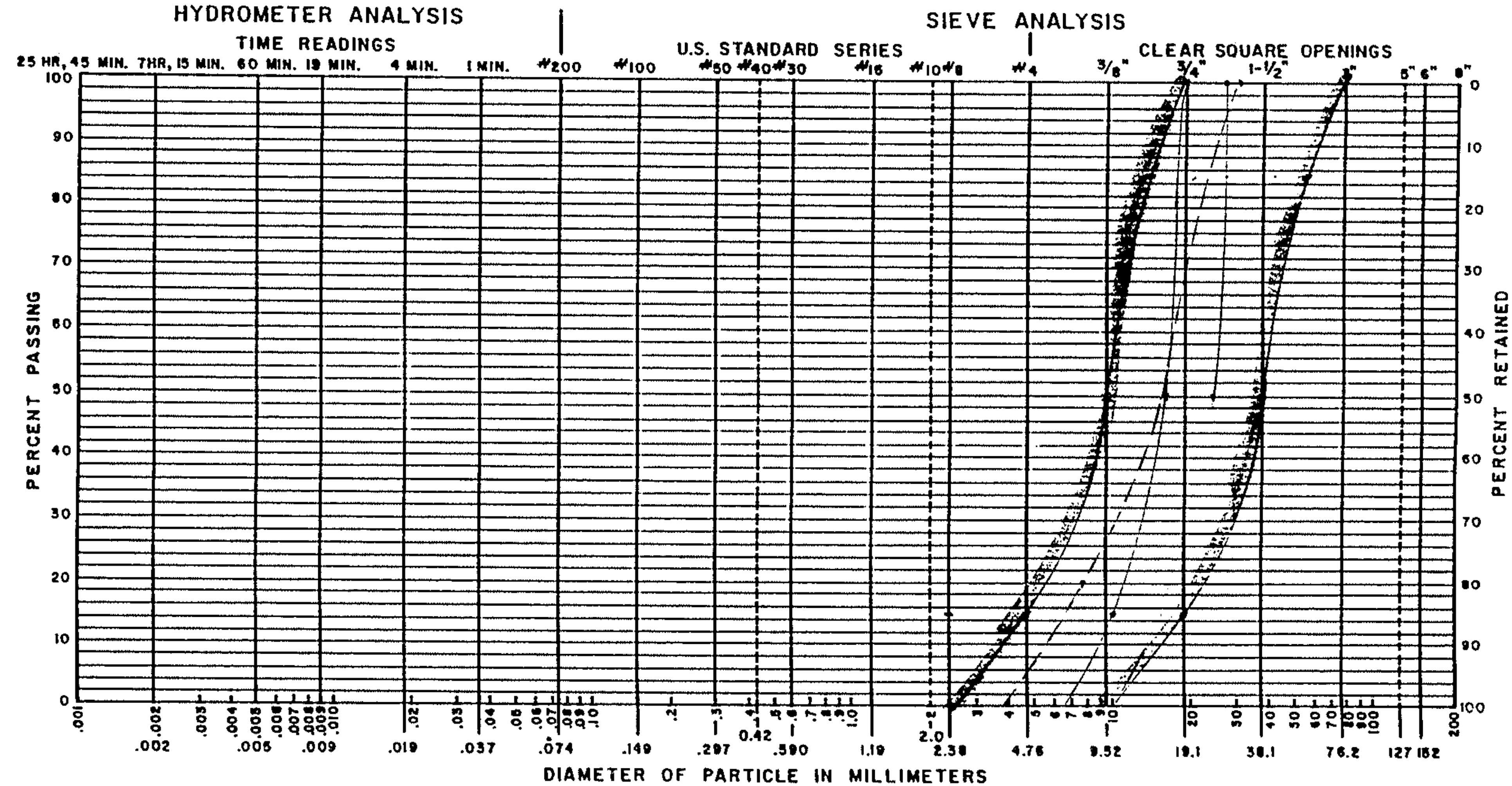
Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 0.6 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	1.2	30.48
D_{50}	0.6	15.24
D_{20}	0.3	7.62

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ——— CORPS OF ENGINEERS
— — — NUREG/CR-4480

CONCEPTUAL DESIGN OF ROCK MULCH BASED ON 1% SLOPE, FLOW LENGTH = 550'

maximum size = 3",
D_{50} = 3/8" to 1½" (conservative design 3/4" to 1½")
D_{15} = #4 to 3/4" (conservative design 3/8" to 3/4")

DESIGNATION ______ EXCAVTION NO. ______ DEPTH (FT.) ______ rock mulch layer thickness = 3" to 6"

APPENDIX A-3

EROSION PROTECTION FOR 5:1 SIDESLOPES OF RECLAIMED HEAP

Maybell Reclamation Project - Design of Erosion Protection

- Design Reference: Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, U.S. Nuclear Regulatory Commission, August 1990.

- PMP Determination: "The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local PMP storm results in high peak flows of very short duration. A general PMP storm results in much lower peak flows than the local storm, but has a higher toral volume of runoff. The 1-hour, local PMP storm for the Maybell site was determined with the data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches." (Section 6.6.1, page 17, Reclamation Plan for Maybell Heap Leach Facility, Umetco Minerals Corporation, January 23,1989)

Erosion Protection for 5:1 Side Slopes:

Riprap Design is based on D_{50} rock sized as determined by procedures given in Appendix D, NRC STP.

Design Data:

Side Slope of Reclamation Cover = 20%
Maximum Flow Length = 400 ft.
PMP = 7.05 inches
Design Method - Stephenson Method

Design D_{50}:

Slope Length	Calculated D_{50}
100	5.30"
200	5.89"
300	6.27"
400	6.55"

Design Gradation based on methods for determination of Riprap grading recommended by Corps of Engineers and NUREG/CR-4480.

Percent Passing (Finer)	**Size Range (inches)**
Maximum Size	**9"**
D_{50}	**5" to 8"**
D_{15}	**3" to 6"**

RIPRAP DESIGN:
Stephenson Method for Slopes Greater than 10%

Project: Maybell Heap Reclamation
Date: May 25,1994

Hydrology:

Length of Slope (L)	100	feet	
Elevation Difference (H)	20	feet	
PMP	7.05	inches	(enter 0 if not PMP application)
Runoff Coefficient	1	Recommended runoff coefficient of 1 be used for PMF applications. (refer to NUREG CR-4620, section 4.8.1)	
Flow Concentration Factor	3	Enter 0 if Flow Concentration Factor is not utilized. (refer to page 68, NUREG/CR-4620; Flow Concentration Factor of 3 is recommended, see discussion below)	
Slope	0.20	ft/ft	
Slope (angle from horizontal)	11.31	degrees	
Area (unit-width basis)	0.00	acres	
Time of Concentration (tc)	0.01	hours	(SCS Triangular Hydrogragh Theory)
	0.50	minutes	
% of 1-hour PMP	27.50		
PMP rainfall depth	1.94	inches	
Rainfall Intensity (i)	231.19	inches/hour	
Peak Flow Rate (q)	1.59	cfs/ft	Rational Formula for unit width analysis.

Riprap Design:

Rockfill Porosity (n)	0.4	
Relative Density of Rock (s)	2.68	
Angle of Friction	40	degrees
Empirical Factor (C)	0.27	(varies from 0.22 for gravel and pebbles to 0.27 for crushed granite)

D50 = 0.44 feet
5.30 inches

TYPICAL VALUES:

Porosity of Rock Layer (n)	0.39 to 0.46
Angle of Friction	37 to 42
Relative Density of Rock (s):	
Limestone -	2.42 to 2.74
Limy Sandstone -	2.14 to 2.67
Sandstone -	2.20 to 2.50
Quartzite -	2.66
Basalt -	2.58
Granite -	2.41

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

RIPRAP DESIGN:
Stephenson Method for Slopes Greater than 10%

Project: Maybell Heap Reclamation
Date: May 25,1994

Hydrology:

Length of Slope (L)	200	feet	
Elevation Difference (H)	40	feet	
PMP	7.05	inches	(enter 0 if not PMP application)
Runoff Coefficient	1	Recommended runoff coefficient of 1 be used for PMF applications. (refer to NUREG CR-4620, section 4.8.1)	
Flow Concentration Factor	3	Enter 0 if Flow Concentration Factor is not utilized. (refer to page 68, NUREG/CR-4620; Flow Concentration Factor of 3 is recommended, see discussion below)	
Slope	0.20	ft/ft	
Slope (angle from horizontal)	11.31	degrees	
Area (unit-width basis)	0.00	acres	
Time of Concentration (tc)	0.01	hours	(SCS Triangular Hydrogragh Theory)
	0.86	minutes	
% of 1-hour PMP	27.50		
PMP rainfall depth	1.94	inches	
Rainfall Intensity (i)	135.58	inches/hour	
Peak Flow Rate (q)	1.87	cfs/ft	Rational Formula for unit width analysis.

Riprap Design:

Rockfill Porosity (n)	0.4	
Relative Density of Rock (s)	2.68	
Angle of Friction	40	degrees
Empirical Factor (C)	0.27	(varies from 0.22 for gravel and pebbles to 0.27 for crushed granite)

D50 =	**0.49**	**feet**
	5.89	**inches**

TYPICAL VALUES:

Porosity of Rock Layer (n)	0.39 to 0.46
Angle of Friction	37 to 42
Relative Density of Rock (s):	
Limestone -	2.42 to 2.74
Limy Sandstone -	2.14 to 2.67
Sandstone -	2.20 to 2.50
Quartzite -	2.66
Basalt -	2.58
Granite -	2.41

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

RIPRAP DESIGN:
Stephenson Method for Slopes Greater than 10%

Project: Maybell Heap Reclamation
Date: May 25,1994

Hydrology:

Length of Slope (L)	300	feet	
Elevation Difference (H)	60	feet	
PMP	7.05	inches	(enter 0 if not PMP application)
Runoff Coefficient	1	Recommended runoff coefficient of 1 be used for PMF applications. (refer to NUREG CR-4620, section 4.8.1)	
Flow Concentration Factor	3	Enter 0 if Flow Concentration Factor is not utilized. (refer to page 68, NUREG/CR-4620; Flow Concentration Factor of 3 is recommended, see discussion below)	
Slope	0.20	ft/ft	
Slope (angle from horizontal)	11.31	degrees	
Area (unit-width basis)	0.01	acres	
Time of Concentration (tc)	0.02	hours	(SCS Triangular Hydrogragh Theory)
	1.17	minutes	
% of 1-hour PMP	27.50		
PMP rainfall depth	1.94	inches	
Rainfall Intensity (i)	99.22	inches/hour	
Peak Flow Rate (q)	2.05	cfs/ft	Rational Formula for unit width analysis.

Riprap Design:

Rockfill Porosity (n)	0.4	
Relative Density of Rock (s)	2.68	
Angle of Friction	40	degrees
Empirical Factor (C)	0.27	(varies from 0.22 for gravel and pebbles to 0.27 for crushed granite)

D50 = 0.52 feet
6.27 inches

TYPICAL VALUES:

Porosity of Rock Layer (n)	0.39 to 0.46
Angle of Friction	37 to 42
Relative Density of Rock (s):	
Limestone -	2.42 to 2.74
Limy Sandstone -	2.14 to 2.67
Sandstone -	2.20 to 2.50
Quartzite -	2.66
Basalt -	2.58
Granite -	2.41

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

RIPRAP DESIGN:
Stephenson Method for Slopes Greater than 10%

Project: Maybell Heap Reclamation
Date: May 25,1994

Hydrology:

Length of Slope (L)	400	feet	
Elevation Difference (H)	80	feet	
PMP	7.05	inches	(enter 0 if not PMP application)
Runoff Coefficient	1	Recommended runoff coefficient of 1 be used for PMF applications. (refer to NUREG CR-4620, section 4.8.1)	
Flow Concentration Factor	3	Enter 0 if Flow Concentration Factor is not utilized. (refer to page 68, NUREG/CR-4620; Flow Concentration Factor of 3 is recommended, see discussion below)	
Slope	0.20	ft/ft	
Slope (angle from horizontal)	11.31	degrees	
Area (unit-width basis)	0.01	acres	
Time of Concentration (tc)	0.02	hours	(SCS Triangular Hydrogragh Theory)
	1.46	minutes	
% of 1-hour PMP	27.50		
PMP rainfall depth	1.94	inches	
Rainfall Intensity (i)	79.50	inches/hour	
Peak Flow Rate (q)	2.19	cfs/ft	Rational Formula for unit width analysis.

Riprap Design:

Rockfill Porosity (n)	0.4	
Relative Density of Rock (s)	2.68	
Angle of Friction	40	degrees
Empirical Factor (C)	0.27	(varies from 0.22 for gravel and pebbles to 0.27 for crushed granite)

D50 = 0.55 feet
6.55 inches

TYPICAL VALUES:

Porosity of Rock Layer (n)	0.39 to 0.46
Angle of Friction	37 to 42
Relative Density of Rock (s):	
Limestone -	2.42 to 2.74
Limy Sandstone -	2.14 to 2.67
Sandstone -	2.20 to 2.50
Quartzite -	2.66
Basalt -	2.58
Granite -	2.41

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

Riprap Gradation - Corps of Engineers Method

Specific Gravity = 2.68
Design D_{50} = 5.3 inches

Design W_{50} = 7.5440 lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	15.0880	37.7200
W_{50}	7.5440	25.1467
W_{15}	2.3575	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	6.6780	9.0631	(layer thickness)	169.62	230.20
D_{50}	5.3004	7.9175	(layer thickness/1.5)	134.63	201.10
D_{15}	3.5970	*		91.36	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 5.3 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	10.6	269.24
D_{50}	5.3	134.62
D_{20}	2.65	67.31

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.

Riprap Gradation - Corps of Engineers Method

Specific Gravity =	2.68		
Design D_{50} =	5.89	inches	
Design W_{50} =	10.3543	lbs	

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	20.7086	51.7714
W_{50}	10.3543	34.5143
W_{15}	3.2357	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	7.4213	10.0719	(layer thickness)	188.50	255.83
D_{50}	5.8904	8.7988	(layer thickness/1.5)	149.62	223.49
D_{15}	3.9974	*		101.53	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 5.89 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	11.78	299.212
D_{50}	5.89	149.606
D_{20}	2.945	74.803

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.

Riprap Gradation - Corps of Engineers Method

Specific Gravity = 2.68
Design D_{50} = 6.27 inches

Design W_{50} = 12.4904 lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	24.9808	62.4521
W_{50}	12.4904	41.6347
W_{15}	3.9033	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	7.9000	10.7217	(layer thickness)	200.66	272.33
D_{50}	6.2704	9.3664	(layer thickness/1.5)	159.27	237.91
D_{15}	4.2553	*		108.08	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:
1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 6.27 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	12.54	318.516
D_{50}	6.27	159.258
D_{20}	3.135	79.629

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.

Riprap Gradation - Corps of Engineers Method

Specific Gravity = 2.68

Design D_{50} = 6.55 inches

Design W_{50} = 14.2396 lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	28.4792	71.1981
W_{50}	14.2396	47.4654
W_{15}	4.4499	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	8.2528	11.2004	(layer thickness)	209.62	284.49
D_{50}	6.5504	9.7846	(layer thickness/1.5)	166.38	248.53
D_{15}	4.4453	*		112.91	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

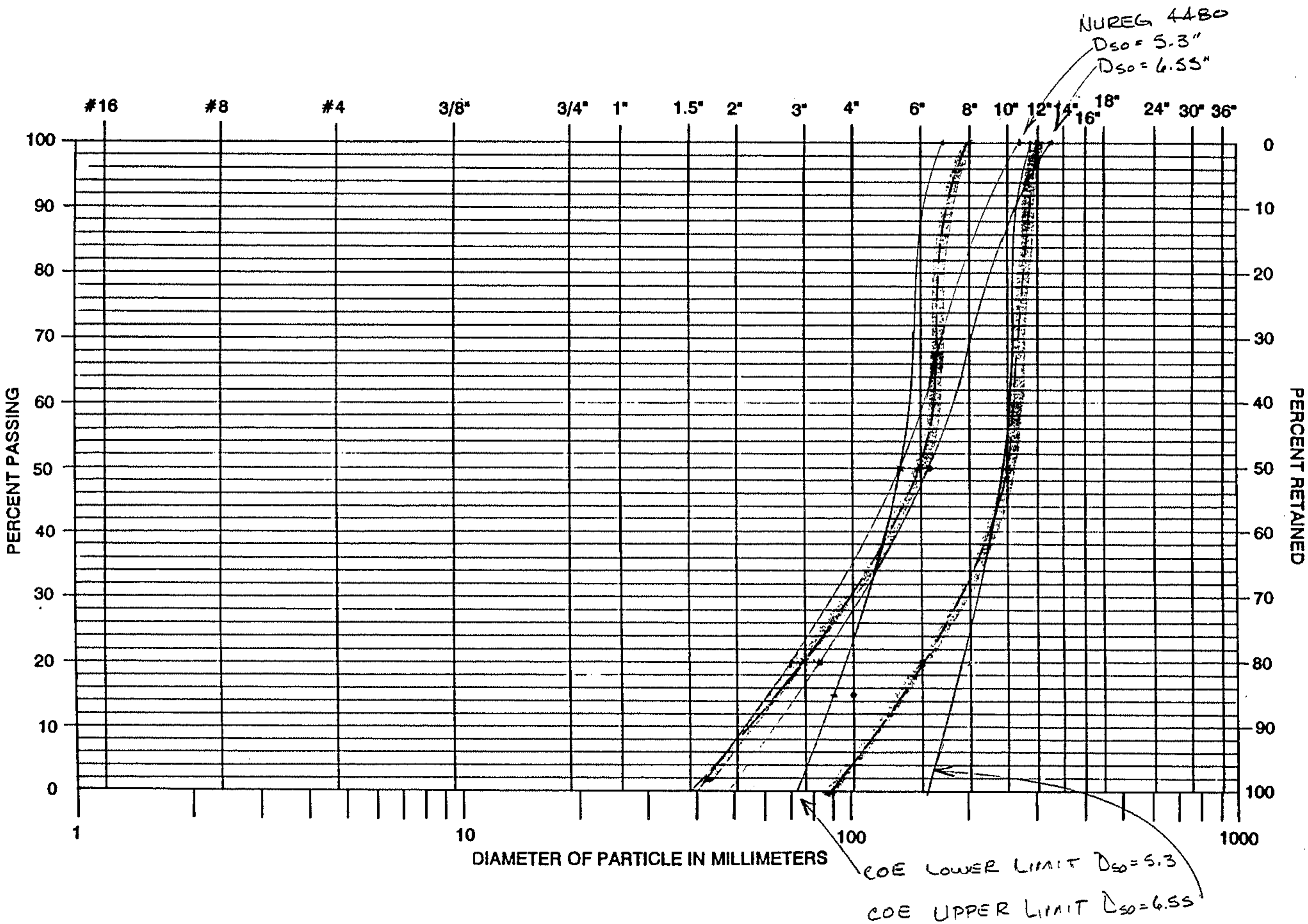
Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 6.55 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	13.1	332.74
D_{50}	6.55	166.37
D_{20}	3.275	83.185

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.



NUREG 4480
D50 = 5.3"
D50 = 6.55"
#16
#8
#4
3/8"
3/4"
1"
1.5"
2"
3"
4"
6"
8"
10"
12"
14"
16"
18"
24"
30"
36"
PERCENT PASSING
PERCENT RETAINED
DIAMETER OF PARTICLE IN MILLIMETERS
1
10
100
1000
COE LOWER LIMIT D50 = 5.3
COE UPPER LIMIT D50 = 6.55

APPENDIX A-4

HYDROLOGY, SIZING AND DESIGN OF EROSION PROTECTION FOR CHANNELS

CHANNEL NO. 1

- Design Reference: Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, U.S. Nuclear Regulatory Commission, August 1990.

- PMP Determination: "The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local PMP storm results in high peak flows of very short duration. A general PMP storm results in much lower peak flows than the local storm, but has a higher toral volume of runoff. The 1-hour, local PMP storm for the Maybell site was determined with the data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches." (Section 6.6.1, page 17, Reclamation Plan for Maybell Heap Leach Facility, Umetco Minerals Corporation, January 23,1989)

Erosion Protection Channel Discharging from Top of Heap: (Segment 1)

Riprap Design is based on D_{50} rock sized as determined by procedures given in Appendix D, NRC STP.

Design Data:

Channel Slope = .0054 ft/ft
Drainage Area = 30.10 acres
Length of Slope = 1580 ft.
Cover Slope = 0.01 ft/ft
PMP = 7.05 inches
Design Method - Safety Factors Method

Peak Flow Rate (q) = 625.61 cfs

Design D_{50} = 2.5 inches

Design Gradation based on methods for determination of Riprap grading recommended by Corps of Engineers and NUREG/CR-4480.

Percent Passing (Finer)	Size Range (inches)
Maximum Size	6"
D_{50}	2" to 5"
D_{15}	3/4" to 3"

RIPRAP DESIGN FOR CHANNELS Date:

Safety Factors Method

Work sheet to be utilized without hydrology calculations is on sheet 2 (below).

Project: Maybell - Channel (Top of Heap)

Hydrology:

Length of Slope (L)	1580	feet	
Elevation Difference (H)	11.5	feet	
PMP	7.05	inches	
Drainage Area	30.1	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.01	ft/ft	
Slope (angle from horizontal)	0.42	degrees	
Area	30.10	acres	
Time of Concentration (tc)	0.25	hours	(SCS Triangular Hydrograph Theory)
	15.09	minutes	
% of 1-hour PMP	74.14	%	
PMP rainfall depth	5.23	inches	
Rainfall Intensity (i)	20.78	inches/hour	
Peak Flow Rate (q)	625.61	cfs/ft	Rational Formula for unit width analysis)

Q for channel design

~~Riprap Design:~~

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	35	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	5.33	feet (from FlowMaster or channel design calculations)
D_{50} of Riprap	6	inches (Input Trial Riprap D_{50})

Channel Slope	0.42	degrees
Mannings Coefficient	0.0352	
Bed Shear Stress	2.4208	lbs/sq. ft.
Stability Number	0.9699	
Safety Factor =	**1.0201**	

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Flow Concentration Factor:

The Flow Concentration Factor is multiplied by the peak flow rate. Flow Concentration Factor is incorporated into the design process to account for cover modifications resulting from differential settlement, collapsing soils, marginal quality control in cover placement, erosion, major hydraulic events and monitoring disturbance. It is reasonable to assume that values between 2 and 3 are attainable with only a slight evolutionary chage in the cover.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Maybell - Channel (top of heap)

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0054 ft/ft
Discharge........	625.61 cfs

Computed Results:

Depth............	2.93 ft
Velocity.........	5.50 fps
Flow Area........	113.69 sf
Flow Top Width...	47.58 ft
Wetted Perimeter.	48.54 ft
Critical Depth...	2.20 ft
Critical Slope...	0.0148 ft/ft
Froude Number....	0.63 (flow is Subcritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date:

Project: Channel (top of heap)

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.93	feet (from FlowMaster or channel design calculations)
Channel Slope	0.0054	ft./ft.
D_{50} of Riprap	2.5	inches (Input Trial Riprap D_{50})
Channel Slope	0.31	degrees
Mannings Coefficient	0.0304	
Bed Shear Stress	0.9873	lbs/sq. ft.
Stability Number	0.9493	
Safety Factor =	**1.0463**	

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer s

Riprap Gradation - Corps of Engineers Method

Specific Gravity =	2.68	
Design D_{50} =	2.5	inches
Design W_{50} =	.7918	lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	1.5835	3.9588
W_{50}	.7918	2.6392
W_{15}	.2474	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	3.1502	4.2754	(layer thickness)	80.02	108.59
D_{50}	2.5004	3.7349	(layer thickness/1.5)	63.51	94.87
D_{15}	1.6968	*		43.10	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 2.5 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	5	127
D_{50}	2.5	63.5
D_{20}	1.25	31.75

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.

Riprap Gradation - Corps of Engineers Method

Specific Gravity = 2.68
Design D_{50} = 2.5 inches

Design W_{50} = .7918 lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	1.5835	3.9588
W_{50}	.7918	2.6392
W_{15}	.2474	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	3.1502	4.2754	(layer thickness)	80.02	108.59
D_{50}	2.5004	3.7349	(layer thickness/1.5)	63.51	94.87
D_{15}	1.6968	*		43.10	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

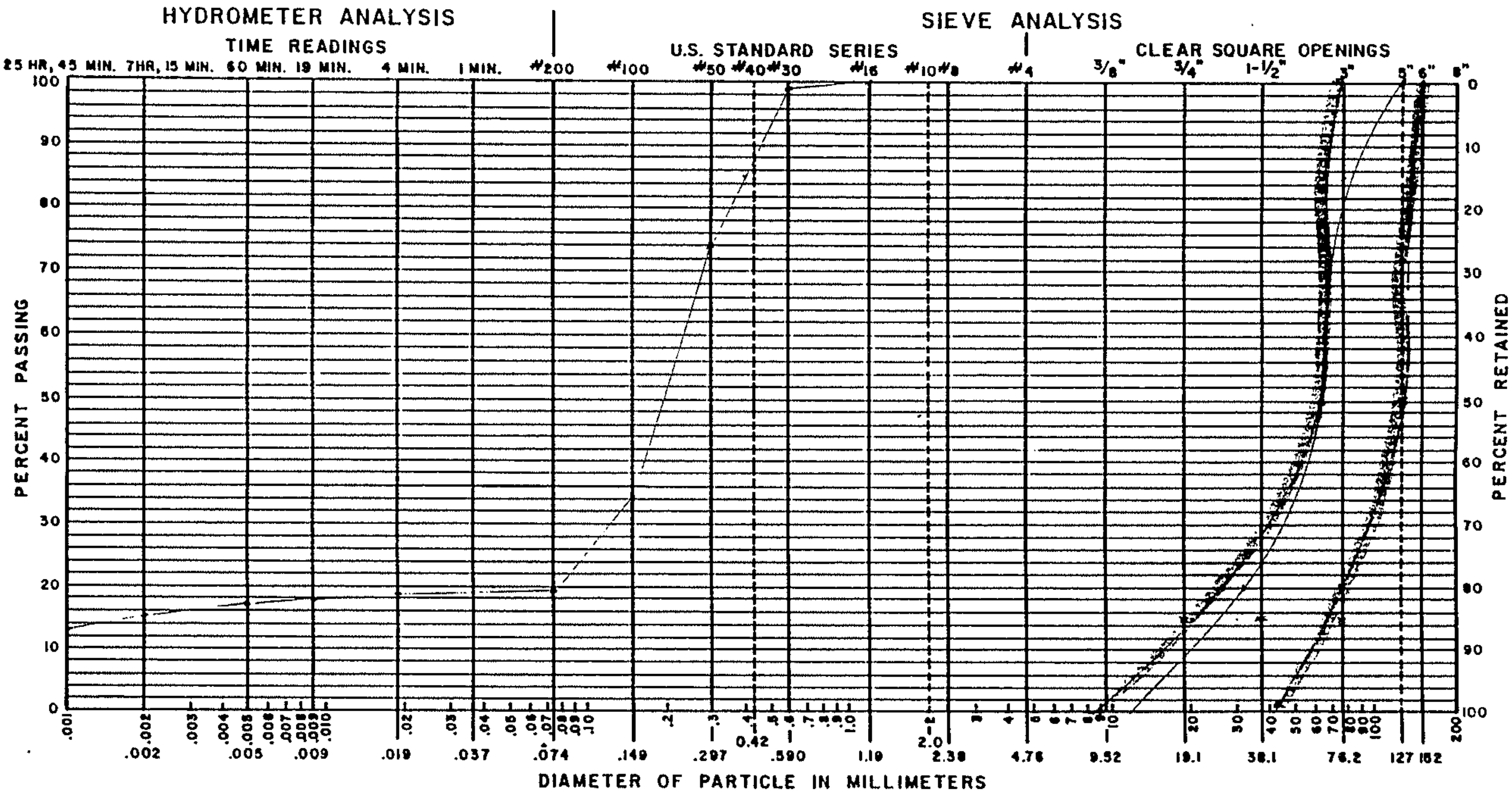
Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 2.5 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	5	127
D_{50}	2.5	63.5
D_{20}	1.25	31.75

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES:

DESIGNATION ______________ EXCAVTION NO. ______________ DEPTH (FT.) ______________

- Design Reference: Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, U.S. Nuclear Regulatory Commission, August 1990.

- PMP Determination: "The PMF at the Maybell site is caused by the Probable Maximum 1-hour local storm (thunderstorm). The high rainfall intensity associated with the local PMP storm results in high peak flows of very short duration. A general PMP storm results in much lower peak flows than the local storm, but has a higher toral volume of runoff. The 1-hour, local PMP storm for the Maybell site was determined with the data and procedure developed in the Hydrometeorological Report No. 49 (NOAA 1977). The 1-hour, local PMP storm is 7.05 inches." (Section 6.6.1, page 17, Reclamation Plan for Maybell Heap Leach Facility, Umetco Minerals Corporation, January 23,1989)

Erosion Protection Channel Discharging from Top of Heap: (Segment 2)

Riprap Design is based on D_{50} rock sized as determined by procedures given in Appendix D, NRC STP.

Design Data:

Channel Slope = 0.2000 ft/ft

PMP = 7.05 inches
Design Method - Safety Factors Method

Peak Flow Rate (q) = 625.61 cfs

Design D_{50} = 22.5 inches

Design Gradation based on methods for determination of Riprap grading recommended by Corps of Engineers and NUREG/CR-4480.

Percent Passing (Finer)	Size Range (inches)
Maximum Size	30"
D_{50}	18" to 24"
D_{15}	5" to 10"

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Maybell - Channel (5:1 side slopes)

Solve For Depth

Given Input Data:

Bottom Width.....	100.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.2000 ft/ft
Discharge........	625.61 cfs

Computed Results:

Depth............	0.56 ft
Velocity.........	11.09 fps
Flow Area........	56.43 sf
Flow Top Width...	103.33 ft
Wetted Perimeter.	103.51 ft
Critical Depth...	1.06 ft
Critical Slope...	0.0232 ft/ft
Froude Number....	2.64 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS Date:
Safety Factors Method

Project: Channel (5:1 side slope)

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	0.56	feet (from FlowMaster or channel design calculations)
Channel Slope	0.2	ft./ft.
D_{50} of Riprap	22.5	inches (Input Trial Riprap D_{50})

Channel Slope	11.31	degrees
Mannings Coefficient	0.0439	
Bed Shear Stress	6.9888	lbs/sq. ft.
Stability Number	0.7467	

Safety Factor = **1.0002**

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Riprap Gradation - Corps of Engineers Method

Specific Gravity = 2.68
Design D_{50} = 22.5 inches

Design W_{50} = 577.1940 lbs

	Lower Limit (lbs)	Upper Limit (lbs)
W_{100}	1154.3880	2885.9701
W_{50}	577.1940	1923.9801
W_{15}	180.3731	**

	Lower Limit (inches)	Upper Limit (inches)		Lower Limit (mm)	Upper Limit (mm)
D_{100}	28.3458	38.4700	(layer thickness)	719.98	977.14
D_{50}	22.4986	33.6071	(layer thickness/1.5)	571.46	853.62
D_{15}	15.2682	*		387.81	*

** The Upper Limit of W_{15} Stone should be less than the upper limit of W_{50} Stone to satisfy criteria for graded stone filters.

Layer Thickness:

1) Should not be less than the spherical diameter of the upper limit D_{100} stone or less than 1.5 times the upper limit D_{50} stone, whichever results in the greater thickness.
2) Should not be less than 12 inches for practical placement.

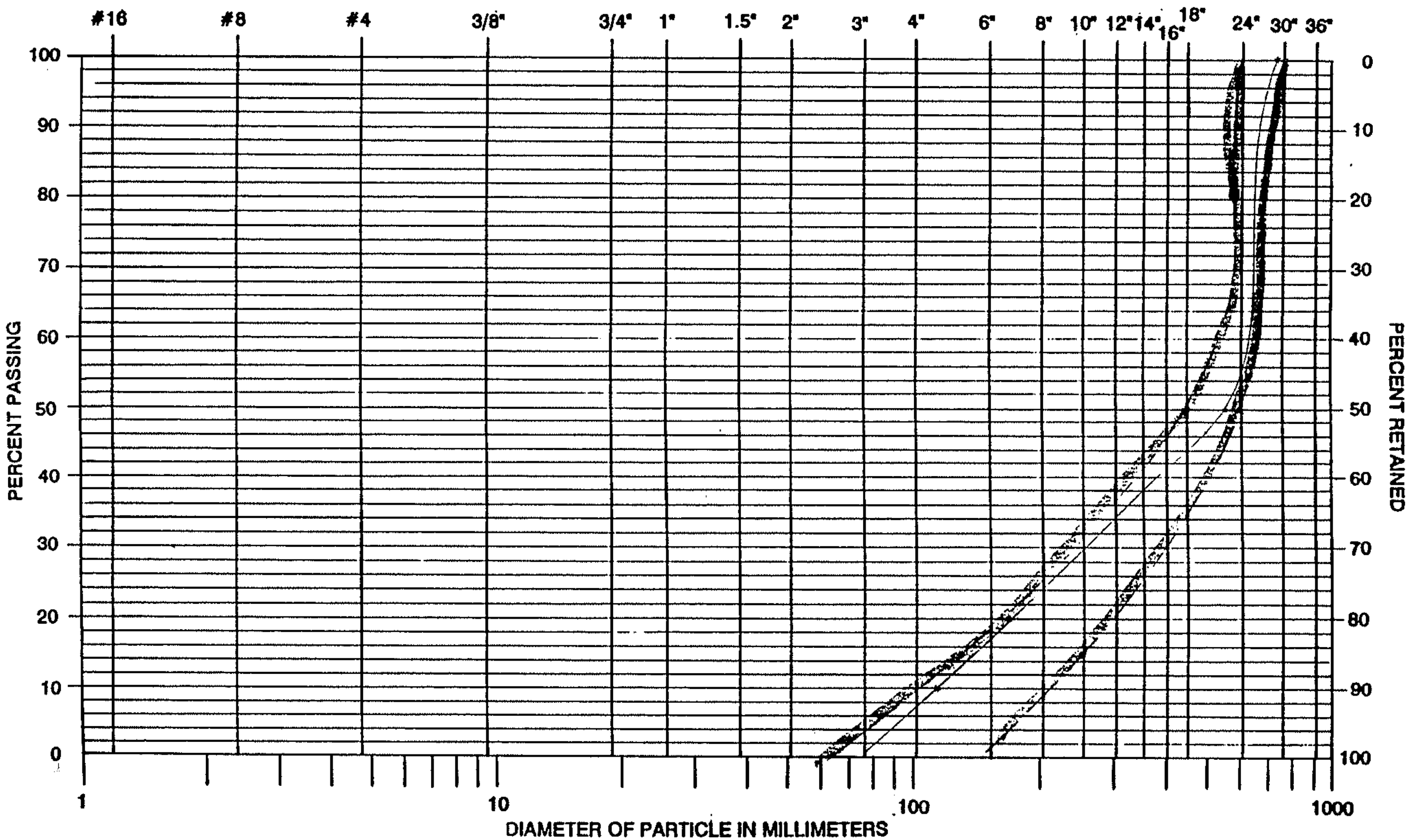
Riprap Gradation - NUREG/CR-4480 (page 30)

Design D_{50} = 22.5 Note: For D_{50} > than 18", refer to NUREG/CR-4480

	Lower Limit (inches)	Lower Limit (mm)
D_{max}	45	1143
D_{50}	22.5	571.5
D_{20}	11.25	285.75

Minimum thickness should be sufficient to accomodate the largest rock particle (D_{max}).

Refer to page 32 for filter and bedding requirements and design criteria.



#16
#8
#4
3/8"
3/4"
1"
1.5"
2"
3"
4"
6"
8"
10"
12"
14"
16"
18"
24"
30"
36"
PERCENT PASSING
PERCENT RETAINED
DIAMETER OF PARTICLE IN MILLIMETERS
1
10
100
1000

CHANNEL NO. 2

Small Basin Hydrology Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #1, sta 0+00 to 3+63.07

Hydrology:

Length of Slope (L)	900	feet	
Elevation Difference (H)	71	feet	
PMP	7.05	inches	
Drainage Area	12.7	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.08	ft/ft	
Slope (angle from horizontal)	4.51	degrees	
Area	12.70	acres	
Time of Concentration (tc)	0.07	hours	(SCS Triangular Hydrograph Theory)
	3.91	minutes	
% of 1-hour PMP	37.36	%	
PMP rainfall depth	2.63	inches	
Rainfall Intensity (i)	40.43	inches/hour	
Peak Flow Rate (q)	513.49	cfs	Rational Formula

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 2; Segment 1, sta 0+00 to 3+63.07

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0100 ft/ft
Discharge........	515.00 cfs

Computed Results:

Depth............	2.21 ft
Velocity.........	6.37 fps
Flow Area........	80.82 sf
Flow Top Width...	43.24 ft
Wetted Perimeter.	43.96 ft
Critical Depth...	1.95 ft
Critical Slope...	0.0153 ft/ft
Froude Number....	0.82 (flow is Subcritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #1, sta 0+00 to 3+63.07

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.21	feet (from FlowMaster or channel design calculations)
Channel Slope	0.01	ft./ft.
D_{50} of Riprap	3.36	inches (Input Trial Riprap D_{50})

Channel Slope	0.57	degrees
Mannings Coefficient	0.0319	
Bed Shear Stress	1.3790	lbs/sq. ft.
Stability Number	0.9866	

Safety Factor = 1.0014

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 2; Segment 2, sta 3+63.07 to 4+93.07

Solve For Depth

Given Input Data:

Bottom Width.....	50.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.1000 ft/ft
Discharge........	515.00 cfs

Computed Results:

Depth............	0.91 ft
Velocity.........	10.54 fps
Flow Area........	48.87 sf
Flow Top Width...	57.29 ft
Wetted Perimeter.	57.53 ft
Critical Depth...	1.43 ft
Critical Slope...	0.0216 ft/ft
Froude Number....	2.01 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #2, sta 3+63.07 to 4+93.07

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	0.91	feet (from FlowMaster or channel design calculations)
Channel Slope	0.1	ft./ft.
D_{50} of Riprap	15.6	inches (Input Trial Riprap D_{50})

Channel Slope	5.71	degrees
Mannings Coefficient	0.0413	
Bed Shear Stress	5.6784	lbs/sq. ft.
Stability Number	0.8750	

Safety Factor = 1.0015

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Small Basin Hydrology Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #3, sta 4+93.07 to 7+55.08

Hydrology:

Length of Slope (L)	1200	feet	
Elevation Difference (H)	54	feet	
PMP	7.05	inches	
Drainage Area	15.8	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.05	ft/ft	
Slope (angle from horizontal)	2.58	degrees	
Area	15.80	acres	
Time of Concentration (tc)	0.10	hours	(SCS Triangular Hydrograph Theory)
	6.05	minutes	
% of 1-hour PMP	48.59	%	
PMP rainfall depth	3.43	inches	
Rainfall Intensity (i)	33.94	inches/hour	
Peak Flow Rate (q)	536.32	cfs	Rational Formula

Note: Total Q must include 515 cfs from segment 1 and 2.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 2; Segment 3, sta 4+93.07 to 7+55.08

Solve For Depth

Given Input Data:

Bottom Width.....	50.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0054 ft/ft
Discharge........	1055.00 cfs

Computed Results:

Depth............	2.98 ft
Velocity.........	5.71 fps
Flow Area........	184.79 sf
Flow Top Width...	73.87 ft
Wetted Perimeter.	74.65 ft
Critical Depth...	2.25 ft
Critical Slope...	0.0145 ft/ft
Froude Number....	0.64 (flow is Subcritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #3, sta 4+93.07 to 7+55.08

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.98	feet (from FlowMaster or channel design calculations)
Channel Slope	0.0054	ft./ft.
D_{50} of Riprap	2.5	inches (Input Trial Riprap D_{50})
Channel Slope	0.31	degrees
Mannings Coefficient	0.0304	
Bed Shear Stress	1.0041	lbs/sq. ft.
Stability Number	0.9655	
Safety Factor =	**1.0288**	

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Small Basin Hydrology **Date: 1/15/95**

Project: Maybell - Channel No. 2; Segment #4, sta 7+55.08 to 17+55.08

Hydrology:

Length of Slope (L)	1050	feet	
Elevation Difference (H)	68	feet	
PMP	7.05	inches	
Drainage Area	18.7	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.06	ft/ft	
Slope (angle from horizontal)	3.71	degrees	
Area	18.70	acres	
Time of Concentration (tc)	0.08	hours	(SCS Triangular Hydrograph Theory)
	4.75	minutes	
% of 1-hour PMP	43.24	%	
PMP rainfall depth	3.05	inches	
Rainfall Intensity (i)	38.52	inches/hour	
Peak Flow Rate (q)	720.29	cfs	Rational Formula

Note: Total Q must include 515 cfs from segment 1 and 2 and 540 cfs from segment 3.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 2; Segment 4, sta 7+55.08 to 17+55.1

Solve For Depth

Given Input Data:

Bottom Width.....	50.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.0400 ft/ft
Discharge........	1775.00 cfs

Computed Results:

Depth............	2.48 ft
Velocity.........	12.45 fps
Flow Area........	142.54 sf
Flow Top Width...	64.89 ft
Wetted Perimeter.	65.69 ft
Critical Depth...	3.18 ft
Critical Slope...	0.0170 ft/ft
Froude Number....	1.48 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 2; Segment #4, sta 7+55.08 to 17+55.08

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.48	feet (from FlowMaster or channel design calculations)
Channel Slope	0.04	ft./ft.
D_{50} of Riprap	15.7	inches (Input Trial Riprap D_{50})

Channel Slope	2.29	degrees
Mannings Coefficient	0.0413	
Bed Shear Stress	6.1901	lbs/sq. ft.
Stability Number	0.9478	

Safety Factor = 1.0038

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

CHANNEL NO. 3

Small Basin Hydrology Date: 1/15/95

Project: Maybell - Channel No. 3; Segment #1, sta 0+00 to 8+00

Hydrology:

Length of Slope (L)	1450	feet	
Elevation Difference (H)	128	feet	
PMP	7.05	inches	
Drainage Area	17.5	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.09	ft/ft	
Slope (angle from horizontal)	5.04	degrees	
Area	17.50	acres	
Time of Concentration (tc)	0.09	hours	(SCS Triangular Hydrograph Theory)
	5.40	minutes	
% of 1-hour PMP	46.37	%	
PMP rainfall depth	3.27	inches	
Rainfall Intensity (i)	36.30	inches/hour	
Peak Flow Rate (q)	635.25	cfs	Rational Formula

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 3; Segment 1, sta 0+00 to 8+00

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0200 ft/ft
Discharge........	635.00 cfs

Computed Results:

Depth............	2.04 ft
Velocity.........	8.61 fps
Flow Area........	73.72 sf
Flow Top Width...	42.25 ft
Wetted Perimeter.	42.91 ft
Critical Depth...	2.22 ft
Critical Slope...	0.0148 ft/ft
Froude Number....	1.15 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 3; Segment #1, sta 0+00 to 8+00

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.04	feet (from FlowMaster or channel design calculations)
Channel Slope	0.02	ft./ft.
D_{50} of Riprap	6.3	inches (Input Trial Riprap D_{50})

Channel Slope	1.15	degrees
Mannings Coefficient	0.0355	
Bed Shear Stress	2.5459	lbs/sq. ft.
Stability Number	0.9714	

Safety Factor = 1.0046

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 3; Segment 2, sta 8+00 to 11+40

Solve For Depth

Given Input Data:

Bottom Width.....	50.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.1000 ft/ft
Discharge........	635.00 cfs

Computed Results:

Depth............	1.04 ft
Velocity.........	11.54 fps
Flow Area........	55.04 sf
Flow Top Width...	56.22 ft
Wetted Perimeter.	56.55 ft
Critical Depth...	1.65 ft
Critical Slope...	0.0206 ft/ft
Froude Number....	2.05 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 3; Segment #2, sta 8+00 to 11+40

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	1.04	feet (from FlowMaster or channel design calculations)
Channel Slope	0.1	ft./ft.
D_{50} of Riprap	17.8	inches (Input Trial Riprap D_{50})

Channel Slope	5.71	degrees
Mannings Coefficient	0.0422	
Bed Shear Stress	6.4896	lbs/sq. ft.
Stability Number	0.8764	

Safety Factor = 1.0000

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

CHANNEL NO. 4

Small Basin Hydrology Date: 1/15/95

Project: Maybell - Channel No. 4 (Segment No. 1; sta 0+00 to 10+00)

Hydrology:

Length of Slope (L)	1650	feet	
Elevation Difference (H)	125	feet	
PMP	7.05	inches	
Drainage Area	18.7	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.08	ft/ft	
Slope (angle from horizontal)	4.33	degrees	
Area	18.70	acres	
Time of Concentration (tc)	0.11	hours	(SCS Triangular Hydrograph Theory)
	6.33	minutes	
% of 1-hour PMP	49.53	%	
PMP rainfall depth	3.49	inches	
Rainfall Intensity (i)	33.09	inches/hour	
Peak Flow Rate (q)	618.78	cfs	Rational Formula

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 4; Segment 1 (sta 0+00 to 10+00)

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0200 ft/ft
Discharge........	620.00 cfs

Computed Results:

Depth............	2.01 ft
Velocity.........	8.55 fps
Flow Area........	72.55 sf
Flow Top Width...	42.08 ft
Wetted Perimeter.	42.73 ft
Critical Depth...	2.19 ft
Critical Slope...	0.0149 ft/ft
Froude Number....	1.15 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS Date: 1/15/95
Safety Factors Method

Project: Maybell - Channel No. 4 (Segment No. 1; sta 0+00 to 10+00)

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	2.01	feet (from FlowMaster or channel design calculations)
Channel Slope	0.02	ft./ft.
D_{50} of Riprap	6.2	inches (Input Trial Riprap D_{50})

Channel Slope	1.15	degrees
Mannings Coefficient	0.0354	
Bed Shear Stress	2.5085	lbs/sq. ft.
Stability Number	0.9726	

Safety Factor = 1.0034

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 4; Segment 1 (sta 10+00 to 18+00)

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.0500 ft/ft
Discharge........	620.00 cfs

Computed Results:

Depth............	1.67 ft
Velocity.........	10.60 fps
Flow Area........	58.48 sf
Flow Top Width...	40.02 ft
Wetted Perimeter.	40.56 ft
Critical Depth...	2.19 ft
Critical Slope...	0.0194 ft/ft
Froude Number....	1.55 (flow is Supercritical)

RIPRAP DESIGN FOR CHANNELS
Safety Factors Method

Date: 1/15/95

Project: Maybell - Channel No. 4 (Segment No. 2; sta 10+00 to 18+00)

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	1.67	feet (from FlowMaster or channel design calculations)
Channel Slope	0.05	ft./ft.
D_{50} of Riprap	13.4	inches (Input Trial Riprap D_{50})

Channel Slope	2.86	degrees
Mannings Coefficient	0.0402	
Bed Shear Stress	5.2104	lbs/sq. ft.
Stability Number	0.9347	

Safety Factor = 1.0046

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

CHANNEL NO. 5

Small Basin Hydrology **Date: 1/15/95**

Project: **Maybell - Channel No. 5; Segment #1, sta 0+00 to 8+92.34**

Hydrology:

Length of Slope (L)	1400	feet	
Elevation Difference (H)	60	feet	
PMP	7.05	inches	
Drainage Area	19.3	acres	
Runoff Coefficient	1	Runoff Coefficient of 1 is recommended for PMP applications. (refer to NUREG/CR-4620, section 4.8.1)	
Flow Concentration Factor	1	Flow Concentration Factor of 3 is recommended. (Refer to NUREG/CR-4620, page 68; Enter 0 if Flow Concentration Factor is not utilized; see discussion below.	

Slope	0.04	ft/ft	
Slope (angle from horizontal)	2.45	degrees	
Area	19.30	acres	
Time of Concentration (tc)	0.12	hours	(SCS Triangular Hydrograph Theory)
	6.95	minutes	
% of 1-hour PMP	51.62	%	
PMP rainfall depth	3.64	inches	
Rainfall Intensity (i)	31.43	inches/hour	
Peak Flow Rate (q)	606.63	cfs	Rational Formula

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Maybell

Comment: Channel 5; Segment 1, sta 0+00 to 8+92.32

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0040 ft/ft
Discharge........	610.00 cfs

Computed Results:

Depth............	3.06 ft
Velocity.........	4.73 fps
Flow Area........	129.04 sf
Flow Top Width...	54.45 ft
Wetted Perimeter.	55.25 ft
Critical Depth...	2.12 ft
Critical Slope...	0.0151 ft/ft
Froude Number....	0.54 (flow is Subcritical)

RIPRAP DESIGN FOR CHANNELS Date: 1/15/95
Safety Factors Method

Project: Maybell - Channel No. 5; Segment #1, sta 0+00 to 8+92.32

Riprap Design:

Specific Weight of Liquid	62.4	
Specific Weight of Rock	2.68	
Angle of Repose of Riprap	40	(Refer to Fig. 4.8; Page 46; NUREG/CR-4620)
Depth of Flow	3.06	feet (from FlowMaster or channel design calculations)
Channel Slope	0.004	ft./ft.
D_{50} of Riprap	1.9	inches (Input Trial Riprap D_{50})
Channel Slope	0.23	degrees
Mannings Coefficient	0.0291	
Bed Shear Stress	0.7638	lbs/sq. ft.
Stability Number	0.9663	
Safety Factor =	**1.0298**	

NUREG/CR4620 recommends a minimum SF of 1.5 for non-PMF applications. A SF of slightly greater than 1.0 is recommended for PMF or maximum credible flood circumstances. Refer to page 48, Section 4.2.2.1 for minimum riprap thickness.

<u>APPENDIX A-5</u>

EROSION PROTECTION - FILTER CRITERIA

Maybell Reclamation Project - Design of Erosion Protection

<u>*Filter Criteria*</u> *- from NUREG/CR-4620*

suggested criteria:

D_{15} Filter / D_{85} Base = <5 (Riprap to Bedding)

D_{15} Filter / D_{85} Base = <10 (Bedding to Base)

TYPE A - Rock Mulch/Bedding to Base (Random Fill)

D_{15} TYPE A - Mulch/Bedding = #4 to $^3/_4$" or 4.76mm to 19.1mm (mean = 11.93mm)

D_{85} Random Fill = #40 to #10 or 0.42mm to 2.0mm (mean = 1.21mm)

D_{15} TYPE A - Mulch / D_{85} Random Fill = 11.93/1.21 = 9.85 (<10) ok

TYPE B - Riprap to TYPE A - Bedding

D_{15} TYPE B - Riprap = 3" to 6" or 76.2mm to 152mm (mean = 114.1mm)

D_{85} TYPE A - Bedding = 15mm to 55mm (mean = 35mm)

TYPE C - Riprap to TYPE A - Bedding

D_{15} TYPE C - Riprap = $^3/_4$" to 3" or 19.1mm to 76.2mm (mean = 47.65mm)

D_{85} TYPE A - Bedding = 15mm to 55mm (mean = 35mm)

D_{15} TYPE C - Riprap / D_{85} TYPE A - Bedding = 47.65/35 = 1.36 (<5) ok

TYPE D - Riprap to TYPE A - Bedding

D_{15} TYPE D - Riprap = 5" to 10" or 127mm to 254mm (mean = 190.5mm)

D_{85} TYPE A - Bedding = 15mm to 55mm (mean = 35mm)

D_{15} TYPE D - Riprap / D_{85} TYPE A - Bedding = 190.5/35 = 5 (=5) ok

APPENDIX A-6

RIPRAP DURABILITY

WESTERN ENGINEERS, INC. SINCE 1953
CONSULTING ENGINEERS / LAND SURVEYORS
2150 Hwy 6 & 50, Grand Junction, CO 81505 • 303/242-5202

May 12, 1994

UMETCO Reclamation
P.O. Box 1029
Grand Junction, CO 81502

ATTN: Tom Gieck

RE: Maybell, Colorado, durability tests on limestone sample submitted on 4-27-94 from Steele Quarry.

Tom:

Following are test results for the above sample:

TEST	SAMPLE SIZE 3/8"-1.5"	2.5"-3.5"	3.5"-4.5"	4.5"-5.5"	5.5"+
Soundness (Percent Loss)		0.65	0.41	0.03	
L A Abrasion (Percent Loss)					
100 Revolutions	7.6				
500 Revolutions	28.8				
Specific Gravity			2.68	2.71	
Absorption (Percent)			0.28	0.31	
Indirect Tensile (lbs/sq in)					1,186.3
Schmidt Rebound					65.2

Please call me if you have any questions.

Submitted by:
WESTERN ENGINEERS, INC.

Bruce D. Marvin P.E.

NRC SCORING CRITERIA FOR DETERMINING ROCK QUALITY

Maybell - Steel Quarry

ROCK TYPE: 1

Limestone = 1
Sandstone = 2
Igneous = 3

LABORATORY TEST	TEST RESULT	SCORE	WEIGHT	SCORE * WEIGHT	MAX. SCORE
Specific Gravity	2.68	8.60	12	103.20	120.00
Absorption, %	0.28	9.10	13	118.30	130.00
Sodium Sulfate, %	0.65	10.00	4	40.00	40.00
L/A Abrasion (100 revs), %	7.60	6.44	1	6.44	10.00
Schmidt Hammer	65.20	9.04	11	99.44	110.00
Tensile Strength, psi	1186.30	8.93	6	53.59	60.00

ROCK RATING, % **89.57**

RATING ANALYSIS:

Critical Areas- ACCEPTABLE, NO OVERSIZING REQUIRED
Oversizing, % =

Non-Critical Areas- ACCEPTABLE, NO OVERSIZING REQUIRED
Oversizing, % =

APPENDIX B
TABLE OF CONTENTS

APPENDIX B-1

HELP Model

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\DATA10.D10
OUTPUT DATA FILE:            C:\HELP3\RCRA.OUT


TIME:  13:29     DATE:   1/13/1995


******************************************************************************

     TITLE:  Maybell Heap Reclamation Project - 1/13/95

******************************************************************************


     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  21
           THICKNESS                     =       6.00   INCHES
           POROSITY                      =       0.3970 VOL/VOL
           FIELD CAPACITY                =       0.0320 VOL/VOL
           WILTING POINT                 =       0.0130 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.0669 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =   0.300000012000     CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	54.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1900 VOL/VOL
WILTING POINT	=	0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1535 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.690000015000E-04 CM/SEC

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	28.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.398	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.348	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.948	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	16.374	INCHES
TOTAL INITIAL WATER	=	16.374	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LANDER WYOMING

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128

END OF GROWING SEASON (JULIAN DATE) = 284
AVERAGE ANNUAL WIND SPEED = 6.90 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 60.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 50.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 41.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 59.00 %

NOTE: PRECIPITATION DATA FOR LANDER WYOMING
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LANDER WYOMING

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
16.50	21.60	31.80	42.20	51.60	60.10
67.00	64.90	54.90	44.00	31.00	19.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LANDER WYOMING

STATION LATITUDE = 45.00 DEGREES

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1974

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.43	0.99	0.56	2.35	0.31	0.37
	0.47	0.66	1.07	2.02	0.19	0.66
RUNOFF	0.058	0.225	0.070	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.032
EVAPOTRANSPIRATION	0.334	0.494	0.849	2.249	0.240	0.598
	0.813	0.809	0.906	0.835	1.001	0.503
PERCOLATION THROUGH	0.0254	0.0206	0.0206	0.0180	0.0159	0.0159
LAYER 3	0.0153	0.0153	0.0138	0.0134	0.0123	0.0120

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON LAYER 3	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. DEVIATION OF DAILY HEAD ON LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

****

****

ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.08	36590.406	100.00
RUNOFF	0.385	1395.907	3.81
EVAPOTRANSPIRATION	9.632	34962.383	95.55
PERC./LEAKAGE THROUGH LAYER 3	0.198599	720.914	1.97
AVG. HEAD ON TOP OF LAYER 3	0.0003		
CHANGE IN WATER STORAGE	-0.135	-488.811	-1.34
SOIL WATER AT START OF YEAR	16.374	59438.953	
SOIL WATER AT END OF YEAR	16.240	58950.141	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.014	50.556	0.14
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1975

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.74	0.43	1.18	1.68	4.44	1.88
	0.29	0.10	0.38	1.37	0.73	0.79
RUNOFF	0.000	0.021	0.099	0.000	0.060	0.028
	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION	0.440	0.640	0.859	1.933	2.389	2.340
	1.646	0.097	0.380	0.834	0.805	0.550
PERCOLATION THROUGH LAYER 3	0.0113	0.0097	0.0102	0.0069	0.0002	0.0001
	0.0509	0.1063	0.1027	0.0738	0.0481	0.0417

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000
	0.023	0.143	0.109	0.010	0.001	0.001
STD. DEVIATION OF DAILY HEAD ON LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000
	0.033	0.016	0.029	0.016	0.000	0.000

****

****

ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.01	50856.301	100.00
RUNOFF	0.208	756.460	1.49
EVAPOTRANSPIRATION	12.912	46870.988	92.16
PERC./LEAKAGE THROUGH LAYER 3	0.461782	1676.267	3.30
AVG. HEAD ON TOP OF LAYER 3	0.0239		
CHANGE IN WATER STORAGE	0.414	1502.025	2.95
SOIL WATER AT START OF YEAR	16.240	58950.141	
SOIL WATER AT END OF YEAR	16.235	58933.660	
SNOW WATER AT START OF YEAR	0.014	50.556	0.10
SNOW WATER AT END OF YEAR	0.432	1569.060	3.09
ANNUAL WATER BUDGET BALANCE	0.0139	50.560	0.10

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1976

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.27	0.82	0.43	1.17	2.09	1.97
	1.05	0.40	0.54	1.67	0.40	0.14
RUNOFF	0.000	0.034	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.786	0.581	0.551	1.238	2.072	2.002
	1.211	0.487	0.469	0.823	0.844	0.285
PERCOLATION THROUGH LAYER 3	0.0361	0.0273	0.0267	0.0229	0.0194	0.0191
	0.0183	0.0181	0.0166	0.0156	0.0142	0.0141

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON LAYER 3	0.001	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

****

****

ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.95	39748.508	100.00
RUNOFF	0.034	123.587	0.31
EVAPOTRANSPIRATION	11.348	41194.113	103.64
PERC./LEAKAGE THROUGH LAYER 3	0.248471	901.951	2.27
AVG. HEAD ON TOP OF LAYER 3	0.0003		
CHANGE IN WATER STORAGE	-0.681	-2471.163	-6.22
SOIL WATER AT START OF YEAR	16.235	58933.660	
SOIL WATER AT END OF YEAR	15.987	58031.559	
SNOW WATER AT START OF YEAR	0.432	1569.060	3.95
SNOW WATER AT END OF YEAR	0.016	59.745	0.15

ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.59	0.11	3.30	1.47	1.11	0.66
	2.50	0.47	0.18	0.91	0.65	0.29
RUNOFF	0.000	0.000	1.233	0.160	0.000	0.000
	0.258	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.617	0.157	0.771	1.968	1.208	1.223
	1.896	0.807	0.318	0.599	0.599	0.465
PERCOLATION THROUGH	0.0131	0.0111	0.0116	0.0106	0.0104	0.0091
LAYER 3	0.0053	0.0000	0.0101	0.0107	0.0098	0.0065

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON LAYER 3	0.000	0.000	0.000	0.000	0.000	0.000

****

****

ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.24	44431.203	100.00
RUNOFF	1.651	5993.207	13.49
EVAPOTRANSPIRATION	10.628	38579.258	86.83
PERC./LEAKAGE THROUGH LAYER 3	0.108514	393.905	0.89
AVG. HEAD ON TOP OF LAYER 3	0.0001		

CHANGE IN WATER STORAGE	-0.164	-594.911	-1.34
SOIL WATER AT START OF YEAR	15.987	58031.559	
SOIL WATER AT END OF YEAR	15.838	57491.402	
SNOW WATER AT START OF YEAR	0.016	59.745	0.13
SNOW WATER AT END OF YEAR	0.001	4.991	0.01
ANNUAL WATER BUDGET BALANCE	0.0165	59.746	0.13

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.63	0.50	0.38	0.69	5.79	0.16
	0.82	0.25	1.17	0.65	2.15	1.22
RUNOFF	0.094	0.067	0.004	0.000	0.024	0.000
	0.000	0.000	0.000	0.000	1.152	0.000
EVAPOTRANSPIRATION	0.281	0.328	0.765	0.417	3.079	1.182
	1.684	0.241	1.182	0.319	0.761	0.671
PERCOLATION THROUGH	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008
LAYER 3	0.0925	0.1143	0.1111	0.1143	0.1096	0.1119

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
LAYER 3	0.690	1.503	1.604	1.509	1.327	1.100
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON LAYER 3	0.471	0.083	0.010	0.045	0.060	0.073

****

****

ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.41	52308.312	100.00
RUNOFF	1.342	4870.621	9.31
EVAPOTRANSPIRATION	10.909	39600.289	75.71
PERC./LEAKAGE THROUGH LAYER 3	0.654560	2376.052	4.54
AVG. HEAD ON TOP OF LAYER 3	0.6444		
CHANGE IN WATER STORAGE	1.504	5461.316	10.44
SOIL WATER AT START OF YEAR	15.838	57491.402	
SOIL WATER AT END OF YEAR	17.344	62957.707	
SNOW WATER AT START OF YEAR	0.001	4.991	0.01
SNOW WATER AT END OF YEAR	0.016	57.562	0.11
ANNUAL WATER BUDGET BALANCE	0.0000	0.036	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.53	0.57	1.17	1.47	2.75	1.01
	1.03	0.38	0.67	1.32	0.82	0.62
STD. DEVIATIONS	0.18	0.34	1.23	0.62	2.30	0.86
	0.88	0.21	0.43	0.55	0.77	0.43
RUNOFF						
TOTALS	0.030	0.069	0.281	0.032	0.017	0.006
	0.052	0.000	0.000	0.000	0.230	0.006
STD. DEVIATIONS	0.044	0.090	0.534	0.071	0.026	0.013
	0.115	0.000	0.000	0.000	0.515	0.014
EVAPOTRANSPIRATION						
TOTALS	0.492	0.440	0.759	1.561	1.798	1.469
	1.450	0.488	0.651	0.682	0.802	0.495
STD. DEVIATIONS	0.208	0.197	0.124	0.740	1.100	0.697

0.434	0.324	0.376	0.227	0.145	0.140

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0172	0.0137	0.0138	0.0117	0.0092	0.0090
	0.0365	0.0508	0.0509	0.0456	0.0388	0.0372
STD. DEVIATIONS	0.0139	0.0105	0.0103	0.0090	0.0089	0.0086
	0.0357	0.0548	0.0513	0.0466	0.0425	0.0439

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 3

AVERAGES	0.0003	0.0002	0.0002	0.0002	0.0001	0.0001
	0.1426	0.3294	0.3427	0.3038	0.2656	0.2202
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
	0.3060	0.6590	0.7066	0.6737	0.5931	0.4918

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.34	(1.879)	44786.9	100.00
RUNOFF	0.724	(0.7242)	2627.96	5.868
EVAPOTRANSPIRATION	11.086	(1.2000)	40241.41	89.851
PERCOLATION/LEAKAGE THROUGH FROM LAYER 3	0.33439	(0.22112)	1213.818	2.71020
AVERAGE HEAD ACROSS TOP OF LAYER 3	0.134	(0.286)		
CHANGE IN WATER STORAGE	0.188	(0.8317)	681.69	1.522

****

****

PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	2.11	7659.300
RUNOFF	0.875	3176.2554
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.003706	13.45439
AVERAGE HEAD ACROSS LAYER 3	1.614	
SNOW WATER	1.92	6964.3501

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2038
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0635

****

****

FINAL WATER STORAGE AT END OF YEAR 1978

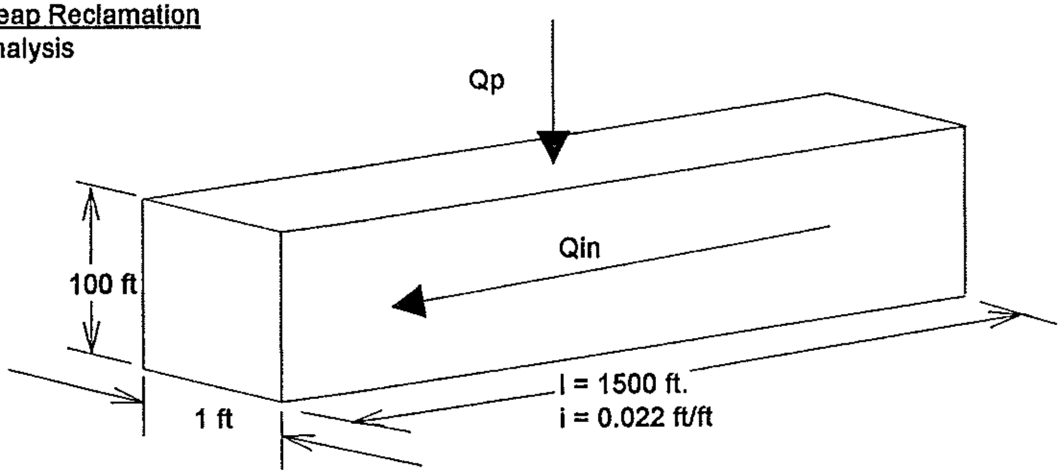
LAYER	(INCHES)	(VOL/VOL)
1	0.1836	0.0306
2	9.4741	0.1754
3	7.6860	0.4270
SNOW WATER	0.000	

****
****

APPENDIX B-2

DILUTION CALCULATIONS

Maybell Heap Reclamation
Dilution Analysis



l = Length of Heap parallel to groundwater flow (1500 ft)
assume dilution in upper 100' of aquifer.

Qin = KiA where: K = 100 gal/day/ft^2
i = 0.022 ft/ft
A = 100 ft^2

Qin = 100 x 0.022 x 100 = 220 gal/day
= 220 gal per day / 7.48 = 29.41 ft^3/day
= 29.41 ft^3/day x 365 = 10,734.65 ft^3/year

Qp: 1500 x 1ft. width = 1500 ft^2

seepage from HELP model = 0.0279 ft^3/ft^2/year

Qp = 0.0279 ft^3/ft^2 x 1500 = 41.85 ft^3/year

Dilution Ratio:

Qin / Qp = 10,734.65 ft^3 / 41.85 ft^3 = 256.5 ft^3

Dilution ration in wxcess of about 250 to 1, calculated using simple mixing model.

APPENDIX C

RADON FLUX CALCULATIONS

-----*****! RADON !*****-----

ersion 1 - April 1, 1986 - G.F. Birchard tel.# (301) 492-7000
.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

AYBELL; TOP COVER - 1/17/95

CONSTANTS

RADON DECAY CONSTANT	.0000021	1/s
ADON WATER/AIR PARTITION COEFFICIENT	.26	
PECIFIC GRAVITY OF COVER & TAILINGS	2.65	g/cm^3

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	3	
O LIMIT ON RADON FLUX		
AYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi/l
URFACE FLUX PRECISION	.01	pCi*m^-2/s

LAYER INPUT PARAMETERS

LAYER 1

AYER THICKNESS	500	cm
CALCULATED LAYER POROSITY	.3660377358490566	
EASURED LAYER DENSITY	1.68	g/cm^3
EASURED RADIUM ACTIVITY	53	pCi/g
MEASURED LAYER EMANATION COEFFICIENT	.265	
CALCULATED LAYER SOURCE TERM	1.354D-04	pCi*cm^-3/s
AYER WEIGHT % MOISTURE	9	%
MOISTURE SATURATION FRACTION	.413	
MEASURED LAYER DIFFUSION COEFFICIENT	.0172	cm^2/s

LAYER 2

LAYER THICKNESS	45.72	cm
CALCULATED LAYER POROSITY	.339622641509434	
EASURED LAYER DENSITY	1.75	g/cm^3
EASURED RADIUM ACTIVITY	2.32	pCi/g
MEASURED LAYER EMANATION COEFFICIENT	.193	
ALCULATED LAYER SOURCE TERM	4.845D-06	pCi*cm^-3/s
AYER WEIGHT % MOISTURE	10.49	%
MOISTURE SATURATION FRACTION	.541	
EASURED LAYER DIFFUSION COEFFICIENT	.014	cm^2/s

LAYER 3

LAYER THICKNESS	121.92	cm
ALCULATED LAYER POROSITY	.3283018867924528	
EASURED LAYER DENSITY	1.78	g/cm^3
MEASURED RADIUM ACTIVITY	3.06	pCi/g
MEASURED LAYER EMANATION COEFFICIENT	.106	
ALCULATED LAYER SOURCE TERM	3.693D-06	pCi*cm^-3/s
LAYER WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.325	
EASURED LAYER DIFFUSION COEFFICIENT	.022	cm^2/s

ARE SOURCE FLUX FROM LAYER 1: 4.466D+01 pCi*cm^-3/s

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m^2/s)	EXIT CONC. (pCi/l)
1	5.000D+02	2.045D+01	3.480D+04
2	4.572D+01	1.421D+01	1.384D+04
3	1.219D+02	8.935D+00	0.000D+00

Maybell Heap Reclamation
Radon Attenuation Design
Rogers & Associates Test Result Data

Sample	Dry Density (g/cm^3)	Saturation (%)	Moisture (%)	Specific Gravity (g/cm^3)	Diffusion Coefficient
1975 Heap	1.680	0.400	9.1	2.7	1.80E-02
1976 Heap	1.680	0.400	9.1	2.7	1.80E-02
1977 Heap	1.680	0.450	9.5	2.6	1.60E-02
1978 Heap	1.670	0.450	9.6	2.6	1.90E-02
1979 Heap	1.680	0.420	8.8	2.6	1.60E-02
1980 Heap	1.680	0.390	8.7	2.7	1.60E-02
Average Heap	**1.678**	**0.418**	**9.13**	**2.65**	**1.72E-02**
Clay Soil (125A)	1.750	0.520	10.4	2.7	1.90E-02
Clay Soil (126A)	1.750	0.550	11.1	2.7	9.00E-03
Average Clay Soil	**1.750**	**0.535**	**10.75**	**2.7**	**1.40E-02**
Random Fill South Rob #1	1.700	0.270	5.9	2.7	2.20E-02
Random Fill South Rob #2	1.700	0.270	5.8	2.7	2.20E-02
Average Random Fill	**1.700**	**0.270**	**5.850**	**2.700**	**0.022**

Sample	Moisture (%)	Radium (pCi/g)	Emanation (%)
1975 Heap	7.28	29.10	0.240
1976 Heap	6.86	33.34	0.265
1977 Heap	5.88	121.30	0.270
1978 Heap	6.50	29.57	0.241
1979 Heap	6.60	43.20	0.311
1980 Heap	9.20	58.65	0.260
Average Heap	**7.053**	**52.527**	**0.265**
Clay Soil (125A)	8.01	2.34	0.194
Clay Soil (126A)	7.66	2.30	0.192
Average Clay Soil	**7.835**	**2.320**	**0.193**
Random Fill South Rob #1	6.59	3.23	0.106
Random Fill South Rob #2	6.77	2.88	0.105
Average Random Fill	**6.680**	**3.055**	**0.106**

Rogers & Associates Engineering Corporation
Post Office Box 330
Salt Lake City, Utah 84110-0330
(801) 263-1600 • FAX (801) 262-1527

January 13, 1994

C9400/10

Tom Gieck
UMETCO Minerals
P.O. Box 1029
Grand Junction, CO 81502

Dear Mr. Gieck:

Enclosed are the results from the Radium Content, Radon Emanation, Radon Diffusion, and Specific Gravity measurements that were performed on the soil samples sent to our laboratory. We will be sending the soil samples back to you in the next couple of weeks. Please let us know where we can send them. If you have any questions or if we can be of any further assistance, please call.

Sincerely,

Tye K. Rogers

Tye K. Rogers

515 East 4500 South • Salt Lake City, UT 84107-2918
Additional Offices in: Idaho Falls, ID • Santa Fe, NM • Washington DC

Rogers & Associates Engineering Corporation

REPORT OF RADIUM CONTENT AND EMANATION
COEFFICIENT MEASUREMENTS

(LAB PROCEDURE RAE-SQAP-3.1)

Report Date 1/13/95

Contract C9400/10

By TKR

Date Received 12/01/95

Sample Identification Heap Material, Clayey Soils, and Random Fill Soils

Submitted by Tom Gieck (UMETCO Minerals)

Sample ID	Moisture (Dry Wt. %)	Radon Emanation Coefficient	Radium (pCi/g)	Comments
1975 Heap	7.3	0.24 ± 0.01	29.1 ± 0.4	
1976 Heap	6.9	0.27 ± 0.01	33.3 ± 0.4	
1977 Heap	5.9	0.27 ± 0.01	121.3 ± 0.5	
1978 Heap	6.5	0.24 ± 0.01	29.6 ± 0.3	
1979 Heap	6.6	0.31 ± 0.01	43.2 ± 0.4	
1980 Heap	9.2	0.26 ± 0.01	58.7 ± 0.5	
125 A	8.0	0.19 ± 0.02	2.3 ± 0.3	
126 A	7.7	0.19 ± 0.02	2.3 ± 0.3	
South Rob. #1	6.6	0.11 ± 0.01	3.2 ± 0.3	
South Rob. #2	6.8	0.11 ± 0.01	2.9 ± 0.3	

RAE

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

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS
(TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

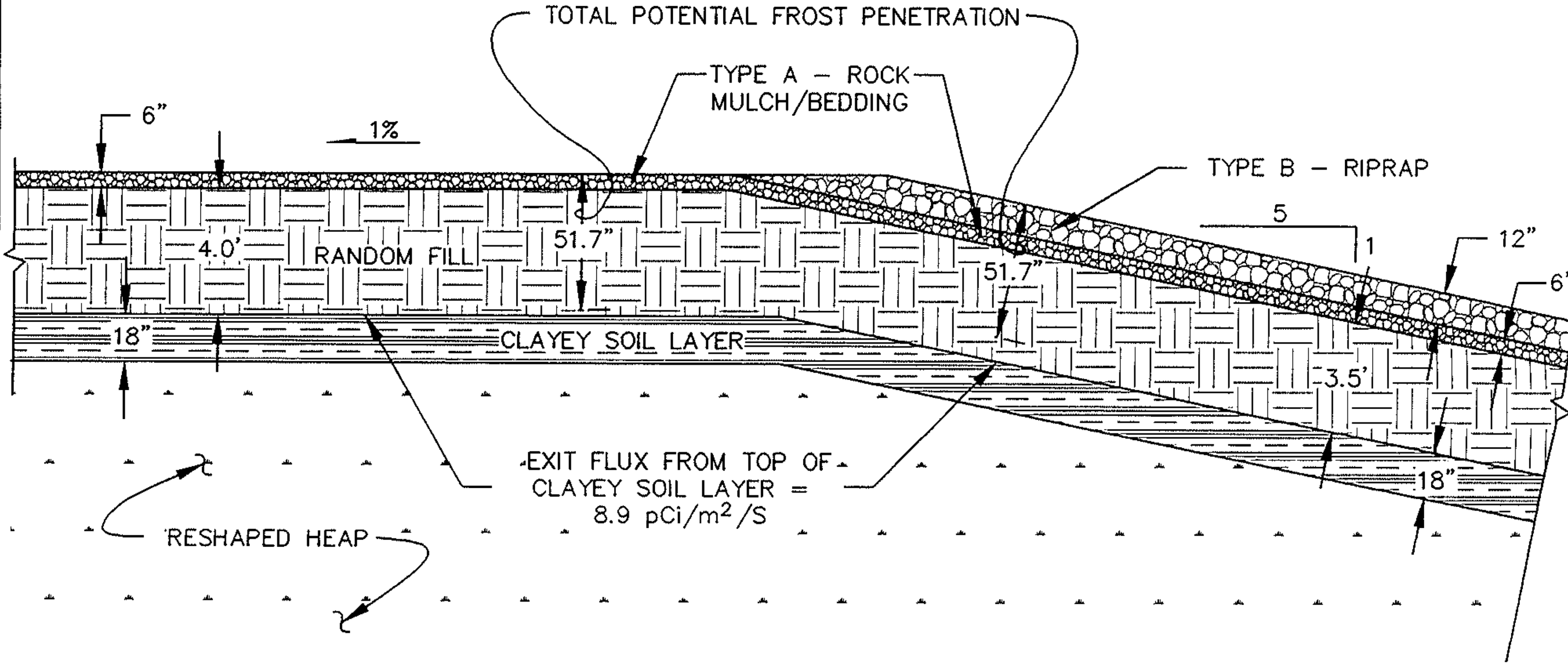
Report Date 1/13/95
Contract C9400/10
By TKR
Date Received 12/01/94

Sample Identification Heap Material, Clayey Soils, and Random Fill Soils
Submitted by Tom Gieck (UMETCO Minerals)

Sample ID	Moisture (Dry Wt. %)	Density (g/cm^3)	Radon Diffusion Coefficient (cm^2/s)	Saturation (Mρ/P)	Specific Gravity (g/cm^3)
1975 Heap	9.1	1.68	1.8E-02	0.40	2.7
1976 Heap	9.1	1.68	1.8E-02	0.40	2.7
1977 Heap	9.5	1.68	1.6E-02	0.45	2.6
1978 Heap	9.6	1.67	1.9E-02	0.45	2.6
1979 Heap	8.8	1.68	1.6E-02	0.42	2.6
1980 Heap	8.7	1.68	1.6E-02	0.39	2.7
125 A	10.4	1.75	1.9E-02	0.52	2.7
126 A	11.1	1.75	9.0E-03	0.55	2.7
South Rob. #1	5.9	1.70	2.2E-02	0.27	2.7
South Rob. #2	5.8	1.70	2.2E-02	0.27	2.7

RAE

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



SCALE: 1" = 5'

Umetco Minerals Corporation

MAYBELL HEAP
RECLAMATION COVER
RADON ATTENUATION

JAN 1995

FIGURE 2.2.1-1

APPENDIX D

SLOPE STABILITY ANALYSIS

MAYBELL HEAP - STABILITY ANALYSIS

UTEXAS 2 - INPUT FILE:

```
HEADING
MAYBELL HEAP RECLAMATION
JANUARY 11, 1995
TYPICAL SECTION WITH 5 : 1 SLOPE
PROFILE LINE DATA
1  1  RANDOM FILL (COVER)
      0 6286 270 6270 690 6186

2  2  CLAYEY SOIL LAYER
      0 6264 270 6266 495 6221

3  3  HEAP MATERIAL
      0 6262.5 270 6264.5 482.5 6222

4  4  CLAY LINER
      0 6217.5 482.5 6222 495 6221

5  5  MINE SPOIL
      0 6216 495 6221 495 6219 660 6186

6  6  FOUNDATION
      0 6186 660 6186 690 6186 920 6186


MATERIAL PROPERTIES
1   RANDOM FILL (COVER)
118
CONVENTIONAL SHEAR
0 33.8
NO PORE PRESSURE
2   CLAYEY SOIL LAYER (COVER)
118
CONVENTIONAL SHEAR
1100 0
NO PORE PRESSURE
3   HEAP MATERIAL
115.5
CONVENTIONAL SHEAR
0 33.8
PIEZOMETRIC LINE
     1
4   CLAY LINER
118
CONVENTIONAL SHEAR
1100 0
NO PORE PRESSURE
5   MINE SPOIL
115.5
```

CONVENTIONAL SHEAR
0 33.8
NO PORE PRESSURE
6 FOUNDATION
118
CONVENTIONAL SHEAR
230 33.8
NO PORE PRESSURE

PIEZOMETRIC LINE DATA AS FOLLOWS
1 PIEZOMETRIC LINE DATA
0 6217.5 440 6222 482.5 6222

ANALYSIS/COMPUTATION
CIRCULAR SEARCH
440 6440 1 6100
TANGENT
6220

COMPUTE

UTEXAS 2 - OUTPUT FILE:

UTEXAS2 - VER. 1.211 - 4/10/87 - SNNONE - (C) 1985 S. G. WRIGHT
Date of this run: 1:12:1995 Time of this run: 12:24:44
MAYBELL HEAP RECLAMATION
JANUARY 11, 1995
TYPICAL SECTION WITH 5 : 1 SLOPE

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - - 395.000
Y Coordinate of Center - - - - - - - 6460.000
Radius - - - - - - - - - - - - - - - 240.000
Factor of Safety - - - - - - - - - - 3.412
Side Force Inclination - - - - - - - -9.79

Number of circles tried - - - - - - 83
No. of circles F calc. for - - - - - 74

MAYBELL HEAP - STABILITY ANALYSIS

UTEXAS 2 - INPUT FILE:

```
HEADING
MAYBELL HEAP RECLAMATION
JANUARY 12, 1995
TYPICAL SECTION WITH 5 : 1 SLOPE - PSEUDO-STATIC ANALYSIS
PROFILE LINE DATA
1  1  RANDOM FILL (COVER)
      0 6286 270 6270 690 6186

2  2  CLAYEY SOIL LAYER
      0 6264 270 6266 495 6221

3  3  HEAP MATERIAL
      0 6262.5 270 6264.5 482.5 6222

4  4  CLAY LINER
      0 6217.5 482.5 6222 495 6221

5  5  MINE SPOIL
      0 6216 495 6221 495 6219 660 6186

6  6  FOUNDATION
      0 6186 660 6186 690 6186 920 6186


MATERIAL PROPERTIES
1   RANDOM FILL (COVER)
118
CONVENTIONAL SHEAR
0 33.8
NO PORE PRESSURE
2   CLAYEY SOIL LAYER (COVER)
118
CONVENTIONAL SHEAR
1100 0
NO PORE PRESSURE
3   HEAP MATERIAL
115.5
CONVENTIONAL SHEAR
0 33.8
PIEZOMETRIC LINE
    1
4    CLAY LINER
118
CONVENTIONAL SHEAR
1100 0
NO PORE PRESSURE
5    MINE SPOIL
115.5
```

CONVENTIONAL SHEAR
0 33.8
NO PORE PRESSURE
6 FOUNDATION
118
CONVENTIONAL SHEAR
230 33.8
NO PORE PRESSURE

PIEZOMETRIC LINE DATA AS FOLLOWS
1 PIEZOMETRIC LINE DATA
0 6217.5 440 6222 482.5 6222

ANALYSIS/COMPUTATION
CIRCULAR SEARCH
470 6700 1 6100
TANGENT
6220
SEISMIC COEFFICIENT
0.25

COMPUTE

UTEXAS 2 - OUTPUT FILE:

UTEXAS2 - VER. 1.211 - 4/10/87 - SNNONE - (C) 1985 S. G. WRIGHT
Date of this run: 1:12:1995 Time of this run: 12:49:42
MAYBELL HEAP RECLAMATION
JANUARY 12, 1995
TYPICAL SECTION WITH 5 : 1 SLOPE - PSEUDO-STATIC ANALYSIS

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - - 468.000
Y Coordinate of Center - - - - - - - 6673.000
Radius - - - - - - - - - - - - - - - 454.000
Factor of Safety - - - - - - - - - - 1.478
Side Force Inclination - - - - - - - -22.72

Number of circles tried - - - - - - 143
No. of circles F calc. for - - - - - 140

TABLE A.1
SUMMARY OF LABORATORY TEST RESULTS
CHEN & ASSOCIATES JOB NO. 1 150 88

SAMPLE LOCATION	OPTIMUM[1] MOISTURE CONTENT (%)	MAXIMUM[1] DRY DENSITY (pcf)	SPECIFIC GRAVITY	ATTERBERG LIMITS		GRADATION ANALYSIS			REMOLDED[2] PROPERTIES				SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)	SILT & CLAY (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)	UNDRAINED TRIAXIAL COHESION (psf)	DIRECT SHEAR ϕ/COHESION	HYDRAULIC CONDUC-TIVITY (cm/sec)	
Rob Pit Overburden South Pit	14.5	114.3	2.69		NP	0	81	19			33.8°/230	6.9×10^{-5}	Silty sand
Yampa Valley Alluvial Clay	14.1	114.0	2.70	25	8	0	30	70	2320	1100		1.2×10^{-7}	Silty, sandy clay
Mancos Shale Near Juniper Hot Springs	19.2	107.5	2.77	36	17	0	13	87	3000	1500		7.2×10^{-7}	Sandy clay
1978 Heaps			2.69		NP	0	80	20					Silty sand
1980 Heaps			2.63		NP	0	83	17					Silty sand

NOTES:

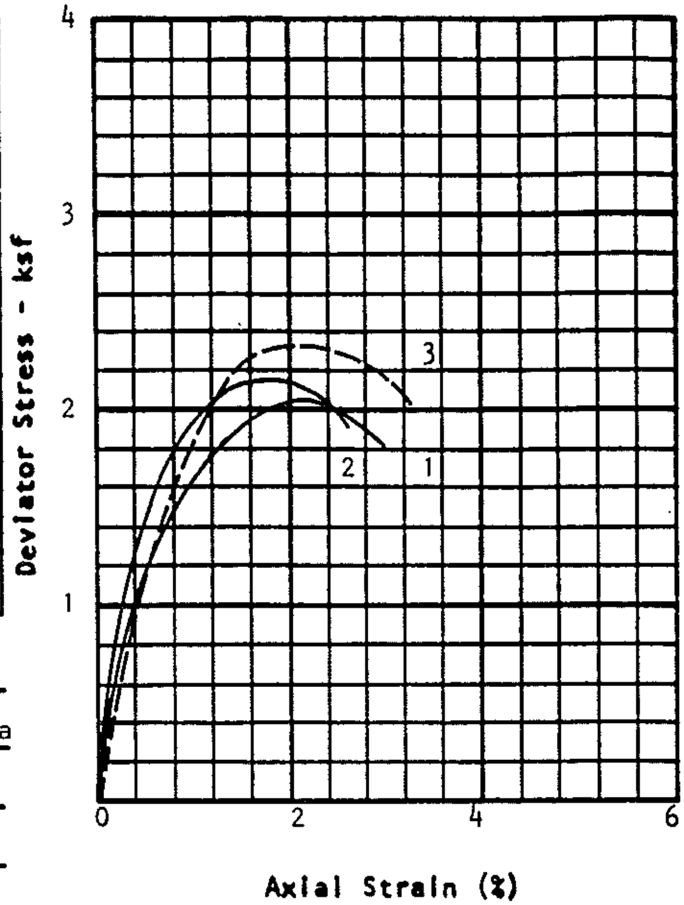
(1) Moisture-density relationships determined by ASTM D-698 Test Methods (Standard Proctor).

(2) Specimens were remolded at approximately 92% maximum dry density at optimum moisture content.

CHEN AND ASSOCIATES

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
			UNCON-FINED	
HEIGHT - INCH	3.915	3.902	3.908	
DIAMETER - INCH	1.880	1.880	1.880	
WATER CONTENT - %	14.1	13.9	13.9	
DRY DENSITY - pcf	104.8	105.2	104.7	
$\sigma_1 - \sigma_3$	2.030	2.140	2.325	
σ_1 - ksf	2.275	2.644	2.325	
σ_3 - ksf	0.245	0.504	0	



TYPE OF SPECIMEN: Remolded

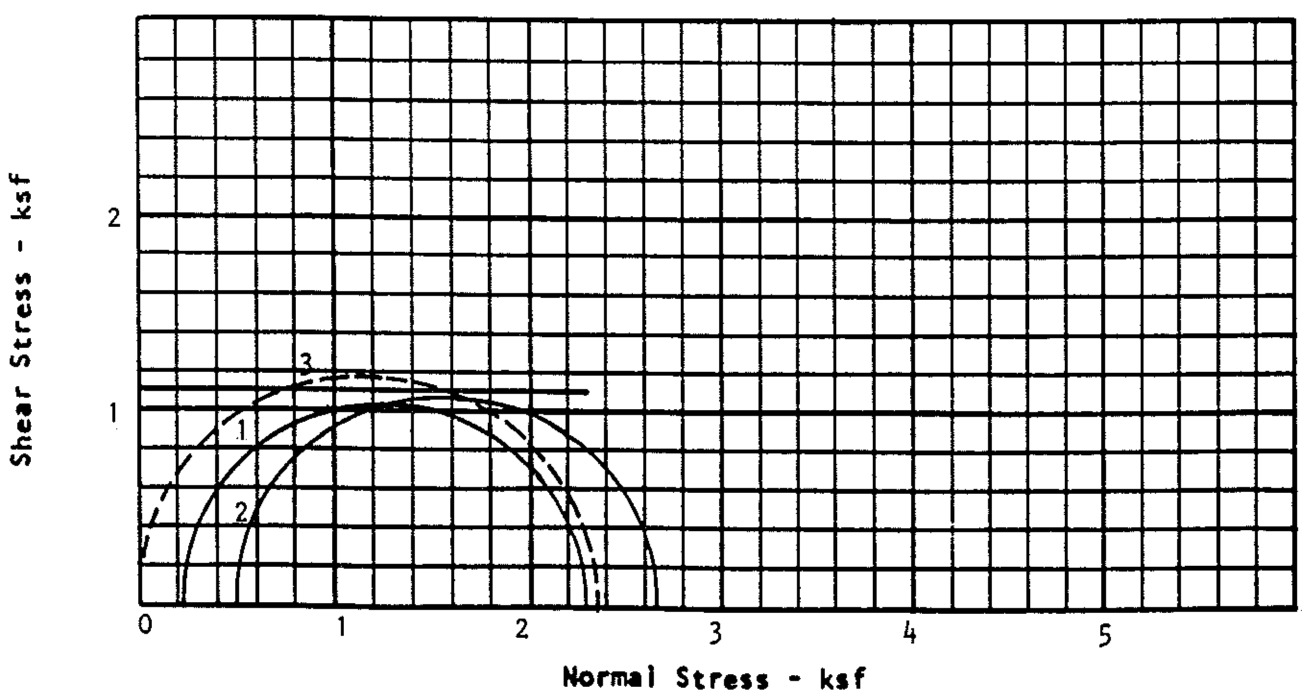
SOIL DESCRIPTION: Silty, sandy clay from Yampa Valley Alluvium.

TYPE OF TEST: Unsaturated, Unconsolidated, Undrained.

TAN ∅: 0

∅: 0

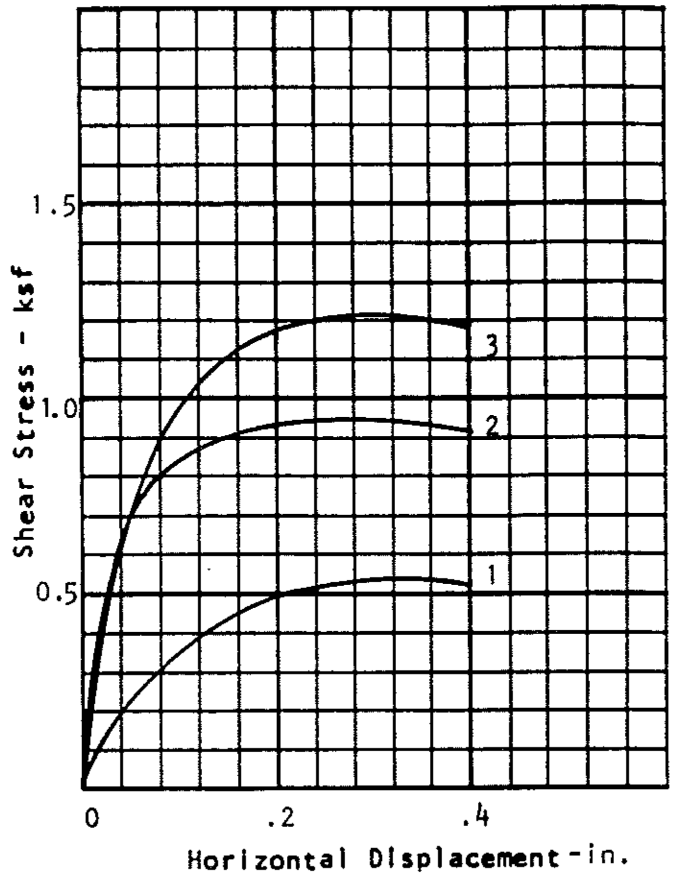
COHESION - ksf: 1.1 (average)



CHEN AND ASSOCIATES

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION		ROB PIT OVERBURDEN		
HEIGHT-INCH	.975	.975	.975	
DIAMETER-INCH	2.744	2.744	2.744	
WATER CONTENT - %	14.0	13.8	14.0	
DRY DENSITY - pcf	106.0	105.8	105.6	
NORMAL LOAD - ksf	0.50	1.00	1.50	
SHEAR STRESS - ksf	0.54	0.95	1.21	



TYPE OF SPECIMEN: Remolded

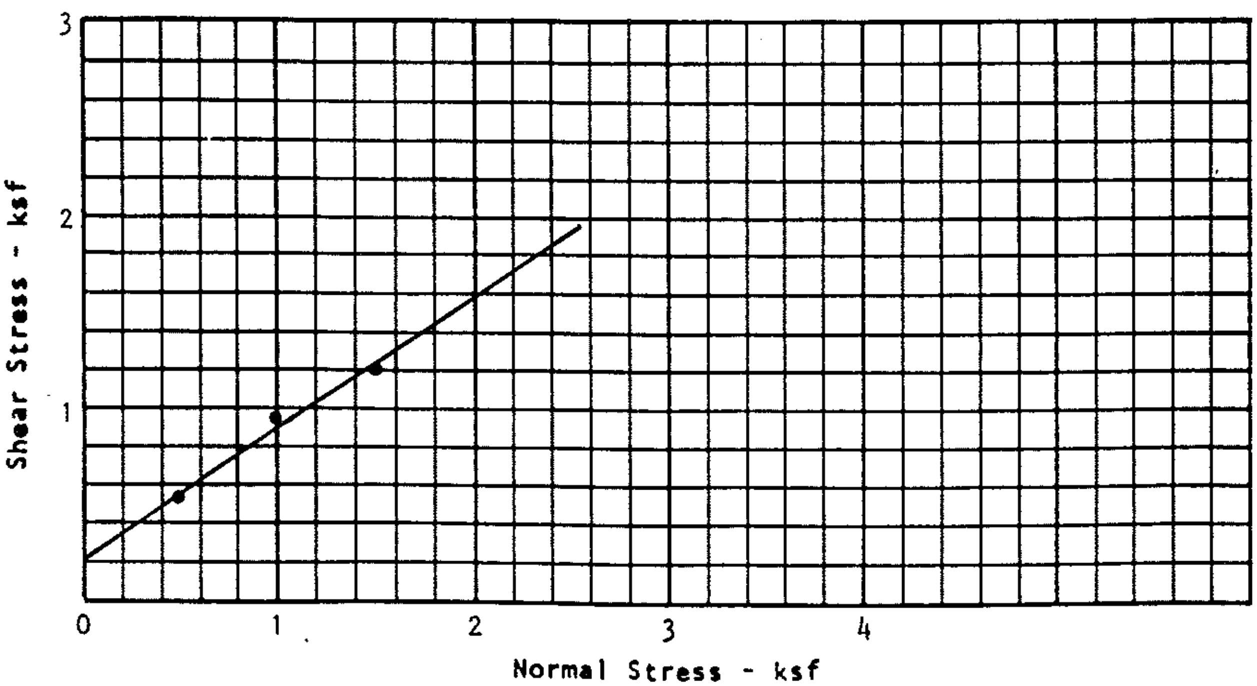
SOIL DESCRIPTION: Silty sand

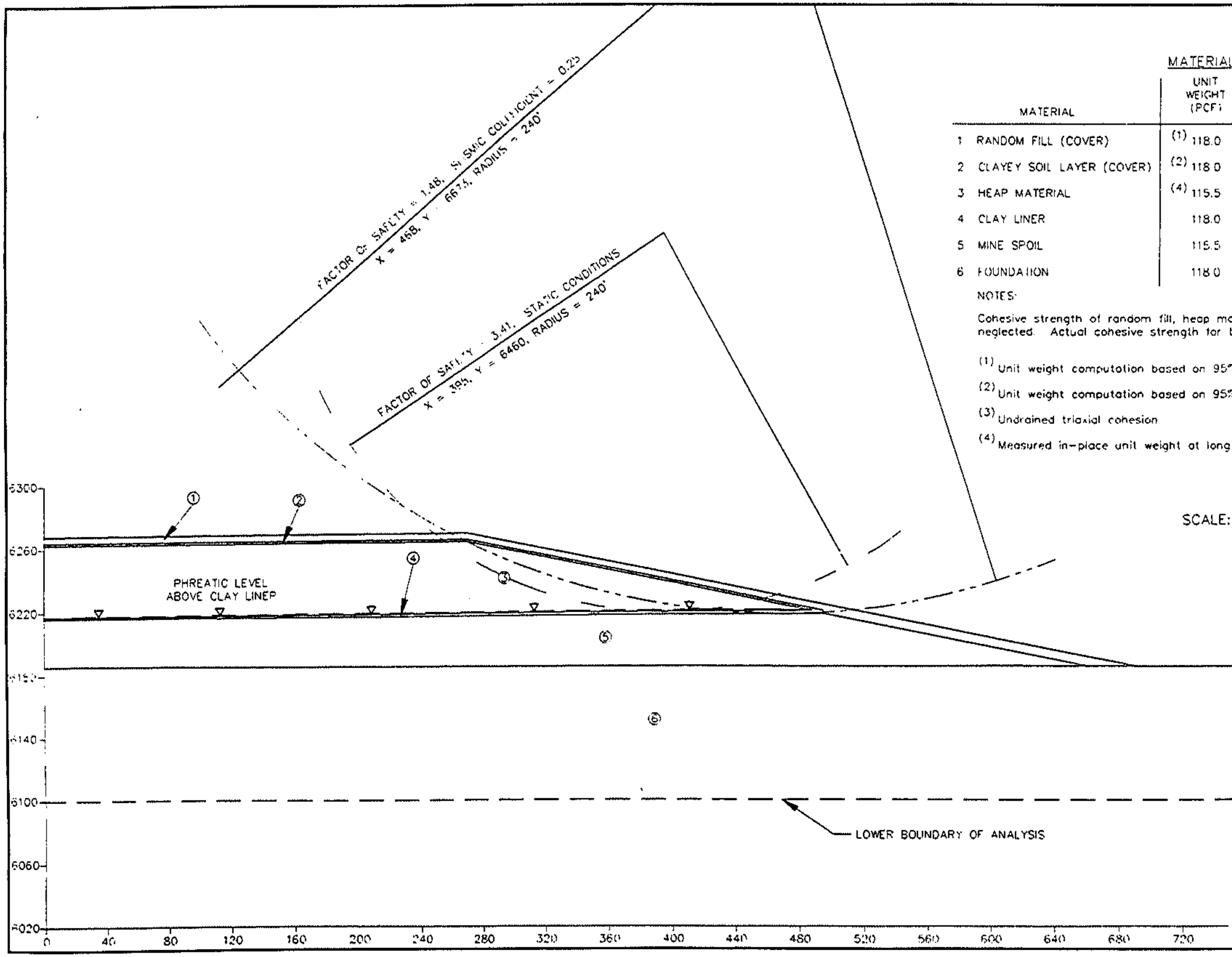
TYPE OF TEST: Saturated, Unconsolidated, Undrained

TAN Ø: 0.67

Ø: 33.8°

COHESION - ksf: 0.23





MATERIAL PROPERTIES

	MATERIAL	UNIT WEIGHT (PCF)	COHESION (PSF)	INTERNAL ANGLE OF FRICTION (DEGREES)
1	RANDOM FILL (COVER)	(1) 118.0	0	33.8
2	CLAYEY SOIL LAYER (COVER)	(2) 118.0	(3) 1100	0
3	HEAP MATERIAL	(4) 115.5	0	33.8
4	CLAY LINER	118.0	(3) 1100	0
5	MINE SPOIL	115.5	0	33.8
6	FOUNDATION	118.0	230	33.8

NOTES:

Cohesive strength of random fill, heap materials and mine spoil were neglected. Actual cohesive strength for these materials is 230 psf

(1) Unit weight computation based on 95% maximum density (D698) @ 6% moisture

(2) Unit weight computation based on 95% maximum density (D698) @ 9% moisture

(3) Undrained triaxial cohesion

(4) Measured in-place unit weight at long term moisture content of 10%.

SCALE: 1" = 60'

Umetco Minerals Corporation

MAYBELL HEAP
STABILITY ANALYSIS

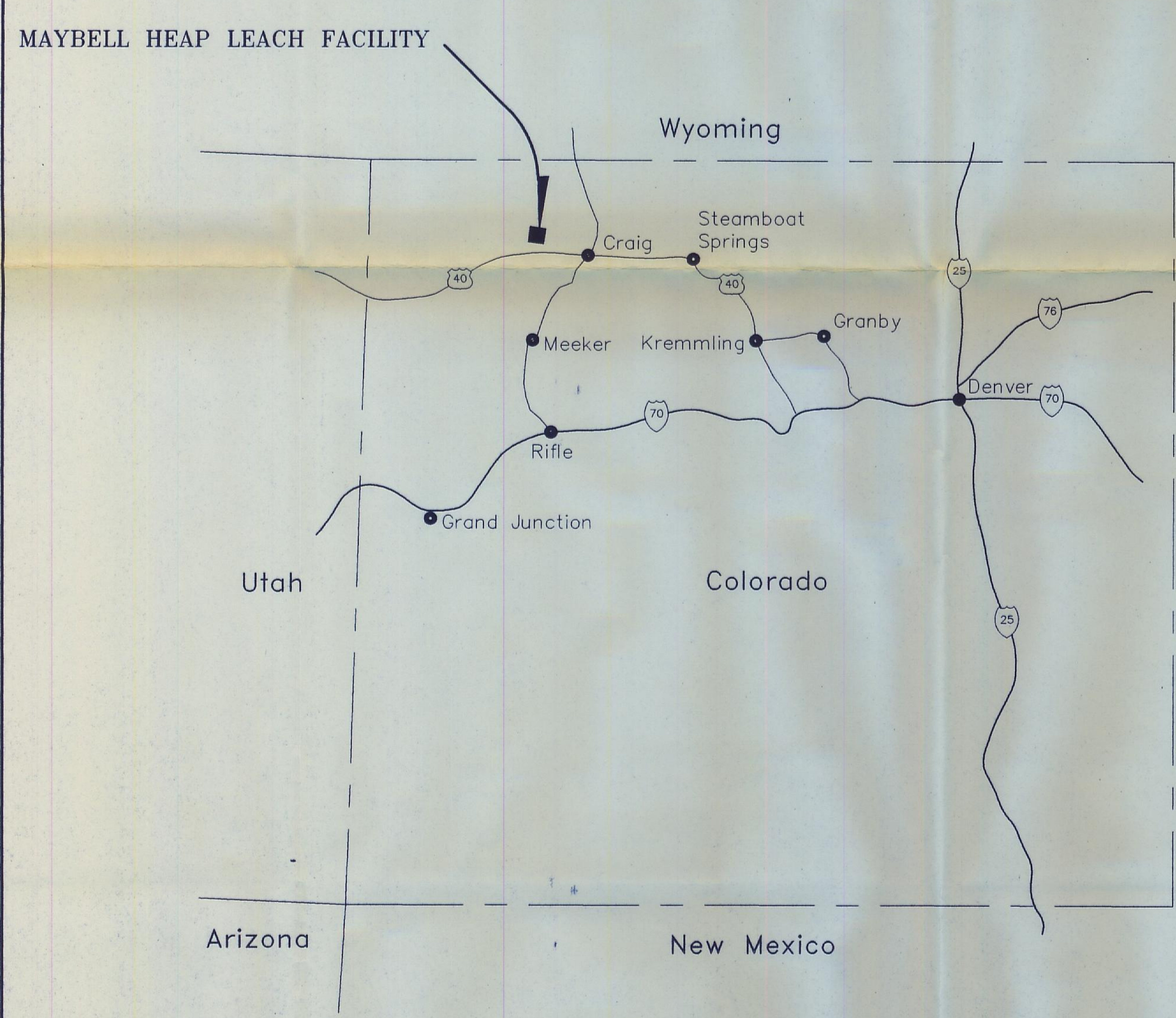
JANUARY 1995

FIG. 2.2.3-1

APPENDIX E

DRAWINGS

RECLAMATION PLANS FOR UMETCO MINERALS CORPORATION'S MAYBELL HEAP LEACH FACILITY



SHEET NO.	DRAWING TITLE
M-120	COVER SHEET
M-121	PRE RECLAMATION SITE PLAN
M-122	POST RECLAMATION DRAINAGE PLAN
M-123	FINAL COVER AND GRADING PLAN
M-124	HEAP CROSS SECTIONS
M-125	SECTIONS
M-126	DETAILS
M-127	EXCAVATION MAP

NO.	DATE	REVISION - DESCRIPTION	BY	DWG
1	3/15/95	EDIT TEXT & ADD AREA MAP	WRJ	

Umetco Minerals Corporation

MAYBELL RECLAMATION PROJECT

COVER SHEET AND VICINITY MAP

DESIGN:
DRAWN: T.L.B.
CHECKED BY:
DATE: 27 JAN 1995
UMETCO APPROVAL: *(signature)*
SHEET M-120


E 15,000
E 15,500
E 16,000
E 16,500
E 17,000
E 17,500
E 18,000
E 18,500
E 19,000
N 20,500
N 20,000
N 19,500
N 19,000
N 18,500
N 18,000
N 17,500
N 17,000
RESHAPED HEAPS
ROB PIT RAMP
ROB PIT
SOUTH ROB PIT OVERBURDEN BORROW AREA
PROCESS AREA
NEW EVAPORATION POND
PROCESS AREA
WINTER STORAGE POND
N
200' 0 200'
SCALE IN FEET
CONTOUR INTERVAL : 2'
Umetco Minerals Corporation
MAYBELL RECLAMATION PROJECT
PRE RECLAMATION SITE PLAN
DESIGN:
DRAWN: T.L.B.
SHEET
CHECKED BY:
DATE: 25 JAN 1995
M-121
UMETCO APPROVAL
NO. DATE REVISION - DESCRIPTION BY DWG

NOTES:

1) Post reclamation contours are intended to show the general configuration of the land surface only.
2) The ground surface shall be free of localized depressions that allow ponding of water.
3) Construction limits shall be established by field surveys.

NO.	DATE	REVISION - DESCRIPTION	BY	DWG

Umetco Minerals Corporation

MAYBELL RECLAMATION PROJECT

POST RECLAMATION DRAINAGE PLAN

DESIGN:	DRAWN: T.L.B.	SHEET
CHECKED BY:	DATE: 25 JAN 1995	M-122
UMETCO APPROVAL: [signature]		

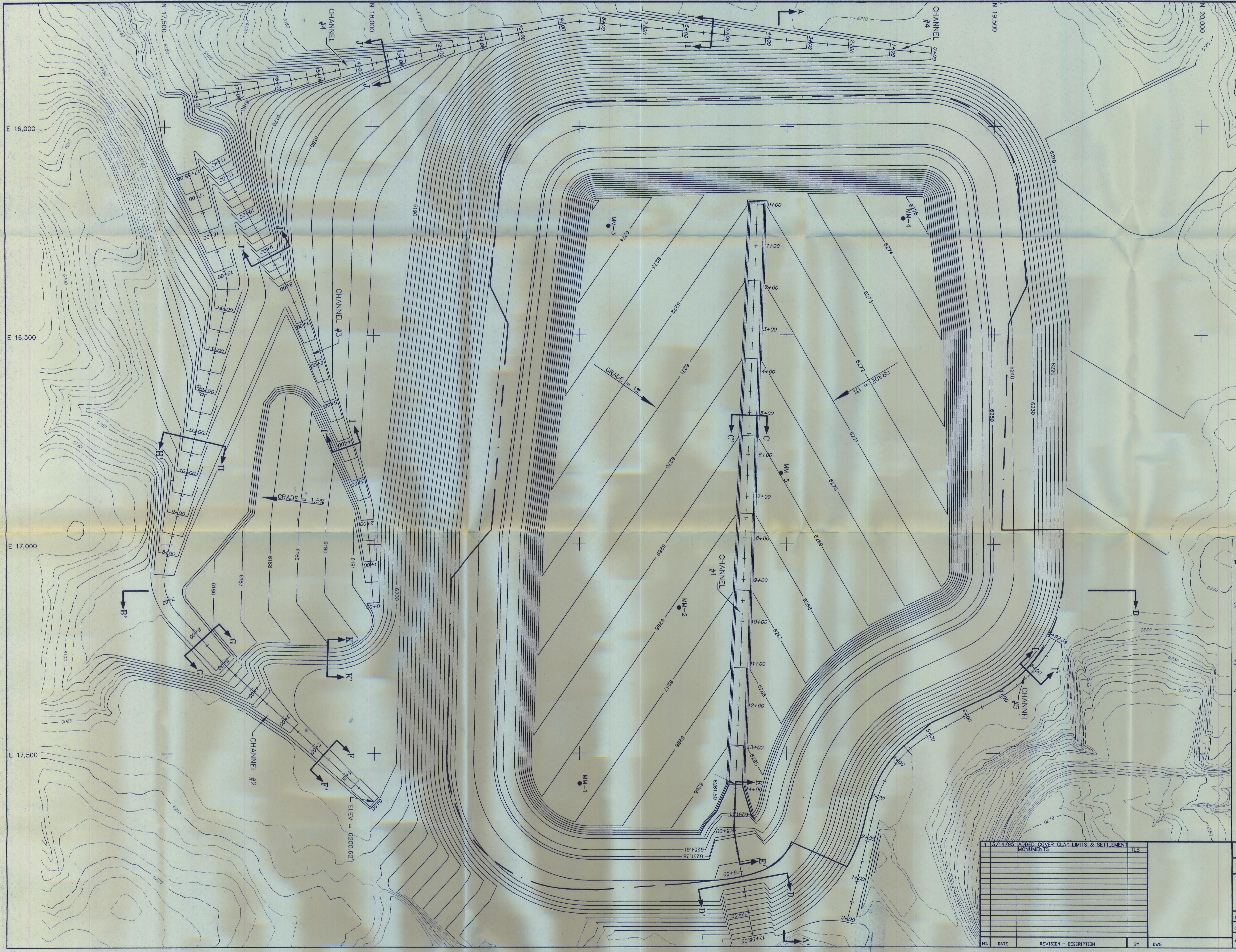


TABLE 1

CHANNEL	STATION FROM	STATION TO	GRADE
1	0+00	14+61.11	0.54%
1	14+61.11	17+56.56	20.00%
2	0+00	3+63.07	1.00%
2	3+63.07	4+93.07	10.00%
2	4+93.07	7+55.08	0.76%
2	7+55.08	17+55.08	4.00%
3	0+00	8+00	2.00%
3	8+00	11+40	10.00%
4	0+00	10+00	2.00%
4	10+00	18+00	5.00%
5	0+00	8+92.34	0.45%

NOTES:

1) The limits of features shown and design assumptions area based on interpretation of surficial conditions and recent topography. Unforseen field conditions may require some modifications to limits and/or locations of design details shown.

2) Crest elevations, reclamation contours and grades for the top of the heap are based on estimated volumes to be placed during reclamation. this information is shown on the drawings to present the reclamation design concept. acutal crest elevations will be deterimined during reclamation construction.

3) Channel alignments may be adjusted in the field as appropriate to conform to existing ground conditions.

4) Channel grades are shown in Table 1.

NO.	DATE	REVISION - DESCRIPTION	BY
1	3/14/95	ADDED COVER CLAY LIMITS & SETTLEMENT MONUMENTS	TLB

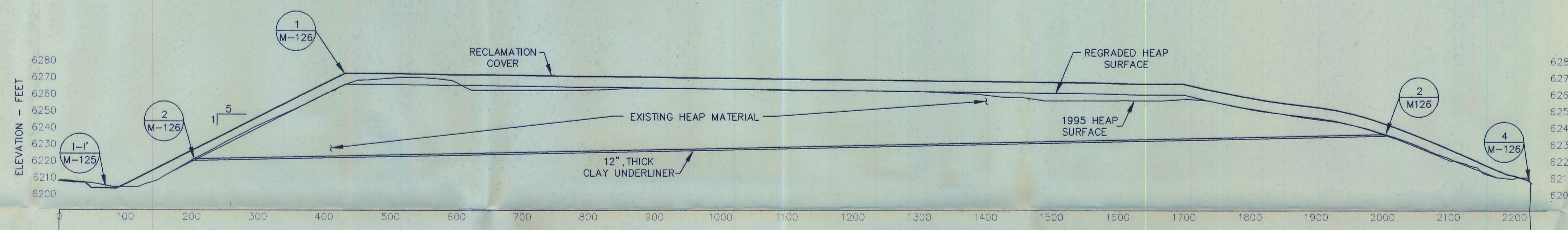
DWG

Umetco Minerals Corporation

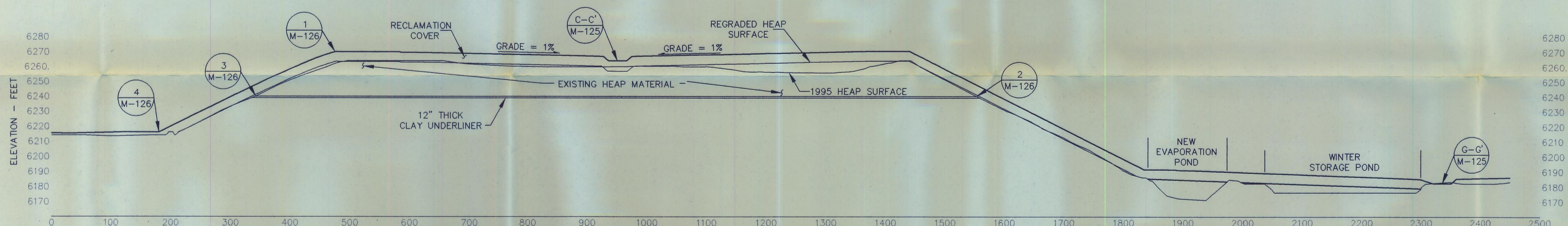
MAYBELL RECLAMATION PROJECT

FINAL COVER AND GRADING PLAN

DESIGN: TB | DRAWN: TB
CHECKED BY: | DATE: 25 JAN 1995
UMETCO APPROVAL: [signature]
SHEET M-123



SECTION A–A'
HORIZ. SCALE : 1" = 100'
VERT. SCALE : 1" = 40'



SECTION B–B'
HORIZ. SCALE : 1" = 100'
VERT. SCALE : 1" = 40'

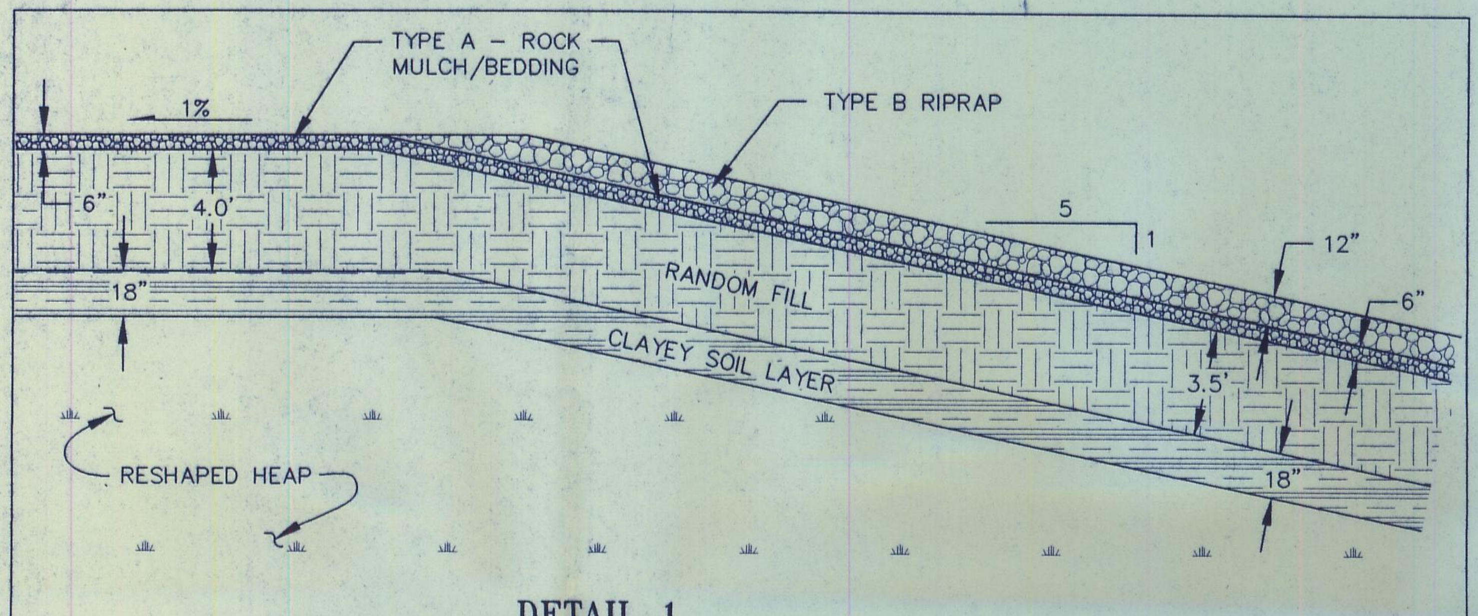
NO.	DATE	REVISION - DESCRIPTION	BY	DWG
1	3/14/95	CORRECTED SHEET REFERENCED BY SECTION G-G'	TLB	

Umetco Minerals Corporation
MAYBELL RECLAMATION PROJECT

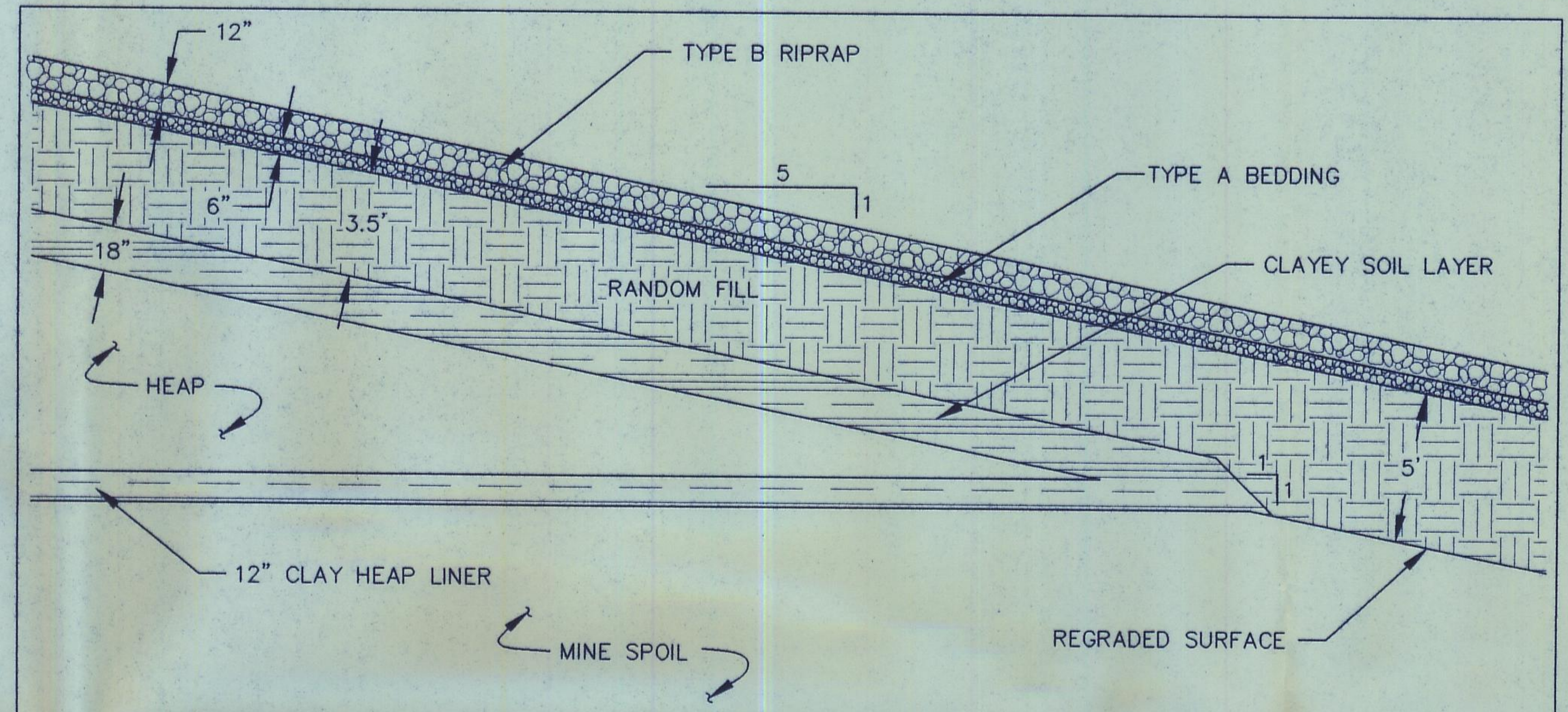
HEAP CROSS SECTIONS

DESIGN:	DRAWN: T.L.B.	SHEET
CHECKED BY:	DATE: 26 JAN 1995	M-124
UMETCO APPROVAL		

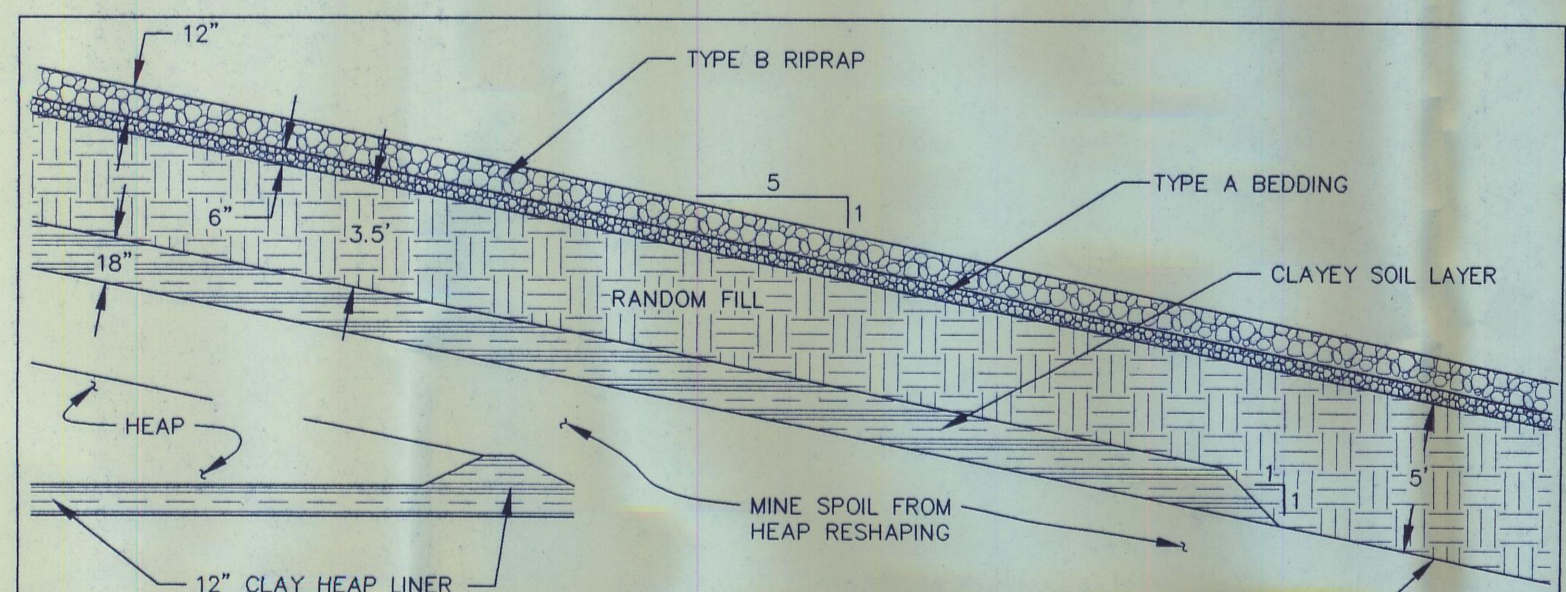
TYPE C RIPRAP
TYPE A MULCH/BEDDING
30'
1%
RANDOM FILL
CLAYEY SOIL LAYER
REGRADED HEAP SURFACE
HEAP
SECTION CC'
SCALE: 1" = 5'
CHANNEL 1, STA 0+00 TO 14+61.1
TYPE D RIPRAP
TYPE B RIPRAP
TYPE A BEDDING
100'
VARIES 3' TO 1'
SECTION DD'
SCALE: 1" = 5'
CHANNEL 1, STA 14+61.1 to End (18+00)
TOP OF RECLAMATION COVER
TYPE B BEDDING
TOP OF CHANNEL
S = 0.0054
S = 0.200
REGRADED HEAP SURFACE
SECTION EE'
SCALE: 1" = 5'
SECTION FF'
CHANNEL 2, STA 0+00 TO 3+63.07
SCALE: 1" = 5'
SECTION GG'
CHANNEL 2, STA 3+63.07 to 7+55.08
SCALE: 1" = 5'
SECTION HH'
CHANNEL 2, STA 7+55.08 TO END
SCALE: 1" = 5'
TYPE B RIPRAP 5:1 SLOPE OF RECLAMATION COVER
SECTION II'
CHANNEL 3, STA 0+00 TO 8+00
CHANNEL 4, STA 0+00 TO 10+00
CHANNEL 5, STA 0+00 TO 8+92.34
SCALE: 1" = 5'
SECTION JJ'
CHANNEL 4, STA 10+00 TO END
CHANNEL 3, STA 8+00 TO END
SCALE: 1" = 5'
TYPE A MULCH
COMPACTED RANDOM FILL
EXISTING GROUND SURFACE
CLAYEY SOIL LAYER
WASTE OR FILL SOILS PLACED IN EVAPORATION POND
SECTION KK'
SCALE: 1" = 5'
1 3/13/95 Corrected text to channels
NO. DATE REVISION - DESCRIPTION BY
DWG M-065.DWG
Umetco Minerals Corporation
MAYBELL RECLAMATION PROJECT
CHANNEL SECTIONS
DESIGN TG
DRAWN RTB
CHECKED BY:
DATE: JAN 1995
UMETCO APPROVAL
SHEET M-125



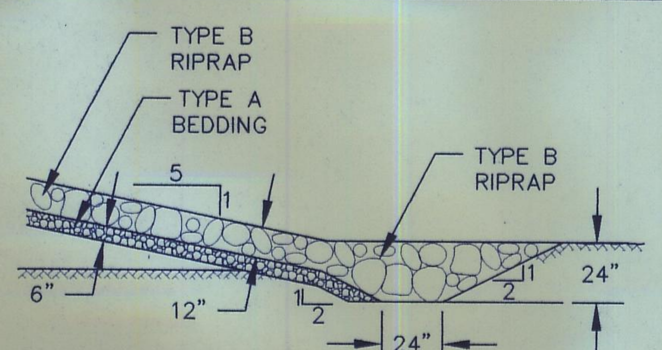
DETAIL 1
TYPICAL COVER SECTION
SCALE: 1" = 5'



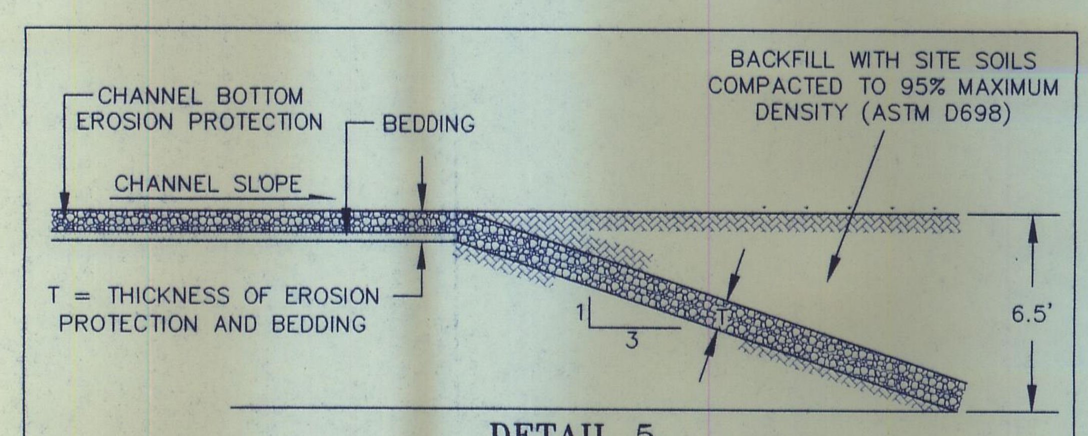
DETAIL 2
TYPICAL COVER CONSTRUCTION FOR AREAS WHERE CLAY LINER EXPOSED TO REGRADED SLOPE OF HEAP
SCALE: 1" = 5'



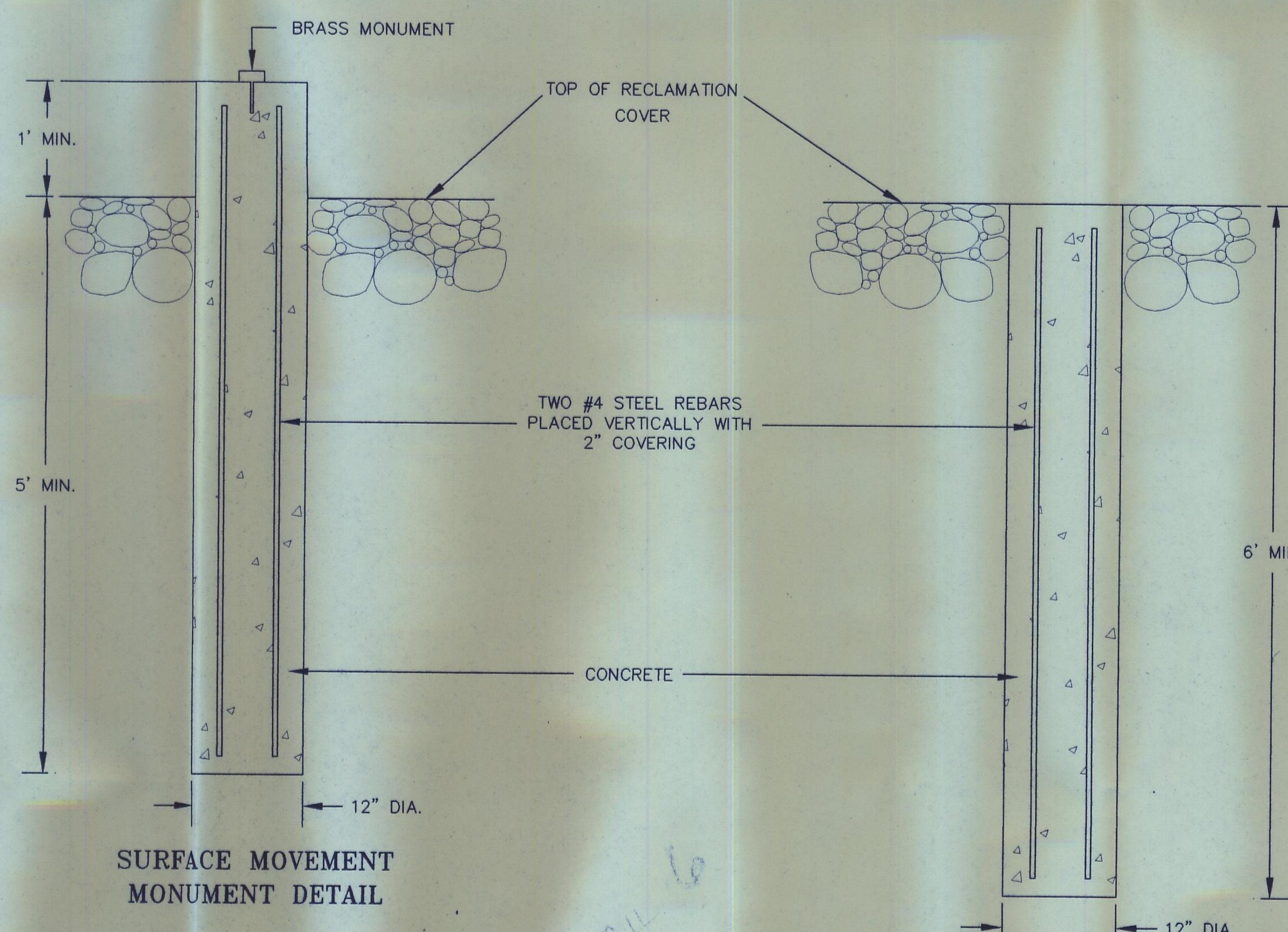
DETAIL 3
TYPICAL COVER CONSTRUCTION FOR AREAS WHERE CLAY LINER TERMINATES BELOW GRADED SURFACE
SCALE: 1" = 5'



DETAIL 4
TYPICAL TOE DETAIL
SCALE: 1" = 5'



DETAIL 5
TYPICAL CHANNEL OUTLET
SCALE: 1" = 5'



SURFACE MOVEMENT MONUMENT DETAIL

TYPICAL DETAIL
NTS

EROSION MONUMENT DETAIL

RIPRAP PLACEMENT TABLE

APPLICATION	PEAK DISCHARGE CFS	DESIGH D_{50} INCHES	PROTECTION SPECIFIED EROSION	SPECIFIED THICKNESS INCHES
Top of Reclamation Cover	1.3 cfs/ft	0.6	Type A	6
5:1 Reclamation Cover Slopes	2.19 cfs/ft (maximum)	6.5	Type B	12
			Type A–Bedding	6
CHANNEL 1				
STA 0+00 TO 14+61.1	625.6	2.5	Type C	12
			Type A–Bedding	6
STA 14+61.1 TO END (18+00)	625.6	22.5	Type D	30
			Type A–Bedding	6
CHANNEL 2				
STA 0+00 TO 3+63.07	515	3.36	Type B	9
STA 3+63.07 TO 4+93.07	515	15.6	Type D	30
			Type A–Bedding	6
STA 4+93.07 TO 7+55.08	1055	2.5	Type D	30
			Type A–Bedding	6
STA 7+55.08 TO 17+55.08	1775	15.7	Type D	30
			Type A–Bedding	6
CHANNEL 3				
STA 0+00 TO 8+00	635	6.3	Type B	12
			Type A–Bedding	6
STA 8+00 TO 11+40	635	17.8	Type D	30
			Type A–Bedding	6
CHANNEL 4				
STA 0+00 TO 10+00	620	6.2	Type B	12
			Type A–Bedding	6
STA 10+00 TO 18+00	620	13.4	Type D	30
			Type A–Bedding	6
CHANNEL 5				
STA 0+00 TO 8+92.34	610	1.9	Type B	12
			Type A–Bedding	6

RIPRAP MATERIALS TABLE

TYPE	DESIGN D_{50} INCHES	MAXIMUM SIZE INCHES	D_{50} INCHES	SPECIFIED D_{15} INCHES
Type A	0.6	3"	3/8" to 1 1/2"	#4 to 3/4"
Type B	6.5	9"	5" to 8"	3" to 6"
Type C	2.5	6"	2" to 5"	3/4" to 3"
Type D	22.5	30"	18" to 24"	5" to 10"

1) Erosion Protection Materials (Riprap) shall be placed by dozer or excavator utilizing a methodology that will minimize segregation of rock.

2) Random Fill shall consist of sandy overburden soils excavated from the South Rob Pit Overburden Stockpile. Brush, roots, sod or other perishable or unsuitable materials shall be removed. Random Fill shall have a maximum particle size of eight inches. Soil shall be compacted to at least 95% of the Standard Proctor maximum density (ASTM D698) at a moisture content of between ± 2% of optimum.

3) Clayey Soils shall have at least 30% passing the No. 200 Sieve (based on minus #4 fraction) and shall have a maximum particle size of 6 inches. Liquid limit of the soil shall be at least 25% with a minimum plasticity index of 10%. Clayey soils shall be compacted to at least 95% of the Standard Proctor maximum density at a moisture content of between optimum and four percent above optimum as determined by ASTM D698.

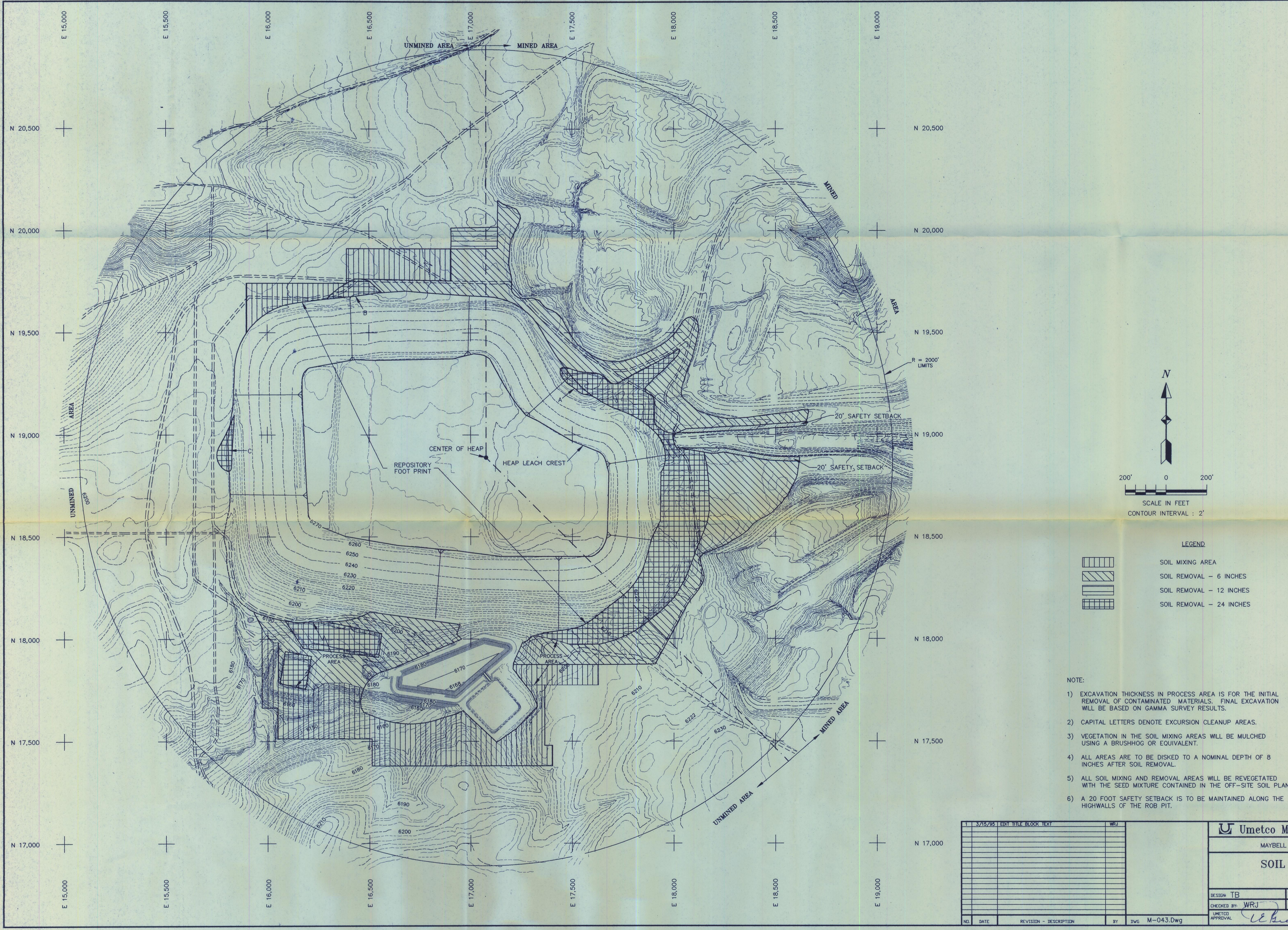
NO.	DATE	REVISION – DESCRIPTION	BY
1	3/13/95	Addition, deletion & change of text	TB

DWG M–066.DWG

Umetco Minerals Corporation
MAYBELL RECLAMATION PROJECT

DETAILS

DESIGN: TG | DRAWN: RTB | CHECKED BY: | DATE: JAN 1995 | UMETCO APPROVAL: | SHEET M–126



NOTE:

1) EXCAVATION THICKNESS IN PROCESS AREA IS FOR THE INITIAL REMOVAL OF CONTAMINATED MATERIALS. FINAL EXCAVATION WILL BE BASED ON GAMMA SURVEY RESULTS.

2) CAPITAL LETTERS DENOTE EXCURSION CLEANUP AREAS.

3) VEGETATION IN THE SOIL MIXING AREAS WILL BE MULCHED USING A BRUSHHOG OR EQUIVALENT.

4) ALL AREAS ARE TO BE DISKED TO A NOMINAL DEPTH OF 8 INCHES AFTER SOIL REMOVAL.

5) ALL SOIL MIXING AND REMOVAL AREAS WILL BE REVEGETATED WITH THE SEED MIXTURE CONTAINED IN THE OFF-SITE SOIL PLAN.

6) A 20 FOOT SAFETY SETBACK IS TO BE MAINTAINED ALONG THE HIGHWALLS OF THE ROB PIT.

NO.	DATE	REVISION - DESCRIPTION	BY
1	3/15/95	EDIT TITLE BLOCK TEXT	WRJ

DWG M-043.Dwg

Umetco Minerals Corporation

MAYBELL RECLAMATION PROJECT

SOIL EXCAVATION MAP

DESIGN: TB
DRAWN: RB
CHECKED BY: WRJ
DATE: 7 APR 1994
UMETCO APPROVAL:
SHEET M-127