Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115 UMT/NRC/0588-59

MAY 24 1988

Mr. Paul Lohaus
Director, Division of Low-Level Waste
Management & Decommissioning
U.S. Nuclear Regulatory Commission
1 White Flint North
11555 Rockville Pike
Rockville, MD 20852

Dear Paul,

As discussed in our meeting with NRC on April 20, 1988, regarding the proposed EPA groundwater protection standards, we are transmitting details of the DOE special studies currently being undertaken to provide design features that will enable compliance with the new standards. These are provided for your information and review. If you have further questions on any specific study, please contact Don Leske of my staff at 846-1207.

Sincerely,

Wanda Fiske for
W. John Arthur, III
Project Manager
Uranium Mill Tailings Project Office

Enclosure

NL01
WM-58

SPECIAL STUDIES TECHNICAL APPROACH WITH

REGARD TO THE PROPOSED EPA GROUNDWATER PROTECTION STANDARDS

1.0 COVER MOISTURE STUDY AT EXISTING UMTRA STABILIZED PILES

The purpose of this study is to develop an ability to predict from climatological data the moisture content of, and from this the moisture flux through, the fine-grained, low-permeability radon/infiltration barriers designed to cover tailings in the UMTRA stabilized piles. To accomplish this, the covers of the first completed piles, now approximately a year old, are being tested for moisture content and for other parameters that may aid in prediction of steady-state moisture conditions.

1.1 SUMMARY OF DRILLING & SAMPLING ACTIVITIES AT SHIPROCK PILE

1.1.1 Phase I drilling / sampling activities

Drilling was conducted at the Shiprock remediated pile on February 3 and 4, 1988. Four borings were advanced through the radon barrier and 50 samples of the filter layer, radon barrier and tailings were collected. Samples were sent to Chen & Associates (Denver) and to the University of Arizona Hydrology Laboratory for evaluation of hydrologic and geotechnical properties. Following drilling, all boreholes were backfilled with cuttings and grouted to ground surface.

The borings were drilled through the radon barrier and into tailings with a hollow stem auger. Boring locations (Figure 1) were selected to provide information on the spatial variability of moisture content across the pile. Drilling logs are presented in Attachment A. The borings were continuously sampled, and five shelby samples and 45 brass-ring samples were collected.

A selected total of 33 brass-ring samples were shipped to Chen & Associates; 22 samples were analyzed for properties such as moisture content by weight, dry bulk density, saturated and unsaturated hydraulic conductivity, capillary moisture characteristics, atterberg limits, and hydrometer analyses. Eleven extra samples were sent to the laboratory, should further testing be required. Two additional radon barrier samples are being analyzed at the University of Arizona Department of Hydrology laboratory to determine unsaturated hydraulic conductivity as a function of soil tension.

1.1.2 Observations

The weather was rainy during the first day of drilling, and the sandy filter layer overlying the clay radon barrier was

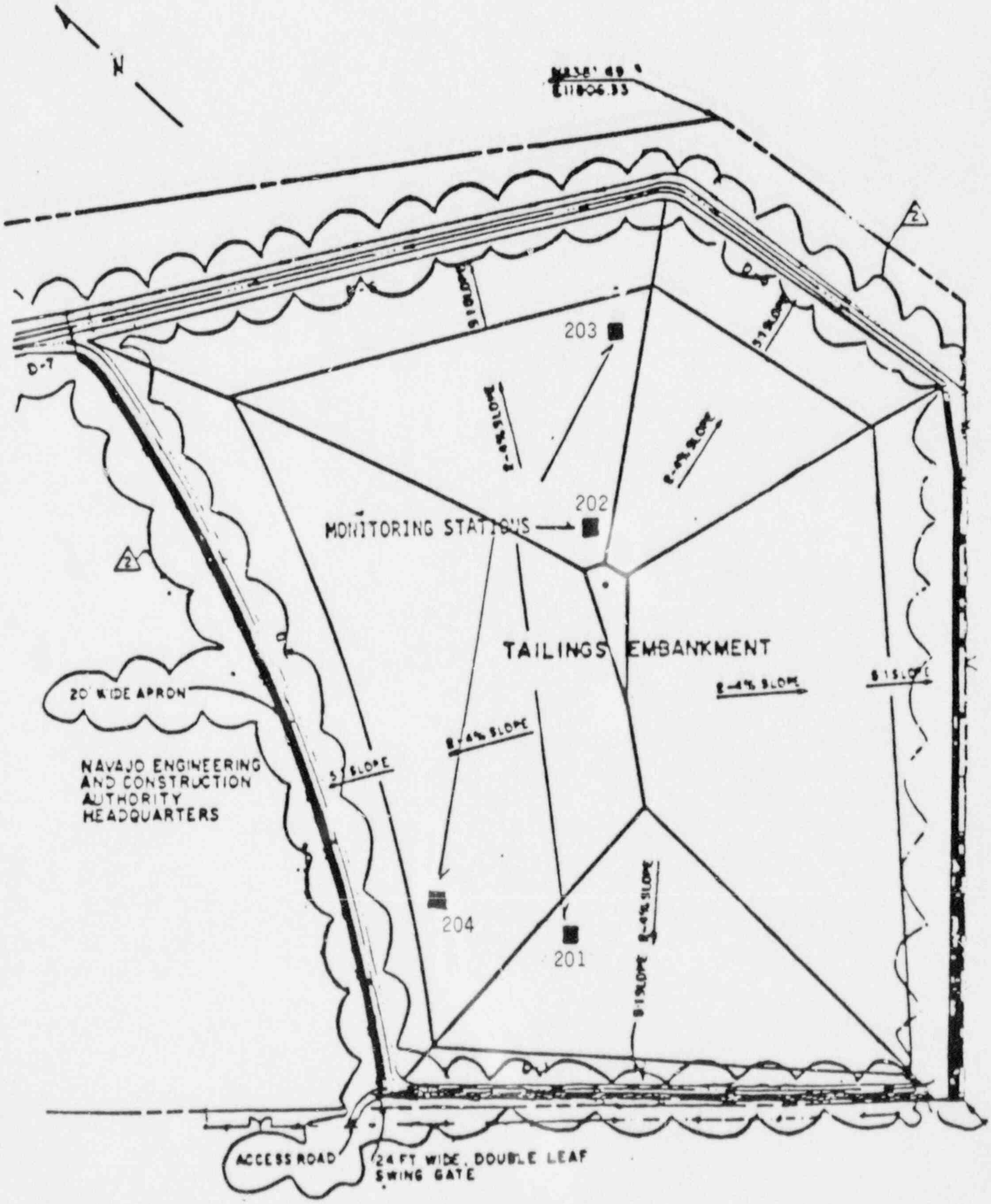


Figure 1. Sample Borehole Locations on the Shiprock Pile

saturated across the pile. It was not clear whether this saturation was a temporary phenomenon due only to the ongoing precipitation, or whether it was seasonal, reflecting some combination of high precipitation and reduced evaporation during the winter. The filter layer is not a clean, well sorted sand; however, considerable drainage was occurring across the top of the pile through the filter layer, and water could be heard percolating through the rip rap near the toe of the pile.

The saturation of the filter layer made installation of the planned four neutron-probe access tubes infeasible. Current design did not account for the possibility of saturation of the filter layer, and the borehole drilled for the first of the neutron-probe tubes flooded prior to installation of the tube, rendering the hole useless. The borehole was subsequently backfilled with cuttings and grouted to ground surface. A field decision was made to delay the installation of the neutron-probe tubes until Phase II (the instrumentation phase) of the project, when surface casing and bentonite seals could be utilized to prevent inundation of the boreholes.

Radon barrier clay samples from each of the boreholes appeared uniform in composition, and no visible changes in water content with depth were observed. Radon barrier samples did not appear saturated, even immediately below the then-saturated filter layer.

Four brass-ring samples of tailings were collected from borehole #203. The tailings were extremely fine grained materials and appeared slightly moist. No additional samples of contaminated material were collected from other boreholes, as refusal was encountered by the bras ing sampler immediately beneath the radon barrier.

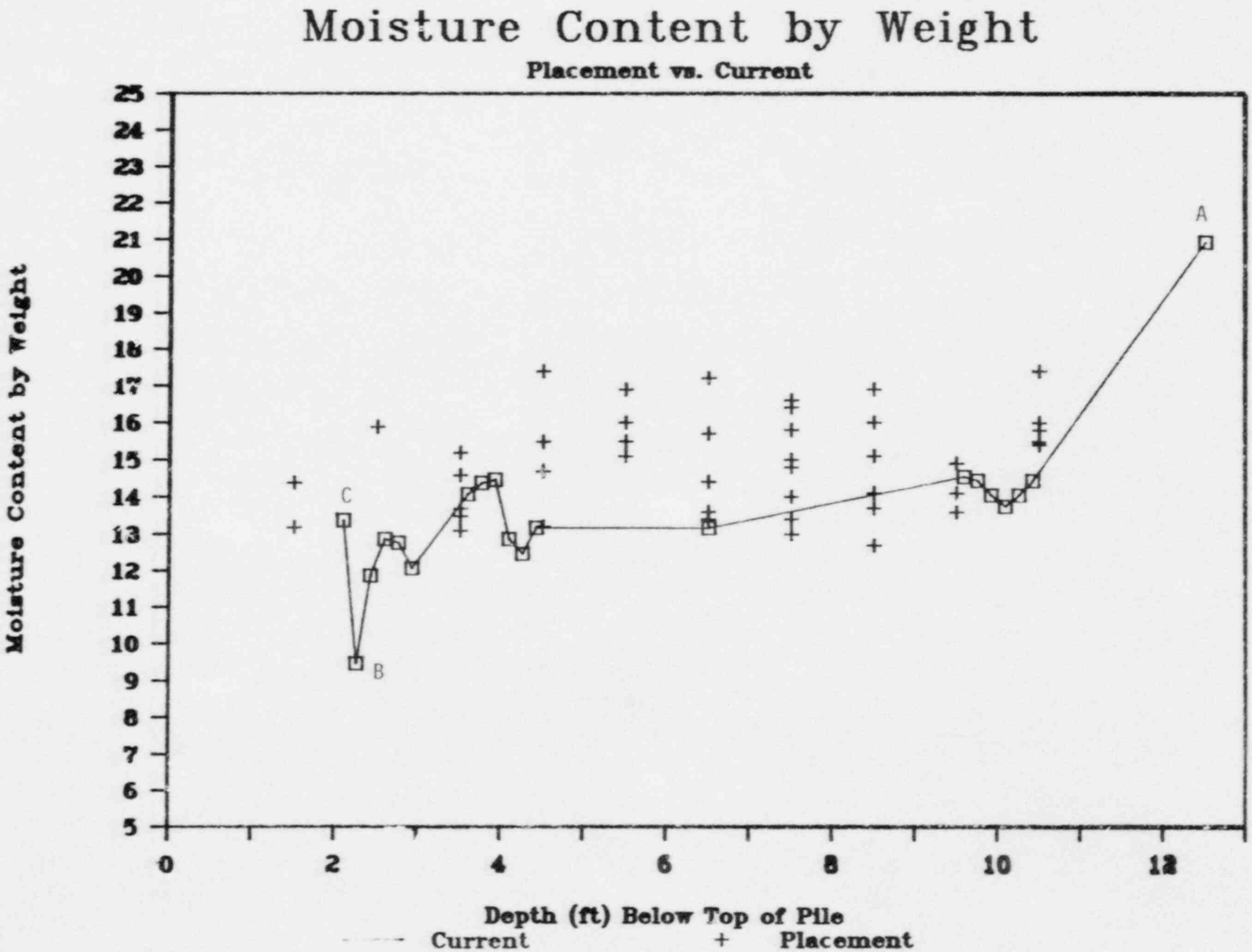
1.2 PRELIMINARY RESULTS

Attachment B contains the results of tests completed to date on samples collected during the Phase I drilling at Shiprock. The measurement of the capillary moisture curves and the unsaturated hydraulic conductivity curves has not been completed. In addition, we are still awaiting the results for tests on the atterberg limits and hydrometer analyses for several samples.

1.2.1 Radon Barrier Moisture Content Data:

A plot of moisture content versus depth is shown in Figure 2. The scattered data points represent placement conditions in the vicinity of Borehole 203, while the solid line represents the current moisture content profile measured in samples from Borehole 203. Point A represents the moisture content in the

Figure 2. Percent moisture content by weight versus depth for samples from Borehole 203



tailings, and contains the highest moisture content of all the samples collected (21% by weight, or 95% of the pore volume). This high moisture content probably represents placement conditions for the tailings.

The moisture content profile at Borehole 203 ranges from 12 to 15 percent by weight (approximately 80 per cent saturation by volume). Point B, representing a sample near the top of the radon barrier, contains the lowest moisture content of the profile, possibly reflecting evaporation during the summer of 1987. Point C, the uppermost radon barrier sample, contains more moisture than the sample represented by Point B, suggesting recharge that has occurred during the winter. The remainder of the moisture content data are within the range of data representing placement conditions, and suggest no significant changes in moisture content have occurred since placement.

Figure 3 presents the moisture content by weight versus depth for all the samples collected during the Phase I drilling at Shiprock. Moisture content varies from 10 to 15 percent by weight, and no trends with depth are apparent. The point with a moisture content of 21% represents the tailings sample from borehole #203.

1.2.2 Saturated Hydraulic Conductivity Data

The hydraulic conductivity for the saturated condition was measured for five radon barrier samples and one tailings sample, and the results are summarized in the following table.

Borehole	Depth below top of pile (ft)	Saturated K (cm/s)
201	5.3	2.6 E-7
201	9.8	6.9 E-7
202	4.8	2.3 E-6
203	6.6	8.8 E-8
203	12.6 (tailings)	3.5 E-8
204	6.1	6.4 E-8

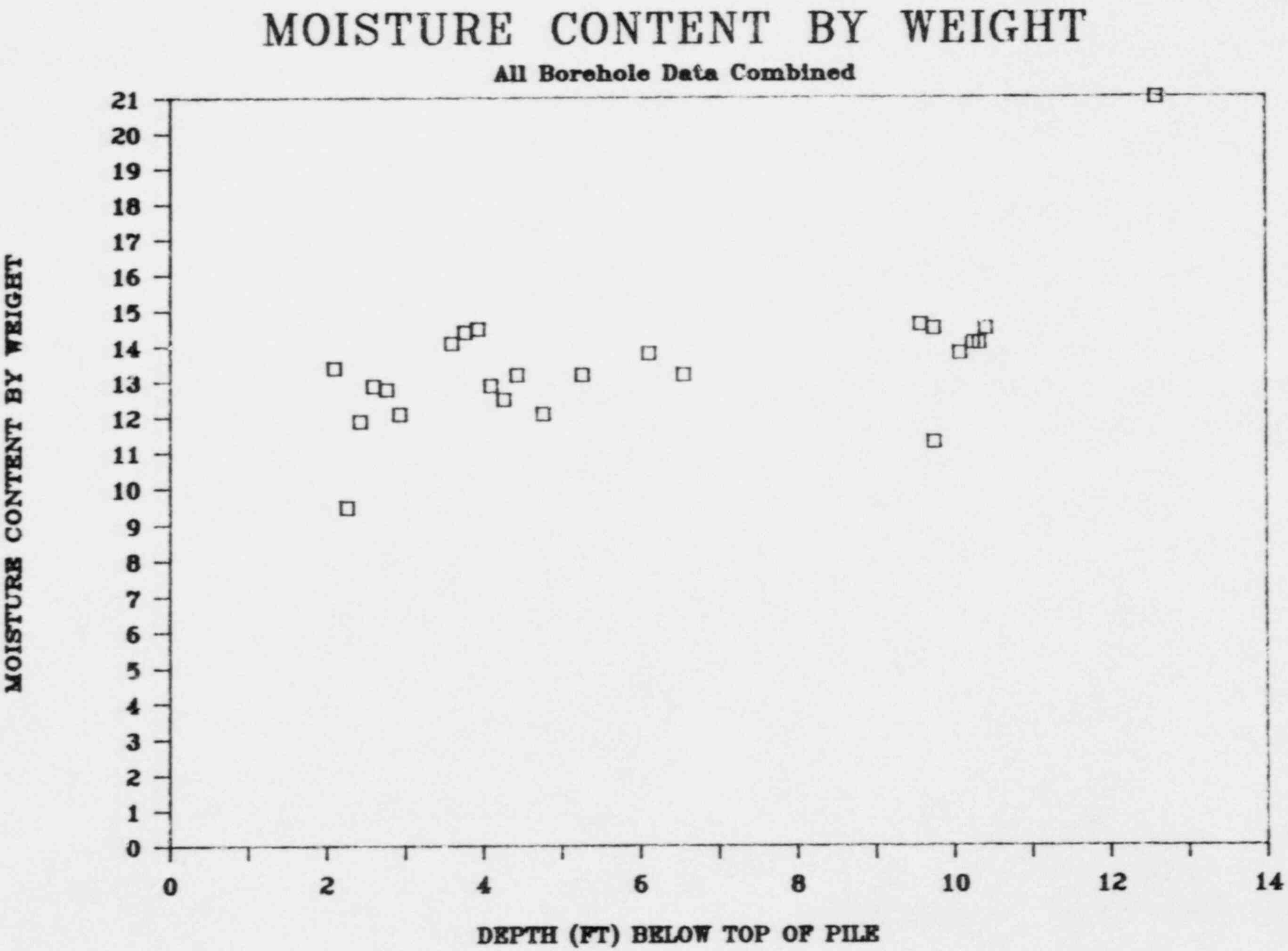
Note that the lowest saturated hydraulic conductivity (3.5 E-8 cm/s) was measured in the tailings. This could explain the relatively higher moisture content in the tailings compared to the radon/infiltration barrier.

1.3 FUTURE ACTIVITIES FOR THE SHIPROCK INFILTRATION STUDY:

1.3.1 Phase II Drilling and Instrumentation at Shiprock:

Phase II of the Shiprock Special Study will involve instrumenting the filter layer and radon barrier. Four neutron-probe tubes will be installed at various locations across the

Figure 3. Percent moisture content by weight versus depth for radon samples from all boreholes at the Shiprock Pile



pile. Surface casing and bentonite seals will be used to prevent flooding of the boreholes, and samples of the radon barrier will be collected along the entire profile of each hole for neutron probe calibration. Stevens and Associates will conduct neutron logging at the site on a monthly basis to assess the movement of any wetting fronts within the radon barrier.

A series of tensiometers, gypsum blocks, thermocouples, and microlysimeters will be located at two locations on the pile, and measurements will be recorded electronically using data loggers (Figure 4). Meteorological information will also be recorded with a data logger. A tipping-bucket raingauge, anemometer, thermal probe, and psychrometer will be used to measure daily precipitation, wind velocity, temperature, and relative humidity, respectively.

1.3.2 Sampling for cover moisture measurements at Clive & Burrell

Drilling, sample collection and analysis is currently being conducted at the Clive pile and will be conducted at the Burrell pile to measure present moisture contents at various depths in these radon barriers. The Clive site is being drilled under contract by Chen & Associates (Salt Lake City) as a result of litigation that is unrelated to TAC responsibilities. Continuous, undisturbed samples are being collected for the cover moisture study, and a TAC field technical representative is present. Drilling at Clive was initiated April 26th, and will probably be completed within two weeks.

Drilling at Burrell is scheduled to begin sometime in May. Portable drilling equipment will be used to aid in obtaining undisturbed samples on this site. No instrumentation or continuous monitoring is planned for the Clive and Burrell sites following collection and analyses of the initial samples.

1.3.3 Evaluation of moisture content profiles in existing compacted earth dams

Because the Shiprock, Clive and Burrell piles were completed within the last several years, moisture content profiles from their low-permeability radon barriers may not represent steady-state equilibrium conditions. Consequently, existing data on current moisture content profiles in compacted earth dams which were constructed 20 to 30 years ago are also being evaluated. Several of the dams being studied were designed specifically as flood-control structures, and have never retained water for long periods of time. Although none of the dams being evaluated are armored with rip-rap, the moisture content data is believed to be

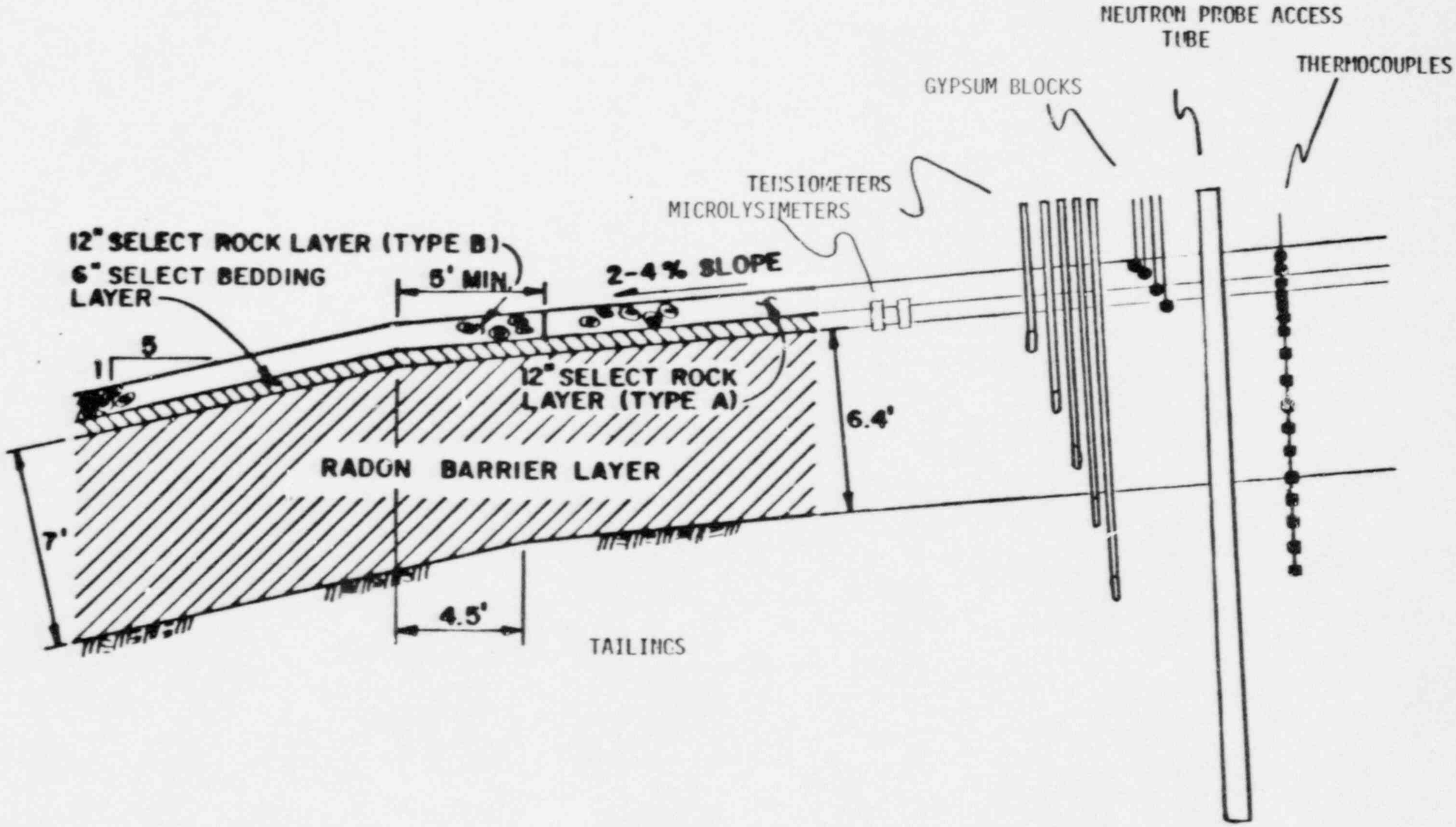


FIGURE 4. Typical monitoring station

more representative of steady state conditions, and may provide useful information on long-term evaporation and infiltration in compacted clay structures.

1.4 INTERPRETIVE, FINAL REPORT

The final phase of the study will consist of the interpretation of all the field data to determine the effects of climate on evaporation from the pile. The data collected from the Shiprock, Clive, and Burrell sites will be used to calibrate the steady-state infiltration routine of SOILMOIST, so that infiltration through radon barriers can be more accurately predicted. Since the predicted infiltration is the source of vadose-zone transport water, this is input to the calculation of long-term concentrations of contaminants in groundwater and to the accurate assessment of compliance with the proposed EPA groundwater standards at Shiprock and other sites.

2.0 MILESTONES FOR COVER MOISTURE STUDY

3/31/88 All preliminary Shiprock data should be received from Chen & Associates.

4/30/88 Shiprock progress report and summary of preliminary findings.

5/2/88 Initiation of drilling and sampling activities at the Clive remediated pile.

5/2 - 5/8/88 Drilling at the Shiprock site.

5/22/88 Completion of instrumentation installation at Shiprock.

5/__/88 Initiation of drilling and sampling activities at the Burrell site.

5/23/88 Soilmoist update, incorporating preliminary data from Shiprock and Clive, and DOE briefing.

6/1/88 Presentation of the modified SOILMOIST to the NRC.

7/15/88 Shiprock progress report and data presentation.

9/15/88 Shiprock FY 1988 Interim Report and cumulative data summary.

ATTACHMENT A

BOREHOLE LOGS
FOR THE
SHIPROCK PHASE I DRILLING

ATTACHMENT B

PRELIMINARY RESULTS
FOR THE
SHIPROCK PHASE I SAMPLING

ATTACHMENT A

BOREHOLE LOGS

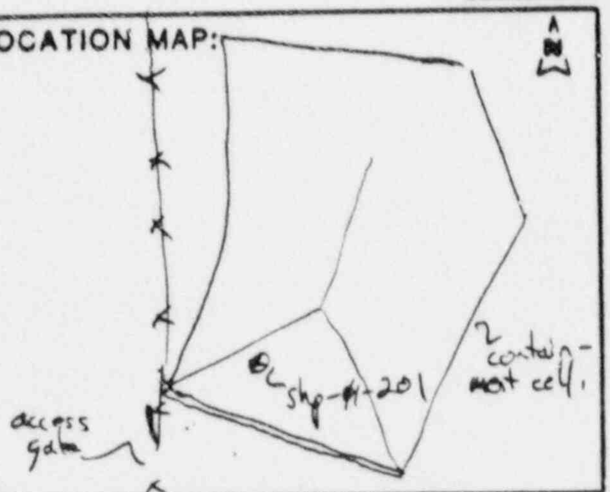
FOR THE

SHIPROCK PHASE I DRILLING

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (SOIL)

LOCATION MAP:



SITE ID: Shp 01 LOCATION ID: 201
SITE COORDINATES (ft.):
N N/K E N/K
GROUND ELEVATION (ft, MSL): N/K
DRILLING METHOD: 6 5/8" HSA
DRILLING CONTR.: SHB
DATE STARTED: 2/3/88
DATE COMPLETED: 2/4/88
FIELD REP.: Joe Faith

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
N/A		

LOCATION DESCRIPTION SSW section of completed tailings pile
SITE CONDITION 2-4% slop; cobbles

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	BLOWS PER 6 In.	N VALUE	USCS	VISUAL CLASSIFICATION
0									cobbles, (rip-rap)
									~~sand, wet~~ no sample
	X	6"	6"	U	001*				silty clay, sl. moist, med. brn.
	X	12	12	T	002	had to use hammer			
	X	6"	6"	U	003	8-12-9	21		same, but dry; sample from 4-4.5'
5.0	X	6"	6"	U	004*	20-26	46		
6.0	X	6"	6"	U	005*				
	X	0	0	U					
	X	4	4	U	006	12-18-27	45		
7.0	X	6	6	U	007*				
8.0	X	0	0	0					
	X	6	6	U	008*				
9.0	X	6	6	U	009*				
	X	6	6	U	010*	28-46			radiation: (background 16ur)
10.0	X	6	6	U	011*				13ur
	X	5	5	U	012				
11.0	X	5	5	U	013	15-38-100 0/6"			tailings 16ur
	X	5	5	U	014				
12.0									hole backfilled w/cuttings in reverse order; & grouted
									~~As~~ little or no discernible moisture change through hole.

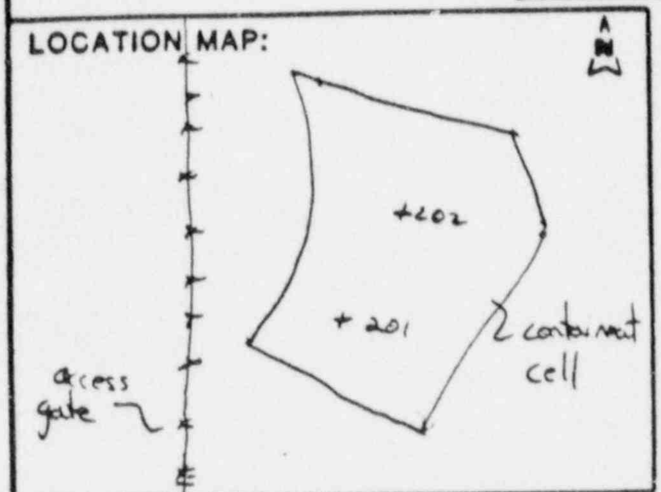
COMMENTS: * good brass ring sample
004, 005, 010, 011 shipped to Chen
007, 008, 009 shipped as optional.

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (SOIL)

LOCATION MAP:



SITE ID: Shp01 LOCATION ID: 202
SITE COORDINATES (ft.):
N N/K E N/K
GROUND ELEVATION (ft. MSL): N/K
DRILLING METHOD: 6 5/8" HSA
DRILLING CONTR.: SHB
DATE STARTED: 2/8/88
DATE COMPLETED: 2/8/88
FIELD REP.: J Fotts

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
N/A		

LOCATION DESCRIPTION near center of completed tailings pile
SITE CONDITION 2-4% slope, cobbles (15' W. of settlement marker)

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	BLOWS PER 6 in.	N VALUE	USCS	VISUAL CLASSIFICATION
0									cobbles, (rip rap)
1.0	X	12"	12"	T	001				sand, wet
2.0	X					30-10-45	55		silty clay; sl moist, med. brn
3.0		6"	6"		002				a baggie sample, Forgot brass rings
4.0	X	6"	6"	U	003*	10-18-18	36		
5.0	X	6"	6"	U	004*				
		6"	6"	U	005*	6-10	—		
6.0	X	6"	6"	U	006*				
		6"	6"	U	007	10-14-18	32		
7.0	X	6"	6"	U	008				
8.0	X	6"	6"	U	009*	10-17-50	67		
		6"	6"	U	010*				
9.0	X				011	6-90/3"	90		tailings probable. (baggie sample)
10.0								—	Hole backfilled w/cuttings in reverse order and grouted to surface.
								—	No discernible moisture change through hole.

COMMENTS: * good sample
003, 004, 009, 010 Shipped to Chem
005, 006, 007, 008 Shipped as optional.

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JEG-AL-ENG-2S (4/85)

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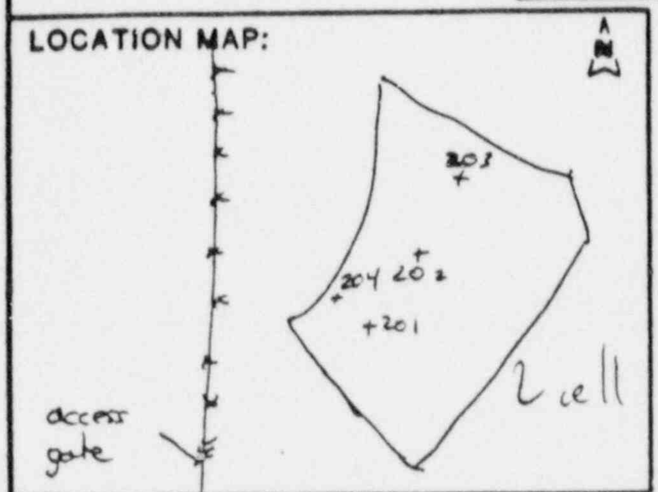
BOREHOLE LOG (SOIL)

LOCATION MAP:



SITE ID: Shp01 LOCATION ID: 203
SITE COORDINATES (ft.):
N N/K E N/K
GROUND ELEVATION (ft. MSL): N/K
DRILLING METHOD: 6 5/8" HSA
DRILLING CONTR.: SHB
DATE STARTED: 2/4/88
DATE COMPLETED: 2/4/88
FIELD REP.: J Faith

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
N/A		

LOCATION DESCRIPTION NNE edge of 2-4% slope of completed tailings pile
SITE CONDITION cobbles

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	BLOWS PER 6 in.	N VALUE	USCS	VISUAL CLASSIFICATION
0									cobbles
									sand + cobble matrix
1.0	X	6"	6"	T	001				
2.0									silty clay, sl. moist, med brn.
	X	5"	6"	U	002	15-25-32	57		
3.0		5"	5"	U	003				
	X	6"	6"	U	004*	14-17-40	67		
4.0		6"	6"	U	005*				
5.0	X	6"	6"	U	006*	10-15-22	37		
6.0		6"	6"	U	007*				
7.0	X	6"	6"	U	008*	19-24-39	63		
		6"	6"	U	009*				
8.0	X	6"	6"	U	010*	10-14-19	33		
9.0		6"	6"	U	011*				radiation: (background 16ur)
10.0	X	6"	6"	U	012*	26-45-36	81		
		6"	6"	U	013*				
11.0	X	5"	5"	U	014	10-12-12	24		tailings, sl. moist
12.0		6"	6"	U	015*				45 ur
13.0	X	6"	6"	U	016*				40ur
		6"	6"	U	017*				44ur
14.0									
15.0									

COMMENTS: * good sample.
002, 003, 004, 005, 008, 009, 012, 013, 016, 017 shipped to Chen
006, 007, 010, 011 shipped as optional

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JEG-AL-ENG-2S (4/85)

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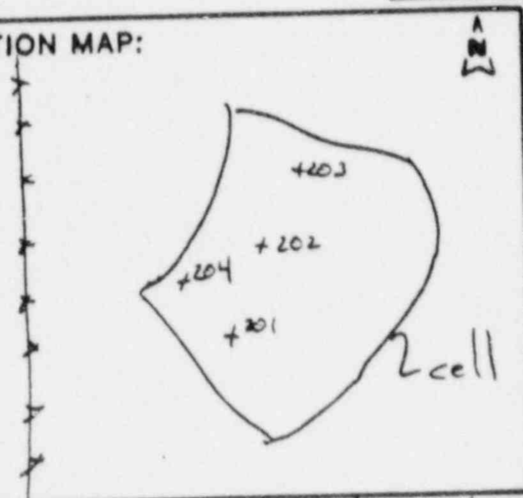
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Page 1 of 1

BOREHOLE LOG (SOIL)

LOCATION MAP:



SITE ID: Sh-01 LOCATION ID: 204
SITE COORDINATES (ft.):
N N/K E N/K
GROUND ELEVATION (ft. MSL): N/K
DRILLING METHOD: 6 5/8" HSA
DRILLING CONTR.: SHB
DATE STARTED: 2/4/88
DATE COMPLETED: 2/4/88
FIELD REP.: J Fritts

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
N/A		

LOCATION DESCRIPTION W. edge of completed tailings pile
SITE CONDITION cobbles

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	BLOWS PER 6 in.	N VALUE	USCS	VISUAL CLASSIFICATION
0									cobbles
									cobbles ~~an~~ and sand, Free water
1.0	X							?	
		12"	12"	T	001				~~sf~~ silty clay, some sand, water from above effecting sample
2.0								?	silty clay, sl. moist med. brn.
3.0	X	0	0	U	—	5-18-45	63		
		0	0	U	—	no recovery			
4.0									
	X	6"	6"	U	002*	6-12-28	40		
5.0		6"	6"	U	003*				background: low radiation:
6.0									
	X	6"	6"	U	004*	12-28-40	68		
		6"	6"	U	005*				
7.0	X	12"	12"	T	006				
8.0									24 ur
									16 ur
	X	6"	6"	U	007*	26-45-37	82		
9.0		6"	6"	U	008*				clay, some gravel nodules - tailings?
10.0									auger refusal

COMMENTS: * good sample
002, 003, 004, 005 shipped to Chen

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JEG-AL-ENG-2S (4/85)

ATTACHMENT B

PRELIMINARY RESULTS

FOR THE

SHIPROCK PHASE I SAMPLING

Chen & Associates
Consulting Geotechnical Engineers

96 South Zuni
Denver, Colorado 80223
303 744-7105

Casper
Colorado Springs
Ft. Collins
Glenwood Springs
Phoenix
Rock Springs
Salt Lake City
San Antonio

March 31, 1988

Subject: Laboratory Testing,
Contract No. 34-6704-S-87-0021,
Site: SHP-01
Delivery Order 011

Job No. 1 165 88

Mr. Wilfred Sanchez, Jr.
Manager, Contracts
Jacobs Engineering Group Inc.
5301 Central Avenue, N.E., Suite 1700
Albuquerque, New Mexico 87108

Dear Mr. Sanchez:

Enclosed are the results for tests completed to date for the subject site, including worksheets and summaries. A list of tests still in progress is as follows:

Capillary Moisture: Sample Nos. 201-4, 201-10, 202-3, 203-8, 203-16, and 204-4

Unsaturated Hydraulic Conductivity: 202-9 and 204-2

Hydrometer Analysis: 202-9 and 204-2

Atterberg Limits: 202-9 and 204-2

If you have any questions regarding this submittal, please call.

Sincerely,

CHEN & ASSOCIATES, INC.

By Sally K. Miller
Sally K. Miller, A.E.T.
Soils Laboratory Supervisor

SKM/djb
Rev. By: KRC
Encl.
cc: Mr. Ned Larson
Mr. Ron Rager
Mr. A. Archuleta

JE **JACOBS SYSTEMS COMPANY**
A DIVISION OF JACOBS ENGINEERING GROUP INC.

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: SHP-01

CHECKED BY:LAB SKM

DATE: 3-31-88

TAC

LAB NAME: CHA

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
203	2	2'0''-2'2''	13.4	107.5
	2	2'2''-2'4''	9.5	114.0
	2	2'4''-2'6''	11.9	110.6
	3	2'6''-2'8''	12.9	109.1
	3	2'8''-2'10''	12.8	109.1
	3	2'10''-3'0''	12.1	109.6
	4	3'6''-3'8''	14.1	103.9
	4	3'8''-3'10''	14.4	103.8
	4	3'10''-4'0''	14.5	105.5
	5	4'0''-4'2''	12.9	108.6
	5	4'2''-4'4''	12.5	108.4
	5	4'4''-4'6''	13.2	108.5
	12	9'6-9'8''	14.6	102.2
	12	9'8''-9'10''	14.5	101.6
	12	9'10''-10'10''	14.1	104.1

JACOBS SYSTEMS COMPANY
A DIVISION OF JACOBS ENGINEERING GROUP INC.

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: SHP-01

CHECKED BY: LAB SKM

DATE: 3-31-88

TAC

LAB NAME: CHA

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
203	13	10'0"-10'2"	13.8	104.3
	13	10'2"-10'4"	14.1	103.6
	13	10'4"-10'6"	14.5	103.4

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PHYSICAL PROPERTY TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 201

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
5	5.5-6.0	29	17	12	2.76
11	9.5-10.0	28	16	12	2.72

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PHYSICAL PROPERTY TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 202

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
4	4.5-5.0	26	20	6	2.74
9,10	7.5-8.5				

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ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PHYSICAL PROPERTY TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 203

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
2	2'0''-2'2''				2.78
2	2'2''-2'4''				2.76
2	2'4''-2'6''				2.76
3	2'6''-2'8''				2.78
3	2'8''-2'10''				2.75
3	2'10''-3'0''				2.74
4	3'6''-3'8''				2.74
4	3'8''-3'10''				2.78
4	3'10''-4'0''				2.76
5	4'0''-4'2''				2.73
5	4'2''-4'4''				2.70
5	4'4''-4'6''				2.73
9	7.0-7.5	27	19	8	2.78

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PHYSICAL PROPERTY TEST RESULTS

SITE ID: SHP-01 LOCATION ID: 203

DATE: CHECKED BY: LAB SVM

LAB NAME: TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
12	9'6''-9'8''				2.73
12	9'8''-9'10''				2.74
12	9'10''-10'0''				2.72
13	10'0''-10'2''				2.75
13	10'2''-10'4''				2.74
13	10'4''-10'6''				2.74
17	13.0-13.5	25	17	8	2.77

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PHYSICAL PROPERTY TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 204

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
2,3	4.5-5.5				
5	6.5-7.0	26	19	7	2.73

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

MECHANICAL SIEVE TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 201

DATE: 3-31-88

CHECKED BY: LAB SKM

TAC

LAB NAME: CHA

SAMPLE ID	DEPTH INTERVAL (FT)	% PASSING STANDARD SIEVE NUMBERS *										
		3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
4	5.5-6.0							99	98	98	96	94
11	9.5-10.0										99	96

*ENTER ONLY VALUES LESS THAN 100%.

JEG-AL-ENG-27 (6/85)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

HYDROMETER ANALYSIS TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 201

DATE: 3-31-88

CHECKED BY: LAB 8KM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% FINER THAN (mm) *							
		.074 mm	.05 mm	.037 mm	.019 mm	.009 mm	.005 mm	.002 mm	.001 mm
4	5.5-6.0	94	--	75	58	44	36	31	28
11	9.5-10.0	96	--	80	60	49	43	35	28

* ENTER ONLY VALUE LESS THAN 100%

JEG-AL-ENG-28 (6/85)

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

MECHANICAL SIEVE TEST RESULTS

SITE ID: SHP-01
LOCATION ID: 202
DATE: 3-31-88
CHECKED BY: LAB SKM
TAC
LAB NAME: CHA

SAMPLE ID	DEPTH INTERVAL (FT)	% PASSING STANDARD SIEVE NUMBERS *										
		3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
4	4.5-5.0						99	96	93	92	90	85
9,10	7.5-8.5											

*ENTER ONLY VALUES LESS THAN 100%.

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

HYDROMETER ANALYSIS TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 202

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% FINER THAN (mm) *							
		.074 mm	.05 mm	.037 mm	.019 mm	.009 mm	.005 mm	.002 mm	.001 mm
4	4.5-5.0	85	--	66	41	29	26	23	19
9,10	7.5-8.5								

* ENTER ONLY VALUE LESS THAN 100%

JEG-AL-ENG-28 (6/85)

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

MECHANICAL SIEVE TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 203

DATE: 3-31-88

CHECKED BY: LAB SKM

TAC

LAB NAME: CHA

SAMPLE ID	DEPTH INTERVAL (FT)	% PASSING STANDARD SIEVE NUMBERS *										
		3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
9	7.0-7.5							99	98	97	95	90
17	13.0-13.5						99	97	94	88	73	57

*ENTER ONLY VALUES LESS THAN 100%.

JEG-AL-ENG-27 (6/85)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

HYDROMETER ANALYSIS TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 203

DATE: 3-31-88

CHECKED BY: LAB SKM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% FINER THAN (mm) *							
		.074 mm	.05 mm	.037 mm	.019 mm	.009 mm	.005 mm	.002 mm	.001 mm
9	7.0-7.5	90	--	67	45	36	32	25	9
17	13.0-13.5	57	--	50	38	32	28	12	9

* ENTER ONLY VALUE LESS THAN 100%

JEG-AL-ENG-28 (6/85)

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

MECHANICAL SIEVE TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 204

DATE: 3-31-88

CHECKED BY: LAB SVM

TAC

LAB NAME: CHA

SAMPLE ID	DEPTH INTERVAL (FT)	% PASSING STANDARD SIEVE NUMBERS*										
		3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
2,3	4.5-5.5											
5	6.5-7.0							99	98	97	96	93

*ENTER ONLY VALUES LESS THAN 100%.

JEG-AL-ENG-27 (6/85)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

HYDROMETER ANALYSIS TEST RESULTS

SITE ID: SHP-01

LOCATION ID: 204

DATE: 3-31-88

CHECKED BY: LAB SWM

LAB NAME: CHA

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% FINER THAN (mm) *							
		.074 mm	.05 mm	.037 mm	.019 mm	.009 mm	.005 mm	.002 mm	.001 mm
2,3	4.5-5.5								
5	6.5-7.0	93	--	76	49	34	30	25	22

* ENTER ONLY VALUE LESS THAN 100%

JEG-AL-ENG-28 (6/85)

JE **JACOBS SYSTEMS COMPANY**
A DIVISION OF JACOBS ENGINEERING GROUP INC.

PERMEABILITY TEST RESULTS

SITE ID: SHP-01

DATE: 3-31-88

LAB NAME: CHA

CHECKED BY: LAB JKM

TAC

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	TEST METH.	COMPACTION (%)	MOISTURE CONTENT (%)		DRY DENSITY (PCF)		SATURATION (%)		TOTAL PRESSURE HEAD (FT)	PERMEABILITY (CM/SEC)
					INIT.	FINAL	INIT.	FINAL	INIT.	FINAL		
201	4	5.0-5.5	TX	N/A	13.2	15.6	122.5	120.4	89.5	100	3.3	2.6×10^{-7}
201	11	9.5-10.0	TX	N/A	11.3	13.6	122.1	123.1	76.2	97.0	3.3	6.9×10^{-7}
202	4	4.5-5.0	TX	N/A	12.1	14.1	120.6	122.2	79.0	96.1	3.3	2.3×10^{-6}
203	8	6.5-6.6	TX	N/A	13.2	14.6	120.8	119.3	83.8	89.4	3.3	8.8×10^{-8}
203	16	12.5-12.7	TX	N/A	21.0	20.5	107.4	109.8	95.4	99.1	7.8	3.5×10^{-8}
204	4	6.0-6.2	TX	N/A	13.8	15.6	116.8	118.6	81.8	96.8	3.3	6.4×10^{-8}

TEST METHODS: CH - CONSTANT HEAD FH - FALLING HEAD TX - TRIAXIAL BACKPRESSURE FALLING HEAD

JEG-AL-ENG-32 (6/85)

2.0 DESIGN ENHANCEMENTS

In developing the technical response to the proposed EPA standards it has become apparent that the ability to design structures capable of meeting the proposed standards will require:

- o Assessment of new and existing technology, including those developed for RCRA, and other DOE projects, to determine applicability to UMTRA Project sites;
- o Reassessment of the technologies evaluated in the research and development phase of the UMTRA Project in light of t proposed EPA groundwater standards;
- o Application of promising technology to current site designs.

The DOE has initiated a series of studies to evaluate the appropriateness of several design features that may reduce groundwater related releases from the pile. The design features to be investigated and their relative priority are:

- o Synthetic membranes - high
- o Hydrogeochemical modification - high
- o Alternate cover materials - medium
- o Sodium-amended covers - medium
- o Alternate cover designs - medium
- o Radon cover freezing potential - medium
- o Vegetative covers and prevention of biointrusion - medium
- o Contaminant flushing of tailings - medium

These features (or components) are directed at one or more of the following objectives:

- o Reducing infiltration into the pile;
- o Reducing contaminant source term availability;
- o Reducing contaminant releases from the pile into the near environment.

The appropriateness of each potential design feature will be assessed for the following effects:

- o Maximum positive effect;

- o Probability of positive effect;
- o Maximum potential negative effect;
- o Probability of negative effect.

A summary of the concept and scope of each study is included in this section.

2.1 SYNTHETIC MEMBRANES

2.1.1 Description

Synthetic membranes are currently being used in RCPA cells to limit groundwater contamination. If used on the UMTRA Project they could have a similar effect, provided that the longevity criterion can be demonstrated. We do know that plastics have been used as protection for buried cast iron pipe for over 35 years and are showing no signs of degradation.

Similarly, it can be expected that a synthetic cover and/or liner layered into the radon cover and thus isolated from the environment will last a considerable length of time. Further, if degradation should occur, a large, but decreasing, area would still be present to impede infiltrating water. Such a system has merit given the proposed standards.

This study would review data obtained by the liner industry for application to the UMTRA Project. Specifically the study would address the potential problem of longevity and synthetics performance.

In conjunction with this study, a site design team for an appropriate site may begin development of a trial design including synthetics in order to test this approach by the reviewing agencies. A site like Monument Valley, projected to exceed the proposed groundwater standards in a relatively short period of time using conventional design approaches might be appropriate. Cost analyses of such systems would also be developed.

2.1.2 Scope

The study would consist of a literature review (starting with the research and development work performed for the UMTRA Project) of current synthetic materials technology and contact with industry personnel in order to determine the design life and the reliability of plastic liners. If after the early stage of this data gathering effort the concept still appears feasible, work would begin on developing the design rationale for site specific application. The design would be set forth as a "trial balloon" in order to obtain review agency comment. A report would be prepared which summarizes the study and draws conclusions of the positive and negative aspects of synthetic membranes.

2.1.3 Schedule

This study would be undertaken immediately as it may offer insight into the implementation of the proposed standards and as a possible retrofit solution to piles already past the design phase. The synthetics industry is considered critical in helping resolve the longevity issue. Since the literature review and longevity findings will have to be completed before specific designs are formulated, a linear approach will be required of each study aspect. Four months will be required to complete and document the study.

2.2 HYDROGEOCHEMICAL BARRIERS

2.2.1 Description

A hydrogeochemical barrier is not a physical barrier to groundwater flow but a constructed zone in which individual contaminant species in leachate from a tailings pile would be rapidly attenuated. One such barrier could be formed by amending a zone of soil or tailings with calcium carbonate; the leachate would react as it passes through the amended zone with a resulting increase in pH. Typically, as the pH of the leachate increases, the solubilities of the metals decrease, thereby precipitating out of solution. This study would be an evaluation of the efficiency of different methods and chemical compounds in forming hydrogeochemical barriers. Part of the investigation would be an assessment of the long-term performance and the effect of potential degradation on the physical and structural integrity of the pile.

2.2.2 Scope

The initial phase of this study would be a literature review and summary investigation of the technologies involved. Included in this phase would be the collection of tailings samples and the preparation of a scope-of-work for the laboratory testing that would follow. During the laboratory testing and analysis phase, different methods and chemical modifiers would be evaluated as to their efficacy in precipitating contaminants out of solution. A final report would include a summary of the findings of the lab testing, an evaluation of the longevity of the barriers, and an assessment of the best ways to incorporate the hydrogeochemical barriers in pile designs.

2.2.3 Schedule

This work will take 3 months to complete and is independent of the other enhancement studies.

2.3 ALTERNATE COVER MATERIALS

2.3.1 Description

This special study will investigate alternate materials (other than the synthetics of Section 2.1) to be incorporated in the cover design to reduce infiltration into the tailings thereby minimizing leachate production. The materials to be studied would include, but may not be limited to, asphalt, gunite, and latex concrete.

Areas of concern would be performance, longevity, constructibility, and cost. Specific areas of interest would include long-term performance of asphalt on steep slopes, fiber reinforcement of gunite, mix design, and placement of concrete on tailings piles, e.g., roller compacted concrete.

Studies have shown that the hydraulic conductivity of high bitumen asphalt can be as low as 10^{-12} cm/sec. A durable cover with a permeability this low, would severely restrict infiltration. Historically, gunite (sprayed, fine-aggregate concrete) has been used extensively to protect and limit infiltration of water into exposed slopes, e.g., road cuts. Construction uses have been for periods of 10-20 years without repair and part of this special study would be to see if this technology could be applied on the UMTRA Project with its longevity requirements. Also, the suitability of other materials (i.e., asphalt emulsion, latex concrete) in meeting the longevity and performance criteria for remedial actions would be investigated.

2.3.2 Scope

This study would initially be a literature review and the contacting of industry personnel and also a re-examination of applicable previous DOE research and development work. In this step, the identification of material properties, performance, and longevity characteristics of the alternate cover materials would be made. Then, the appropriateness of incorporating these materials in the cover designs subject to the unique conditions and concerns of the UMTRA Project could be defined. After these two phases, if still warranted as a design alternative, a site-specific design including these materials could be made as in the case of a synthetic membrane liner.

2.3.3 Schedule

The study would take a maximum of 3 months to complete. The study could be conducted in a shorter period of time by dividing it into a series of tasks related to each alternate cover material. Approximately one month for each would be required, including report.

2.4 SODIUM-AMENDED COVER

2.4.1 Description

The addition of exchangeable sodium, in solution, to a normal, calcium-dominated clayey soil changes the soil structure from a flocculated to a dispersed state. This results in a significant and possibly irreversible reduction of the soil's hydraulic conductivity. Monovalent sodium ions replace the divalent calcium ions bonded to clay particles that act as bridges between the clay colloids. When these bridges are disrupted, soil becomes less permeable through a reduction in the size of the pore spaces. This phenomenon retards infiltration into soils as evidenced by problems in agriculture and land rehabilitation. This effect requires a clay content and the proper cation exchange capacity in the borrow materials used for the radon/infiltration barrier to achieve the desired impermeability.

2.4.2 Scope

This feasibility study would consist of three phases. The first phase would be a literature review and summary investigation of the technologies involved along with preparation of a testing plan. The laboratory testing of existing borrow materials would be bench-scale tests to determine optimum design parameters. Also, leachability tests, used to estimate the longevity and reversibility of this phenomenon, would be performed. The laboratory testing and analysis would be subcontracted; the proposed subcontractor is a soil scientist and professor at New Mexico State University with considerable experience in studying this phenomenon (Dr. George O'Connor). The final phase of this investigation would address how this technology could be best applied to the UMTRA Project and the preparation of a summary report.

2.4.3 Schedule

Approximately four months will be required to complete the study. Two months of the alloted time is reserved for the laboratory testing, including subcontract process.

2.5 ALTERNATIVE COVER DESIGNS

2.5.1 Description

This study would evaluate the potential of alternate cover designs to decrease the time that water remains within the cover system. One idea to be investigated would be the top-slope of the radon cover having a corrugated surface; this would increase the effective slope from 2-4 percent to 15 percent without altering rock size or other engineered aspects of the piles. The effect of a pile design with constant sideslopes of 15-20 percent, with little or no topslopes would also be studied. Other suitable ideas that arise as the study progresses may also be evaluated. Also included in this study will be site specific applications of cover designs successfully formulated in the other design enhancement studies.

2.5.2 Scope

The first phase of this investigation would be the evaluation of the computer models currently being used on the project (e.g., SOILMOIST) as to their suitability for use in this study. The next phase would be the evaluation of each design alternative previously described or proposed, followed by a summary report of the findings.

2.5.3 Schedule

This study is expected to take four months. Because this study would be depen ent on the successful completion of other design enhancement studies, this work will occur late in the overall schedule.

2.6 RADON COVER FREEZING

2.6.1 Description

The purpose of this special study is to determine the effect of freezing upon the hydraulic conductivity of the radon cover. A lab testing program to study the effects of freezing of a saturated fine-grained soil having a limited, perhaps seasonal, source of free water would be undertaken. Conventional soils engineering principles result in the assumption that freezing and thawing of saturated soils changes the soil structure leading to an increase in permeability. Even though newly initiated studies by the TAC may show that radon covers in semi-arid climates are only partially saturated, it is recognized that during part of the year the upper layers of this cover may be temporarily fully saturated. Prepared samples of radon cover materials would be subjected to a series of freeze/thaw cycles and any changes in permeability would be recorded. The results would be used to evaluate current cover designs and determine if any changes are required, e.g., thickening the erosion protection.

2.6.2 Scope

As indicated, this study would primarily be a laboratory testing program. However, the first step would be literature review and consultation with the Cold Regions Research and Engineering Laboratory (CRREL) U.S. Army Engineers, Hanover, N.H. The laboratory program would involve permeability tests before and after a series of freeze/thaw cycles. The final stage would be the evaluation of the data and preparation of engineering recommendations as to cover design criteria.

2.6.3 Schedule

Approximately 2.5 months will be required for this study including a one-month laboratory testing program. The necessity of this study could be negated should it be proven that covers are not saturated. Therefore initial data to be collected from Shiprock may determine the need for this study.

2.7 SOURCE MODIFICATION

2.7.1 Description

A beneficial effect of flushing the tailings, either by natural or artificial means, could be to quickly reduce the source in the tailings and the leachate generated from the tailings piles.

Therefore, contaminants might not exceed water-quality standards in the leachate generated after final stabilization.

2.7.2 Scope

The primary focus of this investigation would be laboratory testing of different tailings materials. An analysis of the rates and amount of water required for flushing would be made for typical tailings samples. Following this analysis would be the design of the engineering features needed for flushing and for completing surveillance and maintenance requirements. Also, an assessment of any effect on long-term stability of the tailings would be performed.

2.7.3 Schedule

A 4 month time frame is required to complete this study, including laboratory testing. Since the concept does not involve pile design, it is independent of that study.

2.8 VEGETATIVE COVERS

2.8.1 Description

Vegetative covers have already been incorporated in pile designs at UMTRA Project sites (i.e., Lakeview, Canonsburg) and this study would determine their suitability at other sites. The primary benefit of plants in a cover design would be their ability to intercept infiltrating water and transpire it to the atmosphere, thereby potentially reducing the amount reaching the radon barrier or underlying tailings. A properly established vegetation community is self-renewing and should be functional for an indefinite period of time. Vegetational stabilization of disturbed land (including mine tailings) has been well studied and demonstrated in the field. Part of this study requires the development of a cover design that would prevent biointrusion. In conjunction with this aspect of the study would be an investigation of the potential effect and probability of biointrusion into the radon barrier on existing UMTRA Project piles.

2.8.2 Scope

This study would primarily be a literature review and summary investigation that would address the practicability and reliability of this approach. This study would evaluate the results of significant research done at Los Alamos National Laboratory on the use of vegetation in the closure of low-level radwaste facilities as well as UMTRA Project work performed to date. The final portion of the study would be the preparation of engineering design details for the establishment of a vegetative cover, a program for maintenance and surveillance on UMTRA Project sites, and a summary report.

2.8.3 Schedule

The vegetative cover study will require 3 months to complete. If it results in positive findings, its completion would trigger the undertaking of an alternate design study.

3.0 KEY PERSONNEL

In staffing the studies for design enhancements individual staff members have been designated as the lead investigator. The following list provides the name and telephone number of the lead investigator for each study.

Study	Lead Investigator	Telephone No.
Synthetic membrane	John McBee	505/846-1329
Hydrogeochemical modification	Pat Longmire	505/846-1250
Alternate cover materials	Ron Rager	505/846-1329
Sodium-amended covers	Charles Reith	505/846-1250
Alternate cover designs	John McBee	505/846-1329
Radon cover freezing potential	Ron Rager	505/846-1329
Vegetation covers	Charles Reith	505/846-1250
Contaminant flushing	Bill Downs	505/846-1250
Cover moisture study	Tim Goering	505/846-1250