Moab, Utah, UMTRA Project

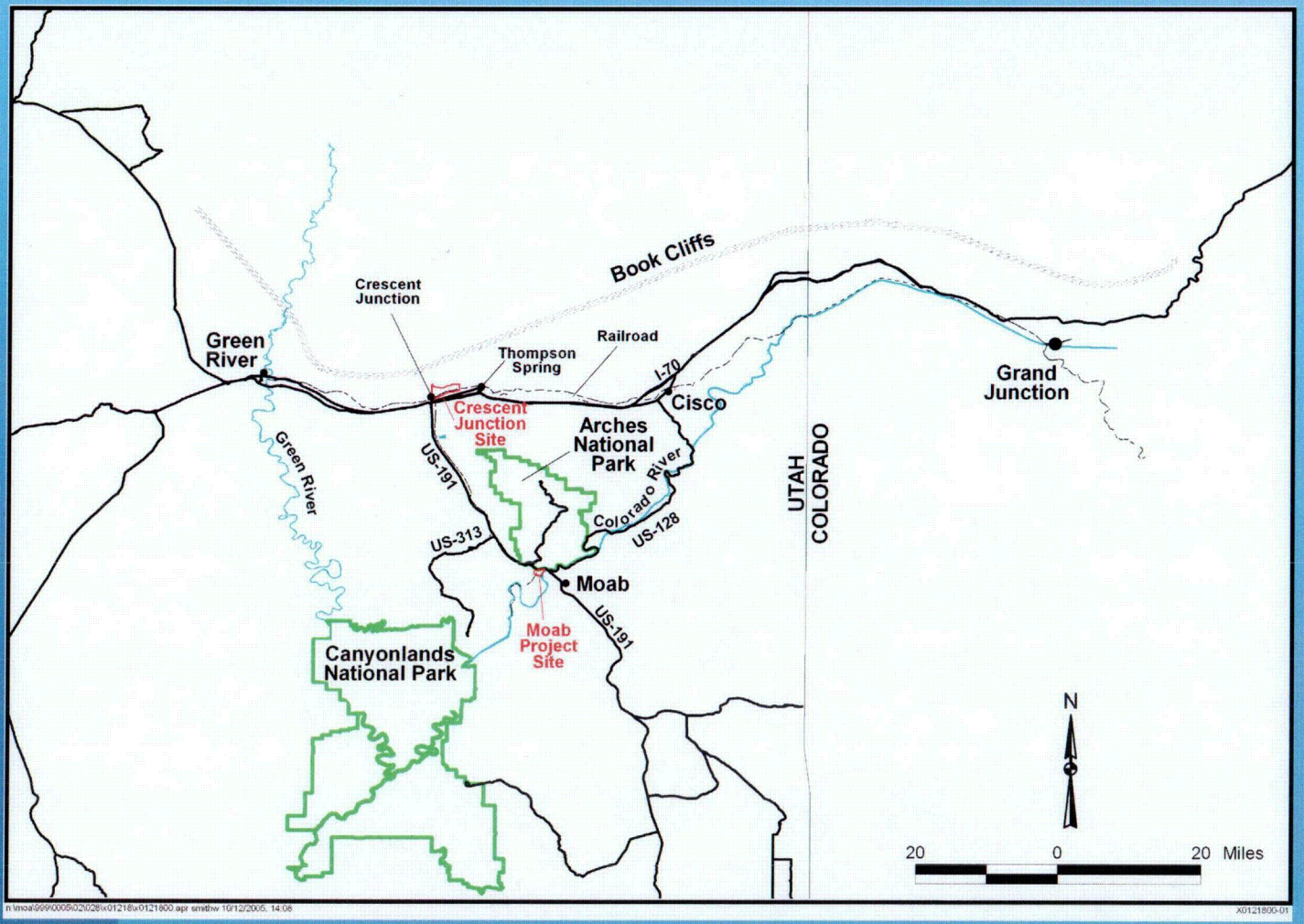
U.S. Nuclear Regulatory Commission
Remedial Action Plan Status Meeting

June 20, 2006

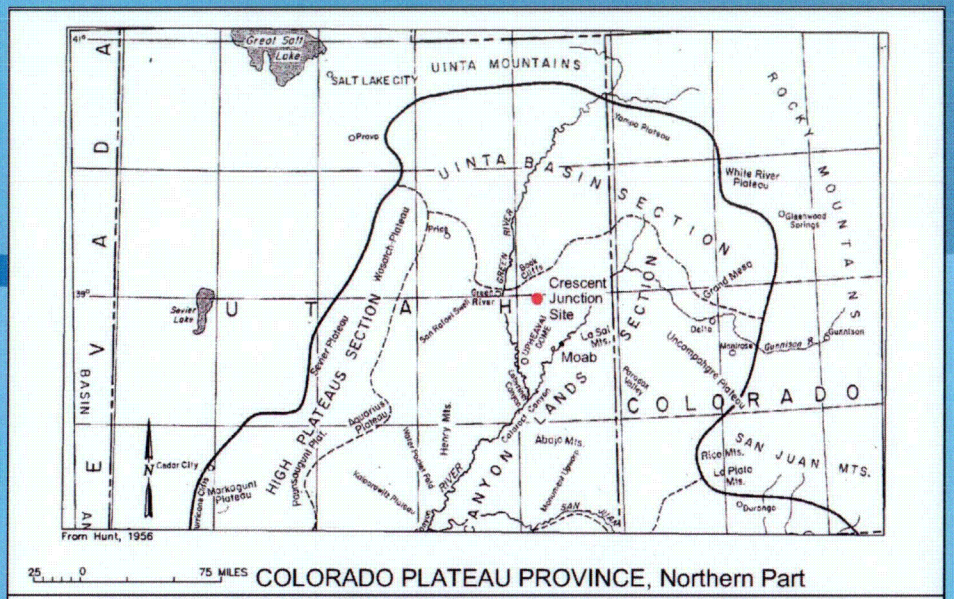
Cell Design

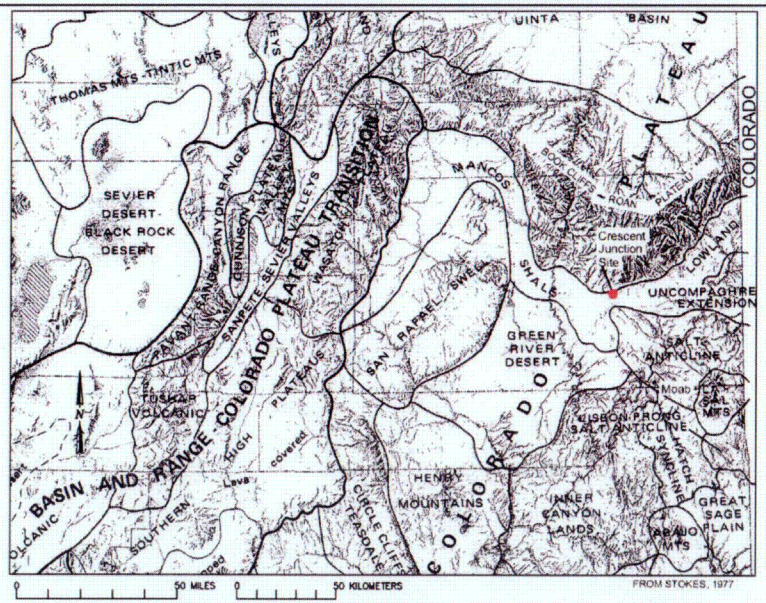
Location Map

Location Map



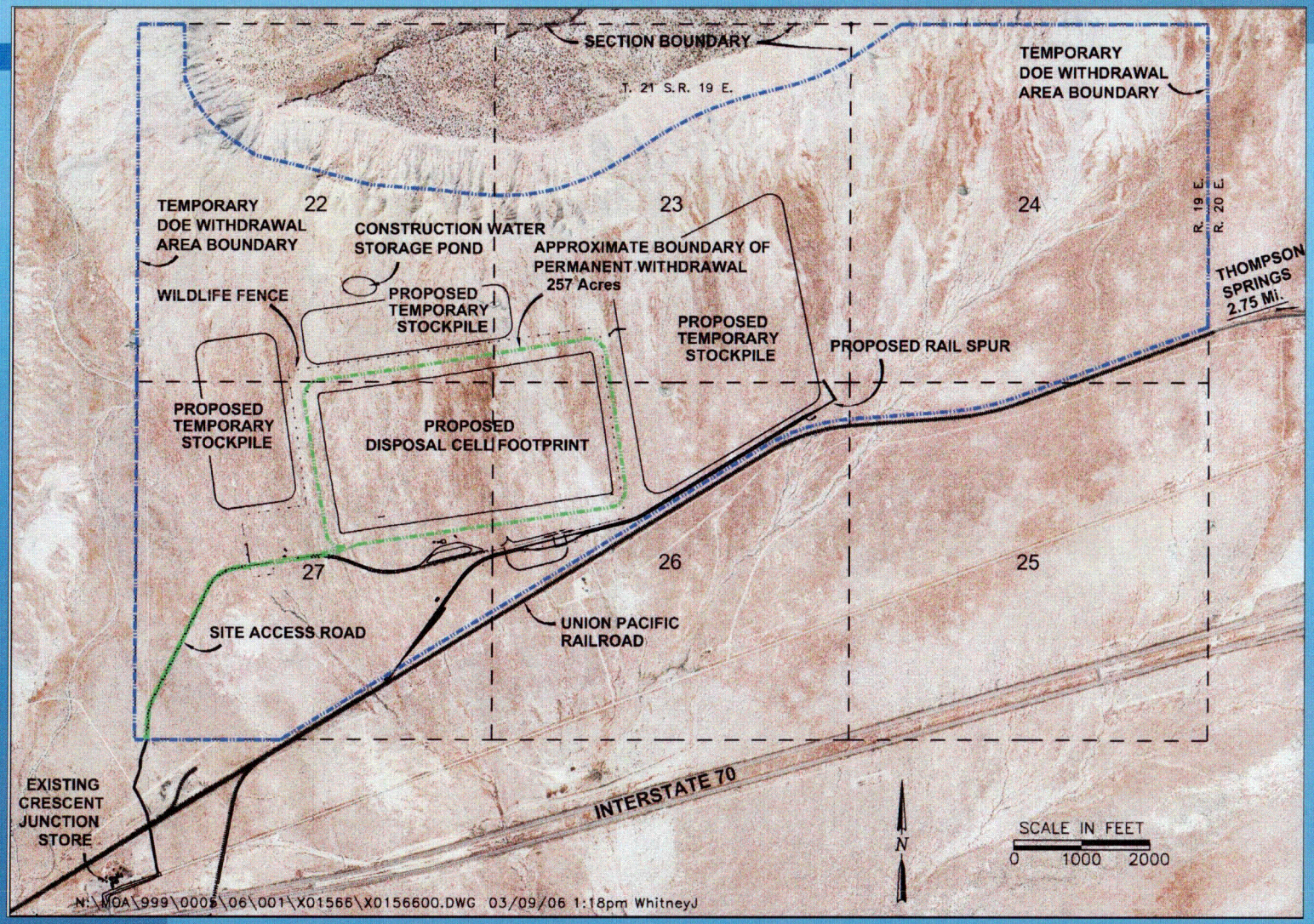
Site in Canyon Lands section of Colorado Plateau in Mancos Shale Lowland



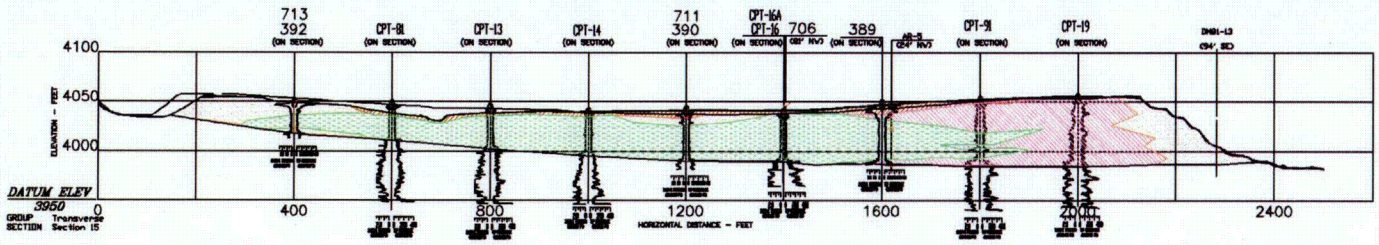


Site location and relation to physiographic features

Crescent Junction, Utah, Site



Atlas Mill Tailings Impoundment



Section 15 Calculation MOA-02-05-2006-5-02-01

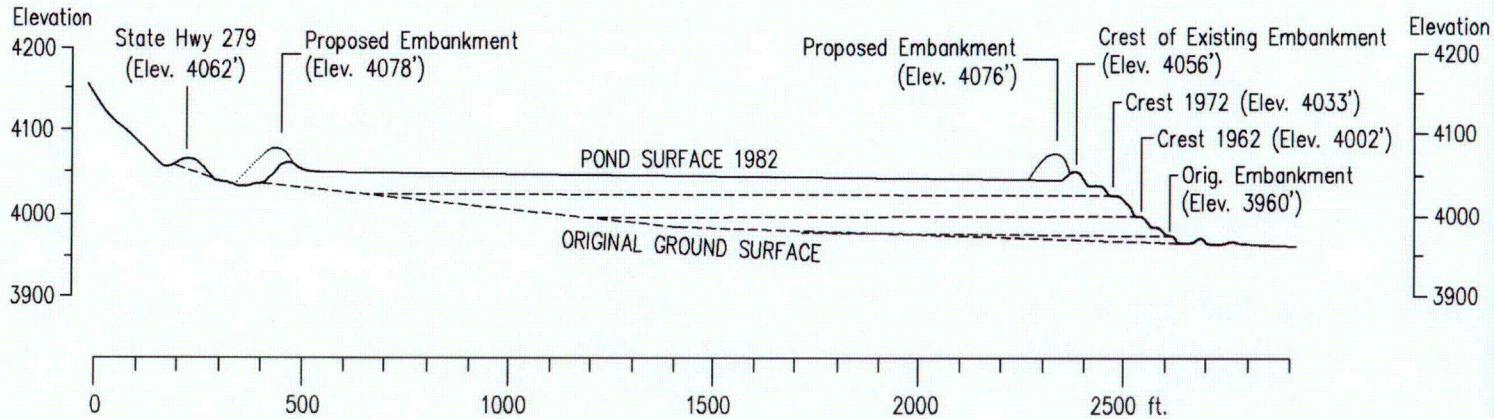


Figure 4 – Atlas Mill Tailings Impoundment Commingled Uranium Tailings Study Technical Report, Vol. II, 1982 A-107

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Tailings Material Properties

The tailings material types are now as follows:

- Sand tailings
  - <30% fines (–74 microns)
  - Silty sands (SM in Unified Soil Classification System [USCS])
  - Specific gravity approximately 2.70
- Transitional tailings (slimey sands and sandy slimes)
  - Slimey sand tailings: >30% and <50% fines
  - Sandy slimes tailings: >50% and <70% fines
  - Silty sands (SM) or low plasticity silts (ML in the USCS); specific gravity of solids approximately 2.65

Tailings Material Properties

- Slimes tailings
  - Between 70% and 100% fines
  - Low plasticity silts (ML) or low plasticity clays (CL in the USCS)
  - USCS: some of the slimes tailings have sufficient plasticity to classify as high plasticity silt (MH) and/or clay (CH)
  - Specific gravity of solids ranges from 2.54 to 3.03

Residual Radioactive Material (RRM) Volume In-Place

Tailings Pile	In Bank Cubic Yards
Sandy Tailings and Alluvial	2,798,400
Transitional Material	3,916,800
Slimes	3,176,300
Other RRM	
Interim Cover Material	452,800
Off-Pile Material	700,000
Vicinity Property Material	120,000
Subpile Material	774,400
Total	**12.0M**

In-Place Volume of Tailings Pile and Other RRM

Material	In-Place Volume (yd^3)	In-Place Wet Density (pcf)	In-Place Moisture Content	In-Place Total Weight (tons)	In-Place Water Weight (tons)	Solids Weight (tons)
Tailings						
Sand Tailings	2,798,384	109	10%	4,117,821	374,347	3,743,474
Transitional Tailings	3,916,789	115	25%	6,080,814	1,216,163	4,864,651
Slimes Tailings	3,176,326	114	50%	4,888,366	1,629,455	3,258,910
Subtotal	**9,891,498**			**15,087,001**	**3,219,965**	**11,867,036**
Other RRM						
Interim Cover	452,800	109	9%	666,295	55,015	611,280
Off-Pile Material	700,000	105	9%	992,250	81,929	910,321
Vicinity Property	120,000	105	9%	170,100	14,045	156,055
Sub-Pile Material	774,000	115	20%	1,201,635	200,273	1,001,363
Subtotal	**2,046,800**			**3,030,280**	**351,262**	**2,679,019**
Total	**11,938,298**			**18,117,281**	**3,571,227**	**14,546,054**

Final Volume of RRM in Disposal Cell

Material	Final Moisture Content	Final Water Weight (tons)	Final Total Weight (tons)	Final Wet Density (pcf)	Final Cell Volume (yd^3)	Volume Change (yd^3)
Tailings						
Sand Tailings	14.3%	535,317	4,278,791	109	2,903,606	105,222
Transitional Tailings	17.5%	851,314	5,715,965	115	3,676,985	-239,803
Slimes Tailings	25.0%	814,728	4,073,638	111	2,712,368	-463,958
Subtotal		**2,201,358**	**14,068,394**		**9,292,959**	**-598,539**
Other RRM						
Interim Cover	12.9%	78,855	690,135	115	443,053	-9,747
Off-Pile Material	11.0%	100,135	1,010,456	113	659,796	-40,204
Vicinity Property	11.0%	17,166	173,221	113	113,108	-6,892
Sub-Pile Material	12.0%	120,164	1,121,526	114	725,783	-48,217
		316,320	**2,995,339**		**1,941,740**	**-105,060**
		2,517,678	17,063,733		11,234,699	-703,599

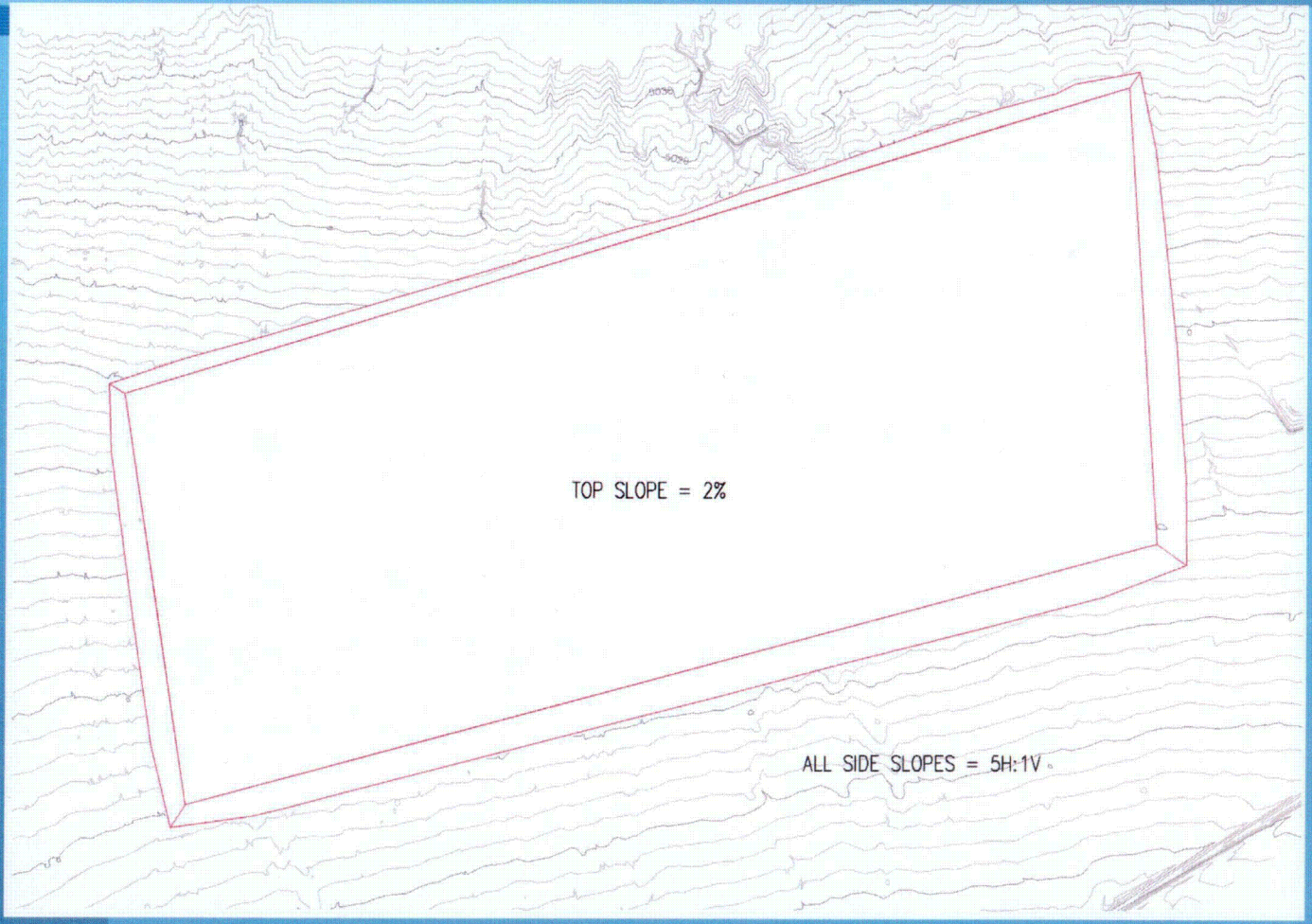
Final Volume of RRM in Disposal Cell

- Total mass of 10,165,000 tons (dry weight) reported processed through the mill; calculated mass is 11,867,036 tons
- Variation between weight of material reported processed by mill and weight of material estimated via volumetric estimates most likely due to volume of material used in the berms
- Current design volume is 12.0 M cubic yards

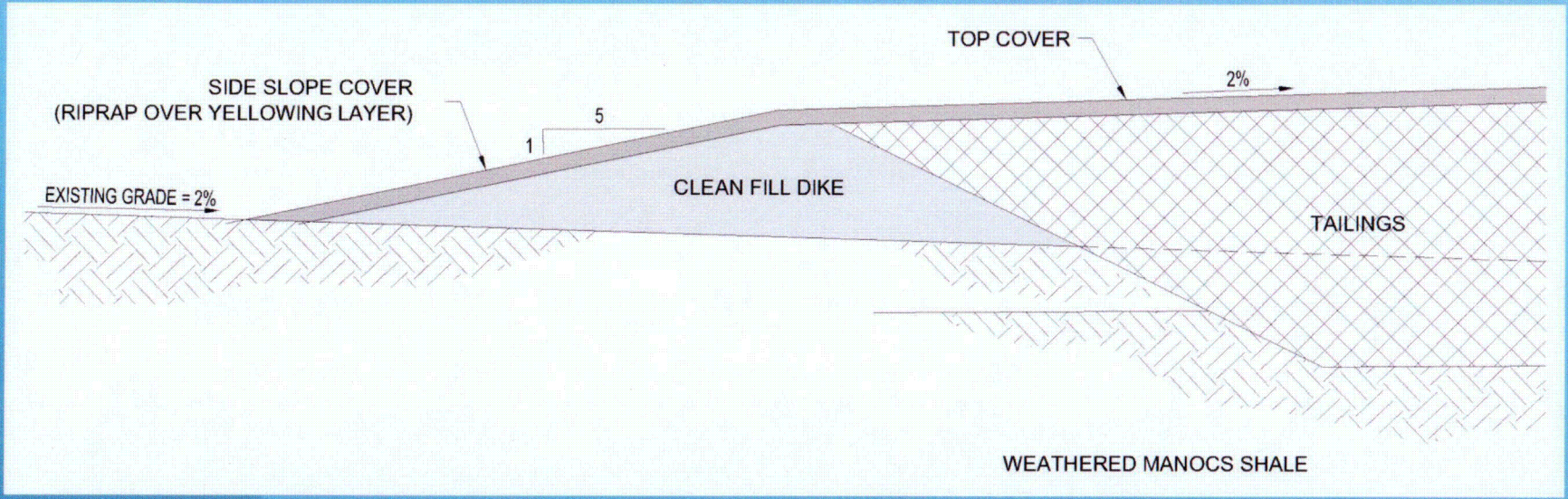
Disposal Cell Layout

- Cover parallel to ground surface to minimize height
- Clean fill dike assists ground water protection strategy
- Bottom keyed into weathered Mancos Shale; depth determined by balance of materials
- Designed to divert off-site sheet flow to west and south

Disposal Cell Layout



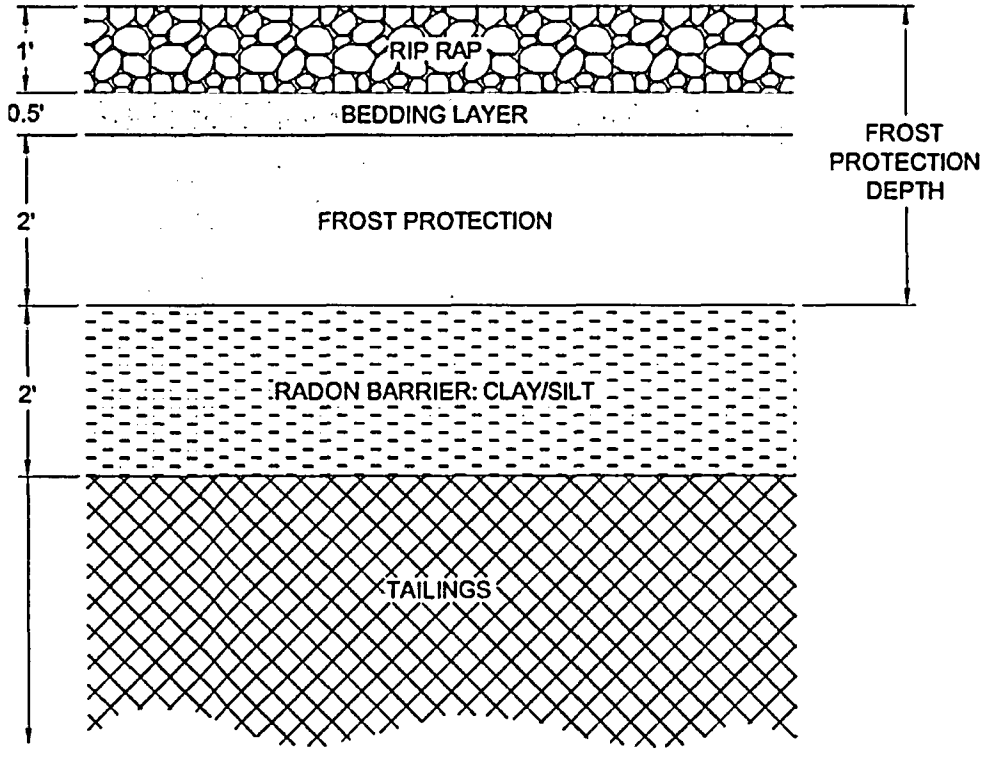
Typical Cross Section Showing Clean Fill Dike and Tailings



Disposal Cell Cover

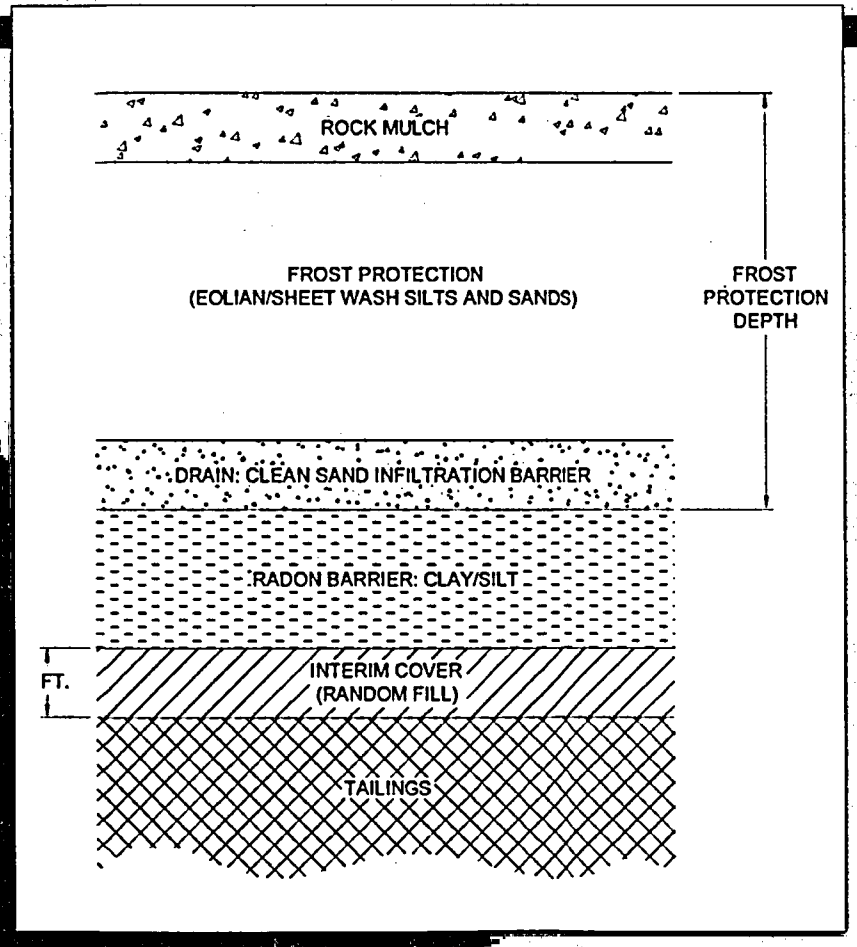
- Cover is most important design element for demonstrating compliance with 40 CFR 192 standards
- Use of on-site materials or nearby borrow sources
- Utilize drainage layer to help control infiltration
- Utilize weathered Mancos Shale or silt/sands for infiltration/ radon barrier
- Biointrusion will be studied to determine need for biobarrier
- Cover design based on Grand Junction (Cheney) disposal cell
- Developed two alternative covers
  - UMTRA checklist
  - Monolithic fill

Grand Junction (Cheney) Cover

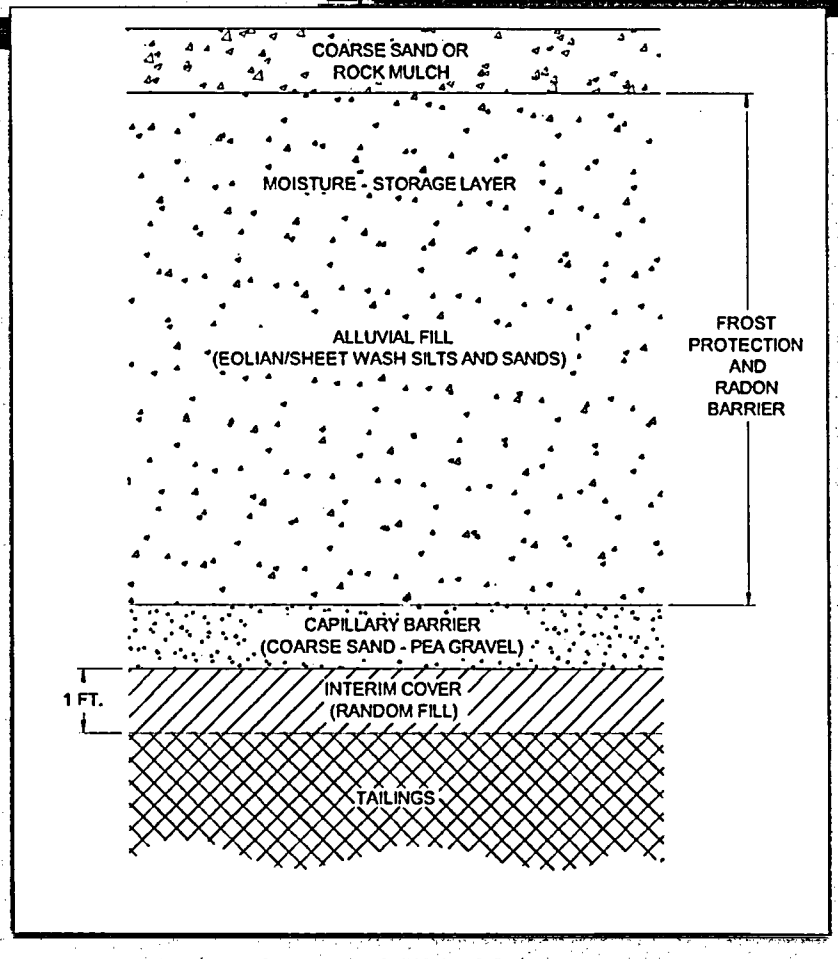


GRAND JUNCTION COVER

UMTRA Checklist and Monofill Covers



UMTRA Checklist Cover



Monofill Cover

RRM Placement in Disposal Cell

- Soil materials placed at a minimum of 90% of maximum density and ± 3% of optimum moisture content (Standard Proctor)
- Oversize material sized to maximum of 10 feet in any one direction
  - Demolition debris from mill
  - Two intact autoclaves
  - HDPE pipe and trestle from slurry line
  - Drums of vanadium oxide

RRM Placement in Disposal Cell

- Cut or crushed as necessary to reduce voids
- Placed in layers and voids filled with soil
- Layers of debris/oversized material must have 5 feet of vertical separation
- Autoclaves placed intact; interior grouted and backfilled around

Settlement and Cracking

- Differential settlement is the primary cause of cover cracking
- Differential settlement is caused by uneven loading, heterogeneous materials, and/or varying densities/moisture contents
- Total tailings settlement acceptable, with construction schedule allowing settling time
- Estimated strain from differential settlement less than strain required to cause cover cracking

Settlement and Cracking

- Material Placement Plan written to address the causes of differential settlement
  - Material placed in even layers
  - Moisture content and compaction specified and monitored in accordance with the Quality Control Plan
  - Debris/oversized material placed in lifts and voids filled
  - Cell designed to be a uniform thickness

Liquefaction

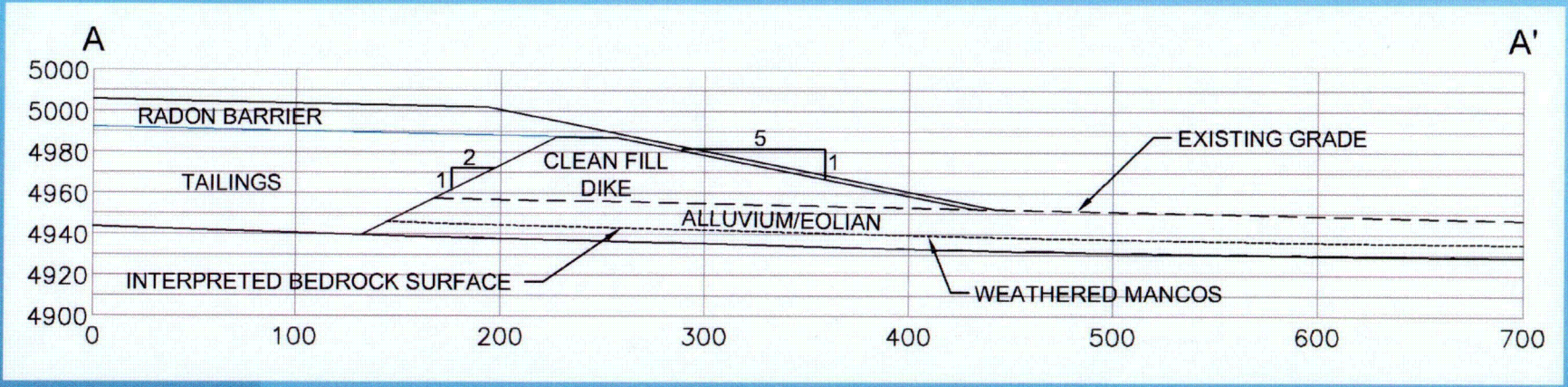
- Compacted tailings are unlikely to be susceptible to liquefaction for several reasons, including
  - Saturation predominantly less than 100%
  - Fines content very high
  - Compacted material has adequate cyclic strength after compaction and settlement
- Confirmatory calculations show stresses that would be caused by seismic event less than stresses required to produce liquefaction

Slope Stability

- Cell slope stability evaluated at highest cross section along perimeter of cell
- Stability evaluated under critical static and seismic conditions
  - Static conditions at end of construction and long term
  - Seismic conditions, pseudo-static, strength loss
- Factors of safety calculated using SLOPE/W and infinite slope methods for likely failure surfaces
- Lowest calculated factor-of-safety values compared with established factor-of-safety criteria
- Criteria met (indicating stable conditions) for all cases analyzed

Slope Stability

Typical cross section from slope stability calculation



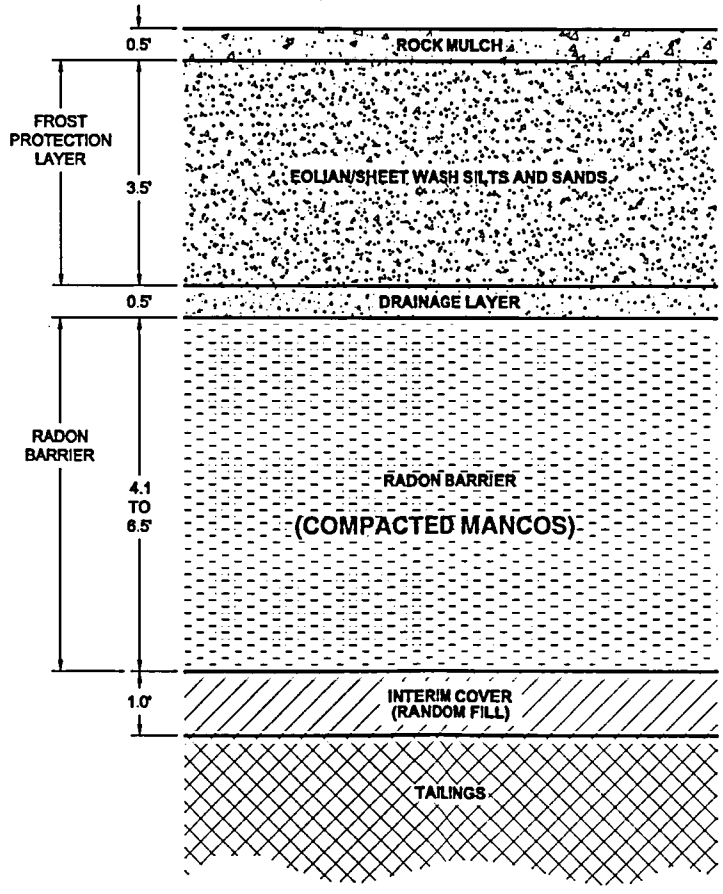
Slope Stability

Loading Condition	Minimum Factor of Safety From TAD	Results of Stability Analysis
End of Construction		
Static	1.3	1.9
Pseudo-Static	1.0	1.2
Infinite Slope (static)		1.9
Infinite Slope (pseudo-static)		1.2
Long Term		
Static	1.5	2.5
Pseudo-Static ($kh = 0.15$ g)	1.0	1.2
Infinite Slope (static)		2.8
Infinite Slope (pseudo-static)		1.2

Radon Attenuation

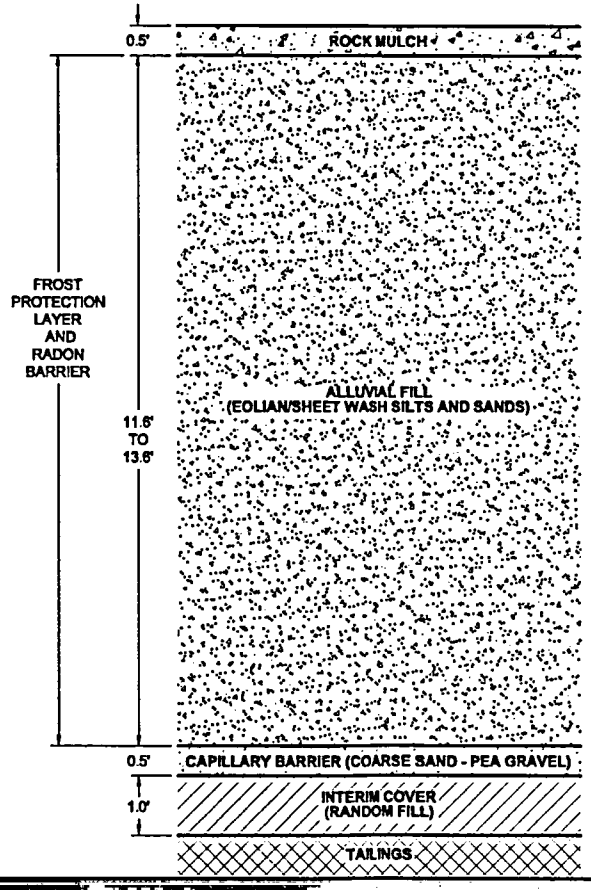
- Emanation rate of Rn-222 estimated with the RADON model
- Conservative parameters used in modeling
  - Long-term water content in tailings and cover soils
  - Tailings Ra-226 one SEM above mean to bottom of cover
  - Background Ra-226 in cover materials
- UMTRA checklist and monofill cover systems were evaluated
- For each cover system alternative, cover thickness was adjusted to achieve 20 pCi average Rn-222 flux

UMTRA Checklist Cover



	Ra-226 ACTIVITY (pCi/g)	WATER CONTENT (%)	DEGREE OF SATURATION (%)	RADON-222 FLUX (pCi/m²-sec)
ROCK MULCH	NOT ANALYZED			
EOLIAN/SHEET WASH SILTS AND SANDS	NOT ANALYZED			
DRAINAGE LAYER	NOT ANALYZED			20
RADON BARRIER (COMPACTED MANCOS)	2.3 - 3.0	10 - 12	51 - 65	314 - 415
INTERIM COVER (RANDOM FILL)	1.9 - 2.0	7 - 8	30 - 35	
TAILINGS	868 - 954	15	54	

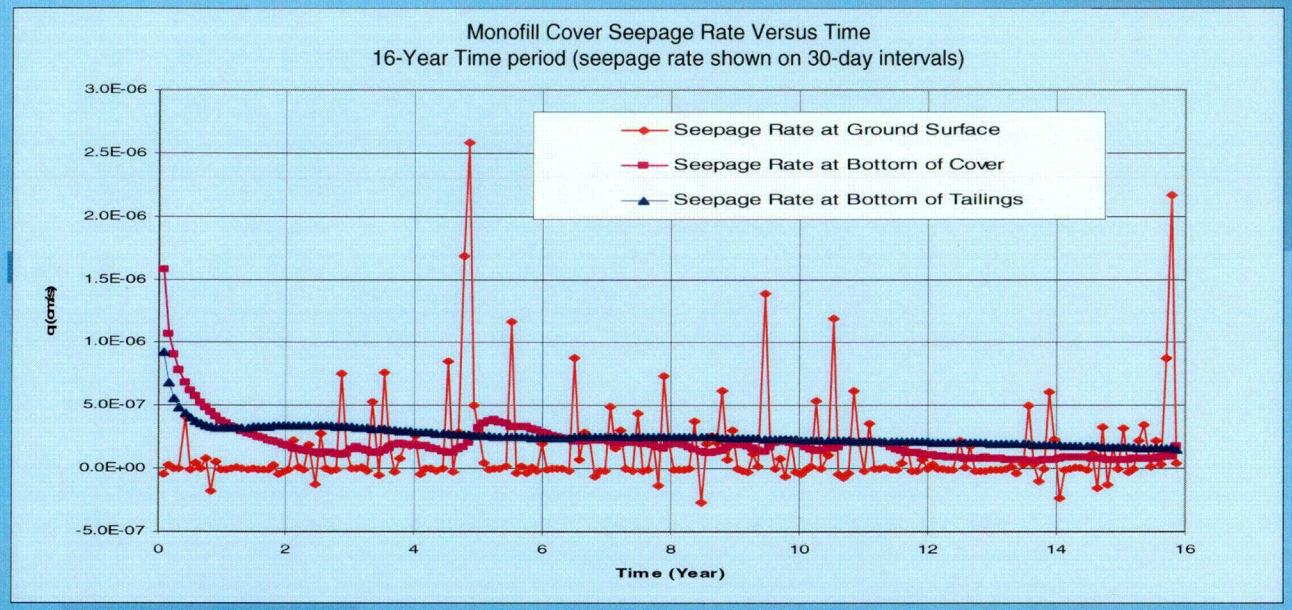
Monofill Cover



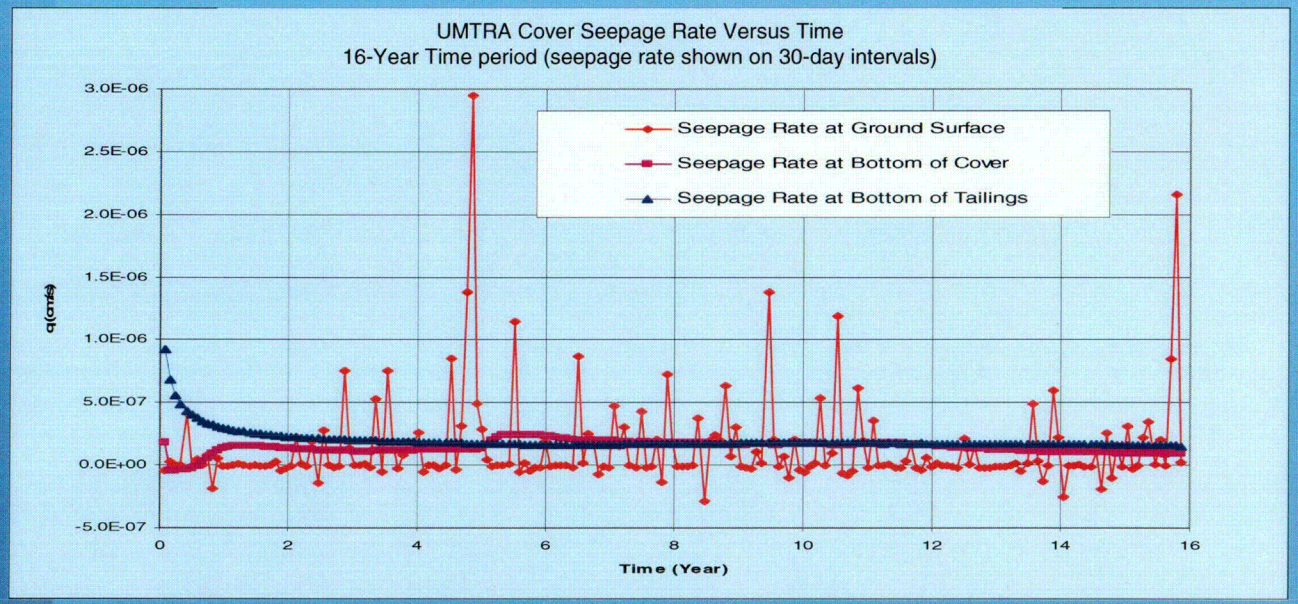
	Ra-226 ACTIVITY (pCi/g)	WATER CONTENT (%)	DEGREE OF SATURATION (%)	RADON-222 FLUX (pCi/m²-sec)
ROCK MULCH	NOT ANALYZED			20
ALLUVIAL FILL (EOLIAN/SHEET WASH SILTS AND SANDS)	1.9 - 2.0	7 - 8	30 - 35	
CAPILLARY BARRIER (COARSE SAND - PEA GRAVEL)	0	0	0	
INTERIM COVER (RANDOM FILL)	1.9 - 2.0	7 - 8	30 - 35	423 - 497
TAILINGS	868 - 954	15	54	

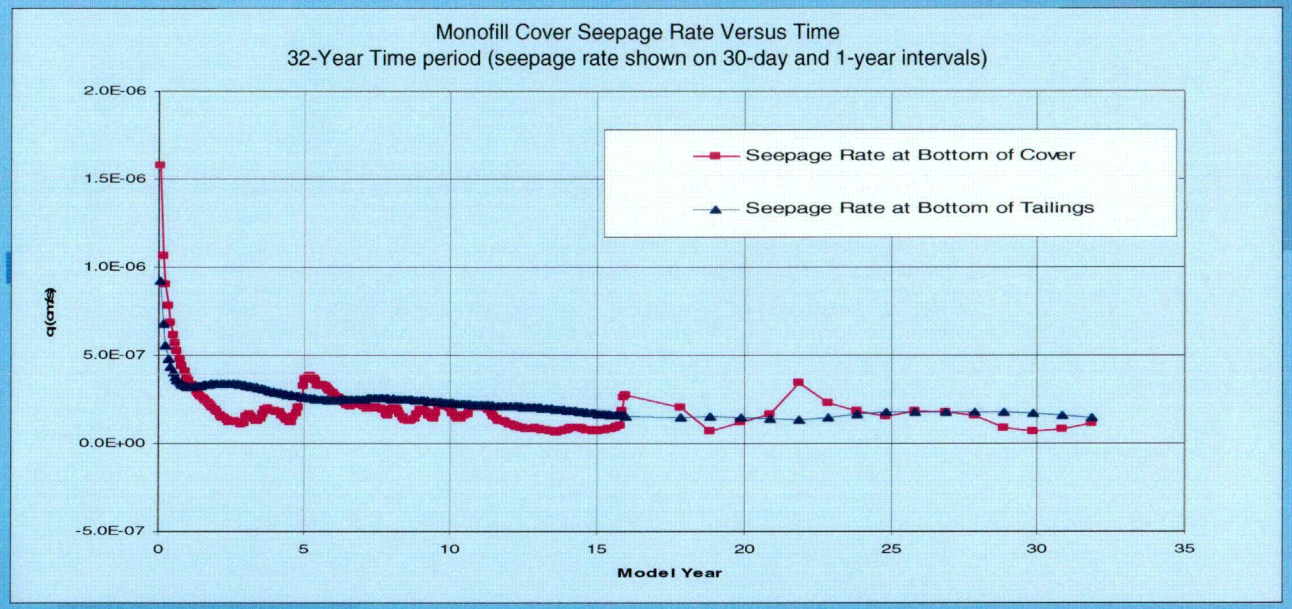
Infiltration Modeling

- Infiltration and water migration through cell modeled with VADOSE/W
- One-dimensional column through cell and weathered Mancos Shale modeled for UMTRA and monofill cover systems
- Daily climatic data from Bryson, Utah, used in model
  - 16-year data set (precipitation, humidity, and temperature)
  - 9.1 inches average annual precipitation
- Modeling on daily time steps for 32-year simulation
  - Slight upward flow with infiltration due to precipitation events
  - Slight difference between cover system alternatives

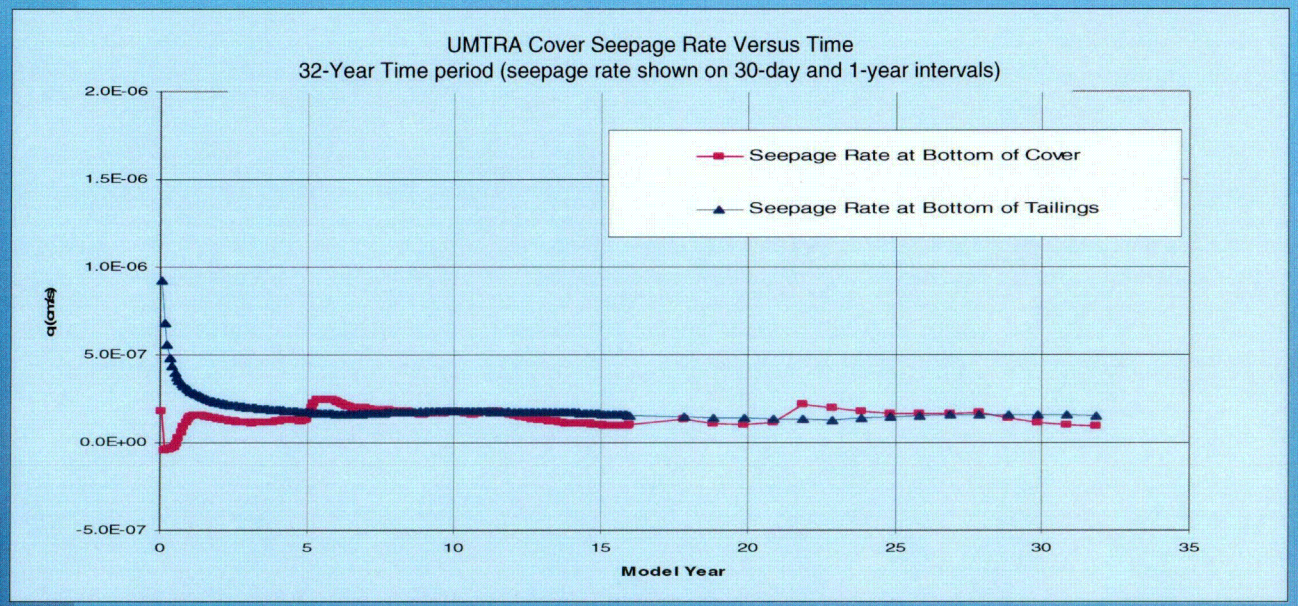


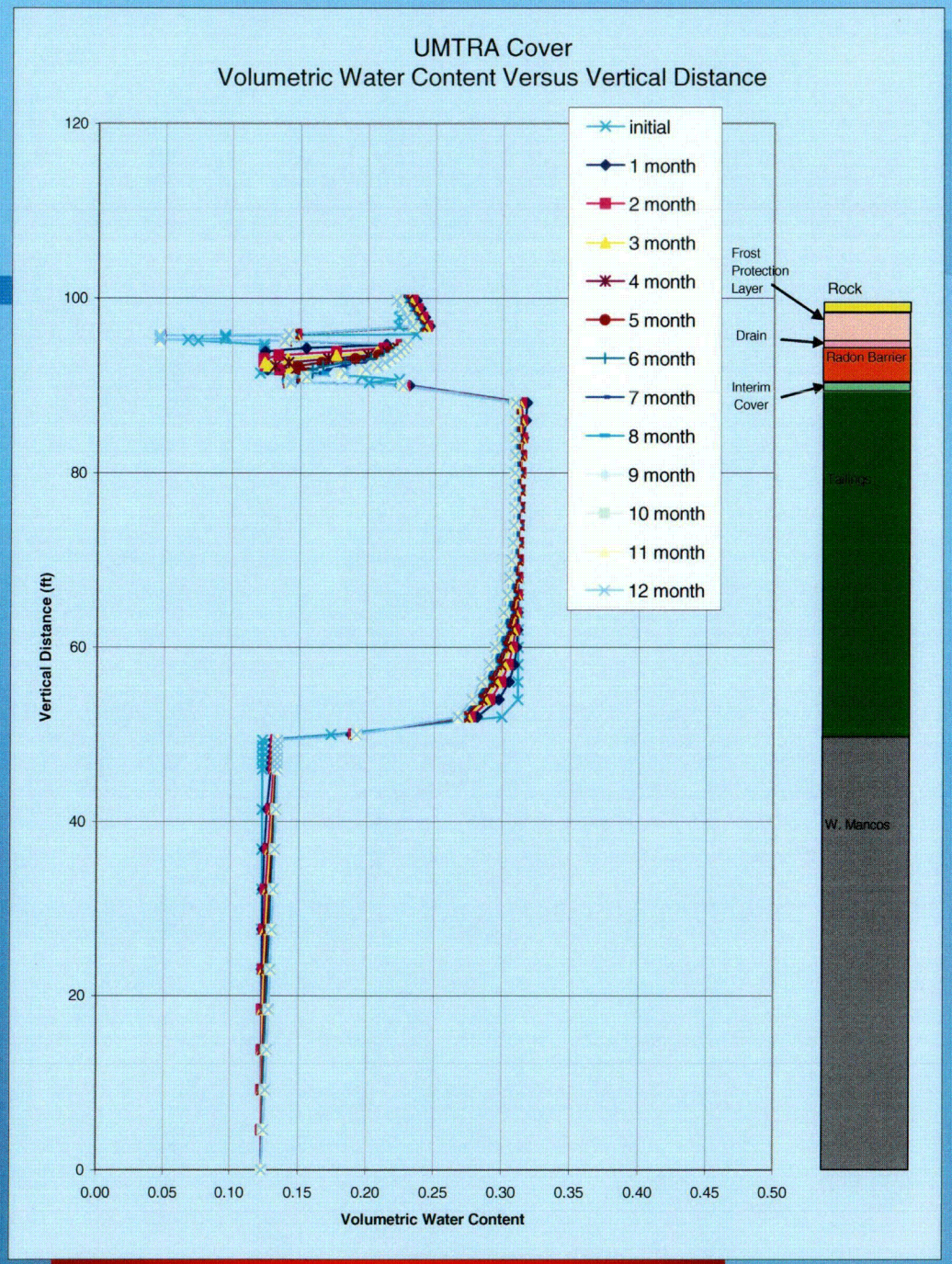
16-Year Seepage Rate From Infiltration Calculation





32-Year Seepage Rate From Infiltration Calculation





1-Year Volumetric Profile

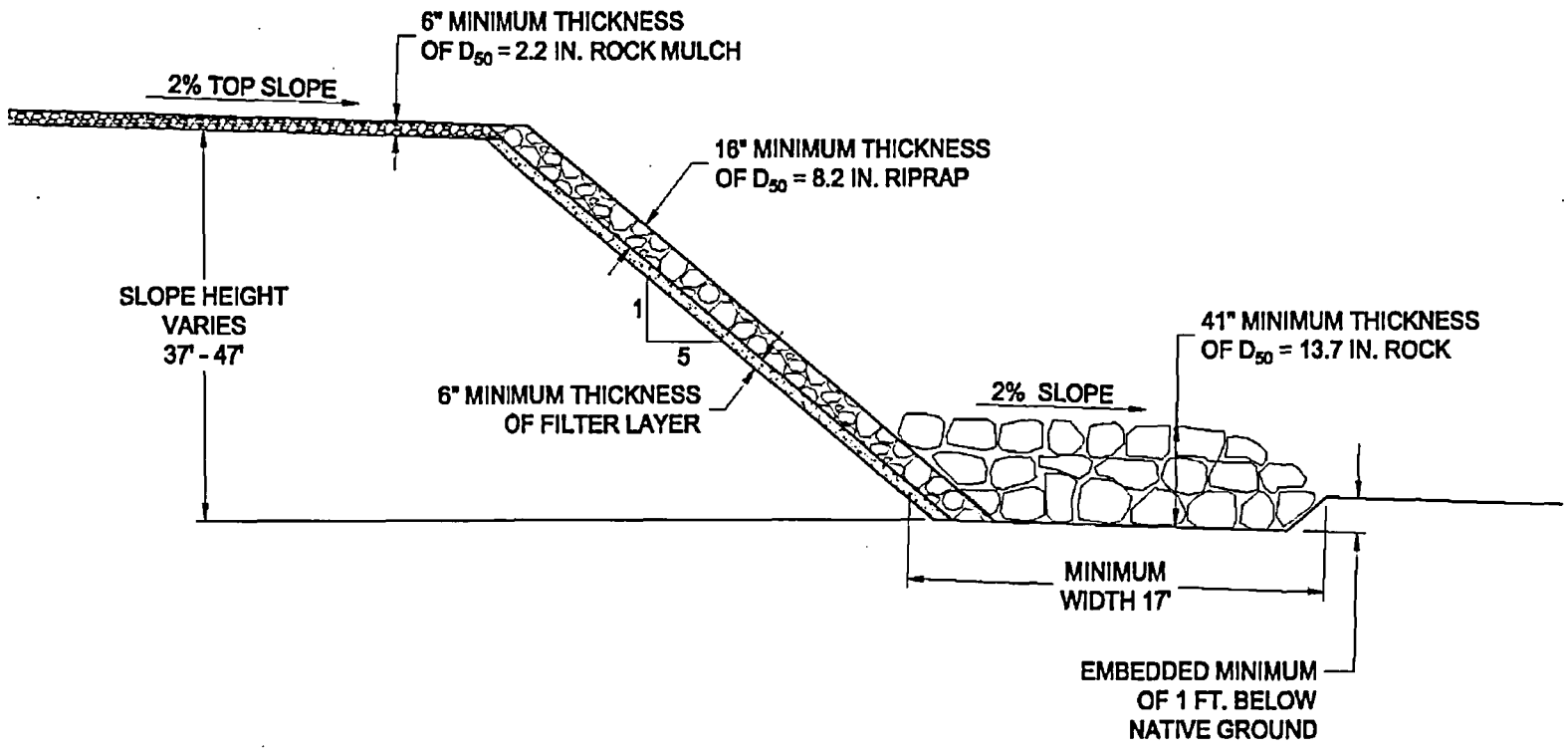
Long-Term Seepage Rate

Description	Long-Term Seepage Rate (end of 32nd year) (cm/s)	
	Bottom of Cover	Bottom of Tailings
Monofill Cover System	1.2 E-7	1.5 E-7
UMTRA Cover System	9.7 E-8	1.5 E-7

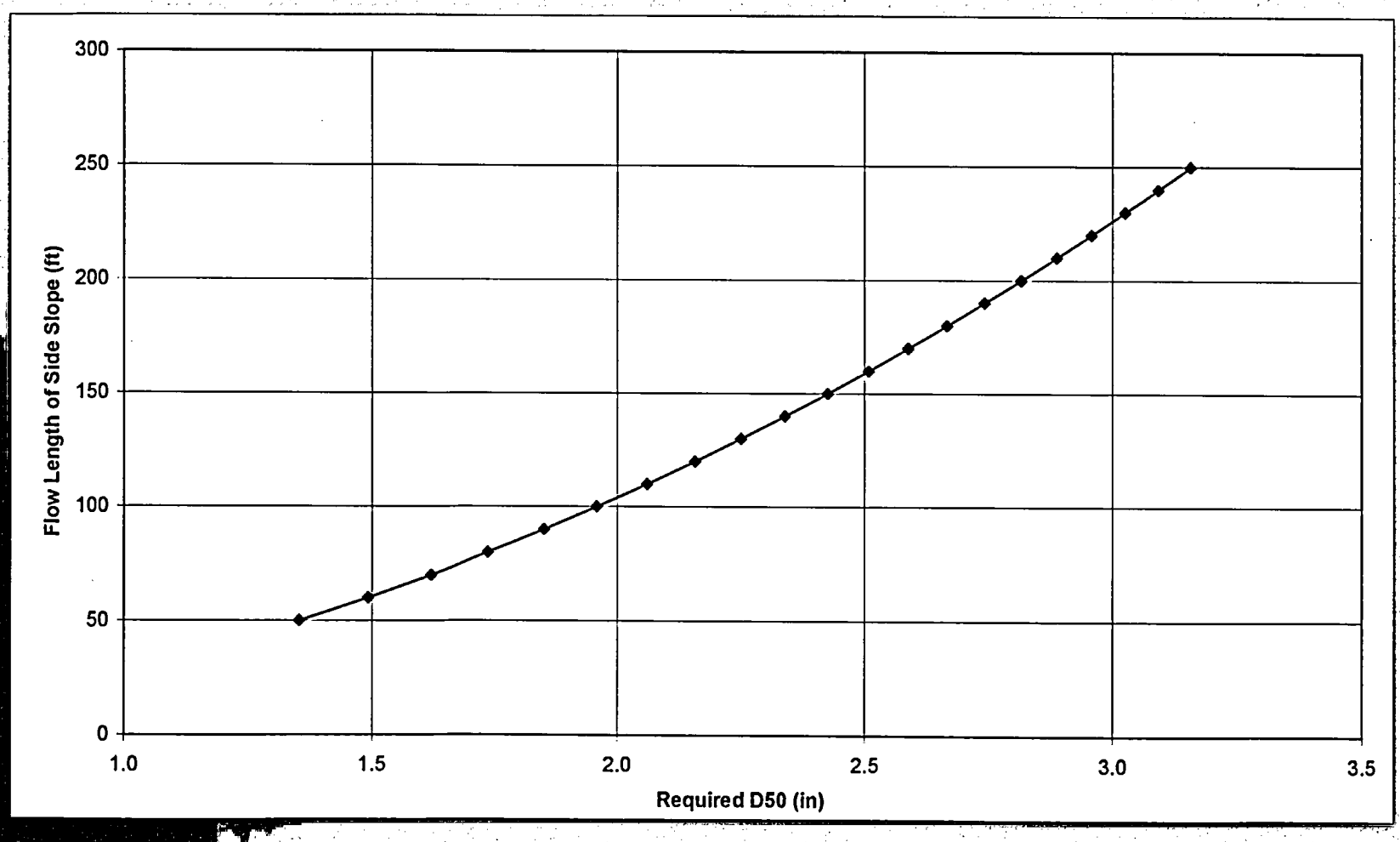
Erosion Protection – Disposal Cell

- Based on flows generated by PMP
- Minimum D_{50} rock sizes calculated for
  - Top slope at 2%
  - Side slopes at 5H:1V
  - Toe apron

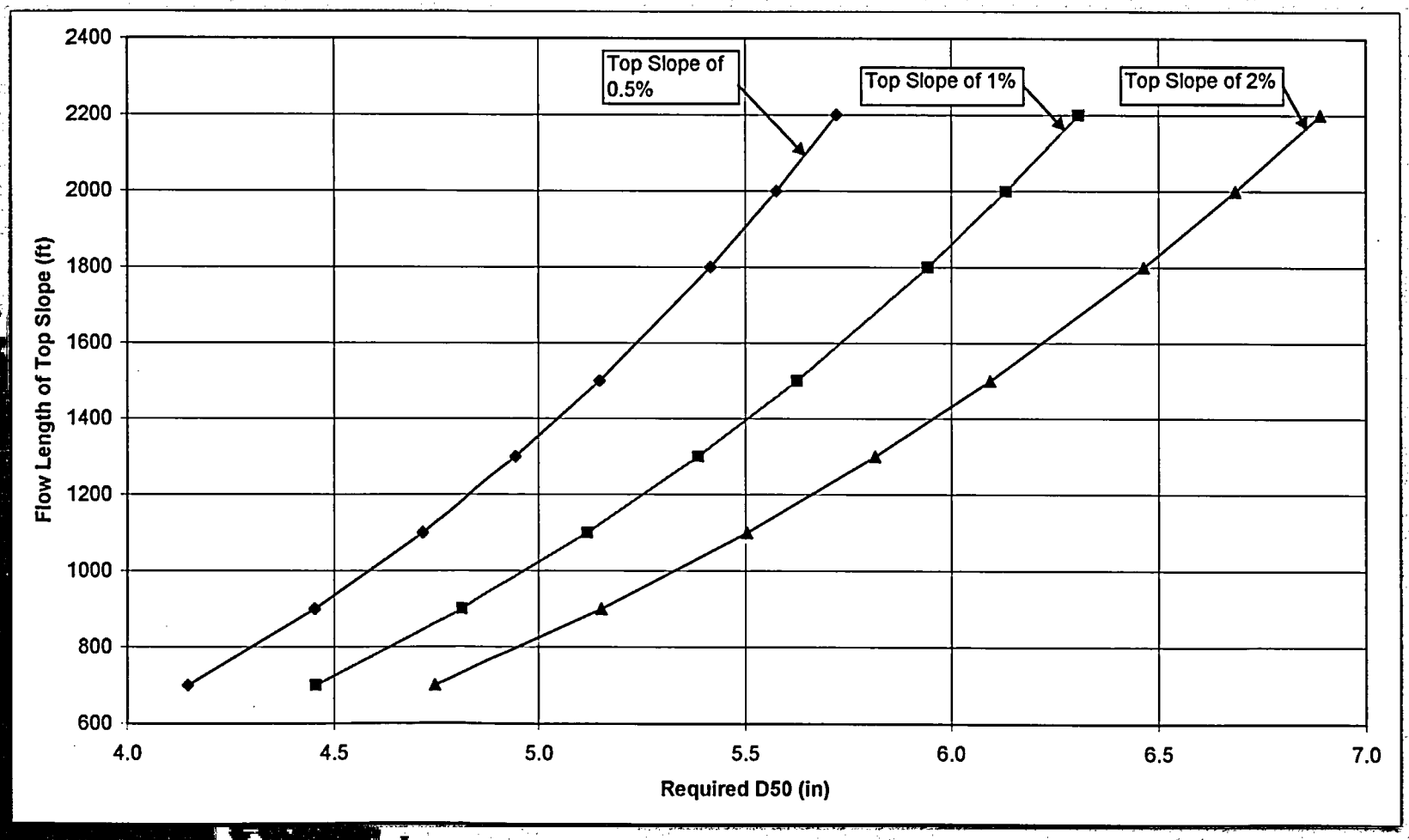
Typical Section Showing South Slope Required Erosion Protection



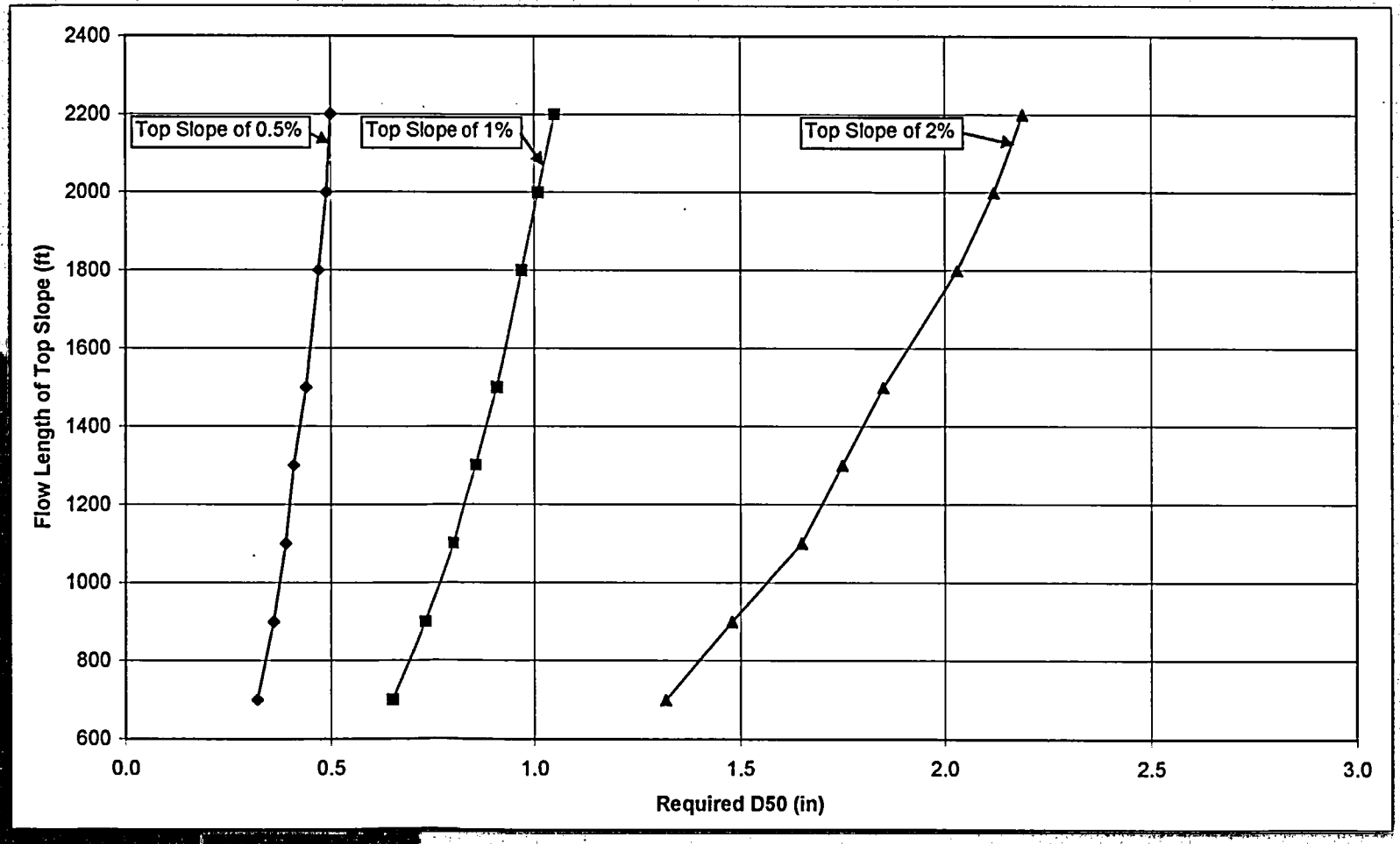
Required D_{50} for Side Slope with No Contributed Flow from Top Slope Assuming Side Slope of 20% (Abt-Johnson Method)



Required D_{50} for Side Slope with Contributed Flow From Top Slope Assuming Variable Top Slope and Top Length, Side Slope of 20%, and Side Slope Length of 150 ft (Abt-Johnson Method)



Required D_{50} for Top of Disposal Cell (Safety Factor Method)



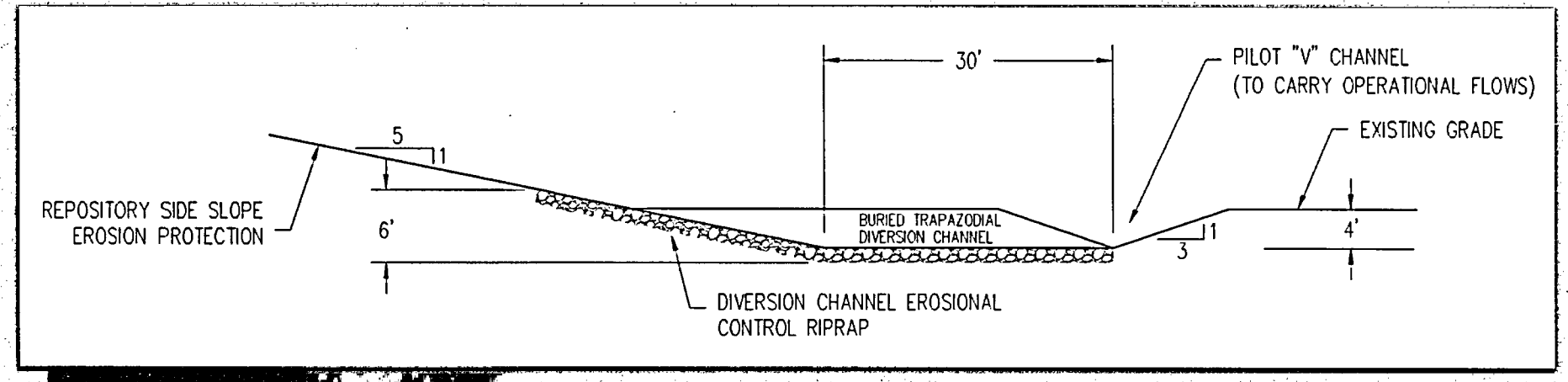
Erosion Protection Results

- Minimum D_{50} requirements
  - Top slope: 2.2 inches
  - North, east, and west side slopes: 1.6 to 2.4 inches
  - South side slope: 8.2 inches
  - East and west aprons: 3.9 to 4.5 inches
  - South apron: 13.7 inches

Diversion Channel Design, North Side Disposal Cell

- Purpose: Divert flows from 0.6 square mile upland area
- System
  - Pilot v-channel to divert flows from events less than 200-year, 24-hour flows
  - Trapezoid channel diverts and provides scour protection from PMF
- Trapezoidal channel
  - 30 ft wide, 6 ft deep, 0.5% slope
  - Rock lined along base and cell side slope
  - Minimum D_{50} = 6 inches
- Pilot channel
  - Unlined
  - Allows for natural erosion and deposition without impacting toe of disposal cell

Diversion Channel Cross Section, North Side



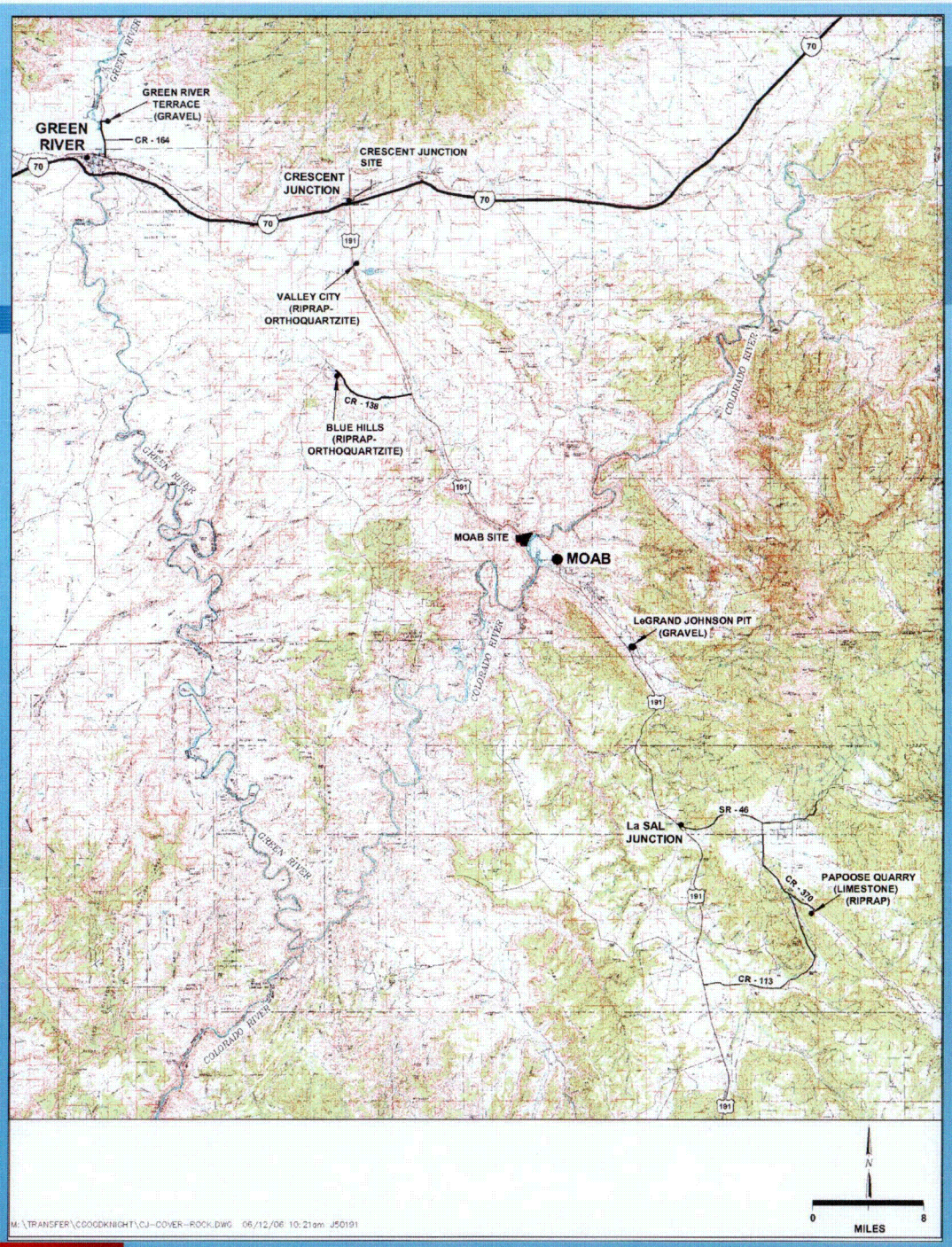
Riprap Sources

- Rock cover for the cell would be in two forms: riprap and aggregate
- Riprap sources
  - Papoose Quarry operated by Cotter Corporation, limestone from Honaker Trail Formation, approximately 65 miles to site
  - Potential quarry on State land, orthoquartzite in Cedar Mountain Formation, approximately 6 miles to site
  - Potential quarry on State land, orthoquartzite in Cedar Mountain Formation, approximately 21 miles to site

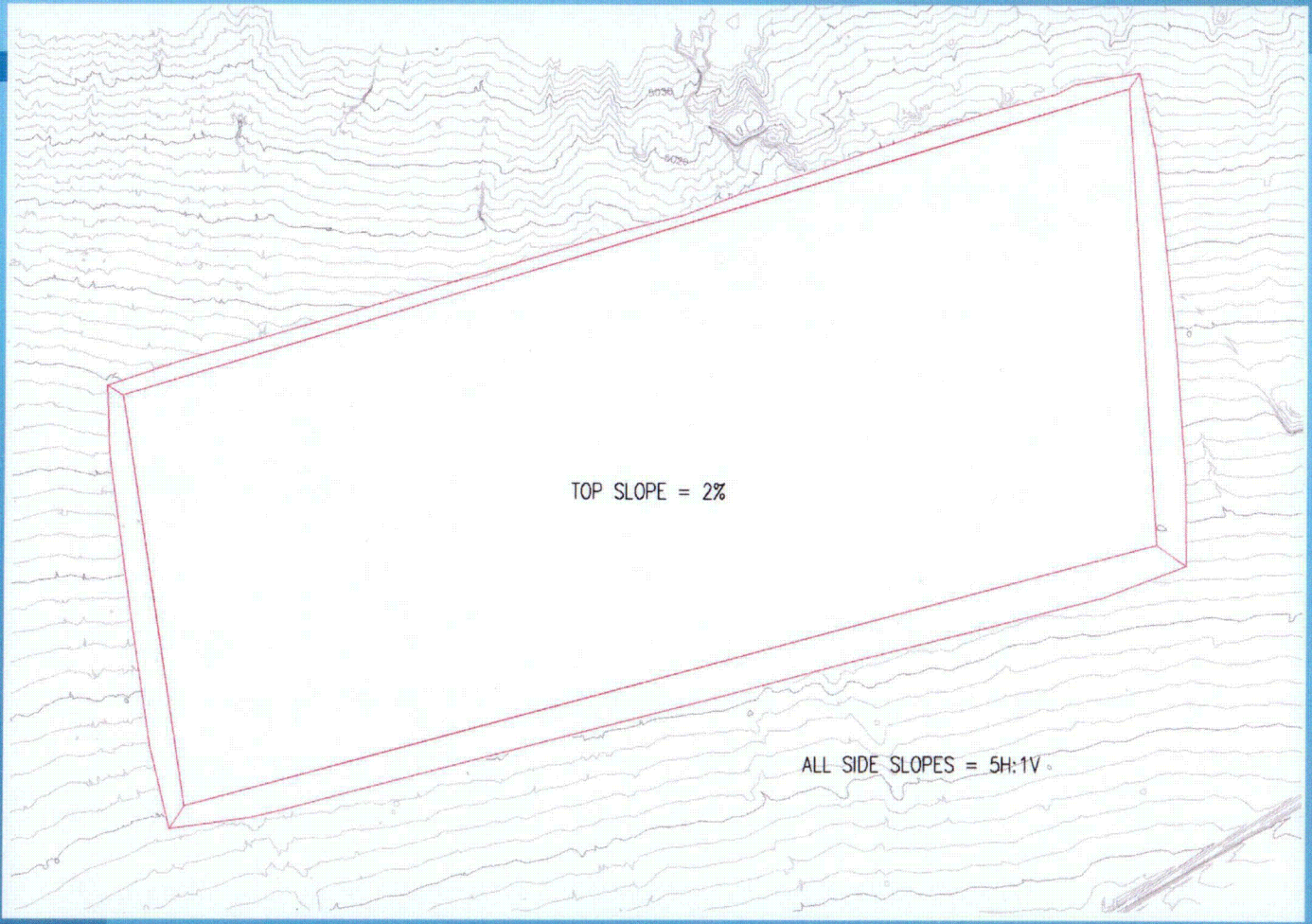
Riprap Sources

- Aggregate sources
  - LeGrand Johnson Pit, gravel from Pack Creek in Spanish Valley, approximately 38 miles to site
  - Potential quarry on State land, gravel terrace above the Green River, approximately 24 miles to site

Potential Borrow Sources for Crescent Junction Rock Cover



Closed Disposal Cell



Questions?