Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project – 2005

Garfield County, Utah

UT-0900480

December, 2005

Plateau Resources, Ltd.
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1.0 INTRODUCTION & SUMMARY

1.1 Introduction

Plateau Resources, Ltd. will, at the end of the planned operation of the mill, decommission its uranium mill and tailings facility, referred to as the Shootaring Canyon Uranium Project. The mill was previously licensed to operate under a U. S. Nuclear Regulatory Commission (NRC) source material license (SUA-1371) and is currently licensed under UT Division of Radiation Control Source Material License (UT-0900480). The mill operated for a very limited period of time and the existing tailings facility contains only 25,000 C.Y. of tailings material. An additional volume of 39,100 (18,907 tons Hanskville and 26,500 C.Y. Hydro-Jet) C.Y. of 11.e(2) material exist in the east and north dikes from the cleanup of the Hanksville buying station and the Hydro-Jet plant. Interim cover placed over the existing tailings is 39,310 C.Y. The existing tailings, 11.e(2) material, and other contaminated materials will be transferred to a synthetic lined disposal cell which will also serve as the location for an evaporation and process solution pond prior to the pending operation of the mill. Thus, the existing tailings material will be contained within the much larger volume of tailings generated with future operation of the mill.

Two future operational scenarios are envisioned, and these are designated as the Cell 1 and Cell 2 operations. The Cell 1 operation includes full utilization of a synthetic-lined tailings cell located upstream of the existing Cross Valley Berm (CVB) and the associated synthetic-lined Evaporation and Process Pond Cell (EPPC). The Cell 2 operation includes the full Cell 1 operation with expansion of the tailings facility to the larger Cell 2 located immediately upstream of the existing Shootaring Canyon Dam. Two reclamation plans are included in this submittal to address these two possible operational scenarios. Within this document, the two reclamation plans are presented in parallel with many sections, tables and figures applying to both plans. Where there is a divergence between the two plans, separate tables and figures are presented with a suffix of CELL-1 or CELL-2 on the table or figure number to indicate the Cell 1 or Cell 2 reclamation plan respectively.

The site is located in a sparsely populated area of Garfield County, southeastern Utah, approximately 50 miles south of Hanksville, Utah, 14 miles north of Bullfrog Basin Marina, and 2 miles west of Utah State Highway 276 (see Figure 1-1). A small town, Ticaboo, is located 2.6 miles south of the site.

This reclamation plan has been prepared according to 10 CFR Part 40, Appendix A and UT regulations (UT Admin. Code R313-24) and the guidance in the NRC Standard Review Plan (NUREG-1620). The goal is to restore lands disturbed by project activities (except for the tailings cell(s)) consistent with past and present uses of the area. It should be noted that this area and southern Utah in general, are considered very unproductive with little native plant growth due to soil and climate characteristics. The low average annual precipitation of 7 inches (18 cm); frequent droughts; extreme temperatures; high wind erosion; and a loose, and undifferentiated soil profile with poor moisture-holding capacity and little organic content are a few of those characteristics.

This plan presents the current condition, reclamation goals and activities, and estimated costs and schedule for reclaiming PRL's mill site and the two anticipated tailings cell configurations.

1.2 Summary

This report presents the final mill decommissioning and tailings reclamation for the Shootaring Canyon tailings site. Contaminated equipment and contaminated structures from the Shootaring Canyon mill will be placed within a synthetic-lined cell. The existing tailings, ore on the top of the cross valley berm, and 11.e(2) material in the east and north dikes adjacent to the existing tailings cell, will be excavated and placed within a synthetic-lined cell that is within the planned tailings cell. Existing ore stockpiles adjacent to the mill will be processed through the mill and the tailings will ultimately be deposited within the lined cells. The remaining area requiring cleanup is on the upstream side of the Shootaring Dam where solution from the tailings cell spilled and ponded in this area. This material will be excavated during construction of the synthetic-lined tailings cells.

A field investigation was conducted to determine the estimated volumes of material to be cleaned up and placed within the synthetic-lined cell(s). Natural soil materials produced during construction of the tailings cell(s) may be used within the tailings cells or stockpiled for use as interim cover, grading material or general fill in the reclamation. The clay in the core of the Shootaring Dam is proposed for the radon/infiltration barrier in the Cell 1 reclamation plan, while an alternate source of clay will be used for the Cell 2 reclamation plan. Rock from the quarry area, Shootaring dam, and other borrow areas will be used to protect the entire surface of the tailings cell and the drainage channels from the tailings. Soil and rock materials are on site or in identified borrow areas in sufficient volumes to complete the reclamation.

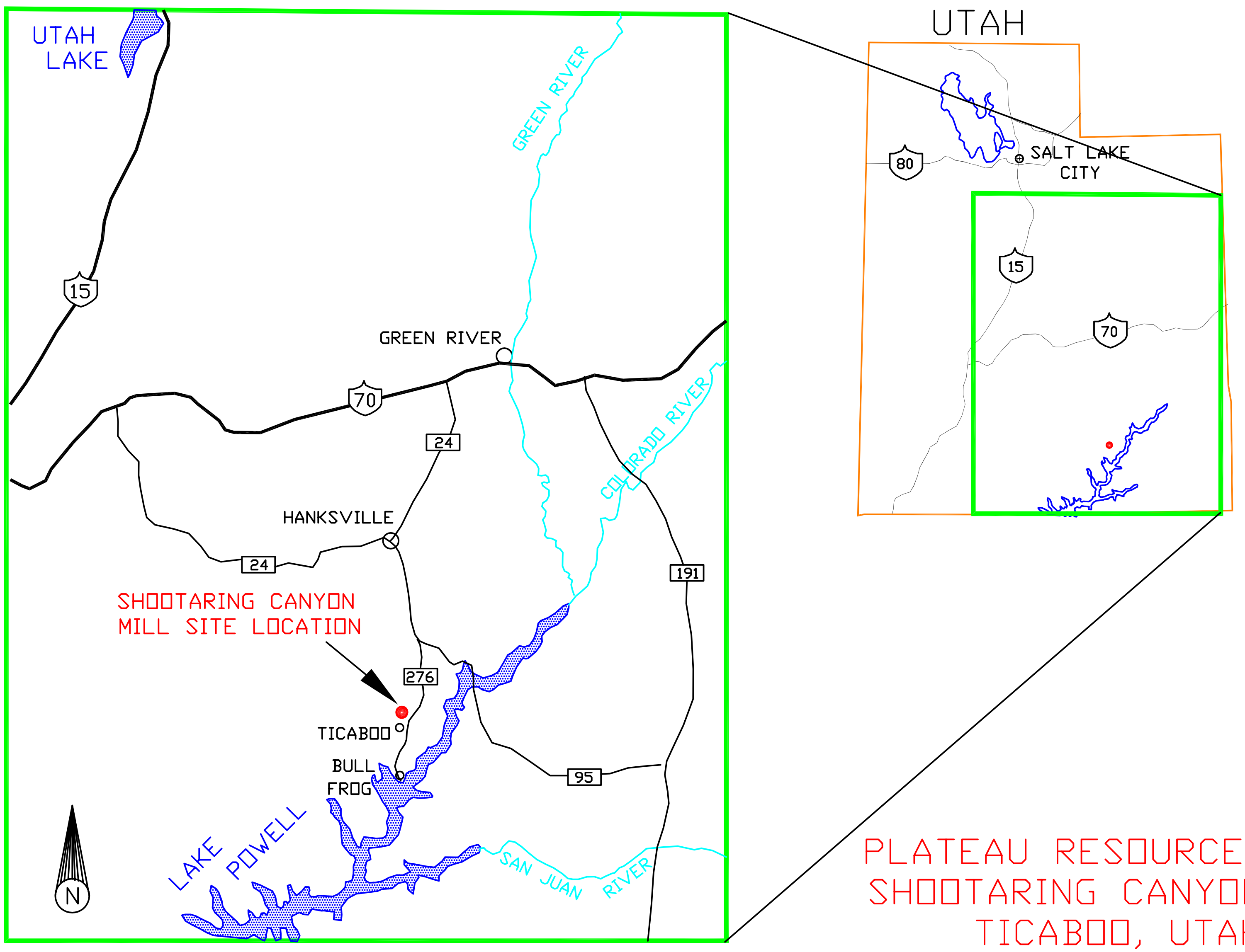
The reclamation schedule for the mill decommissioning and tailings reclamation is estimated to require 20 or 26 months for the Cell 1 and Cell 2 reclamation plans, respectively. The sequence of tasks may result in interim periods of little or no reclamation activity, which may extend the time of completion.

Portions of Cell 1 may be inactive for extended periods after Cell 2 is made operational. Tailings will be covered with an interim cover in parts of the cell that are temporarily inactive. However, reclamation will not proceed on these inactive areas until PRL concludes that a partial reclamation will not compromise the redundant containment provided by the lined tailings cells, and that there will be no further expansion of the tailings cell capacity. Cell 1 serves as an emergency containment for the EPPC, and elements of the reclamation plan for Cell 1 could compromise this containment. There is also the potential for continued above grade placement of tailings in formerly inactive areas of the tailings, and the liner system could be extended to a higher elevation to add capacity in the future.

The estimated cost for the mill decommissioning is $1,483,400. The estimated cost for reclamation of Cell 1, which includes the associated cover cap and erosion protection, is

$4,761,400. These costs with a 15% contingency, 10% PRL management cost and the long-term maintenance costs are combined for a total project cost of $8,638,600.

The estimated cost for the reclamation of Cell 1 and Cell 2, including the associated cover cap and erosion protection, is $11,940,900. These costs with a 15% contingency, 10% PRL management cost and the long-term maintenance costs are combined for a total project cost of $17,720,600.



PLATEAU RESOURCES, Ltd.
SHOOTARING CANYON MILL
TICABOO, UTAH

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FIGURE 1-1. LOCATION OF THE SHOOTARING CANYON MILL SITE

2.0 SITE DESCRIPTION

The mill was originally designed and licensed to produce 1,004,000 pounds of U_3O_8 per year. The ore was processed in an acid circuit at an average daily rate of 500 tons per day and average ore grade of 0.15 percent U_3O_8. Tailings were contained by an engineered earthen and clay dam in a natural depression in the landscape. The existing tailings are located above the cross valley berm on a clay lining system above the natural sandstone in the tailings area. These tailings were placed in the facility during April through August of 1982 during 76 days of operation.

The facilities that exist at the mill site and tailings cell are illustrated on Figure 2-1. Major site features include the mill and associated support buildings, several ore stockpiles adjacent to the mill and the tailings cell. The figure shows the location of the Shootaring dam which was built to hold tailings, but no tailings were deposited between the dam and the cross valley berm. The cross valley berm, which was constructed from fine sand, holds all of the tailings. This figure also shows the east dike and north dike which contains 11.e(2) byproduct material. Future operational plans include an expansion of the ore pad area as shown on Figure 2-1.

The mill building contains the ore grinding and extraction processes including the grinding, extracting, and yellowcake packaging. Counter-current decantation (CCD) tanks and reagent tanks are on an exterior concrete pad. Associated facilities include the laboratory and shop buildings, generator building, exterior reagent storage tanks, fuel storage tanks, ore stockpiles, and outside materials storage areas, as shown in Figure 2-2. The tailings facility consists of a main tailings dam and several smaller berms upgradient of the main dam. During mill operations, ore was stockpiled at the prepared ore pad just north of the mill after being weighed on the receiving scale. Ore was sampled prior to entering the mill building. The mill tailings were slurry pumped to the tailings cell area just west of the mill facility.

The planned operation of the uranium mill includes refurbishing of the mill and addition of a vanadium extraction circuit in a building adjacent to the existing mill. The existing tailings facility will be replaced with synthetic-lined tailings cells as described in the Tailings Management Plan (TMP). The initial tailings cell construction will include construction of an Evaporation and Process Pond Cell (EPPC), where the existing tailings and other contaminated material will be deposited within the lined EPPC prior to installation of a synthetic liner to form the evaporation ponds. The EPPC will have the seven-part liner system described in the TMP which includes a dual HDPE liner with leak detection.

Tailings Cell 1 will be the repository for the tailings initially produced by the reactivated mill. This cell and all tailings cells will have the seven-part liner system described in the TMP. The ultimate capacity of Cell 1 is estimated at approximately 1,500,000 C.Y. with the anticipated reduced moisture placement allowing stacking of the tailings above grade. If the capacity of Cell 1 is likely to be reached, Cell 2 will be constructed immediately upstream of the Shootaring Dam. The ultimate capacity of Cell 2 is estimated at approximately 4,900,000 C.Y. The reclamation plan for Cell 1 includes provisions for a transition to the reclamation configuration for Cell 2, and the reclamation features upstream of the cross-valley-berm are the same for both reclamation plans.

2.1 Land Ownership

The processing facility and its tailings disposal area are located on land purchased by PRL from the State of Utah (State) on November 20, 1981. The patent for this property was obtained on March 1, 1982, from the State of Utah, which obtained the land from the U.S. Bureau of Land Management (BLM). Figure 2-3 shows which land is owned by PRL, the State and BLM.

The United States reserved a right-of-way for ditches and canals constructed by authority of the United States in the purchased lands and has the oil and gas rights. The State of Utah reserved coal and other mineral rights. PRL holds a lease from the State of Utah covering metalliferous minerals. A Garfield County road, constructed and maintained by PRL through an agreement with the county, provides access to the processing facility from State Highway 276, as shown on Figure 2-3. Beehive Telephone Company (an independently owned telecommunications company) that serves the processing facility, Tony M mine and Ticaboo, Utah, was granted a right-of-way for a buried telephone cable that runs, in part, in a generally north to south direction through the eastern portion of the site.

Prior to termination of the source material license, PRL will comply with the ownership requirements of Criterion 11 Appendix A to 10 CFR Part 40 for sites used for tailings disposal. Figure 2-1 shows the proposed Long-Term Care Boundary for the Cell 1 reclamation plan which includes the tailings cell and associated runoff channels. Figure 2-1 also shows the proposed Long-Term Care Boundary for the Cell 2 reclamation plan. All of the land within these two areas is owned by PRL (see Figure 2-3). Title and custody of the byproduct material (tailings), and the tailings disposal area, including any interests therein, will be transferred to the United States or the State of Utah, at the option of the state. As noted above, mineral rights are already owned by the United States (as to oil and gas) and the State of Utah (as to all other minerals). PRL reserves the right to maintain, transfer, sell, or otherwise dispose of its property adjacent to the tailings disposal area.

2.2 History of Operations

Figure 2-1 shows the location of the Shootaring tailings and mill sites with topography. The mill was designed and constructed between 1978 and 1981. The facility operated for approximately five months in the summer of 1982, processing approximately 25,000 cubic yards of ore. All tailings were deposited in the existing approved clay-lined tailings cell shown in Figure 2-1.

Historically, the project area has been used for seasonal livestock grazing and as wildlife habitat. Human use of the project area for activities, such as camping, hiking, sightseeing, and hunting, has been minimal to date in part because of the availability of other areas in southeastern Utah for these activities.

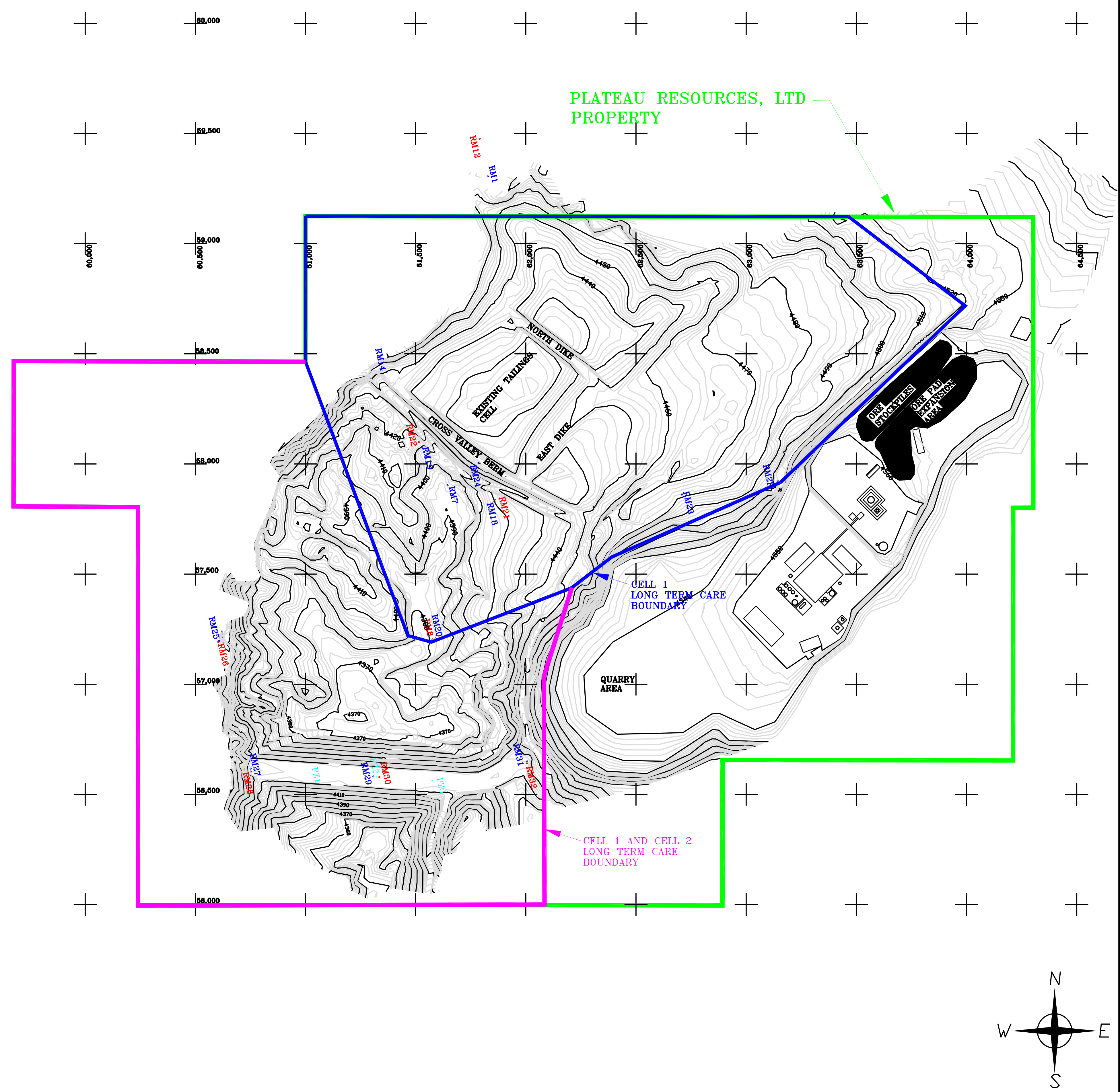
Limited livestock grazing and wildlife habitat will probably continue to be the principal use of the affected area after termination and closure of the project. Agricultural use of the area, for either crop or hay production, is not anticipated due to the poor soil structure and scarcity of water. There are presently no urban or industrial developments in the project area other than the facilities originally related to the project and a boat repair/storage yard. Future development of the property and released structures in and around the mill would most likely be for light industrial, such as boat storage.

Approximately 18 acres (7.25 ha) were leveled for construction of the plant, office, ore stockpile pads, plant buildings, and auxiliary structures. The surface gradient for runoff is sloped toward the tailings impoundment area. Filling was required over the balance of the graded area. Typically, cuts ranged from zero to about 15 feet (4.57 m) in depth except in localized areas (such as the ore dump pocket and connection conveyor tunnel) where excavation was as deep as 45 feet. Maximum fill depth was approximately 40 feet at the southwest corner of the ore storage pad.

2.3 Geology and Hydrology of the Mill Site and Tailings Impoundment Area and Corresponding Tailings Impoundment Dam Design

Thorough investigations of the mill site and tailings impoundment dam were conducted by Woodward-Clyde Consultants prior to the design and construction of the facility. Investigations included demography, meteorology, hydrology of both ground and surface water, the corresponding water uses, and regional and site geology. Woodward-Clyde documented their findings in Woodward-Clyde (1978a and 1979) for the design of the project. Woodward-Clyde (1978b) presents the tailings management plan while Woodward-Clyde (1980) presents the preoperational radiological environmental monitoring program. The mill was constructed in 1980 and 1981. Cross sections from the Woodward-Clyde (1982) as-built report are used in the reclamation plan to define quantities. The analysis of ground-water conditions at the site has been updated in Hydro-Engineering L.L.C. (1998, 1999, 2000, 2005)

Another source for this information can be found in PRL Source Material License Renewal Application SUA 1371, Docket No. 4-8698, Dated March 11, 1996 and operational license status change in March, 1998 (renewed in May 2003), which was submitted and approved by NRC and Utah Division of Radiation Control.



LEGEND

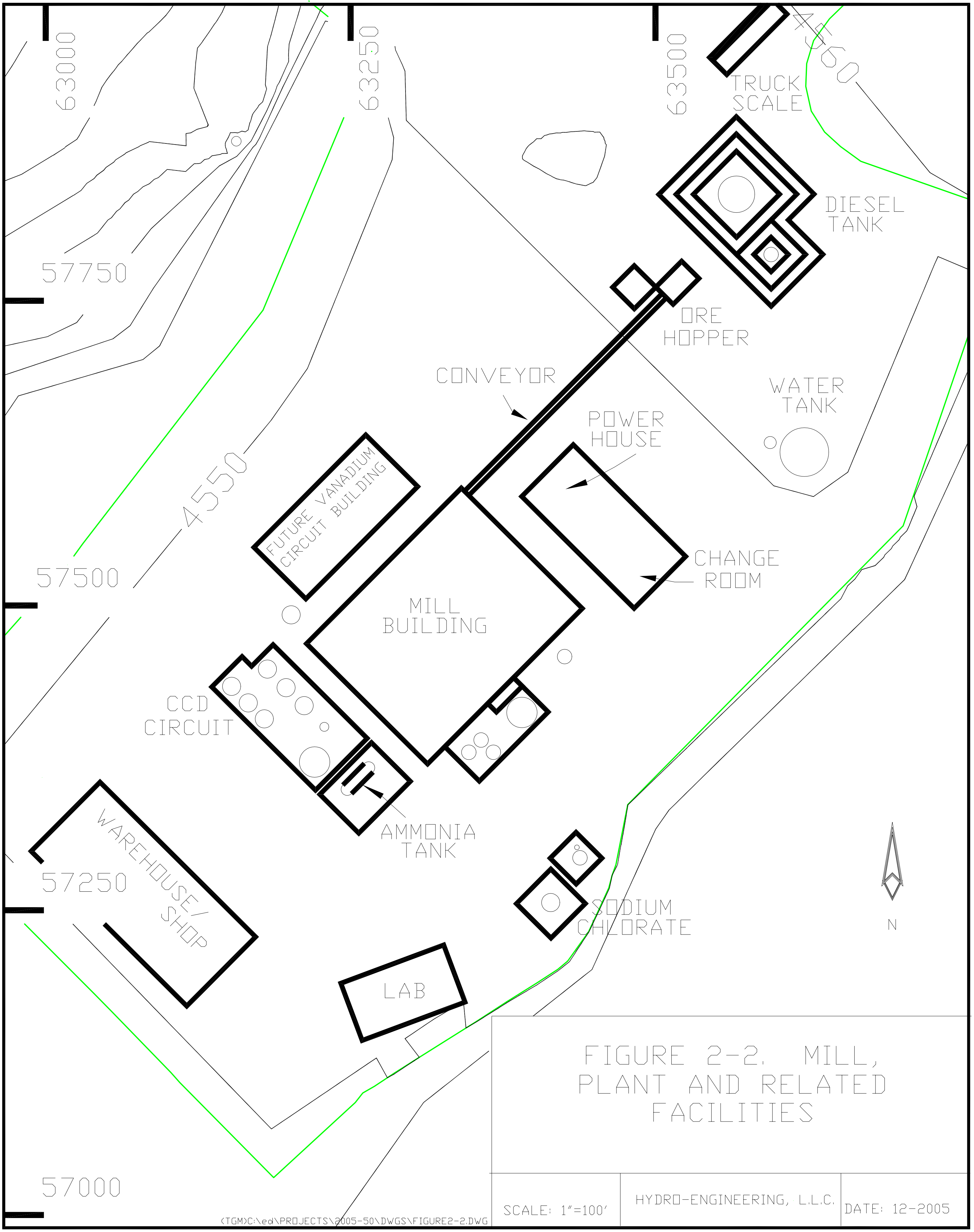
RM12 ○ UPPER ENTRADA WELL
RM1 ○ ENTRADA WELL
PZ1 ○ DAM PIEZOMETER

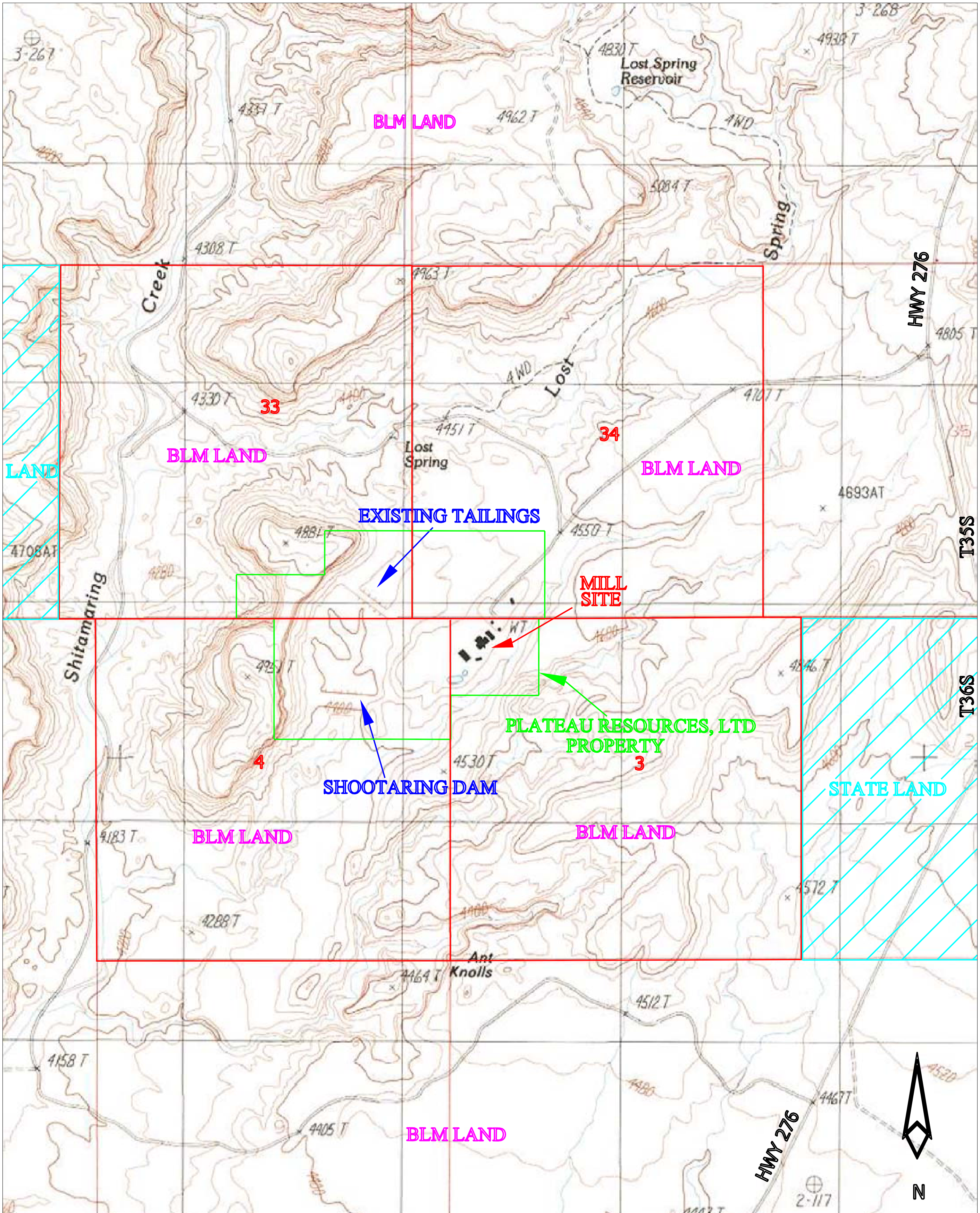
PLATEAU RESOURCES Ltd.

FIGURE 2-1. LOCATION OF SHOOTARING CANYON TAILINGS AND MILL SITE WITH TOPOGRAPHY

DATE: 12-2005	FIG2-1.DWG	SCALE: 1"=500'

 HYDRO-ENGINEERING L.L.C.


63000
63250
63500
4560
TRUCK SCALE
DIESEL TANK
57750
ORE HOPPER
CONVEYOR
WATER TANK
POWER HOUSE
4550
FUTURE VANADIUM CIRCUIT BUILDING
57500
CHANGE ROOM
MILL BUILDING
CCD CIRCUIT
AMMONIA TANK
WAREHOUSE/ SHOP
57250
SODIUM CHLORATE
N
LAB
57000
FIGURE 2-2. MILL, PLANT AND RELATED FACILITIES
SCALE: 1"=100'
HYDRO-ENGINEERING, L.L.C.
DATE: 12-2005
(TGM)C:\ed\PROJECTS\2005-50\DWGS\FIGURE2-2.DWG



SCALE: 1" = 2000'

R11E

FIGURE 2-3. LAND OWNERSHIP AND LOCATION OF THE SHOOTARING TAILINGS AND MILL SITE

3.0 CURRENT SITE CONDITIONS AND OVERVIEW OF THE RECLAMATION PLAN

This section presents the information that was obtained in the development of the Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project that was submitted to the NRC and Utah Division of Radiation Control (UTDRC) in October of 2002 and subsequently approved in March of 2004. The previous reclamation plan was not implemented, but the site conditions are essentially unchanged from those that existed at the time the previous plan was developed. Because dual HDPE-lined tailings cells will replace the existing tailings disposal system, the site characterization that was done in the planned tailings disposal area will allow collection of contaminated materials and disposal within the replacement tailings cells. A radiological survey and numerous test holes and pits were used to obtain samples of site material for defining the present site conditions.

3.1 Soils Characterization

An updated radiological survey of the site was conducted to evaluate existing concentrations of radiological constituents at the site. Radiological measurements were made in the field and samples were collected for radiological laboratory analysis. Samples were also collected for the soil property measurements. Test pits, drill hole cuttings and hand auger sampling were used to evaluate and collect materials from the site. Some shallow surface samples were also taken for measuring radiological conditions near the ground surface.

3.1.1 Test Pits

Approximately 40 test pits were used to collect samples and define the lithologic conditions in the upper few feet of material at the Shootaring site. Figure 3-1A shows the sample site name and locations for the west area, which includes the tailings cell area and the Shootaring dam. Backhoe pits are shown in red on this location map. Some of the backhoe pits are also shown in cyan color if hand auger or drill hole measurements were also made at the same site. Figure 3-1B shows the sample site locations and names for the east area, which includes mainly the mill area. Some overlap with the west area exists in the east area map. Table A-1 in Appendix A presents the lithologic logs of the backhoe pit sites. Lithologic logs for additional backhoe pits in which a hand auger or drill hole was also used for lithologic definition are presented in Table A-4 of Appendix A.

3.1.2 Test Holes

Twelve rotary air drill holes and approximately 40 hand auger drill sites were also used to define position and properties of the materials. The air rotary drill sites are shown in magenta on Figures 3-1A and 3-1B while the hand auger sites are shown in blue. Hand augers were also used at several of the pit locations to aid in definition of lithologic conditions at the pit locations. A drill hole and pit combination was used at one of the sites. Samples were collected from these test hole sites for radiological and materials measurements. Table A-2 of Appendix A presents the air rotary test hole lithologic information, while Table A-3 presents the lithologic logs for the hand auger test holes. Table A-4 presents the lithologic logs for the hand auger or drill hole and backhoe pit combination sample sites.

A thickness of the rock was measured on the tailings dam as shown in Table A-5 of Appendix A. These measurements show that the rock thickness averages 2.5 feet.

3.1.3 Gamma Survey

A gamma survey was conducted to define areas of soil contamination. The measurements were made using Ludlum micro-R meters calibrated using an NIST traceable Ra-226 source. Figure 3-2A presents the location and site name of the gamma measurements for the west area while Figure 3-2B presents the locations for the east area. Locations for gamma measurements in the mill area, which is part of the east area, are also shown on Figure 3-2C to a larger scale. Table B-1 in Appendix B presents the gamma survey location name, gamma reading, and any location remarks.

The gamma readings in units of µR/hr are presented in Figures 3-3A, 3-3B and 3-3C. Figure 3-3A shows a 20 µR/hr contour, which includes the entire existing tailings cell, the cross-valley berm, and the east and north dikes to the tailings cell. The letter A is shown on Figures 3-3B and 3-3C to define the location of the ore stockpiles. The letter ‘B’ shows the location of gamma readings above 20 µR/hr on the east side of the mill while letter ‘C’ labels a spill area on the northwest side of the mill. Area D is associated with the CCD circuit spills and some on the west side of the mill. Area E is two small areas of ore spillage on the southwest side of the maintenance shop and a small area just outside the fence to the east of the mill. Area F is upstream of the Shootaring dam and the clean up of the 1982 tailings solution spill did not meet current standards. Area G is the cross valley berm while H is the east dike which contains 11.e(2) material. Area I is the north dike 11.e(2) material and some area of elevated activity to the north of the dike due to ponding of tailings solution in this area prior to the placement of the north dike. A small area to the north of the north dike is included in gamma readings greater than 20 µR/hr to show the extent of this area. Figure 3-3A presents the location where radium-226 and thorium-230 exceed the cleanup level just above the Shootaring dam where fugitive solution ponded during 1982 (Area F). The cleanup in this area was not sufficient to meet current standards. This area includes the upstream toe of the tailings dam where elevated concentrations exist in the soil in the bottom portion of the rock protection for the dam. It also includes additional soil contamination from thorium-230 over the ponded area.

Figure 3-3B shows the east area, which includes the mill and the ore stockpile. A gamma reading of greater than 20 µR/hr exists around the entire ore stockpile and includes the scale area (Area A). The gamma readings in the mill area are shown at a larger scale in Figure 3-3C. This figure shows several areas in and around the mill where gamma readings exceed 20 µR/hr. Two small areas exist on the southwest side of the maintenance shop where some ore was washed or dropped from equipment parked in this area (Area E). The largest area with gamma readings exceeding 20 µR/hr is on the west side of the CCD circuits and the west portion of the mill (Area D). A large area is also present on the east side of the mill adjacent to the 600 area (Area B). Process solution spills have occurred in areas B and D but the affected area is likely smaller due to gamma shine in these areas. A small contaminated area exists just outside the fence east of the mill and appears to be ore material and was included in Area E.

A pre mill operation laboratory liquid effluent pond has been identified and sampled. Gamma readings were taken from four sample locations at varying depths up to seven feet with only one significant reading. A sample was collected from the elevated gamma reading location. The wet chemical sample analysis for U-nat, Ra226 and Th230 resulted in all levels below background. In order to verify the first analysis, a second analysis was performed using gamma spectrum with no results above background. No cleanup is planned for this site.

3.1.4 Laboratory Radiological Results

Table 3-1 presents the radiological properties for the soil samples collected at the Shootaring site. This table presents the sample location name, shown on Figures 3-1A or 3-1B, and also gives the coordinates for these sample locations. The top and bottom depths of the sample interval are also presented in the table. Radium-226 (Ra-226), thorium-230 (Th-230) and natural uranium (U-nat) concentrations were measured for these samples. Gamma values that were measured in the field for these samples are also tabulated along with these radiological results. Radium concentrations for these sites vary from very low levels for the majority of the mill site samples to a high of 76.6 pCi/g for a below grade sample of the 11.e(2) material in the north dike on the north side of the tailings cell. The highest Th-230 and U-nat concentrations were observed in the samples of the material immediately upstream of the Shootaring dam where cleanup of the solution affected soils was inadequate. This analysis of the level of contamination does not include ore samples (prefaced OP in Table 3-1) where concentrations are significantly greater.

TABLE 3-1. Radiological Properties from Soil Sample at Shootaring Canyon.

Sample	Coordinates			Measurement		Radium 226		Thorium 230		Uranium	Gamma
				top	bottom	Conc.	Precision	Conc.	Precision		
Site	East	North	Date	(ft.)	(ft.)	(pCi/gm)		(pCi/gm)		(pCi/gm)	(uR/hr)
C4	62412	58040	06/05/2002	0.5	3.5	0.5	0.1	0.3	0	0.42	-----
CV4	62166	57809	06/04/2002	0	0.5	45.8	1.6	56.2	1	71.5	-----
D98	62836	57713	06/06/2002	3.5		0.6	0.1	0.4	0	0.57	60
DD1	63179	57052	06/06/2002	0	0.5	0.3	0.1	0.4	0	1.7	7
DD4	63194	57476	06/06/2002	0	0.5	0.2	0.1	0.1	0	3.24	12
DD4	63194	57476	06/06/2002	0.5	1	0.3	0.1	0.2	0	2.24	-----
DD5	63226	57505	06/06/2002	0	0.5	0.5	0.1	0.6	0.1	4.16	15
DD5	63226	57505	06/06/2002	0.5	1	0.8	0.1	0.8	0.1	4.12	-----
DD6	63207	57635	06/06/2002	0	0.5	0.4	0.1	0.5	0	1.8	10
DD6	63207	57635	06/06/2002	0.5	1	0.2	0.1	0.2	0	0.52	-----
DD7	63420	57438	06/06/2002	0	0.5	0.6	0.1	0.4	0	3.35	16
DD7	63420	57438	06/06/2002	0.5	1	0.3	0.1	0.2	0	2.59	15
DD8	63457	57771	06/06/2002	0	0.5	74.1	2.7	83.3	1.8	153	60
DD8	63457	57771	06/06/2002	0.5	1	10.7	0.4	17.5	0.5	38.9	45
DD9	63532	57953	06/06/2002	0	0.5	3.2	0.2	3.6	0.2	4.81	19
DD9	63532	57953	06/06/2002	0.5	1	0.4	0.1	0.3	0	2.19	16
ED2	62123	58113	06/05/2002	5	10	2.1	0.2	5.7	0.3	29.2	-----
H100	61259	56753	06/07/2002	0	0.25	31.7	1.1	49.5	0.8	12	42
H101	61604	56774	06/07/2002	0	0.5	12.3	0.4	35.2	0.7	22.5	31
H101	61604	56774	06/07/2002	0.5	1	2.1	0.2	162	1.7	97.4	22
H102	61250	56753	06/07/2002	1	1.5	10	0.4	95.4	1.4	18.6	24
H99	61242	56822	06/07/2002	0	0.5	0.3	0.1	1.9	0.2	11.2	12
H99	61242	56822	06/07/2002	0.5	1	4.5	0.2	62.4	1	24.2	17
NC1	62173	58588	06/07/2002	0	0.5	27.9	1	27.2	0.7	5.15	90
NC1	62173	58588	06/07/2002	0.5	1	3.5	0.2	79.8	1.3	48.3	90
ND2	62126	58531	06/05/2002	5	10	57.9	2.1	81.1	1.3	52.4	-----
ND3	61975	58663	06/05/2002	5	10	76.6	2.7	85.4	1.2	43.6	-----
NP4	62237	58532	06/04/2002	2	2.5	0.5	0.1	0.2	0	0.31	-----
OP1	63881	58486	04/04/2002	-----	-----	230	2.3	370	2.7	0.23	-----
OP2	63845	58528	04/04/2002	-----	-----	270	2.5	490	3.1	640	-----
OP3	63838	58432	04/04/2002	-----	-----	260	2.5	350	2.5	632	-----
OP4	63790	58483	04/04/2002	-----	-----	190	2	320	2.5	523	-----
OP5	63788	58383	04/04/2002	-----	-----	210	2.2	520	4.2	502	-----
OP6	63735	58433	04/04/2002	-----	-----	250	2.4	390	3.3	476	-----
OP7	63740	58332	04/04/2002	-----	-----	250	2.3	430	3.3	540	-----
OP8	63691	58386	04/04/2002	-----	-----	200	2.1	320	2.6	468	-----
OP9	63692	58286	04/04/2002	-----	-----	310	2.6	360	2.2	649	-----
OP10	63640	58338	04/04/2002	-----	-----	240	8.4	460	2.9	691	-----
OP11	63643	58241	04/04/2002	-----	-----	260	8.7	540	3.6	619	-----
OP12	63586	58291	04/04/2002	-----	-----	280	8.8	330	2.5	691	-----
OP13	63610	58168	04/04/2002	-----	-----	220	8.1	290	2.4	498	-----
OP14	63576	58211	04/04/2002	-----	-----	240	8.4	330	2.4	751	-----
OP15	63540	58252	04/04/2002	-----	-----	240	8.4	320	2.6	528	-----
OP16	63514	58215	04/04/2002	-----	-----	270	9	270	1.9	489	-----
OP17	63514	58069	04/04/2002	-----	-----	260	8.7	320	2.4	640	-----
OP18	63482	58135	04/04/2002	-----	-----	290	9.2	220	1.7	555	-----
OP19	63412	58104	04/04/2002	-----	-----	340	10	300	2.3	697	-----
OP20	63459	58053	04/04/2002	-----	-----	210	2.3	360	2.6	584	-----
OP21	63385	58066	04/04/2002	-----	-----	300	2.7	380	2.9	591	-----
OP22	63352	58043	04/04/2002	-----	-----	340	2.9	350	2.6	751	-----
OP23	63371	58000	04/04/2002	-----	-----	240	2.5	350	2.8	436	-----
OP24	63316	58022	04/04/2002	-----	-----	97	1.5	150	1.8	232	-----
OP25	63308	57948	04/04/2002	-----	-----	110	1.7	130	1.6	267	-----
OP26	63382	57947	04/04/2002	-----	-----	250	2.4	290	1.9	554	-----
OP27	63393	57883	04/04/2002	-----	-----	120	4.3	140	1.4	250	-----
OP28	63416	57856	04/04/2002	-----	-----	106	3.8	96	1.3	162	-----
OP29	63446	57844	04/04/2002	-----	-----	99.2	3.6	93	1.3	169	-----
OP30	63468	57912	04/04/2002	-----	-----	88.2	3.9	94	1.5	149	-----
OP32	63542	58063	06/06/2002	3.7	4.2	6	0.3	6.9	0.3	33.9	280
OP32	63542	58063	06/06/2002	4.2	4.6	0.2	0.1	<0.1		7.85	170
OP33	63624	58107	06/06/2002	2.9	3.4	4.8	0.2	5.3	0.3	22.6	250
OP33	63624	58107	06/06/2002	3.4	3.9	1	0.1	0.9	0.1	7.38	160
T3	61918	58074	06/05/2002	8.0	10.7	45.6	1.6	12.4	0.5	100	-----
T4	61953	58456	06/05/2002	10.0	13.0	51.8	1.9	28.8	0.8	21.5	-----
T7	61785	58315	06/05/2002	3.7	3.9	139	5.0	3800	25	3880	-----
SY1	63055	57190	08/19/2002	0	0.5	6.1	0.3	10.2	0.4	6.73	21
SY1	63055	57190	08/19/2002	0.5	1.0	1.6	0.1	2.5	0.2	7.11	16

Figure 3-4 presents a plot of the Ra-226 concentration versus gamma exposure rates. This figure shows that, in general, as the Ra-226 concentration increases, the gamma reading increases. The figure also shows that a gamma exposure rate higher than 20 μR/h indicates contamination above the proposed cleanup criteria. The site locations for the higher concentrations are listed on the figure also. The gamma reading for the NC1 sample just north of the north dike is high compared to the Ra-226 concentration. Tailings solution existed at the location prior to the placement of the north dike which covers most of the area. Therefore it is likely that subsurface soil contamination is responsible for the elevated gamma levels.

There is only one small off-pile area that indicates elevated Th-230 concentrations relative to Ra-226. This area is where tailings water collected above the Shootaring Dam (Samples H-99-H102) as a result of a failure in the sump pump below the cross valley berm. The water was pumped back into the tailings impoundment and the surface soil/residues removed. However the radiological survey revealed areas where further remediation will be required. The areas exhibiting elevated gamma levels will be excavated to near background levels. The entire Area F has the potential for excess Th-230 contamination. Characterization of this area will be done to identify Th-230 contamination that exceeds the cleanup criteria.

3.1.5 Pre-Operation Cleanup

Prior to construction of the synthetic-lined tailings cell(s), the existing tailings and other contaminated materials in the tailings area will be collected and placed with the HDPE-lined EPPC. This includes areas F, G, H, and I shown in Figure 3-3A. The cleanup criteria will include the procedures and criteria described in Sections 8.4.1 through 8.4.2. The contaminated soils in areas B, C, D and E (see Figure 3-3B) will also be collected prior to any construction or significant activity in the immediate area of the designated contaminated soil areas. The prepared ore pad (Area A in Figure 3-3B) will be utilized during operation of the mill and will not be cleaned up prior to the reactivation of the mill.

3.1.6 Post-Operation Survey and Cleanup

After processing of uranium is discontinued in the mill, a gamma survey and Ra-226 and Th-230 sampling program will be undertaken to identify additional areas where cleanup is necessary. This program will be similar in scope, scale and implementation to the program that was instituted in 2002. The area of sampling and survey will be expanded as necessary to include areas potentially contacted by ore, tailings, solutions or other contaminated materials.

3.2 Tailings Moisture and Limited Drainage from Under Drain System

Three wells were completed into the existing tailings during the drilling of the test holes. Figure 3-5 shows the location of the three tailings wells, T4, T5 and T6. This figure also shows the location of the existing under drain piping for the tailings drain system. This piping lies on top of the clay barrier and has a filter layer of sand and rock on top of the perforated pipes. The Entrada red sand is also used as a drain blanket on top of the clay. The elevations of the top of the existing clay barrier are presented in Figure 3-6. Tailings well T4 was placed near the lowest portion of the clay liner. The clay was generally placed to a minimum thickness of two feet. Recent testing defined one location with a thickness of 16 inches (ED2) and a few locations with a thickness of 18 inches. These contours were developed for the surface prior to the construction of the cross valley berm or the placement of any tailings material in the existing cell. The drain system is tied to the sump on the down-gradient side of the cross valley berm. The completion details for the three tailings wells are presented in Section 7 of this document. None of the three wells have shown any saturation in the tailings other than some water observed in the bottom of well T5 after the August 20th 2002 rain event and some small depths of saturation in well T4 after periods of frequent precipitation. Additional rain after the August 20th 2002 precipitation has not resulted in any observed saturation in well T5. It is believed that this indicated water level in Well T5 resulted when water from precipitation moved through the well annulus prior to the hydration of the bentonite seal in the well, and was ultimately trapped in the cap at the bottom of the well. The observed water in well T4 is thought to be minor and transient saturation of the lowest portion of the tailings during wet cycles. Because the existing tailings will be excavated and placed in the EPPC prior to reactivation of the mill, the moisture status of the existing tailings is only an issue for excavation procedures. The observed tailings well water levels and limited discharge from the under-drain system indicate that excavation of the tailings can likely be done with conventional techniques. This removal of the tailings will also result in practical decommissioning of the under drain system prior to construction of the replacement tailings cells.

Flow to the sump was monitored in 2002 through early 2005 to define the rate of drainage from the under drain system. This flow data is presented in Table 3-2 of Hydro-Engineering L.L.C. (2005). This table shows that the flow rate has varied from a high of 0.27 gal/min for measurement between January 4 to January 9, 2005 to a fairly steady low rate of 0.008 gal/min between May 16th and July 14th, 2002. Figure 3-7 shows the drainage area that presently contributes to the under drain system. The removal of the existing tailings and the replacement of the tailings cell with HDPE-lined cell(s) will render this monitoring moot. However, the limited rate of discharge is a strong indicator that the tailings are dewatered and that excavation of the existing tailings will be relatively straightforward. With the configuration of the reclaimed tailings in both the Cell 1 and Cell 2 plans creating positive drainage, the closed basin capture of runoff in the tailings area will be eliminated.

Water quality samples have also been taken from the tailings sump to monitor the quality of water draining from the under drain system. The results are given in Table 3-3 of Hydro-Engineering L.L.C. (2005) which show that the total dissolved solid concentration is very high for this water with a TDS typically greater than 30000 mg/l. A very high sulfate concentration also exists in the water. Uranium concentration is typically greater than 10 mg/l, indicating that a significant percentage of the water is partially saturated flow coming from the tailings material. Again, the existing tailings will be transferred to a synthetic lined cells, and solutions within the tailings will be captured in a Best Available Technology (BAT) drainage and leak detection system.

3.3 Building Surface Contamination

A surface contamination survey was done in the mill buildings in 2002 to assess the airborne radiation exposure to workers and to assess the feasibility of decontaminating the structures. The survey was biased in that areas most likely to be contaminated were sampled. The results are given in Table 3-2 and show that surface contamination levels are relatively low. The data for areas near the kerosene tanks in SX indicate high removable levels. However, these data probably don't reflect the levels after the kerosene residue is removed and thus should not be considered. Without the kerosene residue samples, the total gross alpha contamination averaged 372 dpm/100 cm^2 with a standard deviation of 125 dpm/100 cm^2. The removable portion averaged 30 dpm/100 cm^2 with a standard deviation of 47 dpm/100 cm^2. This would indicate a minimum removable fraction of 8 percent, depending on the efficiency factor assumed for the wipe tests. Working in these low levels of contamination should not pose a high risk to employees or excessive releases to the environment. This building surface contamination survey will be repeated after operation of the reactivated mill is discontinued.

The yellowcake section is currently sealed and no measurements were made. However it is known that high levels of surface contamination exist. The decommissioning of the yellowcake processing area (YCPA) will require additional procedures to minimize radiation exposure to personnel and limit the release to the environment. A primary consideration in planning the YCPA work is weather conditions, especially wind speeds. A special radiation work permit (RWP) will be developed, including special engineering controls, for performing this work.

Anticipated engineering controls include spraying the equipment with a tack coating after a wash down to fix the contamination while removal and transport to the tailings cell. The SERP will approve all RWPs. See Appendix I for a list of Titles of Standard Operating Procedures (SOP) that are in place and will be utilized and/or updated or modified as needed during the site reclamation and decommissioning. Radiation worker training will be given to all personnel working on the reclamation and decommissioning activities. Personnel working on the site reclamation and decommissioning will be supervised for radiation safety and general safety, and to insure that the work follows the approved Tailings Reclamation Plan.

Table 3-2 Radiation Surveys in Mill Buildings-Floor/Sump Areas

Date	Area	Location	Gamma (uR/hr)	Total Alpha (dpm)	Removable Collection date	Removable count date	Removable Alpha (dpm)
8/9/2002							
	300 Leach	1) 10ft north of SAG	11	498	8/13/2002	8/16/2002	211
		2) under SAG	12	298	8/13/2002	8/21/2002	30
		3) south end under SAG	19	199	8/13/2002	8/21/2002	30
		4) SAG sump west side	16	199	8/13/2002	8/21/2002	15
		5) steps east side into 500area	10	298	8/13/2002	8/21/2002	14
		6) SW corner	19	398	8/13/2002	8/21/2002	18
8/9/2002							
	500 SX	1) 10ft inside main door	18	398	8/13/2002	8/21/2002	13
		2) preg strip soln tank	16	418	8/13/2002	8/23/2002	25
		3) sump kerosene tank	15	298	8/13/2002	8/21/2002	27
		4) floor kerosene tank	13	418	8/13/2002	8/21/2002	264
		5) kerosene tank west	12	796	8/13/2002	8/23/2002	542
		6) south man door floor	10	398	8/13/2002	8/23/2002	15
		7) SW man door floor	12	298	8/13/2002	8/23/2002	12
		8) NW man door floor	18	498	8/13/2002	8/23/2002	36
8/9/2002							
	700 Reagent	1) South end floor near sump	8	318	8/13/2002	8/23/2002	13
		2) under reagent tanks	9	199	8/13/2002	8/23/2002	11
		3) center of floor	8	318	8/13/2002	8/23/2002	14
8/9/2002							
	Sand filters	1) center floor	140	597	8/13/2002	8/21/2002	16
		2) south floor near sump	90	597	8/13/2002	8/21/2002	16
		3) north floor	65	398	8/13/2002	8/21/2002	14
		Mean	26	392		Mean	67
		Standard Dev.	34	150		Standard Dev.	131

Survey meters: Ludlum Model 19 SN 34944 Calib 4-11-02
Ludlum Model 177, SN 14877/4028, Calib 3-28-02, eff 13.4%
SAC-4 SN 361, Calib 5-28-02, eff 41.3%
Survey in Mill conducted by D. Winters and reading swipes by F. Craft

3.4 Tailings Reclamation Performance Objectives

The project goal is to remove all items and soils contaminated with byproduct material and place them into the tailings facility. Once the mill area has been cleaned and any contaminated soils or materials have been identified and removed, the site will be released for unrestricted use. If it is not possible to clean the mill area to standards for release, the mill area will be covered in place with the same cover system specified for the tailings cell(s). See Sections 8, 10 and 11 on mill site decommissioning for a complete explanation, scheduling and cost analysis.

The tailings will be isolated from groundwater by an encapsulation system that includes the seven-part liner system and a clay cap over the cell. This will minimize infiltration and reduce the radon emissions to less than 20 $pCi/m^2/s$. The cap will be extended to intercept the seven-part liner to completely encapsulate the tailings. One hundred forty feet of sandstone lies between the liner system and the groundwater. A cover system has been designed to control erosion, disturbance, and dispersion of tailings by natural forces for a minimum of 1,000 years.

The combination of reduced-moisture placement and the drainage system in the tailings cells will maintain the tailings in a largely dewatered condition throughout operation. The designated disposal area for the mill equipment and mill site wastes is the EPPC. Hence, the reclamation of tailings cell(s) could conceivably proceed within a few months after the cessation of milling. Once the residual tailings solutions are removed from the evaporation and process pond, this cell will become available for disposal of equipment and wastes from the mill. Both the tailings cell(s) and the EPPC will be covered with a specifically-designed radon attenuation cap. This engineered cap will be a combination of clay, soils and rock placed in layers. Quality control practices are specified to assure compliance with the design specifications.

The desired end result of the design, construction, operation, and closure of the tailings disposal system has been planned with the objective of creating a facility that, after closure, will endure for up to one thousand (1000) years without requiring either monitoring or maintenance while continuing to provide an environmentally safe and satisfactory performance. Factors of long-term concern with respect to uranium tailings final disposal are the dispersal of tailings by erosion, the contamination of groundwater, and the release of radon to the atmosphere. These and other concerns addressed in 10 CFR Part 40, Appendix A, State of Utah regulations, and applicable NRC regulations, are addressed in following sections.

3.4.1 Nonproliferation Of Small Waste Disposal Sites

To avoid proliferation of small waste disposal sites and thereby reduce perpetual surveillance obligations, radioactive byproduct, contaminated equipment, and contaminated scrap from milling operations will be placed, with State of Utah approval, in the tailings cell for disposal. Precautions will be taken to place the materials in the tailings in such a way as to minimize any future subsidence of the area.

3.4.2 Site And Design Criteria

PRL's tailings disposal facility was designed to minimize the dispersal of tailings by wind and water, to minimize the upstream rainfall catchment area, to minimize the embankment and cover slopes, to minimize erosion of the cover, to locate the impoundment away from capable faults, and to promote deposition on top of the cover. Specific design criteria for the tailings impoundment and dam are detailed in Woodward-Clyde Consultants studies and designs. Refer to the list of references in Section 14. The design of the cover and reclamation is presented in this document. The design features of the impoundment and cover will provide reasonable assurance of the longevity of the tailings disposal facility (See Section 6).

3.4.3 Control Of Radon Release And Gamma Exposure Rates

This plan covers the design of the radon barrier for the tailings impoundment consisting of one and one-half (1.5) feet of compacted clay covered by two (2) feet of rocky soil covered by a minimum of four (4) inches of a rock cover. Additional general fill will be placed on the tailings to establish design grades prior to placement of the compacted clay cover. The radon barrier was designed to yield a radon emanation rate of 20 pCi/m^2/sec or less. One gamma-ray exposure rate measurement at approximately one meter above the cover system will be made per acre of radon barrier, using a Ludlum Model 19 micro-R meter (or equivalent), to demonstrate that the cover reduces the gamma exposure rate to background levels.

3.4.4 Operational Environmental Monitoring Program

The operational and interim environmental monitoring programs are described in Appendix D of the Tailings Management Plan submitted in December 2005. See Appendix I for Titles of Standard Operating Procedures that are to be utilized for environmental monitoring. This program will be continued during the decommissioning of the site.

3.4.5 Control Of Airborne Effluents

All airborne effluents from milling operations will be reduced to levels that are As Low As Reasonable Achievable (ALARA), which in turn controls exposures to populations around the site and site contamination to the maximum extent reasonably achievable.

Airborne effluent controls include but are not limited to water spraying to minimize dust and interim cover over radioactive materials.

3.4.6 Hazardous Constituents

PRL does not reasonably expect any compound on the list of specific constituents presented in 10 CFR Part 40, Appendix A (Criterion 13) to be present in the groundwater under the PRL mill or tailings area as a result of site operations. Water monitoring since tailings deposition in 1982 has not shown any tailings or mill constituent migration.

3.4.7 Financial Surety

At the present time, surety arrangements have been established at the First Interstate Bank of Casper, WY which names the State of Utah, Department of Environmental Quality, Division of Radiation Control as beneficiary. The surety amount as of July 22, 2005 was $6,471,838. These funds are sufficient to carry out the decontamination and decommissioning of the facility and site, and for reclamation of the existing tailings disposal area as of this date. The amount of funds insured by the surety arrangement is based on the Tailings Reclamation and Decommissioning Plan approved by the NRC on April 16, 2004, which provides for (1) decontamination and decommissioning of mill buildings and the facility site to levels which would allow unrestricted use of these areas and (2) the reclamation of the existing tailings disposal area in accordance with the approved technical criteria. With the approval of the Cell 1 reclamation and decommissioning plan described herein, the amount of the surety will be adjusted to $8,638,600.

3.4.8 Rodent and Plant Penetration into the Radon Barrier

At the completion of the reclamation phase, there will be a significant thickness (forty (40) to sixty-two (62) inches) of interim/grading cover placed over the tailings. This will be overlain by a minimum thickness of one and one-half (1.5) feet of clay cover, followed by one-half (0.5) feet of sand, two (2) feet of rocky soil cover and finally four (4) inches of rock cover placed on top of the tailings in the impoundment area. The rock cover material will make the surface of the impoundment an unlikely habitat area for burrowing rodents, based on the size and thickness of the rock cover.

The establishment of plant growth is improbable for several reasons. Influencing factors include the low average annual precipitation of 7 inches (18 cm); frequent droughts; extreme temperatures; and the fact that the surface of the impoundment will be covered with cobble which has poor moisture-holding capacity and little to no organic content. Therefore, there is little concern for roots penetrating the clay barrier and establishing a pathway for radon migration to the surface.

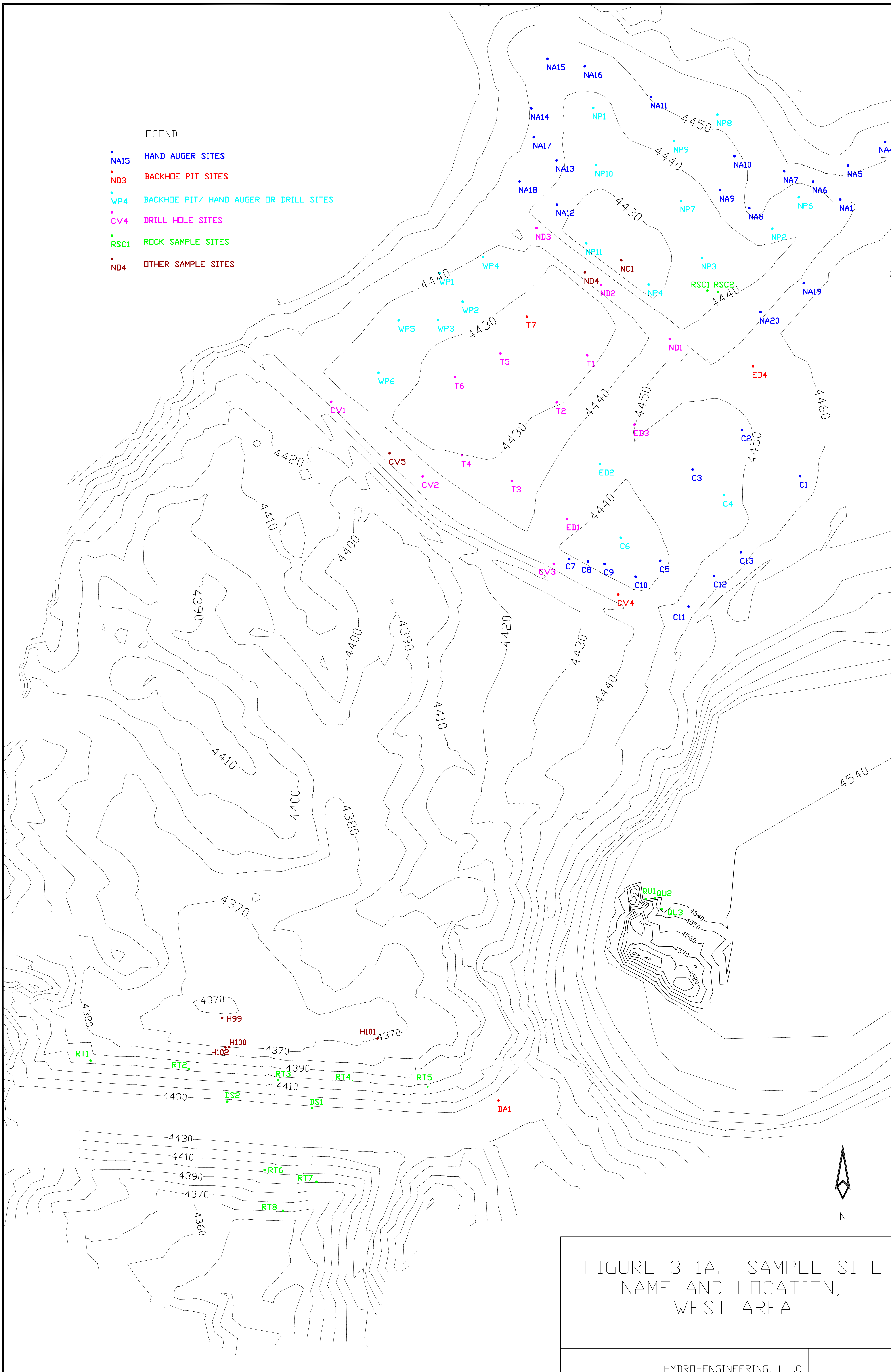


FIGURE 3-1A. SAMPLE SITE NAME AND LOCATION, WEST AREA

SCALE: 1"=200' | HYDRO-ENGINEERING, L.L.C. | DATE: 12/19/05

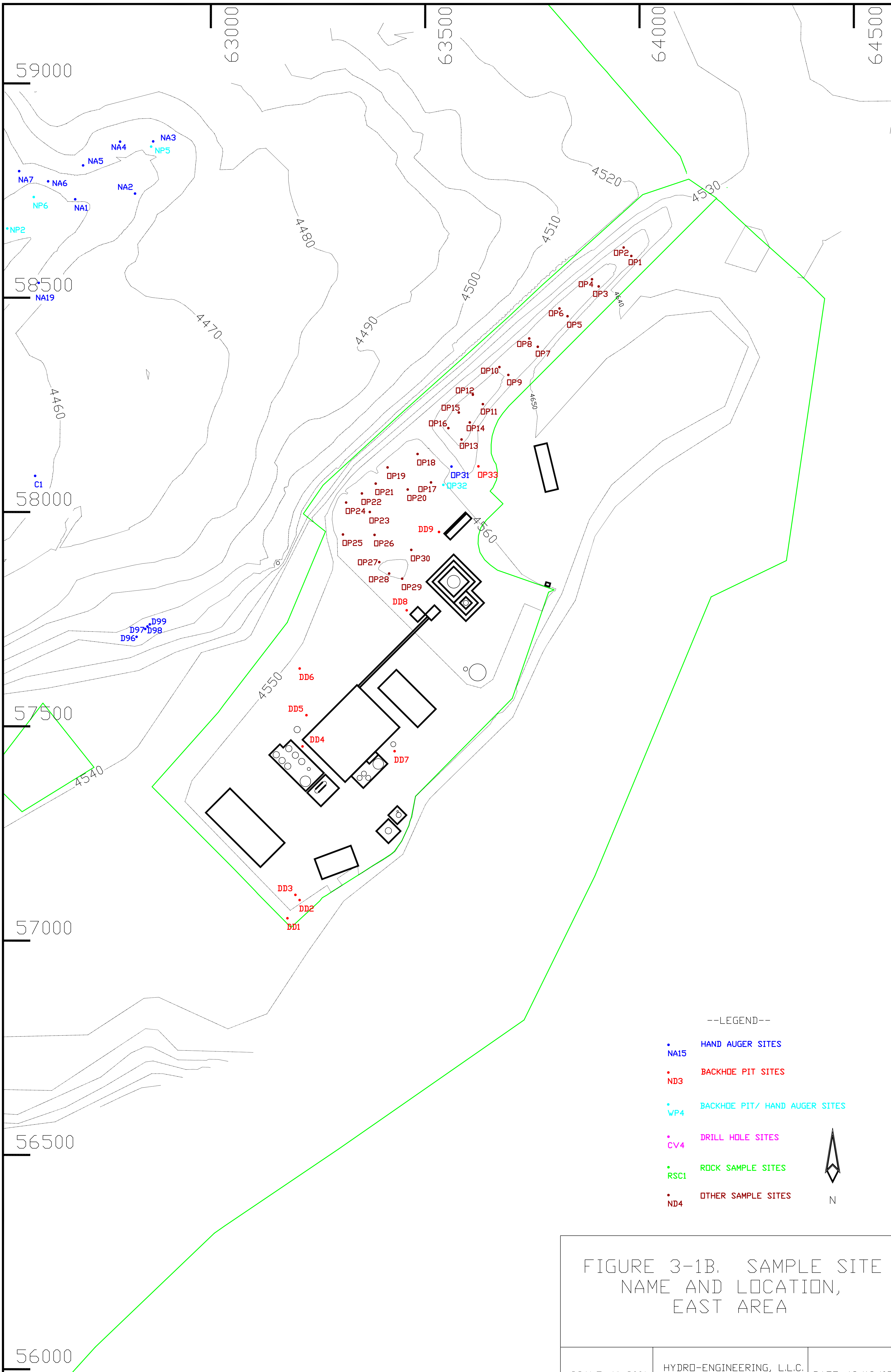


FIGURE 3-1B. SAMPLE SITE NAME AND LOCATION, EAST AREA

SCALE: 1"=200' | HYDRO-ENGINEERING, L.L.C. | DATE: 12/18/05

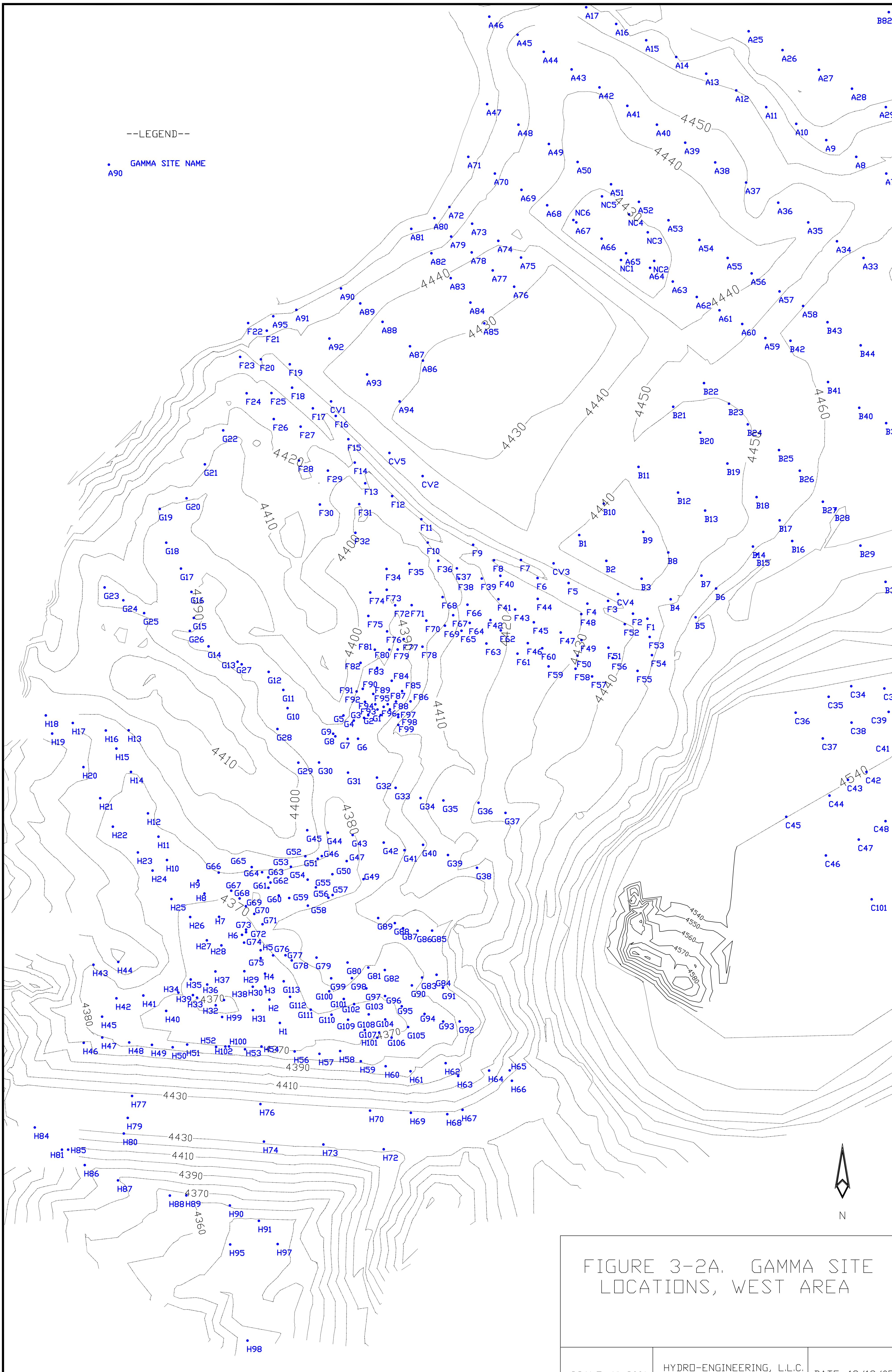


FIGURE 3-2A. GAMMA SITE LOCATIONS, WEST AREA

SCALE: 1"=200'

HYDRO-ENGINEERING, L.L.C.

DATE: 12/19/05

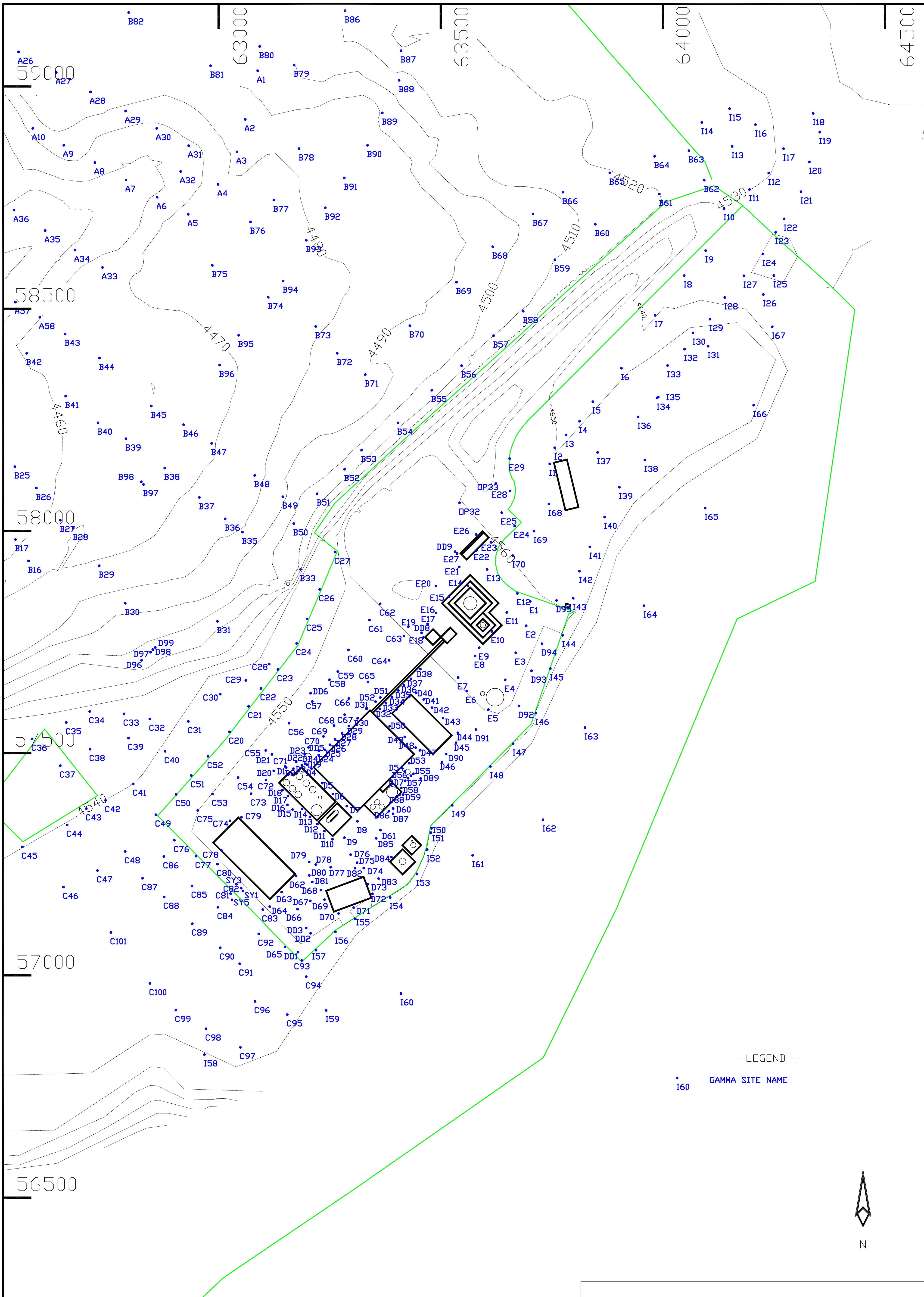


FIGURE 3-2B. GAMMA SITE LOCATIONS, EAST AREA

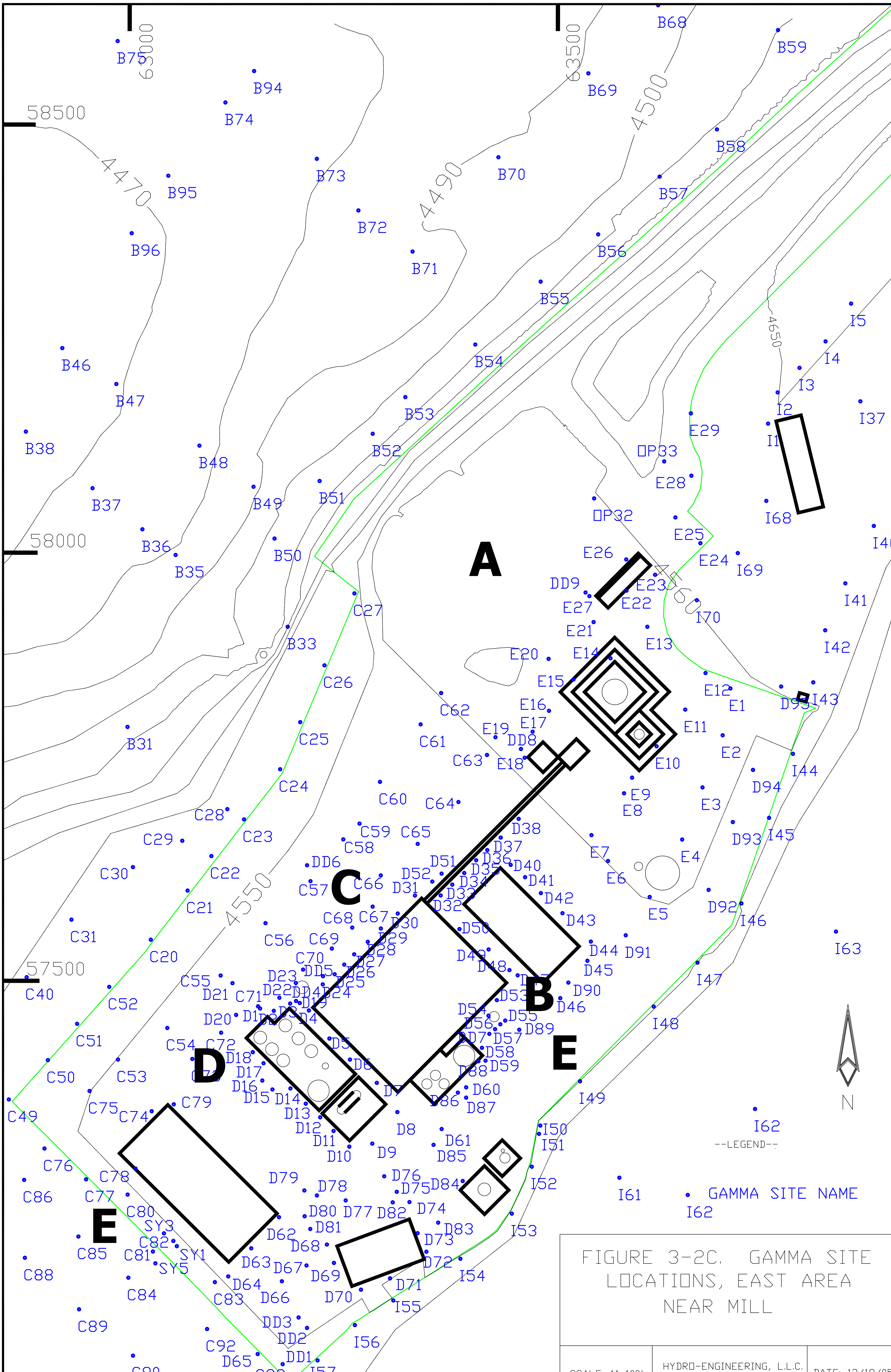


FIGURE 3-2C. GAMMA SITE LOCATIONS, EAST AREA NEAR MILL

SCALE: 1"=100'

HYDRO-ENGINEERING, L.L.C.

DATE: 12/19/05

C:\PROJECTS\2005-50\FIGS-EAST-100.DWG

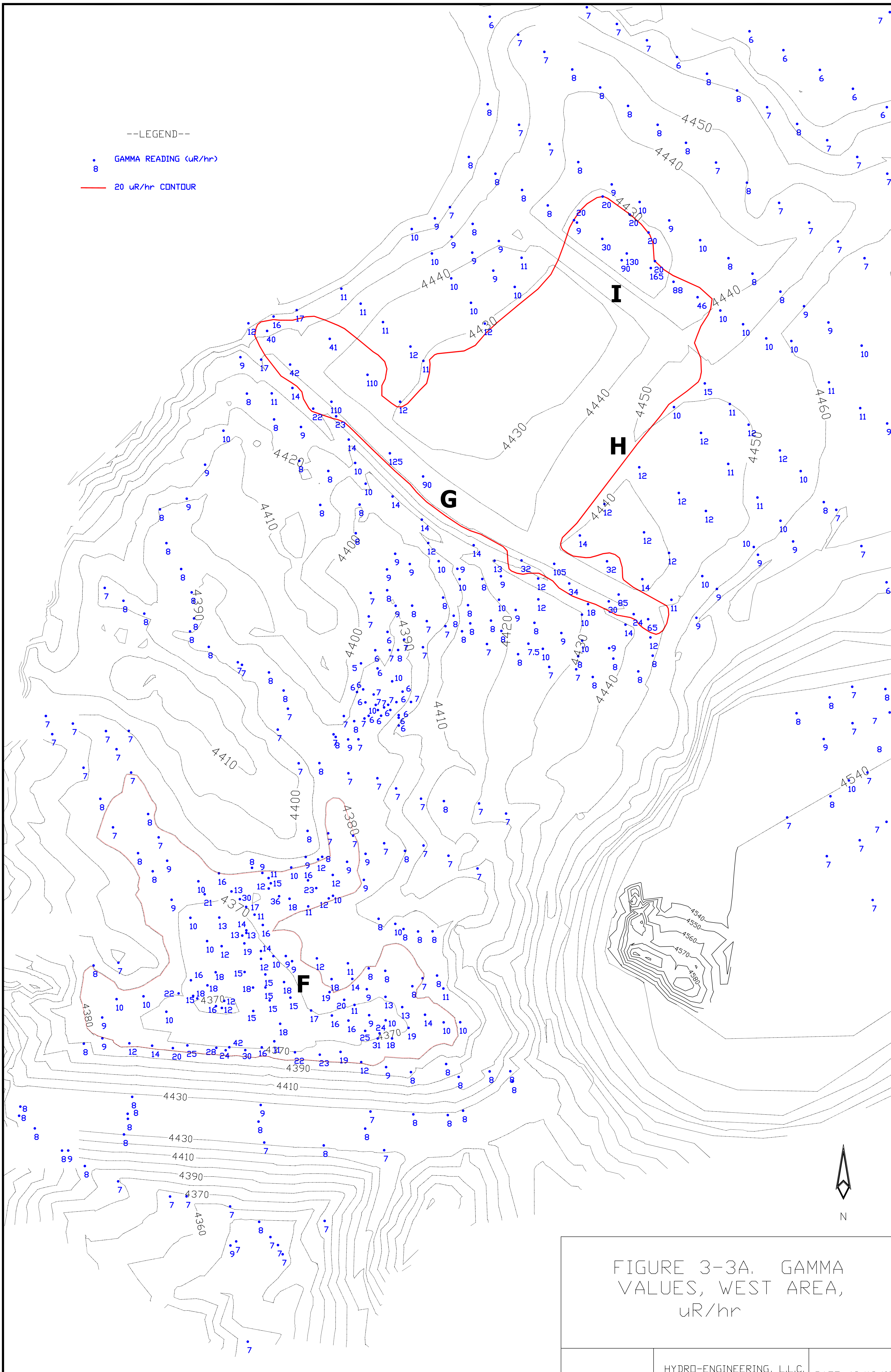


FIGURE 3-3A. GAMMA VALUES, WEST AREA, uR/hr

SCALE: 1"=200'	HYDRO-ENGINEERING, L.L.C.	DATE: 12/19/05

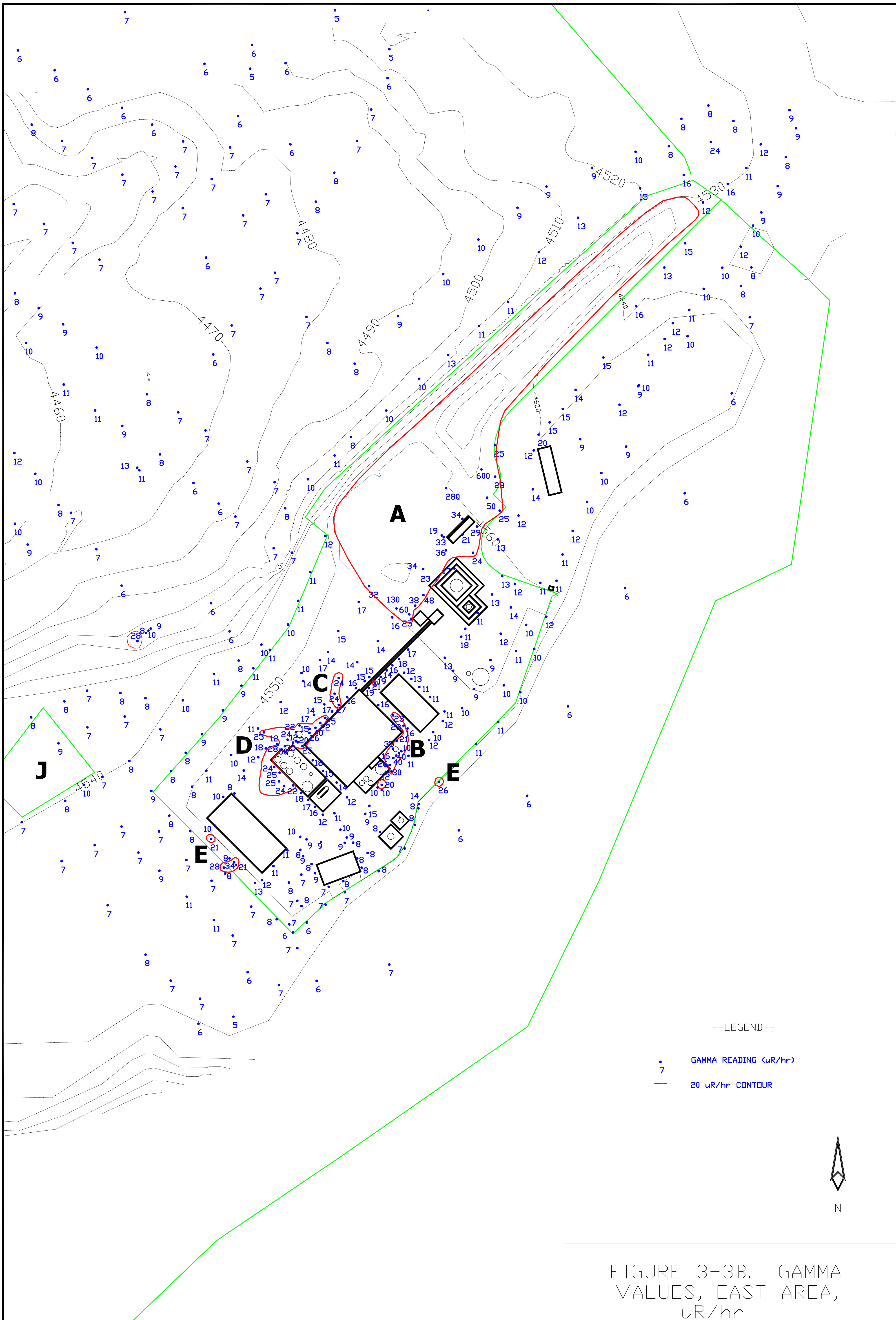


FIGURE 3-3B. GAMMA VALUES, EAST AREA, uR/hr

SCALE: 1"=200' | HYDRO-ENGINEERING, L.L.C. | DATE: 12/18/05

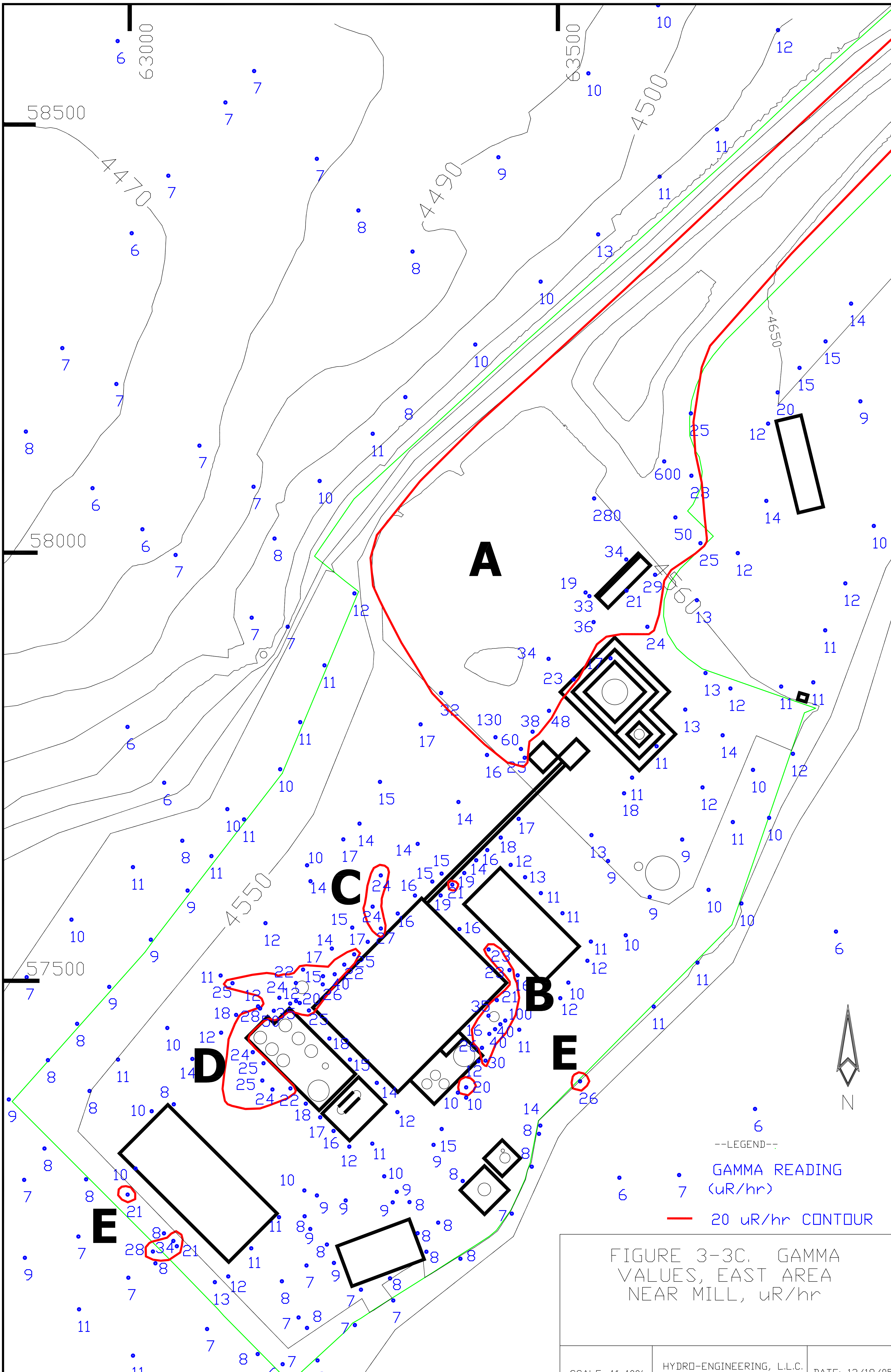


FIGURE 3-3C. GAMMA VALUES, EAST AREA NEAR MILL, uR/hr

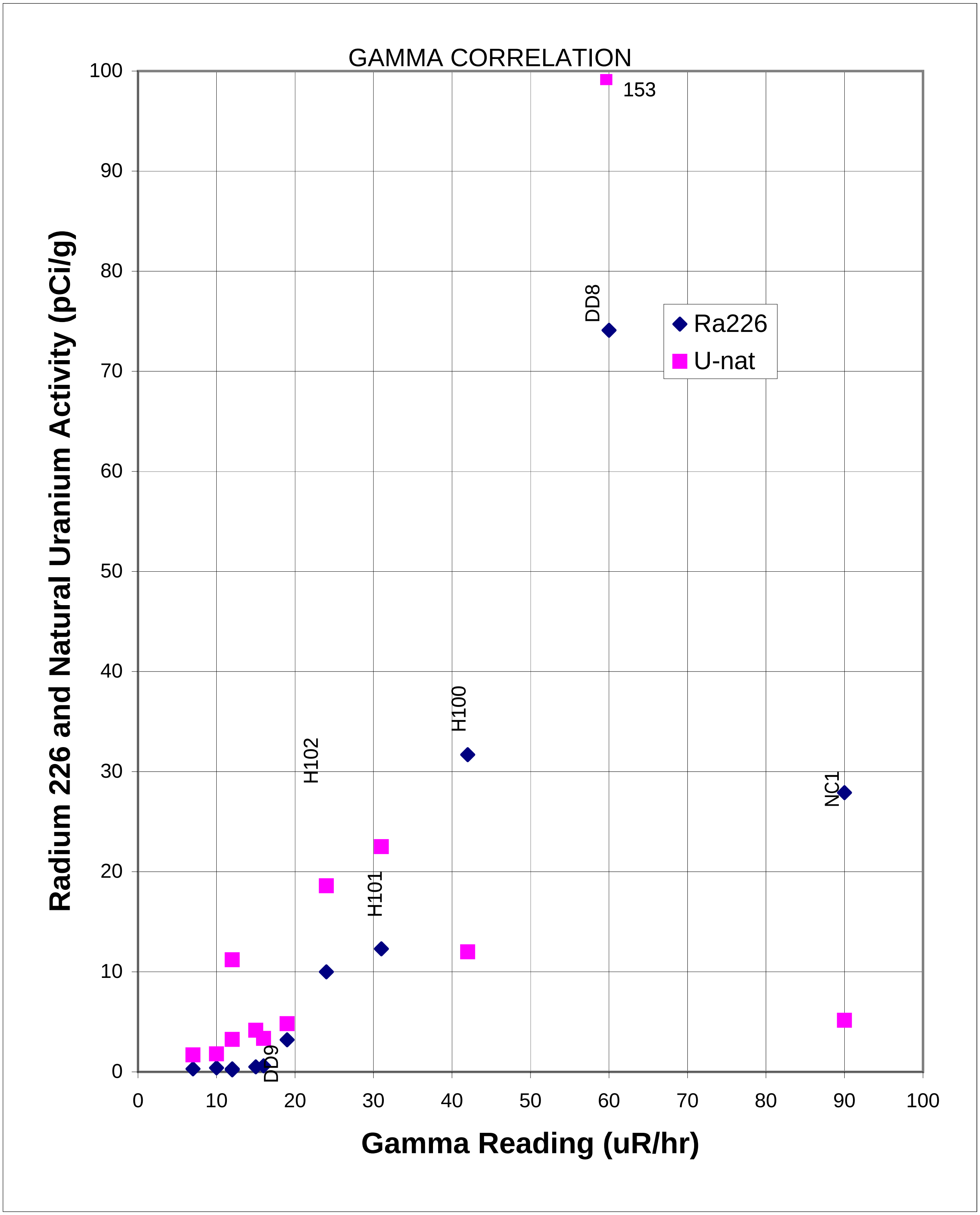


Figure 3-4. Radium 226 and Natural Uranium Activity Versus Gamma

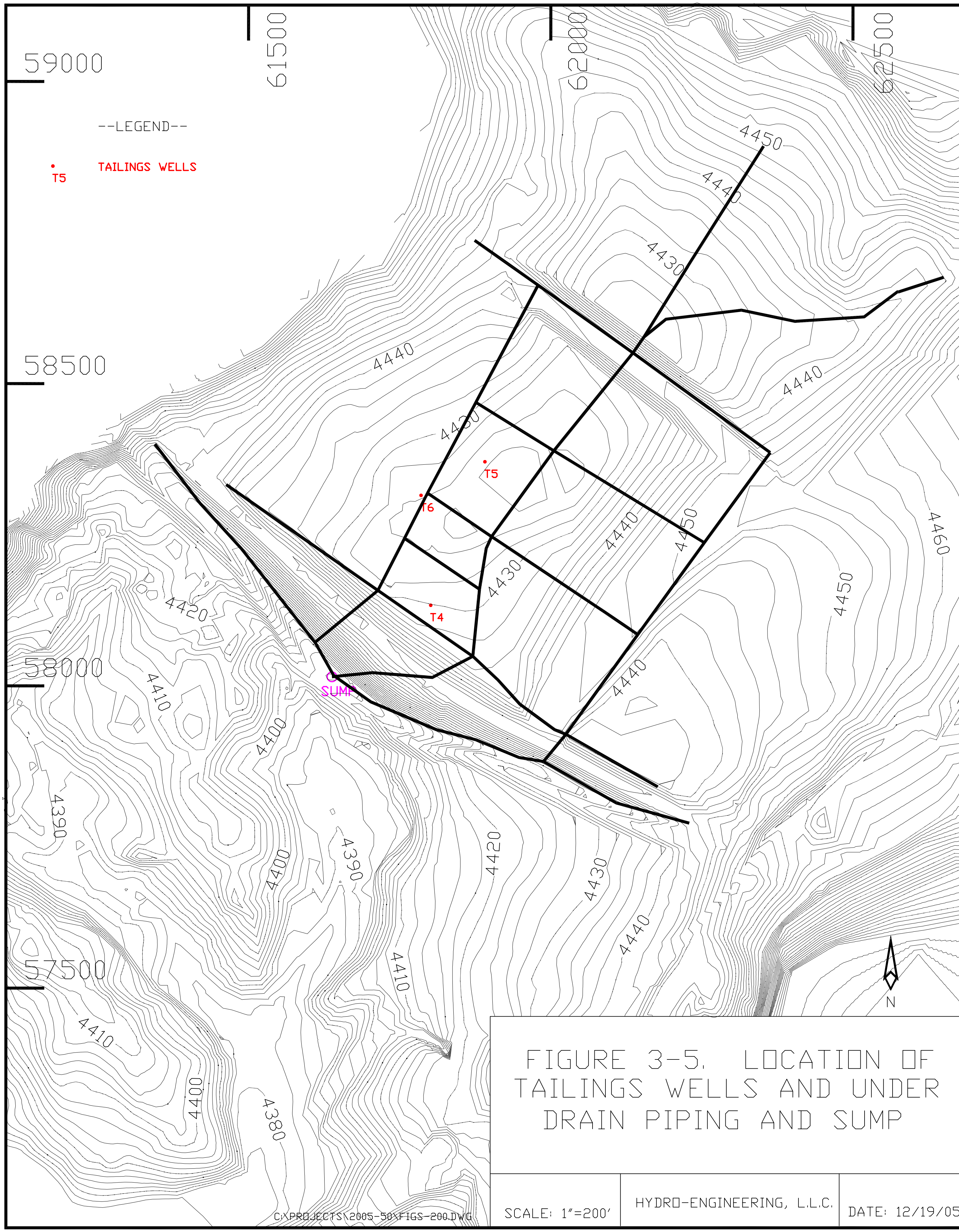


FIGURE 3-5. LOCATION OF TAILINGS WELLS AND UNDER DRAIN PIPING AND SUMP

SCALE: 1"=200'

HYDRO-ENGINEERING, L.L.C.

DATE: 12/19/05

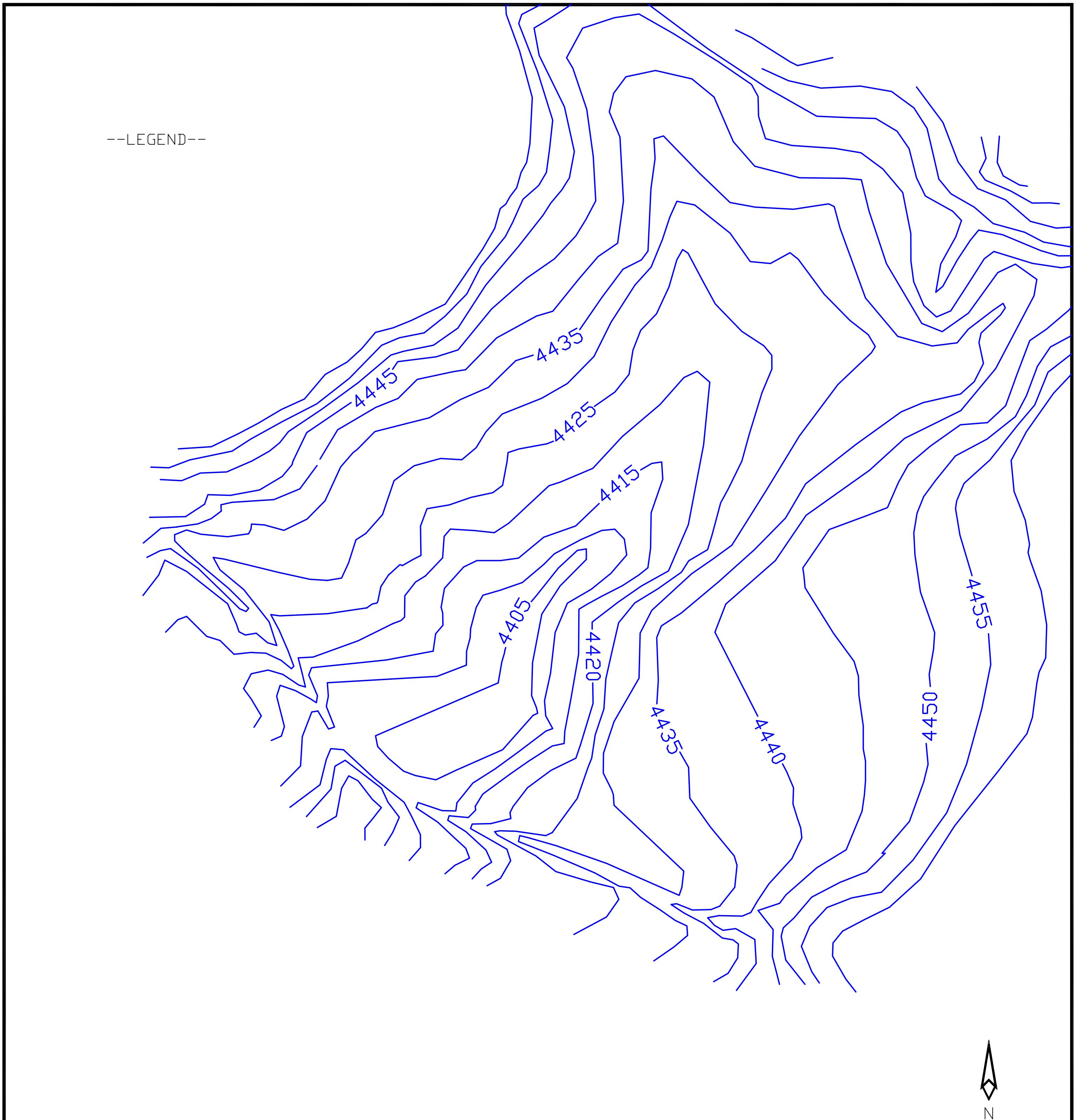


FIGURE 3-6. ELEVATION OF TOP OF EXISTING CLAY BARRIER, FT-MSL

C:\PROJECTS\2005-50\FIGS-200.DWG

SCALE: 1"=200'

HYDRO-ENGINEERING, L.L.C.

DATE: 12/19/05

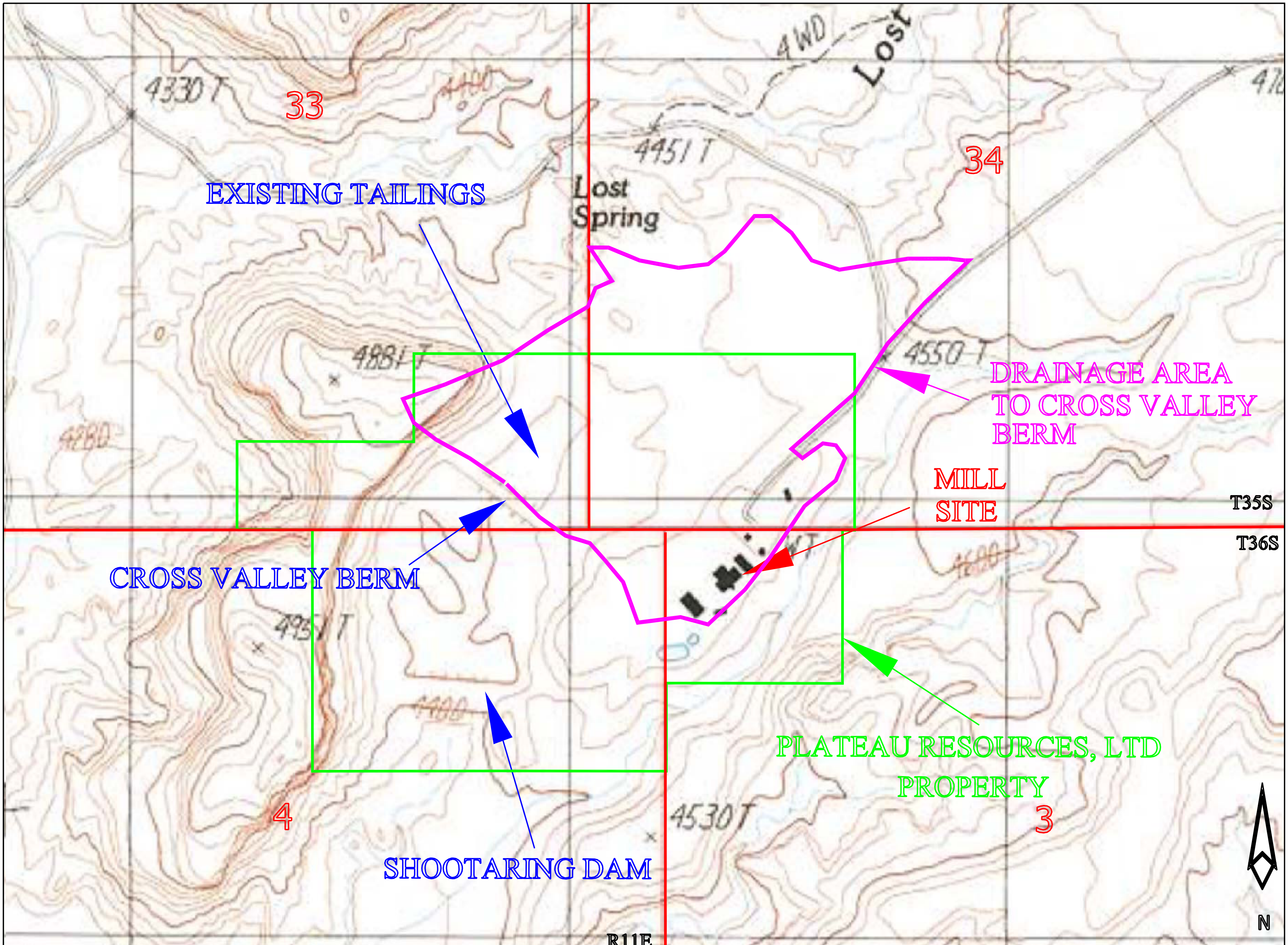


FIGURE 3-7. LOCATION OF DRAINAGE AREA AND EXISTING TAILINGS CELL

4.0 GEOLOGY AND SEISMOLOGY

A comprehensive summary for the Shootaring Canyon site of the geologic and seismologic setting and site and subsurface conditions was presented in previous reports and is generalized here. (Woodward Clyde Consultants, Environmental Report May, 1978c).

4.1 Regional Geology

The project site is located within the Colorado Plateau physiographic province in southeastern Utah. Wide areas of nearly flat-lying rocks separated by abrupt monoclinal flexures form the broad uplifts and intervening basins common to this province. Igneous intrusions have formed several mountains, such as the Henry Mountains near the facility. However, most of the topographic relief in the Colorado Plateau is the result of erosion of deep canyons rather than upstanding mountain ranges (Thornbury, 1965).

The Shootaring facility is located near the southern end of the Henry Mountains' structural basin. The basin contains sedimentary rocks ranging from Mesozoic to Cenozoic in age, and which are cut by the Tertiary intrusives forming the Henry Mountains, including Mt. Ellsworth, see Figure 4-1. The basin is elliptical, with its longer axis 100 miles in length trending northerly and its shorter axis 50 miles in length trending easterly. The basin is bounded on the west by the Waterpocket Fold (monocline) and on the east by the Monument Upwarp. Elevations within the basin range from 4000 to 7000 feet. Major peaks rise 4000 to 5000 feet above the surrounding basin. Fault development in the area is associated with the intrusive igneous centers of the Henry Mountains. These faults commonly have a northeasterly or northwesterly strike and do not generally extend far from the intrusive bodies. Faults are not known to exist within the project area.

4.2 Site Geology and Geomorphology

The processing facility site is located in an area characterized by buttes, mesas and canyons approximately five miles southwest of Mt. Ellsworth (see Figure 4-2). The mill is situated on a low mesa and a small, isolated catchment to the west contains the tailings impoundment. A tall butte separates the site from Shitamaring Canyon. Drainage from the site is to the southwest into Shitamaring Creek. The tributary in which the tailings dam is located has been called Shootaring Canyon. Local relief ranges from 200 to 500 feet. Geologic structure is relatively simple in the immediate area, with the various sedimentary formations dipping gently (2 to 3 degrees) to the west. Sedimentary rocks exposed at the surface are predominantly sandstones of Upper Jurassic age. The high buttes and mesas west and north of the site are capped by the Salt Wash Member of the Morrison Formation. This fluvial sandstone unit contains the uranium deposits that are mined in the area. Exposed cliffs surrounding the buttes and mesas are comprised primarily of the thinly bedded reddish-brown siltstones and mudstones of the Summerville Formation, underlain by the generally massive fine grained reddish-brown Entrada Sandstone. The Entrada Sandstone is the bedrock underlying the mill and the tailings impoundment. In the vicinity of the site the Entrada is approximately 420 feet thick. Cementing agents are commonly calcite and ferric iron. Environment of deposition is believed to be primarily eolian. Subordinate amounts of shale are present locally, evidence of episodes of marginal marine conditions.

No major faulting has been observed in the Entrada Sandstone at the site. Limited sets of joints are widely spaced, steeply dipping and sealed with calcite and gypsum. Joint trends are northwesterly and northeasterly, coinciding with the regional structural pattern.

Beneath the Entrada lies the Carmel Formation, a heterogeneous unit approximately 160 feet thick composed of sandstone, siltstone, mudstone, limestone and gypsum. In the Shootaring Canyon area, the Carmel appears to include substantial layers of shale or mudstone. The Carmel is underlain by the Navajo Formation which is approximately 800 feet thick in the vicinity of the site. The base of the Navajo is approximately 1400 feet beneath the surface of the site. A typical stratigraphic section for the area surrounding the site is given in Figure 4-1.

Shootaring canyon is in the valley with narrow divides and therefore is in a mature geomorphic condition. The tailings cell is located in an upstream portion of a drainage basin which will need controls to prevent the erosional mechanicisms that typically transport sediment from this region of the basin.

4.3 Seismicity

Earthquake activity in the region that may affect the facility site can be evaluated by examining the historical seismicity of the region. Figure 4-3 shows epicenter locations for 112 earthquakes reported between 1853 and January 1976 with magnitudes of 3.5 and greater, or Modified Mercalli intensities of V and greater, within a 200-mile radius of the site. Table 4-1 defines intensity ratings on the Modified Mercalli scale (MM).

Table 4-1. MODIFIED MERCALLI INTENSITY SCALE OF 1931

Intensity	Summary of Observed Effects
I	Not felt by people, except under especially favorable circumstances.
II	Felt indoors by a few people.
III	Felt indoors by several people.
IV	Felt indoors by many people, outdoors by a few people. Awakens a few individuals.
V	Felt indoors by practically everyone, outdoors by most people. Awakens most sleepers.
VI	Felt by everyone, indoors and outdoors. Awakens all sleepers.
VII	Frightens everyone. General alarm. Difficult to stand.
VIII	General fright, alarm approaches panic. Persons driving cars are disturbed.
IX	Panic is general. Ground cracks conspicuously.
X	Panic is general. Extensive damage to well-constructed buildings.
XI	Panic is general. Broad fissures, earth slumps, and land slumps develop in soft, wet ground. Damage to buildings is severe.
XII	Panic is general. Damage is total and practically all buildings are destroyed.

This scale was used in assigning earthquake intensities in Utah prior to the mid-1940's. Table 4-2 describes an additional eight events with magnitude of 3.5 and greater reported within the 200 mile radius between July 1978 and December 1983. Figure 4-4 shows epicenter locations for 94 earthquakes reported between June 1983 to January 1996 with magnitudes of 2.5 and greater within the 200 mile radius. Figure 4-5 shows epicenter locations for all earthquakes reported between 1853 and January 1996 with magnitudes greater than 0.

Table 4-2 LISTING OF FELT EARTHQUAKES WITH MAGNITUDE OF 3.5 OR GREATER - JULY 1978 - DECEMBER 1983

Date/Time		Location	Magnitude
4/30/79	02:07:09.98	37N53.05 110W58.93 Southern Capitol Reef National Park	3.6
4/6/80	10:45:04.3	39N56.86 lllW58.46 1 mile west of Elberta, Utah	3.5
5/24/80	10:03:36.47	39N56.21 lllW57.59 near Elberta, Utah	4.4
2/1/81	02:21:47.67	37N33.82 113W15.83 near Kanarraville, Utah	3.6
4/5/81	05:40:39.69	37N35.49 113W17.87 near Cedar City, Utah	4.6
5/14/81	05:11:04.34	39N28.86 lllW04.72 Hiawatha, Utah	3.5
5/24/82	12:13:26.56	38N42.50 112W02.19 near Richfield, Utah	4.0
12/9/83	08:58:40.72	38N34.62 112W33.93 near Cove Fort, Utah	3.6

Source: Richins, Wm. D. et al. 1981 and 1984
Earthquake Data for Utah Region,
July 1978 to December 1980 and Jan. 1981 to Dec. 1983.
University of Utah, Department of Geology & Geophysics,
Salt Lake City, Utah

A persistent feature of the seismic history of the region is a broad band of activity trending NE-SW. This seismic belt coincides with the boundary between the Basin and Range and the Colorado Plateau physiographic provinces. The seismic activity associated with this belt is located more than

80 miles west of the facility. Seismicity in the nearest portion of the belt appears to be chiefly related to the Elsinore, Tushar and Sevier fault zones which bound the Sevier Valley. The interior of the Colorado Plateau historically exhibits a very low level of seismicity.

The largest recorded event depicted in Figure 4-3 had an epicenter about 110 miles northwest of the site and a maximum (MM) intensity of VIII to IX. Its magnitude was estimated at 6.7 (Cook and Smith, 1967). The event nearest the site had an epicenter about 20 miles southeast of the facility site. This earthquake, which occurred on August 22, 1986, had a magnitude of 4.0 on the Richter scale. The next nearest event occurred on September 20, 1963 and had an epicenter about 38 miles north of the facility with a magnitude of 4.5 on the Richter scale. Published curves relating ground motion intensity to distance from an earthquake's epicenter suggest that the maximum intensity that has occurred at the site is III-IV (MM) (Brazee, 1976). This level of intensity is not normally associated with structural damage (Richter, 1958). Based on the seismic history, the probability of a major damaging earthquake occurring at or near the site is remote. Algermissen and Perkins (1976) indicate a 90% probability exists that a horizontal acceleration of 4% of gravity would not be exceeded in 50 years. However, should such an acceleration level occur, only minor damage would be expected.

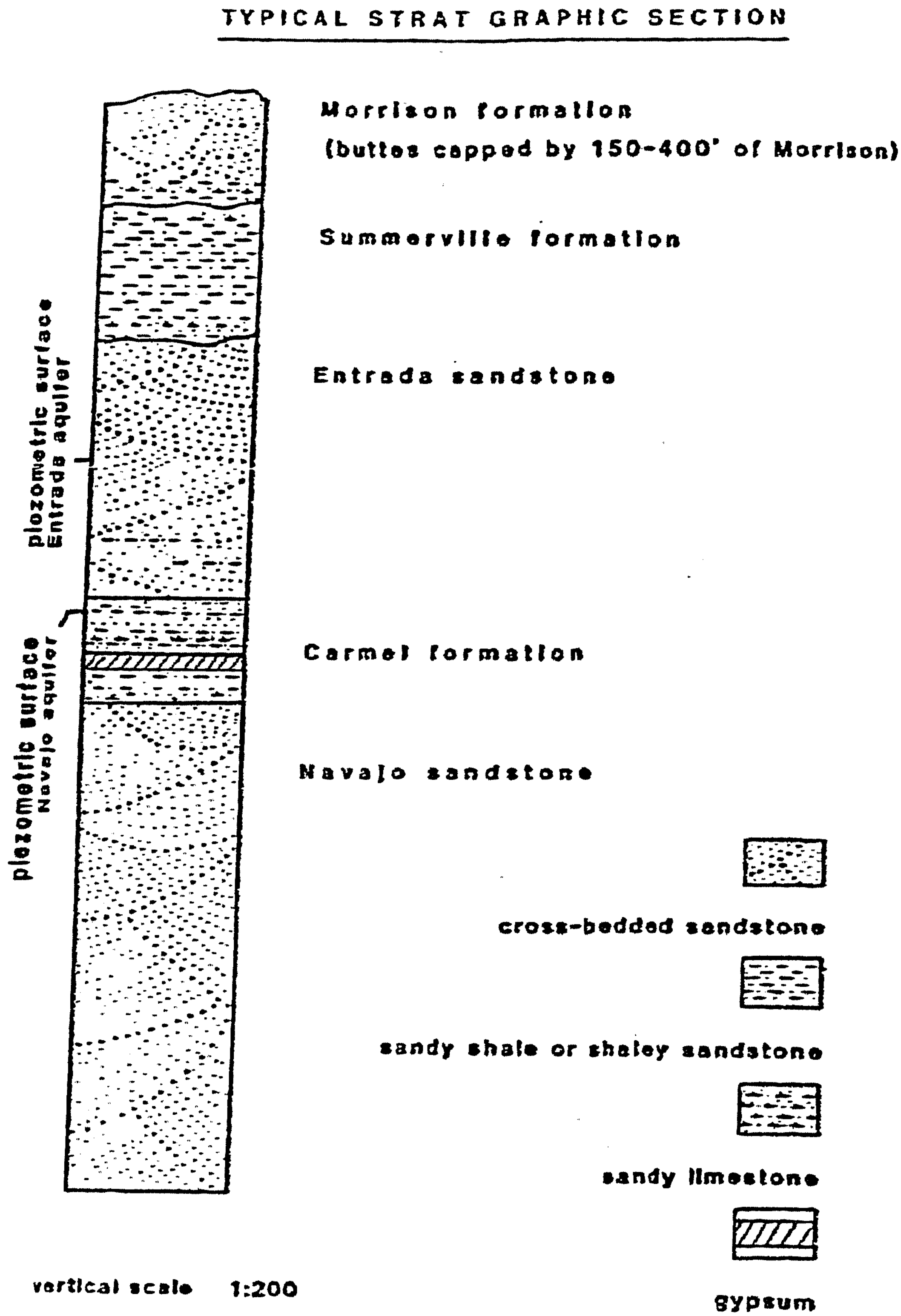


Figure 4-1. Typical Stratigraphic Section

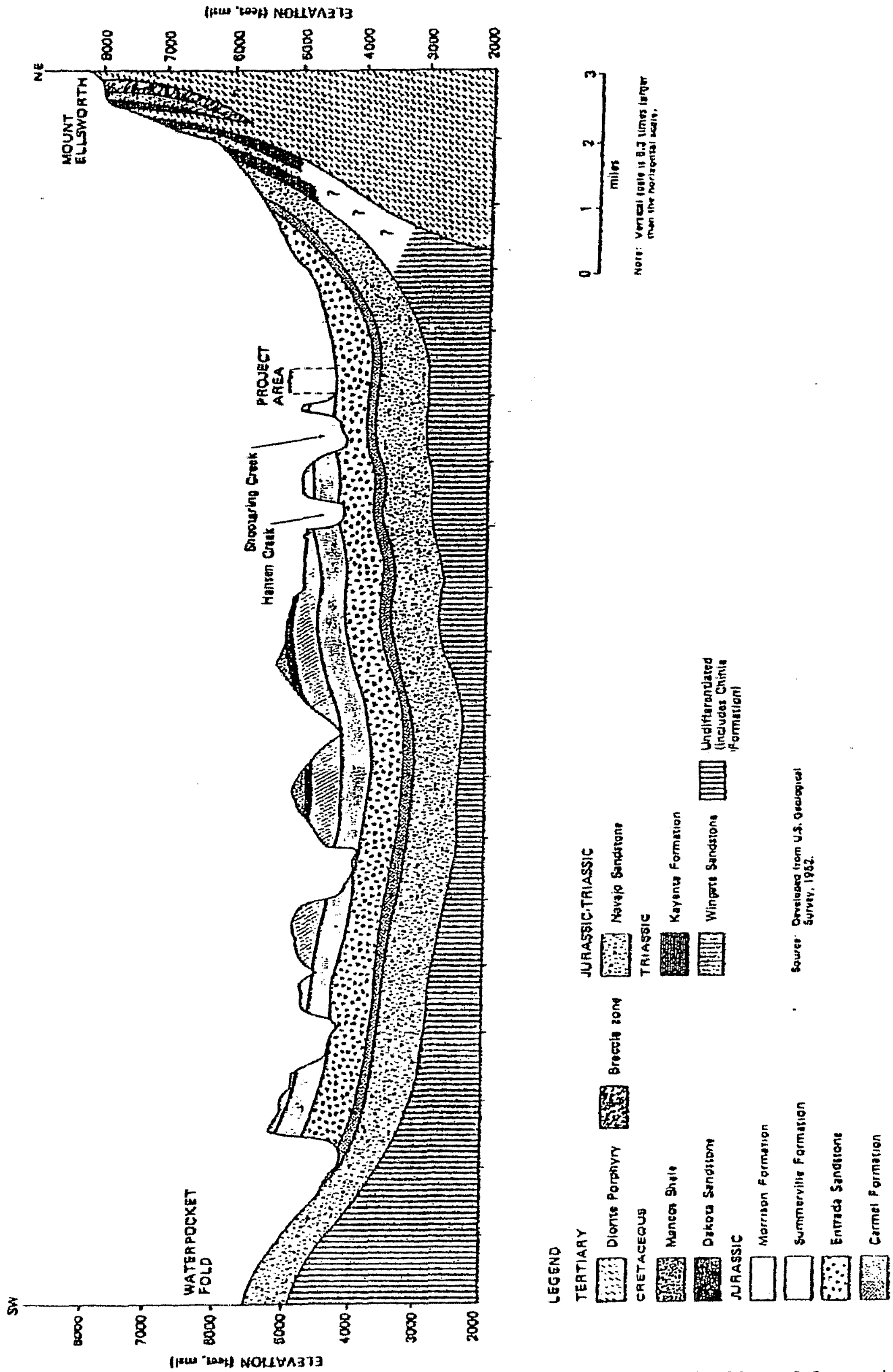


Figure 4-2. Generalized Geological Cross Section Across the Henry Mountain Basin

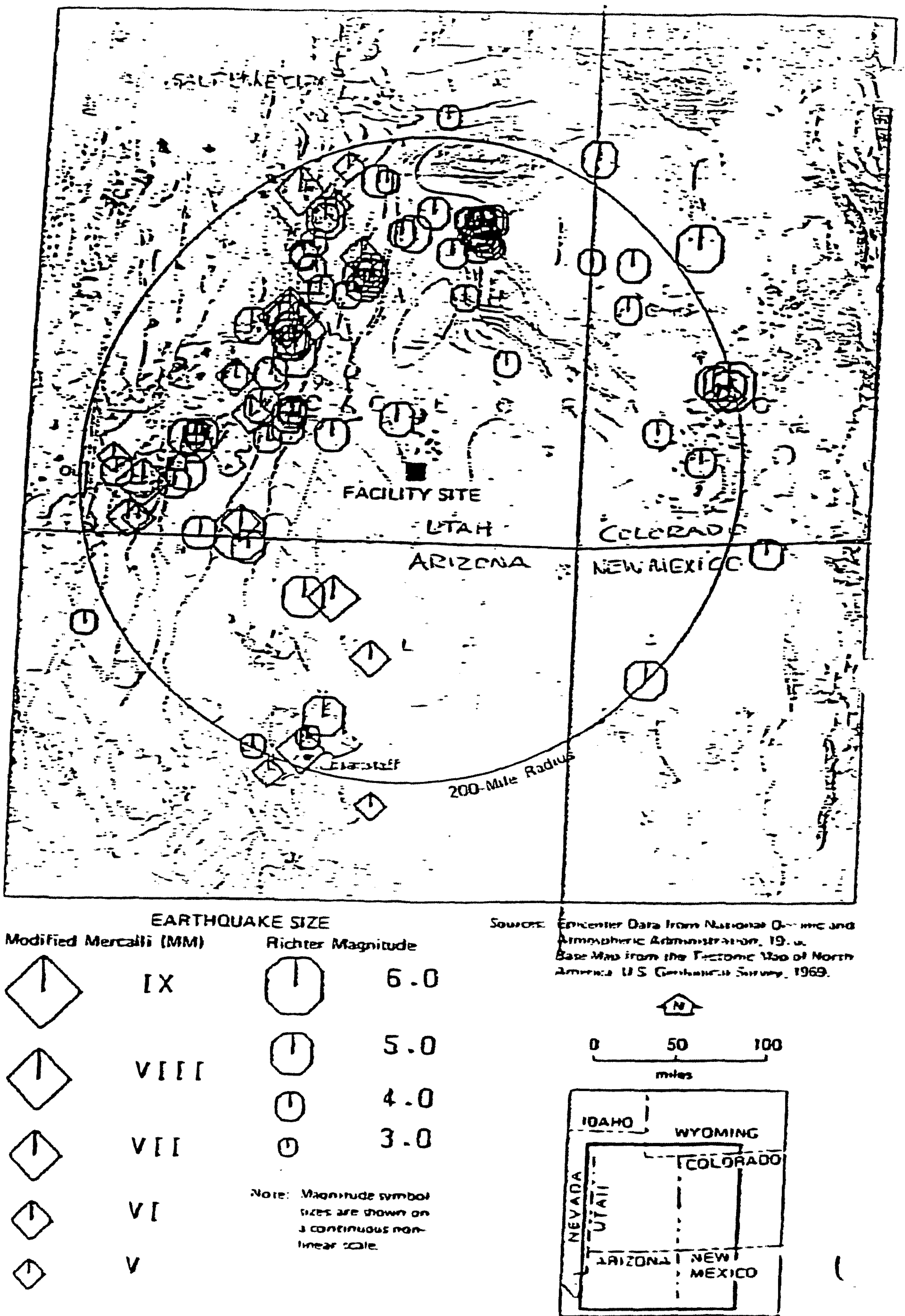
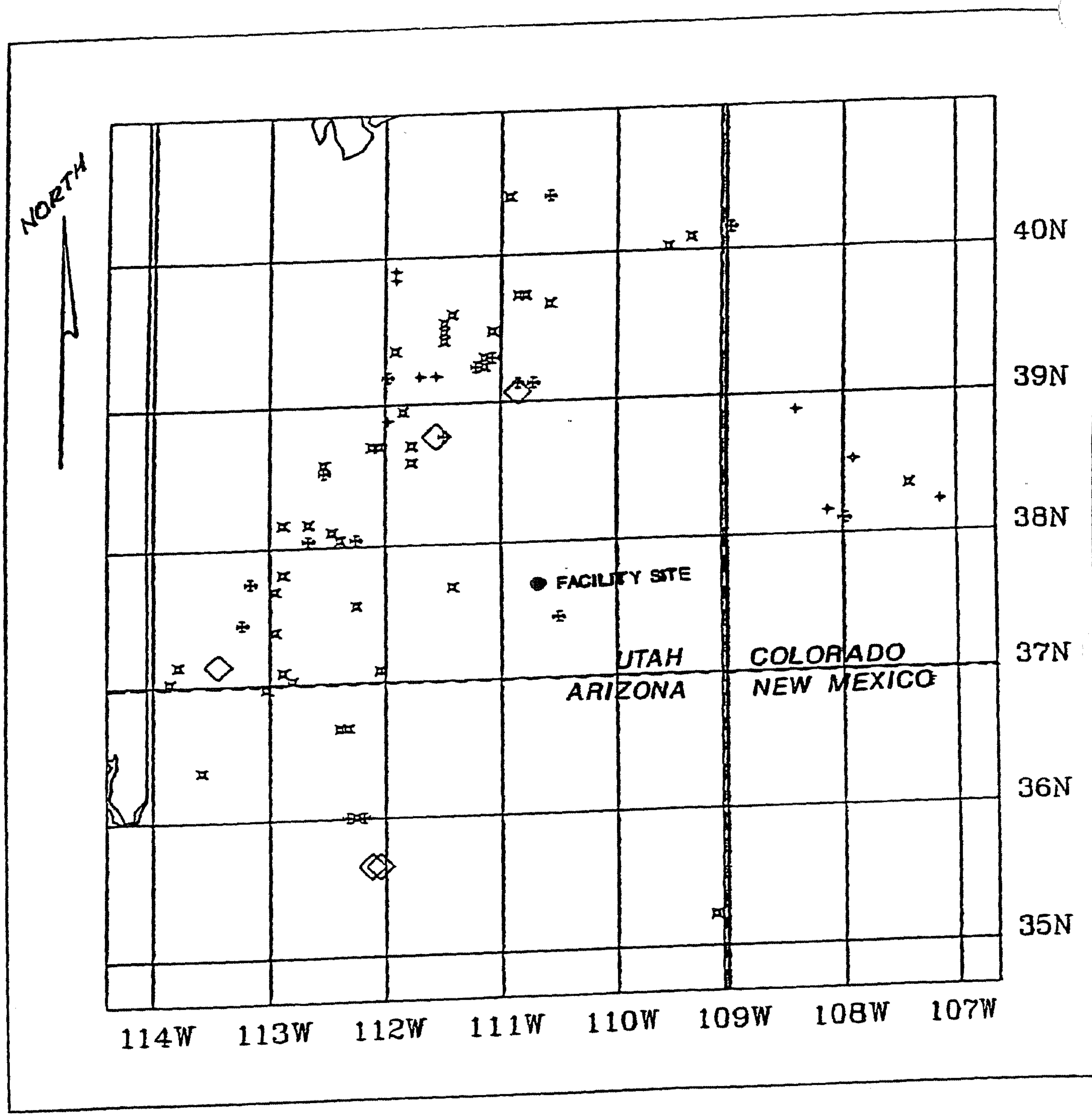


Figure 4-3. Historical Seismicity within a 200 Mile Radius of the Proposed Facility

HDF$:[HDF_PUBLIC_ENERGY]SR125324.DAT

First date: Jun 9, 1983 Last date: Jan 6, 1996



MAGNITUDES:

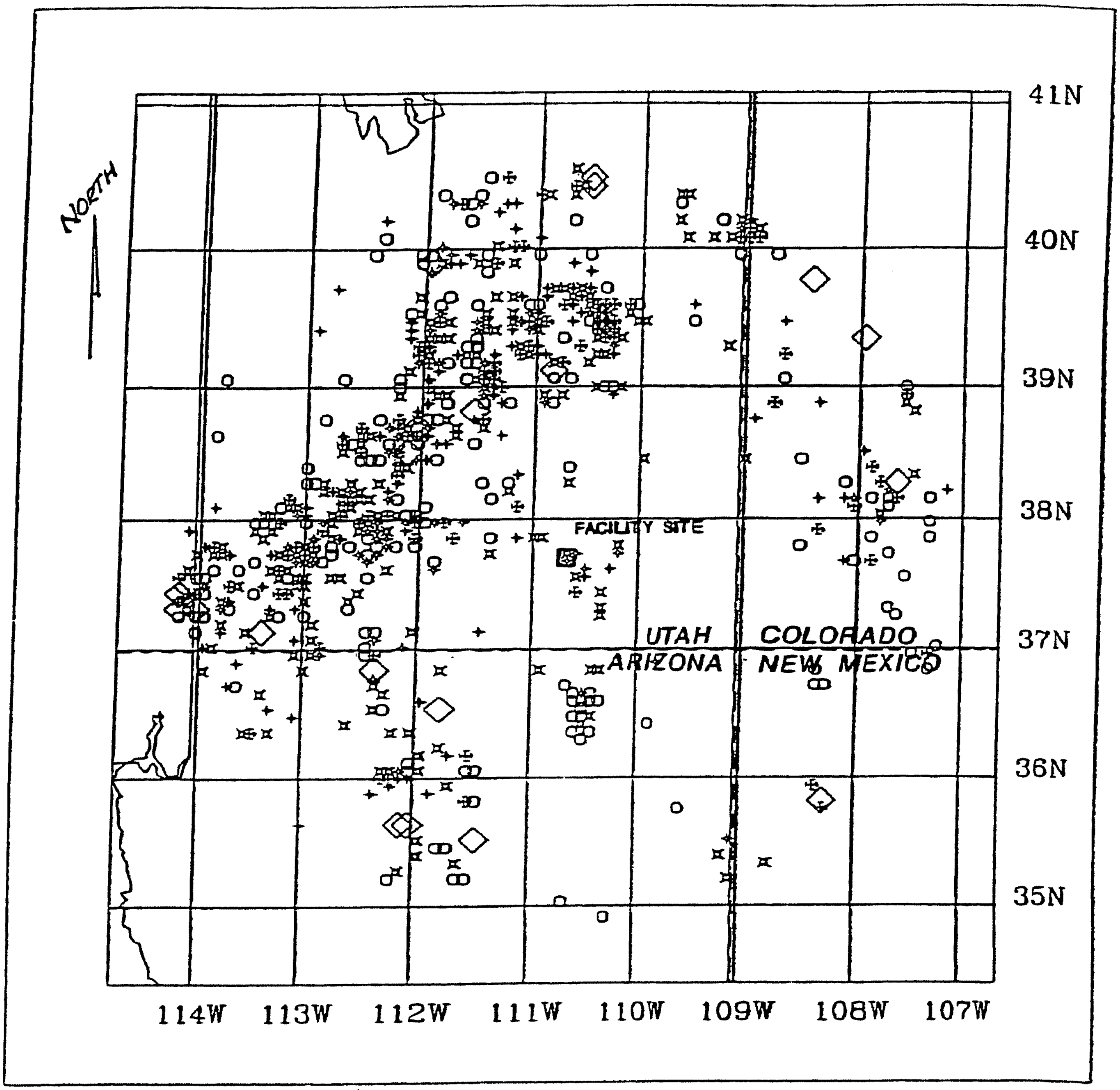
2 + 3 ⌘ 4 ✣ 5 ◇

U. S. Geological Survey, National Earthquake Information Center
Data taken from the Earthquake Data Base System

Figure 4-4 Epicenter Locations for Earthquakes, June 1983 to January 1996

HDF$:[HDF.PUBLIC.ENERGY]SR124731.DAT

First date: Dec 1, 1853 Last date: Jan 8, 1996



MAGNITUDES:

? ○ 1 □ 2 + 3 ¤ 4 ± 5 ◇

U. S. Geological Survey, National Earthquake Information Center
Data taken from the Earthquake Data Base System

Figure 4-5. Epicenter Locations for all Earthquakes, 1853 to January 1996

5.0 GEOTECHNICAL STABILITY

5.1 Site and Uranium Mill Tailings Characteristics

The short operational period for the mill resulted in a very limited quantity of tailings which have been placed upstream of the cross valley berm (see Figure 2-1). There are currently no tailings between the cross valley berm and the Shootaring Canyon dam, and the majority of this area is planned for release under the Cell 1 reclamation plan. Under the Cell 1 reclamation plan, the present Shootaring Canyon dam will be almost completely breached to provide materials for the cover of the tailings. All contaminated materials will be encapsulated upstream of the toe of the reclaimed cross valley berm. With the Cell 2 reclamation plan, the tailings encapsulation system will extend to the Shootaring Canyon dam. The Shootaring Canyon dam will be left in place for the Cell 2 reclamation plan, and the long term care boundary will extend to include the Shootaring Canyon dam. With the Cell 2 reclamation plan, the clay cover materials will be derived from other sources. Other cover materials will be derived from local sources and areas adjacent to the tailings where similar materials have been identified.

5.1.1 Soil and Rock Properties

The fill, cover and rock materials that will be used in the tailings encapsulation system are locally derived. Three sources of rock were sampled including the quarry, rock on the Shootaring Canyon dam, and rock within the rocky soil cover currently lying above the clay liner and drainage system for the tailings cell upstream of the cross valley berm. The three sources of rock each consisted of a fraction of andesite porphyry and a fraction of sandstone. The fractions of each rock type within each source were very similar and it is obvious that the three rock sources have a common origin and are relatively similar. The primary source of rock for reclamation will be the dam and quarry. Large stones from the original borrow area for mill and dam construction and the rocky soil cover may also be collected to supplement large channel riprap. Multiple quality and gradation samples were taken from each rock source and the results are compiled in Appendix C. Petrographic analysis of both the porphyry and the sandstone were also performed. A detailed discussion of the rock quality and implications to the erosion protection are included in Section 6.4.1.

The quarry material contained a significant fraction of finer materials that is planned for use as the top layer of the cover. Similar materials are available in the adjacent borrow areas that were utilized in the original site construction and these materials may also be used. Material within the Shootaring Canyon dam designated as Zone 2 is expected to be very similar and the rocky soil cover also contains a similar fraction of finer materials. In addition to the cobble to boulder-sized stones within these materials, there is a substantial fraction of materials that ranges from gravel to silts and clays. This broad range of particle sizes makes this material very versatile for processing as cover material. The material can be processed to extract the rock in various gradations, thereby leaving a fine fraction for use as a frost barrier/vapor break cover for the tailings cell. This material will still contain enough sand and gravel sized particles to make it function as a bedding/filter material under rock mulch and small channel riprap. Substantial rock fractions can be retained in this cover material provided the layer thickness will accommodate the largest stone.

Additional soil materials that will be produced in the reclamation process include a very uniform fine sand that is generated from the Entrada sandstone which underlies the entire area. The sand produced by ripping and heavy equipment excavation of the sandstone is fine and extremely uniform. Large quantities will be generated during construction of the tailings cell(s) and by channel excavation, and this material will be used as an interim/grading cover beneath the clay barrier layer as well as for general fill. Gradations for this material are presented in Appendix C.

5.1.2 Clay Cover Properties

The clay that will be used for the radon/infiltration barrier in the tailings cap for the Cell 1 reclamation plan was imported and placed as the tailings cell liner and the Shootaring Canyon dam core. This clay was borrowed offsite and has been worked and previously conditioned. A variety of samples of this clay were taken from the in-place clay liner and the tailings dam (see Appendix C and Tables 5-1 and 5-2). These samples were analyzed for a variety of physical properties (gradation, in-place density, moisture content, Atterberg limits, and Proctor density) as well as for hydraulic properties using both in-situ infiltrometers and laboratory permeability tests. The results indicated a consistently high quality clay that is suitable for use as the radon/infiltration barrier. Virtually all of the clay for the tailings cap for the Cell 1 reclamation plan will be taken from the clay core in the Shootaring Canyon dam. The clay in the liner system is very similar, but the majority of this clay will be preserved as the base clay liner in the Cell 1 construction. With the Cell 2 reclamation plan, the dam will be preserved and the clay for the radon/infiltration barrier will be taken from the same source as the clay for the cell liner construction. The properties of this off-site clay are equivalent or superior to those of the clay in the Shootaring Canyon dam. The properties of the clay relevant to the use as a radon/infiltration barrier are discussed in Sections 5.4 and 5.4.1.

TABLE 5-1. MOISTURE CONTENT RESULTS

CLAY AND MISCELLANEOUS SAMPLES			SAMPLE FROM SAND CONE TESTS		
SAMPLE SITE	SOIL TYPE	MOISTURE CONTENT (%)	SAMPLE SITE	SOIL TYPE	MOISTURE CONTENT (%)
NP11	CLAY	22.6	WP1	CLAY	19.1
NP6	CLAY	29.9	WP2	CLAY	28.1
NP5	CLAY	26.5	NP2	CLAY	19.2
NP4	CLAY	24.9	NP4	CLAY	22.3
NP10	CLAY	22.4	NP11	CLAY	22.4
WP4	CLAY	32.3	NP9	CLAY	20.9
NP6	ENTRADA SAND	2.5	CV5	ENTRADA SAND	2.17
T7	TAILINGS SLIMES	73.4	CV2	ENTRADA SAND	2.55
T3	TAILINGS SAND	9.63	ND4	11.e(2)	8.60
			T3	TAILINGS SAND	3.06

TABLE 5-2. RESULTS OF SAND CONE TESTS.

TEST SITE	TEST SETTING	WEIGHT OF SAND BEFORE TEST (LBS.)	WEIGHT OF SAND BEFORE TEST (LBS.)	WEIGHT OF SAND IN CONE (LBS.)	WEIGHT OF MOIST SOIL (LBS.)	MOIST UNIT WEIGHT OF SOIL (LBS/FT^3)	MOISTURE CONTENT (%)	DRY UNIT WEIGHT OF SOIL (LBS/FT^3)
WP1	ON CLAY IN BACKHOE PIT	13.78	6.03	3.92	3.03	**75.6**	**19.1**	**61.1**
WP2	ON CLAY IN BACKHOE PIT	13.14	7.63	3.92	1.62	**97.3**	**28.1**	**70.0**
NP2	ON CLAY IN BACKHOE PIT	9.86	4.01	3.92	2.03	**100.4**	**19.2**	**81.2**
NP4	ON CLAY IN BACKHOE PIT	9.37	3.59	3.92	1.54	**79.1**	**22.3**	**61.4**
NP11	ON CLAY IN BACKHOE PIT	9.91	4.11	3.92	1.64	**83.3**	**22.4**	**64.6**
NP9	ON CLAY IN BACKHOE PIT	8.6	2.6	3.92	2.07	**95.0**	**20.9**	**75.2**
CV5	ON ENTRADA RED SAND IN BACKHOE PIT	8.99	2.7	3.92	2.2	**88.6**	**2.17**	**86.7**
CV2	ON ENTRADA RED SAND IN BACKHOE PIT	9.53	3.68	3.92	1.74	**86.1**	**2.55**	**83.9**
ND4	ON 11.e(2) IN BACKHOE PIT ON NORTH DIKE	10.01	3.35	3.92	3.08	**107.4** **(2" ROCK IN SAMPLE)**	**8.60**	**98.1**
T3	ON TAILINGS SAND IN TAILINGS CELL	9.07	3.14	3.92	1.95	**92.6**	**3.06**	**89.8**

5.2 Slope Stability

Past investigations to evaluate the stability of the Shootaring Canyon dam have revealed that this structure was competent. However, the dam has not impounded tailings and will not contain tailings unless the tailings facility is expanded to the Cell 2 configuration. The dam will be breached in the Cell 1 reclamation configuration but will be left in place in the Cell 2 configuration. The cross valley berm will be substantially reconfigured in the process of constructing tailings Cell 1. The steepest portion of the current outslope of the cross valley berm is at approximately a 1.2H:1V slope with a crest of approximately 4448 feet above MSL. The steepest slope on the cross valley berm after construction of Cell 1 will be 3H:1V. If Cell 2 is added in the future, it will abut Cell 1 on the reconfigured 3H:1V outslope of the cross valley berm. In the Cell 1 reclamation configuration, additional fill will be added at the outboard toe of the cross valley berm to further reduce the slope to a maximum of slope of 5H:1V. In the Cell 2 reclamation configuration, the cross valley berm is essentially covered by the emplaced tailings and cover system. Figure 9-7 illustrates the dramatic alteration of the cross valley berm in the construction of Cell 1 and in the reclamation configuration.

A drain system was installed above the clay liner in the original tailings cell and this system discharges to a sump downstream of the cross valley berm. The existing drain and liner system extends well beyond the cell where the tailings are deposited, so the drain system also captures runoff to the depression outside of the actual tailings disposal cell. The drain system has allowed virtually complete dewatering of the existing tailings, and this was confirmed with the installation of three tailings wells. However, the replacement of the existing tailings cell with Cell 1 will render the current condition of the tailings irrelevant to this reclamation plan.

Tailings Cell 1 and Cell 2 will be equipped with a dual HDPE liner with leak detection and complete drainage system. The drainage system delivers solution within the tailings to a collection sump where it is returned to the milling circuit or discharged to the evaporation pond(s). In combination with the reduced moisture placement of the tailings in solid or semi-solid form, the drainage system maintains the tailings in a largely dewatered state throughout operation.

With the seven-part liner system in Cell 1, the potential for development of a phreatic surface through the cross valley berm is virtually eliminated. The dramatic slope reduction for the cross valley berm and the lack of a phreatic surface within the cross valley berm will result in a stable configuration for the cross valley berm. A further slope reduction of the cross valley berm to 5H:1V during Cell 1 reclamation will virtually eliminate concern for slope stability of the cross valley berm. With the Cell 2 reclamation configuration, the cross valley berm is relegated to a below grade structure.

5.3 Liquefaction Potential

Since the tailings will be placed in a reduced moisture state within a lined cell equipped with a drainage system, there is very little concern for liquefaction of the tailings. Also, since it is not anticipated that tailings will be placed as a slurry, the segregation that results with tailings slurry placement methods is avoided. With a more uniform tailings pile, the high moisture retention and perched water tables associated with segregated slime tailings is also avoided. This in turn reduces the potential for liquefaction.

5.4 Cover System Design

Five materials are considered in the construction of the cover for the tailings and other contaminated materials. The material that will be placed directly over the reshaped and regraded tailings surface is non-specific in that it is planned as an interim cover/grading layer beneath the clay layer. This material may consist of the fine sand produced by excavation within the Entrada sandstone, reject clay materials encountered in channel excavation or borrow from the dam, or other similar non-contaminated materials encountered in the construction. The second layer in the cover system is the clay that is present in the core of the Shootaring Canyon dam or the alternate source of clay that will be used in the cell liner construction. The third layer of material, fine sand, will function as a vapor break and additional radon barrier. The fourth layer of material, rocky soil, is the smaller fraction of the run-of-mine materials from the quarry area and/or similar materials from the original borrow areas for mill construction, or the corollary Zone 2 material in the Shootaring Canyon dam. This material is planned for usage above the clay layer as a protective layer (frost penetration/vapor break) and will also serve to reduce radon release. The fifth material is the erosion protection layer consisting of rock mulch. This material is not considered part of the radon/infiltration barrier and is discussed in Section 6.

5.4.1 Clay Cover

The clay for the Cell 1 reclamation cover system will be borrowed from the Shootaring Canyon dam. The average moisture content for samples of the in-place clay was 24.2% (see Table 5-1). A typical dry density of the in-place clay is 70 lb/ft^3. The maximum dry density of existing clay liner and dam core, as determined by the Proctor method, ranges from 90.4 to 97.4 lb/ft^3 (samples NP-6, NP-10, NP-11, DA1 and C-4) with an optimum moisture content ranging from 25.4% to 30.8%. The percentage of clay samples passing the #200 screen ranges from 82.8% to 88.4%.

The specifications for the Shootaring Canyon dam clay for the radon modeling are a minimum dry density of 90 lb/ft^3 and a minimum percentage passing the #200 screen of 75%. The average in-situ moisture content of 24.2% is used in the modeling and with an assumed particle specific gravity of 2.65, the porosity is approximately 46%.

The alternate source of clay will be used for the Cell 2 reclamation cover system. This clay is mined from an area approximately 30 miles west of the mill area. The test results from samples of this clay are included in Appendix C. The average Standard Proctor density for this clay was 86.15 lb/ft^3 with an optimum moisture content of approximately 31.7%, and the minimum percentage passing the #200 screen was 95.9%. The samples of the clay are classified CH in the USCS and the plasticity index is 61 or greater. Since the clay samples were taken from an active mining area, the natural moisture content was not measured. It was also indicated in the testing that the clay will require some conditioning. Three permeability tests were also conducted with the resulting conclusion that the permeability is on the order of 1E-08 cm/sec or less. In summary, the quality of the clay in the alternate source is very good.

The specifications for the alternate source clay for the radon modeling are a minimum dry density of 86 lb/ft^3 and a minimum percentage passing the #200 screen of 85%. The average moisture content of 25% was estimated based on the tested properties of the soil which indicated very high quality plastic clay with optimum Proctor moisture content of over 30% by weight. An evaluation of the clay is included in Appendix C. With an assumed particle specific gravity of 2.65, the porosity is approximately 48%.

5.4.2 Soil and Rock Cover

The rocky soil cover will be derived from quarry area, adjacent borrow areas, or dam zone 2 material that is processed to remove rocks for rock mulch or riprap or to remove rocks too large to be placed within the cover layer. Gradations for these run-of-mine type materials as well as a sample of the fines are presented in Appendix C. When just the fines (<0.5 inch) are considered, there is an appreciable clay and silt fraction within the material (approximately 10%). The final gradation of this rocky soil cover will depend in large part on the type and gradation of rock products that are removed to produce rock mulch and channel riprap. At a minimum, the stones larger than 9 inches will be removed from this cover material to facilitate placement as cover. If the material is processed to produce rock mulch, the upper limit of the cover gradation will be gravel sized particles. The presence of stones approaching 9 inches in diameter within the cover layer is not expected to have a detrimental effect on the function of the material as cover. In addition to functioning as a protective layer for frost penetration, a competent stone placed with a completely surrounding soil matrix reduces the pore space available for radon transport. For the purposes of radon emanation modeling, the soil cover will be assumed to have a density of 99 lb/ft^3 and a porosity of 40%. The long-term moisture content is estimated at 8% to reflect the presence of the silt and clay fraction.

5.4.3 Unspecified Cover Materials

The fine uniform sand produced by excavation of the Entrada sandstone, the clay that was placed just east of the tailings cell during liner construction, and the rocky soil material that is present in several potential borrow areas surrounding the tailings area are three materials under consideration for interim/grading cover and general fill within the tailings cell. The Entrada sandstone is expected to require ripping and additional heavy equipment effort for excavation. Significant volumes of the sand will be generated during the construction of the cells and in the reclamation construction, and a part of this may be used on the tailings surface as an interim/grading cover before the clay cover is constructed. The rocky soil is also available to use as the interim/grading cover. Likewise, a clay source (represented by sample C-4) may be stockpiled during replacement tailing cell construction and could be available for use as this interim/grading cover. This clay was placed beside the original tailings cell during liner construction and has properties that are similar to the dam and liner clay. This clay will be removed prior to construction of Cell 1 and some of clay may be used in the construction of Cell 1. That portion that is not used in tailings cell construction will be available for use as a cover material for the tailings reclamation. Both the Entrada sandstone and the stockpiled excess clay materials will be considered for use as this interim/grading cover, but the quantity of excess clay is not large enough to comprise a significant portion of the cover. Therefore it will not be considered in the radon modeling. The relevant physical properties of the rocky soil will be generally similar to those of the sand with the possible exception of a greater long-term moisture content. Hence, radon emanation modeling that uses Entrada sand properties for the interim/grading cover will be generally conservative. The sand will be assumed to have a density of 99 lb/ft^3, a porosity of 40%, and a long-term moisture content of 6%.

5.4.4 Tailings Properties

Only a small volume of tailings is in place in the existing tailings facility and the average radium-226 activity for these tailings is 78.8 pCi/gm. The average grade for the ore that was processed through the mill is 0.15% U_3O_8. The anticipated average grade for the future mill feed is 0.25% U_3O_8. A direct linear scaling of the anticipated radium-226 activity based on the ratio of ore grades produces an estimated radium-226 activity of 131 pCi/gm for future tailings. U.S. NRC Regulatory Guide 3.64 (1989) also presents a method for calculating anticipated radium-226 activity based upon ore grade which is based on the assumption of secular equilibrium in the ore. This method produces an estimated radium-226 activity of 703 pCi/gm for an ore grade of 0.25% U_3O_8. This is significantly greater than the measured radium-226 activity of 226 pCi/gm for the existing ore which has a grade of approximately 0.12% U_3O_8. The disparity between the estimate of radium-226 activity based on ore grade and the measured and scaled radium-226 activities for the existing tailings and ore stockpile indicates that the estimate based on ore grade is likely grossly conservative. There will be significant quantities of radium-226 that remains in solution through the moisture reduction process and is eventually deposited in the evaporation ponds. Hence, the radium-226 activity in the tailings will likely be dramatically lower than the activity in the unprocessed ore, and this is supported by the measured activities in the existing tailings. In order to better characterize the tailings at the time of reclamation, the radium-226 activity of the tailings will be measured using a minimum of 20 samples for each of the major cells once the decision is made to proceed to reclamation. The samples may also be analyzed for radon emanation coefficient to further refine the modeling. These measurements will be used to evaluate the radon barrier design, and if necessary, the radon barrier configuration will be altered to ensure that the radon emanation will be limited to 20 pCi/m^2/sec. However, until the measured activities are available, the most conservative activity estimate will be utilized in the modeling with the recognition that the cover thickness will likely be reduced at the time of reclamation. The radiological properties of the ore, tailings and other materials are presented in Table 3-1.

The physical properties of the tailings that will be placed with reduced moisture techniques are unknown. Because the tailings are expected to be more homogenous with the reduced moisture placement, the more uniform distribution of fines within the tailings will likely increase general moisture retention and decrease density when compared with properties of segregated sandy tailings. For the purposes of radon emanation modeling, the tailings are assumed to have a density of 90 lb/ft^3 and a porosity of 46%. The long-term moisture content of the tailings was assumed to be 12% by weight. Like the radium-226 activity, samples of the tailings will be evaluated for physical properties prior to the start of the reclamation process.

5.4.5 Radon Release Modeling

The RADON model described in NRC Regulatory Guide 3.64 (1989) was used to predict radon release at the surface of the cover using the preliminary estimates of radium-226 activity in the tailings. The tailings cover system for the Cell 1 reclamation is shown in Figure 5-1-Cell-1, and the tailings cover system for the Cell 2 reclamation is shown in Figure 5-1-Cell-2. The radon-222 flux predicted by the RADON model was limited to less than 20 pCi/m^2/sec. The rock mulch erosion protection was not included in the RADON modeling. The properties of the tailings radon source and cover materials were discussed in preceding sections and the extremely conservative tailings source radium-226 activity of 703 pCi/gm was used in the modeling. The model inputs and results are summarized in Table 5-3. The radium-226 activity of the clay from the existing clay liner was measured on the C4 and NP4 samples and both were 0.5 pCi/gm and are less than background. A value of zero was used in the modeling for the cover material. The default emanation coefficient of 0.35 was used for all layers in all simulations. Two different scenarios were considered for the radon barrier with the two potential clay sources. The radon-222 flux was limited to less than 20 pCi/m^2/sec for all modeled scenarios.

TABLE 5-3. RADON MODELING RESULTS

Layer	Thickness (cm)	Thickness (in)	Moisture Content (%)	Dry Density (g/cm^3)	Dry Density (lb/ft^3)	Porosity (%)	Radium-226 Activity (pCi/gm)	Emanation Coefficient	Radon Flux (pCi/m^2/s)
Shootaring Dam Clay									
Cover	61	24	8	1.59	99	0.40	0	0.35	19.19
Sand	15.3	6	6	1.59	99	0.40	0	0.35	22.43
Clay Cover	45.7	18	24	1.44	90	0.46	0	0.35	24.41
Grading Sand	101.6	40	6	1.59	99	0.40	0	0.35	56.08
Tailings	500	197	12	1.44	90	0.46	703	0.35	355.90
Alternate Clay Source									
Cover	61	24	8	1.59	99	0.40	0	0.35	19.53
Sand	15.3	6	6	1.59	99	0.40	0	0.35	22.83
Clay Cover	45.7	18	24	1.38	86	0.48	0	0.35	24.85
Grading Sand	157.5	62	6	1.59	99	0.40	0	0.35	47.30
Tailings	500	197	12	1.44	90	0.46	703	0.35	387.70

The preliminary thickness of the cover system excluding the rock mulch ranges from 88 to 110 inches depending on the clay used. The first layer above the tailings is a 40 to 62-inch thick grading/interim cover layer of fine sand with properties as described in Section 5.4.3. Although the thickness of all layers is subject to adjustment according to the updated modeling at the time of reclamation, the thickness of this layer will very likely be reduced if the measured activity is less than 703 pCi/gm. This grading layer is overlain by an 18-inch thick compacted clay layer that functions as the primary infiltration/radon barrier. A 6-inch thick sand layer is then placed over the clay layer to function as a very positive vapor break. The sand layer is in turn overlain by a 24-inch thick rocky soil cover. The predicted radon release for the scenario using Shootaring Dam clay is 19.19 pCi/m^2/s and the predicted radon exit flux for the scenario using the alternate clay is 19.53 pCi/m^2/s. As mentioned previously, the radon release modeling will be reanalyzed once the facility is scheduled for reclamation. The thickness of layers may be adjusted based on the additional modeling.

5.4.6 Dewatering and Settlement

The anticipated settlement in the tailings after the termination of tailings placement is expected to be very small. The tailings will be maintained in an essentially dewatered condition throughout operations because the tailings will be placed with a moisture content that is significantly less than saturation and will be contained within a cell that has an elaborate drainage system. The thickness of saturation within the tailings cell during operation will be limited to less than one foot. Because the tailings will be placed with a reduced moisture content in a solid to semi-solid form, segregation of the tailings will not occur. With a relatively homogeneous tailings pile in terms of gradation, the moisture content and hydraulic properties of the tailings should be reasonably uniform throughout the operation. Because there will be a significant fine fraction within the tailings, the permeability of the tailings is expected to be relatively small, and the drainage process under the partially saturated conditions will be relatively slow. However, the short to intermediate-term extractable water immediately after tailings placement is expected to range from 10% to 20% by weight.

The pore pressures within the majority of the tailings will be negative as the tailings are placed or shortly after placement. It is possible that local lenses of material within the tailings may have dramatically different physical or hydraulic properties due to traffic compaction or the importation of materials for access roads etc. Because the scale of these features will be on the order of a few feet to a few tens of feet, the impact on overall drainage and settlement is not expected to be significant. In the absence of saturation and positive pore pressures, the observable settlement of the tailings will be primarily a load-induced compression process. Without the associated drainage process that generally limits the rate of settlement, the compression process will likely occur very quickly.

This combination of factors leads to the conclusion that ongoing tailings settlement after the use of the cell is discontinued is likely to be very small. The planned placement process includes a series of lifts over most of the plan area of the tailings cell(s), so the installation of permanent settlement monuments in meaningful locations during cell operation is not practical. After tailings placement in a cell is terminated, it will be possible to install temporary monuments to monitor settlement until the reclamation begins. A minimum of four temporary settlement monuments will be installed on each major tailings cell at the earliest possible time when the cell is approaching capacity. Because the load-induced compression and partially-saturated drainage will be occurring throughout operation and prior to the installation of monuments, the analysis of consolidation and settlement will likely be subject to interpretation. The distinct action or point where the consolidation process is initiated will be lacking for the tailings facility, and thus the classical techniques for analysis of consolidation may not be applicable. If the magnitude and rate of settlement is very small as expected, a relatively short period of monitoring should reveal that expected degree of differential settlement will not adversely affect the cover. If the magnitude and rate of settlement is greater than expected, the settlement data will be analyzed prior installation of the cover. In both circumstances, a report of the settlement monitoring will be developed and submitted to the State of Utah for review.

5.4.7 Infiltration

The infiltration of water into and through the tailings will be limited by construction of the clay radon/infiltration barrier. This 18-inch thick clay cover for the Cell 1 reclamation will be constructed from the clay that was used in the dam core, which was from the same source as that used in the original clay liner for the existing tailings cell. The 18-inch thick clay cover for the Cell 2 reclamation will be constructed from the alternate source clay. This clay will also be used in the construction of the replacement tailings cells.

Seven double ring infiltrometer tests were conducted on clay in the liner system and three laboratory permeability tests were conducted. The results of the testing are included in Appendix C. Although infiltrometer tests are not ideal for very low permeability materials (particularly in an environment with extremely high evaporation), they represented an opportunity to test the clay liner in place. The infiltrometer tests were conducted by excavating through the rocky soil cover to the clay in areas surrounding the tailings cell and installing the infiltrometers in the clay liner. In the first tests, a siphon arrangement was used to supply the infiltrometer and maintain a constant water depth in the inner ring. This was unsuccessful because the siphon system was not reliable and the infiltration rate was so low that resolution in the supply system was not adequate. The WP-1 infiltrometer test is an example of one in which the failure of the siphon system compromised the results. In subsequent tests, the depth of water in the rings was monitored and the change in water level was plotted as a function of time. The infiltration rate was very low and with a typical starting depth of water of 4 to 5 inches, none of the infiltrometers required addition of water to the inner ring and the final depth to water was typically 3 to 4 inches. Despite the improvement of reliability and resolution with direct measurement of depth of water, a diurnal cycling of the infiltration rate was observed and this was attributed to evaporation. Two evaporation tests were established by setting sealed caps with similar surface areas adjacent to two of the infiltrometers. All of the infiltrometers and the two evaporation cells were covered to minimize evaporation. Most of the infiltrometer tests were conducted for a period approaching three days and the weather conditions of the test period were extremely high air temperature (up to 108 degrees F) with low humidity and a moderate breeze.

With the cycling of the apparent infiltration and the very small changes in water depth in the rings, the response as shown in the figures in Appendix C does not exhibit the classical asymptotic approach to the saturated hydraulic conductivity. Rather, the plots of infiltration rate versus time are similar to a step function with rates, after a certain time (typically about 1 day or 1440 minutes), exhibiting the diurnal cycling but no discernible trend. For this reason, an average infiltration rate was determined for measurements after the trends were no longer present, and this was considered the apparent saturated hydraulic conductivity. For the six tests that produced usable results, the saturated hydraulic conductivities (more often referred to as the permeability) ranged from 2.37E-6 cm/sec to 4.90E-7 cm/sec. The two evaporation tests produced drops in water level that corresponded to rates of 2.58E-6 cm/sec and 8.92E-6 cm/sec. When the first interval rate is removed, the evaporation test rates were reduced to 1.27E-6 cm/sec and 2.11E-6 cm/sec. The evaporation tests actually produced rates that were greater than the measured infiltration rates. This indicates that the biasing of the infiltrometer results by evaporation is dramatic. It is likely that virtually all of the apparent infiltration can be attributed to evaporation and that the true permeabilities of the in-place clay are much lower than indicated by the infiltrometer tests. This is supported by the laboratory permeabilities of 3.4E-8 cm/sec for sample NP-6 and 6.5E-8 cm/sec for sample NP-10. A test was also conducted on sample C-4 with a resulting permeability of 4.4E-7 cm/sec. This sample was taken from the uncovered clay area where adulteration of the surface materials is likely and the quality of the clay has been slightly reduced by exposure and weathering. The data indicate a best estimate of the clay permeability of 5E-8 cm/sec based on the two laboratory permeabilities. A permeability of 1.0E-7 cm/sec is considered a very conservative expectation of clay permeability placed at a minimum density of 90 lb/ft^3. This density is significantly greater than that of the in-place liner clay for the infiltrometer tests (see Table 5-2) while permeability of the liner is expected to be similar to 1.0E-7 cm/sec when the biasing of the evaporation on the infiltrometer tests is considered.

Three permeability tests were conducted on the alternate source clay. The indicated permeability for all three tests was on the order of 1E-08 cm/sec or less. Because the permeability of the clay is so small and the accumulation of effluent from the columns was too slow, all three tests were terminated prior to accumulation of sufficient effluent to accurately reflect the true permeability. The results of the materials testing for the alternate clay source are included in Appendix C.

Given the climate at the site, this low permeability barrier will limit infiltration through the clay cap to immeasurably small levels. The clay infiltration/radon barrier will be extended to intersect the seven part liner for the cells to form a complete encapsulation of the tailings. Appendix D contains a discussion of infiltration modeling that was performed for the site. This modeling indicates that roughly 0.5 mm (0.02 inch) or less is expected to penetrate the barrier annually, with an expected rate of infiltration of 0.001 gpm per acre of covered area or less. This translates to an estimate of 0.008 gpm of infiltrate entering the EPPC, 0.021 gpm of infiltrate entering tailings Cell 1, and 0.039 gpm of infiltrate entering tailings Cell 2.

5.4.8 Accumulation of Infiltrate Within Tailings

The presence of the seven-part liner beneath the tailings raises concerns for accumulation of infiltrate that penetrates the clay barrier cap. This situation is sometimes referred to as the "bathtub" effect. With the decommissioning of the drainage collection system, reclamation of the tailings, and installation of the clay cap, there will be no provision for collecting drainage from the tailings cell, and the cell will become a semi-sealed system. The clay cap will dramatically limit infiltration of water into and through the tailings but there will be minute quantities of water that penetrate the cap. The primary factor limiting the accumulation of infiltrate is the clay cap which limits the quantity of infiltrate. The clay cap will only be subjected to a positive head during severe precipitation events and then only for brief periods. It will take a very severe precipitation event to produce a temporary "water table" on top of the clay cap, and this saturated zone will only persist briefly until lateral drainage, evaporation or evapotranspiration remove the water.

With the assumption of a perfect liner system, the infiltrate will accumulate at the base of the tailings cell. Using Cell 1 as an example, the estimated infiltration rate of 0.021 gpm over the entire cell will result in a total volume of infiltrate of approximately 11,050 gallons each year. With an assumed initial volumetric moisture content of 15% to 20% below saturation, the below grade volume within Cell 1 will accommodate roughly two to three times the volume of infiltrate that accumulates over a 1000 year period.

5.5 Construction Considerations

The construction of the radon/infiltration barrier is the primary consideration in the cover construction. The specifications for moisture, density, and gradation of the clay barrier material are rigorous. Other cover and fill materials also require a measure of construction control to minimize potential settlement, control dust, and assure an adequate base for placement of subsequent layers.

During construction, the surface of the cover layers will be inspected periodically and following significant precipitation events or windstorms. Any damage to the interim/grading cover, clay radon/infiltration barrier, or rocky soil cover will be corrected prior to proceeding with construction in the areas of damage. Damage may include gullying, sediment deposition, displacement of cover materials by wind or other significant disturbance of the cover layers. The damaged areas will be repaired to meet or exceed the appropriate moisture and/or density specifications.

5.5.1 Tailings Cell Radon Barrier Placement

5.5.1.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by PRL's manpower.

Quality control testing/inspection will be done by PRL and a contract soil testing service.

5.5.1.2 Performance Standards

1. All clay used for the radon barrier will be obtained in the designated borrow areas and subject to the approval of PRL personnel or their representative.

2. The clay will be excavated and processed in a manner protective of the resource and will not be wantonly wasted or adulterated.

3. The clay extracted from the Shootaring Dam will be moisture conditioned to 24% to 30% moisture by weight. The clay from the alternate source will be moisture conditioned to 29% to 35% moisture by weight. The clay may be moisture conditioned at the borrow area or other designated location, but may not be moisture conditioned on the surface of the tailings. Adjustment of the moisture content of the clay on the tailings cover area to compensate for evaporation or delays in coverage of the clay layer will be allowed.

4. The clay radon barrier will be placed in maximum compacted lift thickness of six (6) inches. The clay extracted from the Shootaring Dam will be compacted to a minimum density of 90 lb/ft^3. The clay extracted from the alternate source will be compacted to a minimum density of 86 lb/ft^3. The compaction may be by sheepsfoot, vibratory compactor, or other approved method. Clay that does not meet the density or moisture specifications must be reworked, retested and/or removed.

5. The clay radon barrier will be placed to 90% - 125% of the design thickness of 18 inches in no less than three lifts. The average thickness of the clay barrier on the covered tailings area will not be less than 100% of the design thickness of 18 inches. Exceedence of 125% of the design thickness will be tolerated if there is no detrimental effect on drainage systems or design grades. No clay or fill materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. PRL shall determine when these adverse conditions exist.

5.5.1.3 Testing and Inspection

1. Daily visual inspection of clay excavated and placed during construction shall be performed by PRL or its designee. The visual inspection shall be performed to ensure clay is being placed in conformance to the specifications. All clay used for the radon barrier will be obtained in the designated borrow areas and subject to the approval of PRL personnel or their representative.

2. A complete standard Proctor test (ASTM D-698) will be conducted by PRL or its representative at a frequency of not less than once per 7500 yd^3 of clay barrier. A one-point Proctor test will be conducted by PRL or its representative at a frequency of not less than once per 2500 yd^3 of clay barrier.

3. The gradation of the clay will be determined by PRL or its representative using sieve analysis to the #200 screen at a frequency of not less than once per 1000 yd^3 of clay barrier. A minimum of one sieve analysis will also be conducted by PRL or its representative for every day in which 150 yd^3 or more of clay barrier is placed. For the clay extracted from the Shootaring Dam, a minimum of 75% of the clay barrier material must pass the #200 screen. For the alternate clay source, a minimum of 85% of the clay barrier material must pass the #200 screen.

4. The in-place density and moisture content of the clay will be determined by PRL or its representative using at a frequency of not less than once per 500 yd^3 of clay barrier. A minimum of one in-place density/moisture content test will also be conducted for every day in which 150 yd^3 or more of clay barrier is placed. The minimum acceptable density for the clay from the Shootaring Dam is 90 lb/ft^3, and the moisture content must be within the range of 24% to 30%. The minimum acceptable density for the clay from the alternate source is 86 lb/ft^3, and the moisture content must be within the range of 29% to 35%. Acceptable methods for determining the in-place moisture content include the oven drying method (ASTM D-2216), the microwave drying method (ASTM D-4643), the Speedy moisture meter (AASHTO T217) or the nuclear density gauge (ASTM D-3017). For all methods other than the oven drying method, a duplicate moisture determination will be made with the oven drying method at a frequency of once for every ten moisture content samples. These correlation tests will be used to calibrate the nuclear density gauge or to confirm accuracy of the other testing method to a maximum deviation of 1% in measured moisture content from the oven drying method. In the event of a failure in the correlation tests, the frequency of duplicate moisture determinations will be increased to once per five moisture samples until no failures occur for five successive correlation tests. For the nuclear density gauge, a series of 10 pre-construction correlation tests will be performed for samples in the immediate tailings cell area. If more than 30% of the correlation tests fail after a single calibration, the nuclear density gauge will not be acceptable.

5. The acceptable methods for in-place density determination include the sand cone method (ASTM D-1556), the nuclear density meter (ASTM D-2922), and a combination of the sand cone method and a driven tube density sampler. If the nuclear density meter is used, a correlation/calibration test with the sand cone method will be performed at a frequency of once per five density samples. In addition, a pre-construction series of 10 tests using both the sand cone method and the nuclear density meter will be performed. These tests will be performed on the surface of the tailings to confirm that gamma interference does not bias the nuclear density meter readings. If more than 30% of the tests fail (discrepancy of more than 2.5 lb/ft^3 between the two methods), the nuclear density meter will not be acceptable. If the combination method (driven tube density sampler) is used, a correlation sample will be performed with the sand cone method at a frequency of once per five density samples. If the driven tube density samples are not within an allowable deviation of 2.5 lb/ft^3 when compared with the sand cone method, the frequency of correlation tests will be increased to once per two samples until there are no failures in five successive correlation tests.

6. Clay radon/infiltration barrier that has not been covered within 48 hours of placement will be tested for moisture content to insure the minimum moisture content of 24% for the Shootaring Dam clay or the minimum moisture content of 29% for the alternate source clay is met. The testing will be at frequency of not less than one (1) sample per 10,000 square feet of affected area. The sampling will be to a depth of not more than three (3) inches. If the minimum moisture content is not met, sufficient water to adjust the moisture content to the specified minimum plus 3 (27% for the Shootaring Dam clay and 32% for the alternate source clay) will be uniformly applied to the affected area of the in-place clay barrier. If precipitation on the clay barrier causes the delay in covering of the clay, construction on the cover will be delayed until the surface is dry enough to proceed without damage to the clay by equipment traffic.

7. The thickness of the clay barrier will be determined by survey or by coring. The total thickness will be verified at a frequency of no less than once per 20,000 ft^2 of clay barrier area. PRL and/or its representative will determine the appropriate method for confirming clay barrier thickness.

8. Permeability testing of the clay barrier material will be performed at the direction of PRL or its representative prior to or during construction. A minimum of five permeability tests will be performed at varying density to develop a correlation of density and permeability. This correlation will then be used to determine the required density to produce a permeability of 1.0E-07 cm/sec or less. The minimum density will be that which results in a permeability of 1.0E-07 or less (based on the correlation), or the specified minimum density in item 4 of Section 5.5.1.3, whichever is greater.

5.5.1.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of clay placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

5.5.1.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and any necessary corrective action.

2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.1.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.2 Tailings Cell Interim/Grading Cover Placement

5.5.2.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by PRL's manpower.

Quality control testing/inspection will be done by PRL using a contract soil testing service.

5.5.2.2 Performance Standards

1. All interim/grading cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or their representative. The interim/grading cover will be placed directly on top of the graded surface in the tailings cell.

2. The interim/grading cover will be moisture conditioned to a minimum of 10% by weight (dry basis) for sandy materials and a minimum of 15% by weight for materials with a significant fraction (20% or more by weight) passing the #200 sieve. The moisture conditioning is necessary to facilitate compaction and control dust.

3. The interim/grading cover will be placed in maximum compacted lift thickness of six (6) inches and compacted by sheepsfoot, vibratory compactor, or other approved method.

4. The interim/grading cover will be placed to a minimum of 90% of the design thickness of 40 inches for the Cell 1 reclamation plan in no less than four lifts. The interim/grading cover will be placed to a minimum of 90% of the design thickness of 62 inches for the Cell 1 and Cell 2 reclamation plan in no less than six lifts. Excess thickness of the interim/grading cover may be placed at the direction of PRL or its designee to achieve the desired surface for clay barrier placement. No interim/grading cover materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. PRL shall determine when these adverse conditions exist.

5.5.2.3 Testing and Inspection

1. Daily visual inspection of interim/grading cover excavated and placed during construction shall be performed by PRL or its designee. The visual inspection shall be performed to ensure interim/grading cover is being placed in conformance to the specifications. All interim/grading cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or their representative.

2. The interim/grading cover will be visually classified by PRL personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by PRL or its representative. No frequency of testing is designated because the specification for this material is very broad. Methods of testing will conform to those described in Section 5.5.1.3.

3. The thickness of the interim/grading cover will be determined by survey methods or by coring. The thickness will be verified at a frequency of no less than once per 20,000 ft^2 of interim cover area. PRL and/or its representative will determine the appropriate method for confirming thickness.

5.5.2.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of interim/grading cover placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

5.5.2.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.2.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.3 Tailings Cell Sandy Cover Placement

5.5.3.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by PRL's manpower.

Quality control testing/inspection will be done by PRL using a contract soil testing service.

5.5.3.2 Performance Standards

1. All sandy cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or its representative. The sandy cover will be placed on top of the clay radon/infiltration barrier.

2. If necessary, the sandy cover will be screened to remove stones greater than six inches in diameter to facilitate placement in appropriate layer thickness.

3. Moisture conditioning of the sandy cover will be at the direction of PRL or its representative to control dust and facilitate placement at appropriate density.

4. The sandy cover will be placed in maximum compacted lift thickness of eight (8) inches. The sandy cover will be placed in a manner to avoid disturbance of the clay barrier, and construction traffic will be routed to achieve uniform compaction over the tailings surface.

5. The sandy cover will be placed to a minimum of 90% of the design thickness of 6 inches. Excess thickness of the sandy cover may be placed at the direction of PRL. No sandy materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. PRL shall determine when these adverse conditions exist.

5.5.3.3 Testing and Inspection

1. Daily visual inspection of sandy cover excavated and placed during construction shall be performed by PRL or its designee. The visual inspection shall be performed to ensure sandy cover is being placed in conformance to the specifications. All sandy cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or its representative.

2. The sandy cover will be visually classified by PRL personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by PRL or its representative. No frequency of testing is designated because the specification for this material is very broad. Methods of testing will conform to those described in Section 5.5.1.3.

3. The thickness of the sandy cover will be determined by survey methods or by coring. The thickness will be verified at a frequency of no less than once per 20,000 ft^2 of interim cover area. PRL and/or its representative will determine the appropriate method for confirming thickness.

5.5.3.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of sandy cover placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

5.5.3.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.3.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.4 Tailings Cell Rocky Soil Cover Placement

5.5.4.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by PRL's manpower.

Quality control testing/inspection will be done by PRL using a contract soil testing service.

5.5.4.2 Performance Standards

All rocky soil cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or its representative. The rocky soil cover will be placed on top of the clay radon/infiltration barrier.

1. The rocky soil cover will be screened to remove stones greater than nine inches in diameter to facilitate placement in appropriate layer thickness.

2. Moisture conditioning of the rocky soil cover will be at the direction of PRL or its representative to control dust and facilitate placement at appropriate density.

3. The rocky soil cover will be placed in maximum compacted lift thickness of eight (8) inches. The rocky soil cover will be placed in a manner to avoid disturbance of the underlying materials, and construction traffic will be routed to achieve uniform compaction over the tailings surface.

4. The rocky soil cover will be placed to a minimum of 90% of the design thickness of 24 inches in no less than three lifts. Excess thickness of the rocky soil cover may be placed at the direction of PRL or its designee to achieve the desired surface for rock mulch and riprap placement. No rocky soil materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. PRL shall determine when these adverse conditions exist.

5.5.4.3 Testing and Inspection

1. Daily visual inspection of rocky soil cover excavated and placed during construction shall be performed by PRL or its designee. The visual inspection shall be performed to ensure rocky soil cover is being placed in conformance to the specifications. All rocky soil cover will be obtained in the designated borrow areas and subject to the approval of PRL personnel or its representative.

2. The rocky soil cover will be visually classified by PRL personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by PRL or its representative. No frequency of testing is designated because the specification for this material is very broad. Methods of testing will conform to those described in Section 5.5.1.3.

3. The thickness of the rocky soil cover will be determined by survey methods or by coring. The thickness will be verified at a frequency of no less than once per 20,000 ft^2 of interim cover area. PRL and/or its representative will determine the appropriate method for confirming thickness.

5.5.4.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of rocky soil cover placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

5.5.4.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

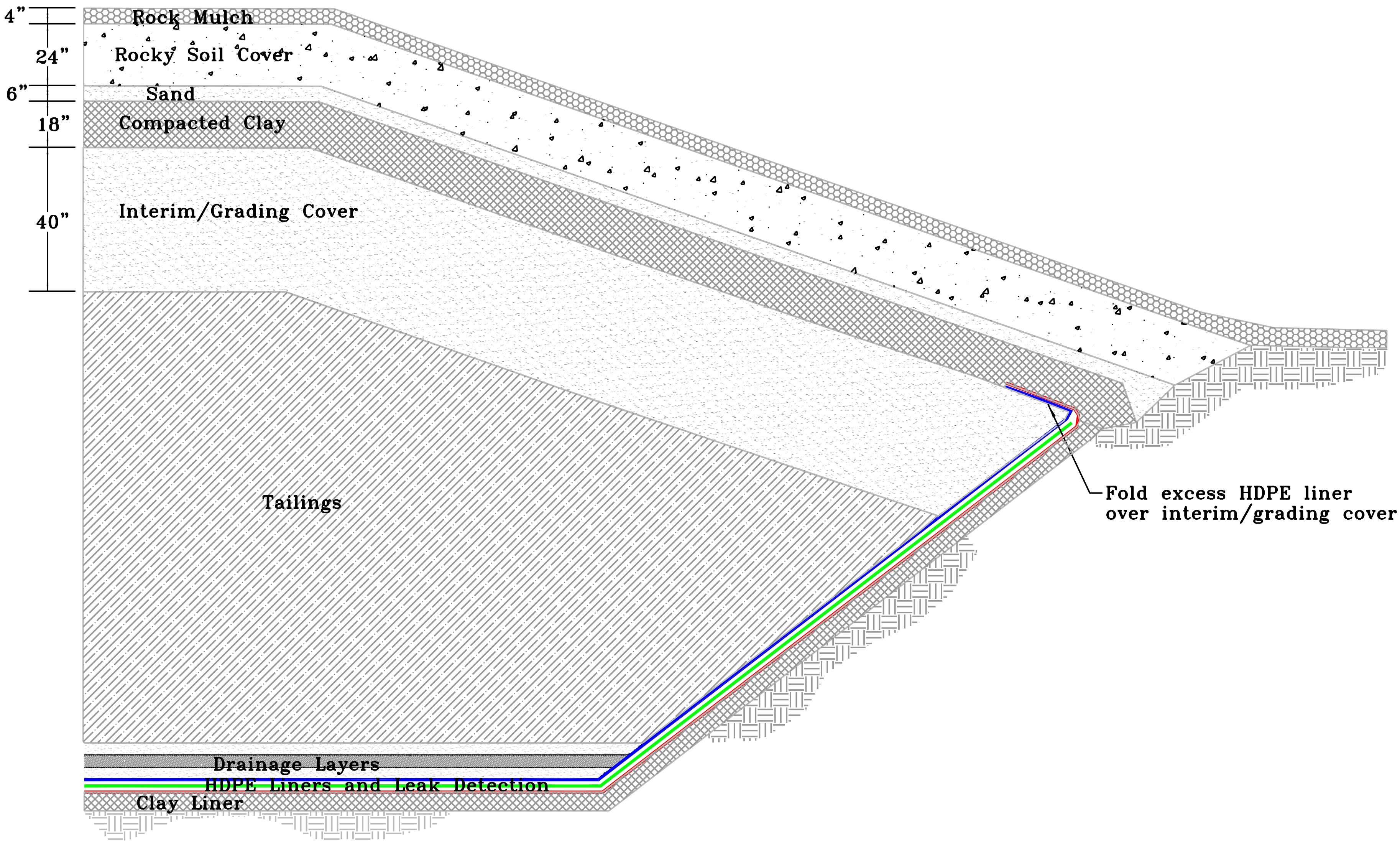
2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

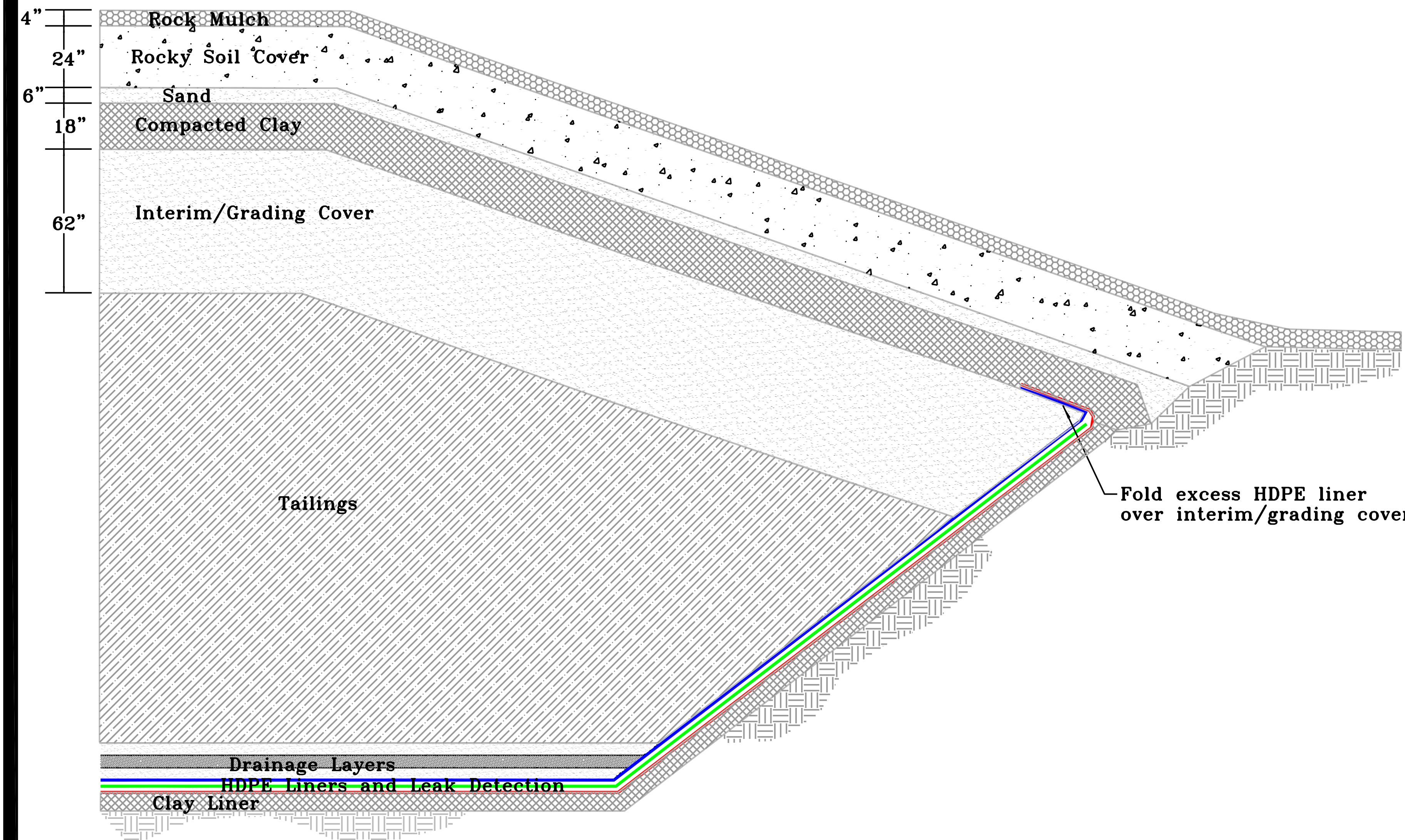
5.5.4.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.



PLATEAU RESOURCES Ltd.		
Figure 5-1-Cell-1. Cell 1 Reclamation Cover System		
DATE: 12-2005	Fig9-5.dwg	NOT TO SCALE
Page: 5-22	HYDRO-ENGINEERING L.L.C.	



PLATEAU RESOURCES Ltd.

Figure 5-1-Cell-2. Cell 1 and Cell 2 Reclamation Cover System

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Page: 5-23	HYDRO-ENGINEERING L.L.C.	

6.0. EROSION PROTECTION OF THE TAILINGS IMPOUNDMENT

6.1 Tailings Dispersal By Erosion

Tailings and other contaminated material will be encapsulated above the existing cross valley berm in the Cell 1 reclamation configuration, and the tailings encapsulation will extend to the Shootaring Dam in the Cell 2 reclamation configuration. The cover system and drainage configuration has been designed to prevent erosion of the tailings cover. Any references to the tailings dam are made with the recognition that the dam does not currently impound tailings and will not impound tailings unless the tailings impoundment is expanded to the Cell 2 configuration.

Erosion control measures will prevent the encroachment of gullies or significant erosion within the protected tailings area. A secondary concern for the drainage configuration is to provide positive drainage for the covered tailings area to prevent extended ponding over the tailings during precipitation events. Where possible, runoff from upland drainage areas is diverted or otherwise excluded from the tailings area drainage system. This is the case for the north drainage diversion where runoff from two drainage areas is diverted to a flat area in the Northwest Diversion drainage basin (see Figures 6-1-Cell-1 and 6-1-Cell-2). An existing berm on the south side of the flat area on the southern edge of this basin will be bolstered to prevent any runoff from the Northeast Diversion and Northwest Diversion basins from discharging to the tailings area. A channel with PMF capacity will be constructed along the general alignment of the north drainage diversion line shown on Figure 6-1-Cell-1 to divert runoff generally to the west. During very severe runoff events where the surge pond formed by the berm is filled, the surge pond will discharge to the west into the Lost Spring drainage. The quarry area will be configured as a small closed basin after reclamation. This also reduces the contributing drainage area to the tailings area drainage.

The cross valley berm outslope will be reconfigured to a steepest slope of 5H:1V. This is also the maximum slope allowed over the covered tailings area. The Cell 1 drainage pattern can be generally described as radially outward flow to a mildly sloping perimeter swale on the west, north and east sides of Cell 1. This swale also captures the drainage from the off-tailings drainage from the west and north sides of Cell 1. The swale passes between Cell 1 and the EPPC and connects to a steeper channel section which conveys runoff to the base of the draw upstream of the Shootaring Dam in the case of Cell 1 reclamation. For the Cell 2 reclamation, the channel is realigned to run along the east side of Cell 2 for eventual discharge to the south on the east side of the Shootaring Dam. Drainage from the central and northern portions of the reclaimed mill area is captured in a perimeter channel around the EPPC. This channel discharges to the swale around the perimeter of Cell 1. Drainage from the south side of the EPPC is collected in a channel that discharges to a confluence with the primary Cell 1 channel. The Cell 1 drainage design upstream of the cross valley berm is identical for the Cell 1 and Cell 2 reclamation plans.

In the Cell 1 reclamation configuration, the tailings dam will be breached and the natural drainage reestablished (see Figures 6-1-Cell-1 and 6-2-Cell-1). The configuration of the dam breach and surrounding area allows for severe flood surge pond storage, which provides additional stability to the tailings area drainage. In the Cell 2 reclamation configuration, the runoff from both Cell 1 and the east side of Cell 2 is conveyed along the east side of Cell 2 to a confluence with a channel that captures drainage from the west side of Cell 2 (see Figures 6-1-Cell-2 and 6-2-Cell-2). The combined channel then discharges to a natural swale on the southeast side of the Shootaring Dam. All channels are protected with riprap ranging in size from a minimum design D_{50} of 2.25 inches to a minimum design D_{50} of 12 inches.

The majority of the tailings surface will be mildly to moderately sloping and the covered tailings will be protected against erosion with rock mulch. With the exception of the reconfigured cross valley berm outslope for the Cell 1 reclamation configuration, the runoff from the covered tailings area is collected in a swale or channel which delivers runoff flows to the south of the covered tailings area. A porous rock ledge consisting of large stones will be installed in the swale between Cell 1 and the EPPC in order to restrict channel capacity and attenuate peak flows. The mildly sloping swales and channels also provide significant flow attenuation. The general slope for the swale that passes between Cell 1 and the EPPC is 0.0026 ft/ft and, with the porous rock ledge, the temporary surge pond storage through the swale dramatically attenuates peak flows. For the Cell 2 reclamation, the west side of the tailings cell is characterized by a bench adjacent to the tailings that is generally formed as fill above the native surface. This results in a series of depressions outside of the covered tailings along the west side of Cell 2 that will impound water, attenuate peak flows for severe events, capture sediment, and trap debris that may fall from the bluff west of Cell 2.

6.2 Below-Grade Disposal

PRL's tailings impoundment is in a natural depression enclosed on all sides by a cap. Such a tailings area minimizes the dispersion of tailings by wind and water erosion. The tailings disposal basin is effectively surrounded by natural cliffs and hills. It is generally anticipated that there will be a net deposition of windborne soils over the rock mulch protected tailings impoundment area, rather than loss of coverings over the tailings due to wind erosion. Accordingly, natural deposition will be exploited to enhance the security of the projected tailings impoundment.

6.3 Drainage Design

The drainage system will be designed to convey the Probable Maximum Flood (PMF) with no damage to the tailings encapsulation system. The PMF is a combination of the Probable Maximum Precipitation (PMP) event and worst-case runoff conditions. The estimated PMP as taken from Hydrometeorological Report No. 49 (NWS, 1977) is 8.25 inches in 1 hour. This storm is derived for a 1 square mile area at an elevation up to 5000 feet above mean sea level. The short duration storm is most applicable for the small drainage at the Shootaring site, and the local high intensity storm over a small area represents the most severe runoff producing storm event for this situation. The riprap and rock mulch protection will be of sufficient size and gradation to withstand the erosive forces, thereby protecting the integrity of the impoundment cap and drainage system.

The PMP storm distribution has a pronounced impact on the magnitude and duration of peak flows. In order to produce runoff estimates representing the most severe plausible precipitation event, the PMP storm was distributed according to two methods. The first method uses a bell shaped rainfall distribution with the peak intensity at the midpoint of the storm (see Figure 6-3). This storm distribution was used in the HEC-1 modeling of the runoff from the entire mill and tailings area drainage basin. The storm distribution presented in Figure 6-4 was used in modeling of overland flow which is discussed in the following paragraphs.

The drainage basin characteristics for the Cell 1 reclamation are presented in Table 6-1-Cell-1, and the basin characteristics for the Cell 2 reclamation are presented in Table 6-1-Cell-2. The time of concentration was calculated with Kirpich's method (see Barfield et al., 1983 and discussions in Appendix K). In calculating the time of concentration, the flow paths were segmented into sections of relatively uniform slope and then the time of concentration for the sub-basin was the sum of the time of concentration for each segment. The PMP distribution in Figure 6-3 produces a very severe runoff condition for basins of the size, shape and slope for the tailings area because the maximum precipitation intensity occurs when the entire basin is contributing runoff to critical locations. HEC-1 was used to evaluate the peak runoff flows for the drainage basin with the SCS curve number method. The curve number was set at 88 for the general drainage area representing poor range conditions with a reasonably well drained soil under antecedent moisture condition III (nearly saturated prior to the storm). This represents a very severe combination of conditions that produces large quantities of runoff. Much of the surface soil in the drainage basin is within the Entrada sandstone or derived from the sandstone and is well-drained and has a relatively high infiltration rate. The curve number for the rock mulch-covered areas of the tailings was set at 70 to reflect the presence of highly permeable rock mulch layer which is underlain by a rocky soil. The curve number for drainage basins containing both surfaces was roughly proportioned according to the area of the two surfaces.

TABLE 6-1-CELL-1. BASIN CHARACTERISTICS FOR THE CELL 1 MILL AND TAILINGS AREA RECLAMATION

BASIN	Area (acre)	Area (mi^2)	Hydrologic High Elev. (ft-msl)	Hydrologic Low Elev. (ft-msl)	Basin Relief (ft)	Basin Length (ft)	Basin Slope (ft/ft)	Kirpich's tc (hour)	Kirpich's tL (hour)	Total Kirpich's tL (hour)	SCS Curve Number
NORTHEAST DIVERSION	17.6	0.027	4640	4518	122	1670	0.073	0.108	0.0648	0.1437	88
(Sect. 2)			4518	4508	10	860	0.012	0.131	0.0789		
NORTHWEST DIVERSION	35.3	0.055	4640	4502	138	2200	0.063	0.142	0.0850	0.0850	88
NORTH MILL	17.8	0.028	4552	4550	2	420	0.005	0.107	0.0641	0.1268	86
(Sect. 2)			4550	4540	10	200	0.050	0.024	0.0146		
(Sect. 3)			4540	4506	34	80	0.425	0.005	0.0032		
(Sect. 4)			4506	4481	25	380	0.066	0.036	0.0216		
(Sect. 5)			4481	4467	14	335	0.042	0.039	0.0233		
CENTRAL MILL	7.9	0.012	4550	4540	10	150	0.067	0.017	0.0105	0.1000	82
(Sect. 2)			4540	4478	62	250	0.248	0.016	0.0094		
(Sect. 3)			4478	4476	2	510	0.004	0.134	0.0802		
SOUTH MILL	12.6	0.020	4552	4550	2	880	0.002	0.251	0.1505	0.2060	86
(Sect. 2)			4550	4540	10	240	0.042	0.030	0.0181		
(Sect. 3)			4540	4538	2	200	0.010	0.045	0.0272		
(Sect. 4)			4538	4460	78	290	0.269	0.017	0.0102		
WEST CELL 1 TAILINGS	17.8	0.028	4516	4463	53	620	0.085	0.047	0.0284	0.1776	81
(Sect. 2)			4463	4459	4	1100	0.004	0.249	0.1491		
CENTRAL CELL 1 TAILINGS	15.3	0.024	4516	4459	57	530	0.108	0.038	0.0231	0.2038	77
(Sect. 2)			4459	4456	3	1180	0.003	0.301	0.1807		
EAST CELL 1 TAILINGS	8.3	0.013	4516	4456	60	455	0.132	0.032	0.0190	0.1403	70
(Sect. 2)			4456	4454	2	730	0.003	0.202	0.1213		
SOUTH	88.8	0.139	4830	4800	30	165	0.182	0.013	0.0077	0.1289	85
(Sect. 2)			4800	4430	370	345	1.072	0.011	0.0068		
(Sect. 3)			4430	4382	48	960	0.050	0.082	0.0490		
(Sect. 4)			4382	4364	18	890	0.020	0.109	0.0654		

TABLE 6-1-CELL-2. BASIN CHARACTERISTICS FOR THE CELL 1 AND CELL 2 MILL AND TAILINGS AREA RECLAMATION

BASIN	Area (acre)	Area (mi^2)	Hydrologic High Elev. (ft-msl)	Hydrologic Low Elev. (ft-msl)	Basin Relief (ft)	Basin Length (ft)	Basin Slope (ft/ft)	Kirpich's tc (hour)	Kirpich's tL (hour)	Total Kirpich's tL (hour)	SCS Curve Number
NORTHEAST DIVERSION	17.6	0.027	4640	4518	122	1670	0.073	0.108	0.0648	0.1437	88
(Sect. 2)			4518	4508	10	860	0.012	0.131	0.0789		
NORTHWEST DIVERSION	35.3	0.055	4640	4502	138	2200	0.063	0.142	0.0850	0.0850	88
NORTH MILL	17.8	0.028	4552	4550	2	420	0.005	0.107	0.0641	0.1268	86
(Sect. 2)			4550	4540	10	200	0.050	0.024	0.0146		
(Sect. 3)			4540	4506	34	80	0.425	0.005	0.0032		
(Sect. 4)			4506	4481	25	380	0.066	0.036	0.0216		
(Sect. 5)			4481	4467	14	335	0.042	0.039	0.0233		
CENTRAL MILL	7.9	0.012	4550	4540	10	150	0.067	0.017	0.0105	0.1000	82
(Sect. 2)			4540	4478	62	250	0.248	0.016	0.0094		
(Sect. 3)			4478	4476	2	510	0.004	0.134	0.0802		
SOUTH MILL	12.6	0.020	4552	4550	2	880	0.002	0.251	0.1505	0.2060	86
(Sect. 2)			4550	4540	10	240	0.042	0.030	0.0181		
(Sect. 3)			4540	4538	2	200	0.010	0.045	0.0272		
(Sect. 4)			4538	4460	78	290	0.269	0.017	0.0102		
WEST CELL 1 TAILINGS	17.8	0.028	4516	4463	53	620	0.085	0.047	0.0284	0.1776	81
(Sect. 2)			4463	4459	4	1100	0.004	0.249	0.1491		
CENTRAL CELL 1 TAILINGS	15.3	0.024	4516	4459	57	530	0.108	0.038	0.0231	0.2038	77
(Sect. 2)			4459	4456	3	1180	0.003	0.301	0.1807		
EAST CELL 1 TAILINGS	8.3	0.013	4516	4456	60	455	0.132	0.032	0.0190	0.1403	70
(Sect. 2)			4456	4454	2	730	0.003	0.202	0.1213		
CELL 2 SWALE	18.2	0.028	4511	4439	72	770	0.094	0.054	0.0325	0.2252	71
(Sect. 2)			4439	4437	2	1090	0.002	0.321	0.1927		
WEST CELL 2	44.6	0.070	4511	4438	73	800	0.091	0.056	0.0338	0.2678	81
(Sect. 2)			4438	4432	6	1860	0.003	0.390	0.2340		
EAST CELL 2	24.8	0.039	4511	4434	77	800	0.096	0.055	0.0331	0.1263	74
(Sect. 2)			4434	4425	9	960	0.009	0.155	0.0933		

Level-pool flood routing was used in the HEC-1 modeling to reflect surge pond storage in the swale around the perimeter of Cell 1. This routing was used for both the Cell 1 and Cell 2 reclamation configurations. The discharge characteristic for the surge pond storage areas and the general channel sections was calculated using Manning's equation for a trapezoidal channel section. Manning's equation is discussed in Appendix K. A large porous rock ledge structure is used to restrict peak flows under severe to catastrophic flows without permanently impounding water. Large stones will be placed in the channel to conform to the design channel configuration at the location of channel hydrologic cross section HC-3. This will create a highly porous "dam" that temporarily restricts extreme event flows. These stones that form the upstream edge of the ledge will have a minimum D_{50} of 24 inches and thus there will be ample voids between the rocks to convey moderate storm runoff. The downstream edge of the ledge will be placed at a relatively mild slope to transition to the downstream discharge channel. The rock size will be gradually reduced to eventually transition to the intermediate riprap in the downstream channel section. The height of the rock ledge will be approximately 3.5 feet and a void in the ledge will be left in the center of the structure to facilitate rapid drainage. Figure 6-5 presents the surge pond area and storage and rock ledge discharge characteristic. The flat section of slightly narrower channel downstream of the porous rock ledge also creates a minor surge pond. Figure 6-6 presents the surge pond area and storage and discharge characteristic for this flat narrow trapezoidal channel section. Level-pool flood routing was used for the very flat channel section on the east side of the EPPC. Figure 6-7 presents the surge pond area and storage and flat east EPPC channel discharge characteristic. Level-pool flood routing was also used for the depressions west of the bench/channel on the west side of Cell 2 and the discharge is conveyed through mildly sloping channel across the top of the Shootaring Dam to a confluence with the east channel. Figure 6-8 presents the surge pond area and storage and discharge characteristic for the Cell 2 west bench area.

The surface of the covered tailings area will be covered by a rock mulch cover to protect the radon barrier and the tailings from wind dispersal and water erosion. This layer will be engineered to meet or exceed the required size, gradation and thickness requirements for the PMF. At the location of intersection or joint where the radon barrier meets the native ground, the transition rock will extend onto the native ground for protection. The PMP distribution in Figure 6-4 was used in the estimation of peak runoff flows for the overland flow paths on the tailings surface shown in Figures 6-2-Cell-1 and 6-2-Cell-2 for the Cell 1 and Cell 2 reclamation configurations, respectively. The distribution was developed using a proportioning technique presented in Hydrometeorological Report No. 55A (NWS, 1988) wherein the largest 15-minute precipitation depth is placed at the beginning of the one-hour storm. Each successive 15-minute precipitation depth is reduced and a polynomial fit was applied to the discrete proportions to give a continuous distribution curve. This distribution places the peak intensity at the beginning of the storm with a declining intensity as the storm continues. With the relatively short time of concentration for the overland flow paths, this type of distribution produces much larger peak flows. The overland flow paths were segmented into sections of relatively uniform slope using the sequential lettering in the suffix of the path name. The time of concentration was summed while moving downstream on each overland flow path. Table 6-2-Cell-1 presents the hydraulic characteristics of overland flow for the Cell 1 reclamation, and Table 6-2-Cell-2 presents the same information for the Cell 2 reclamation. The discharge was calculated on a unit width basis using the Rational Formula expressed as:

$$Q = CIA$$

where: Q = discharge per unit width in cfs/ft.
C = Runoff coefficient
I = Rainfall Intensity in inch/hr.
A = Area in acres

The runoff coefficient was set at 0.8 for the rock mulch areas and there are no areas where overland flow from off tailings areas is conveyed over the covered tailings surface. The rainfall intensity was calculated from the polynomial equation used to develop Figure 6-4 with the time of concentration. A minimum time of concentration of 2.5 minutes was used (recommended in NUREG/CR-4620) and this gave a maximum computational intensity of 32.75 inches/hour. The discharge for each successive segment was calculated using a cumulative area and the progressive time of concentration. The rock mulch sizing is described in following sections and in Appendix K.

TABLE 6-2-CELL-1. CELL 1 OVERLAND FLOW PATH CHARACTERISTICS AND ROCK MULCH DESIGN.

Path Name	Length (feet)	Relief (feet)	Slope (ft/ft)	Progressive Time of Concentration (min)	Discharge (cfs/ft)	Flow Depth (Inch)	Manning's n	Abt/ Johnson Rock D50 (Inch)	Target Rock D50 (Inch)
EP-1A	215	27	0.13	1.09	0.129	0.64	0.031	0.68	1.5
EP-1B	85	15	0.18	1.34	0.180	0.75	0.034	0.95	1.5
EP-1C	24	8	0.33	1.37	0.195	0.71	0.040	1.30	2.25
EP-2A	245	31	0.13	1.20	0.147	0.70	0.031	0.74	1.5
EP-2B	72	22	0.31	1.31	0.191	0.71	0.039	1.24	2.25
O1-1A	370	31	0.08	1.93	0.223	0.97	0.030	0.78	1.5
O1-1B	150	26	0.17	2.26	0.313	1.08	0.036	1.28	2.25
O1-2A	290	36	0.12	1.37	0.174	0.78	0.032	0.80	1.5
O1-2B	160	21	0.13	1.91	0.271	1.03	0.033	1.05	2.25
O1-3A	430	32	0.07	2.26	0.259	1.10	0.029	0.80	1.5
O1-3B	200	28	0.14	2.76	0.379	1.27	0.035	1.30	2.25
O1-4A	230	32	0.14	1.10	0.138	0.66	0.032	0.74	1.5
O1-4B	150	30	0.20	1.52	0.229	0.86	0.036	1.15	2.25
O1-4C	175	35	0.2	1.98	0.334	1.10	0.037	1.42	2.25

TABLE 6-2-CELL-2. CELL 2 OVERLAND FLOW PATH CHARACTERISTICS AND ROCK MULCH DESIGN.

Path Name	Length (feet)	Relief (feet)	Slope (ft/ft)	Progressive Time of Concentration (min)	Discharge (cfs/ft)	Flow Depth (Inch)	Manning's n	Abt/ Johnson Rock D50 (Inch)	Target Rock D50 (Inch)
EP-1A	215	27	0.13	1.09	0.129	0.64	0.031	0.68	1.5
EP-1B	85	15	0.18	1.34	0.180	0.75	0.034	0.95	1.5
EP-1C	24	8	0.33	1.37	0.195	0.71	0.040	1.30	2.25
EP-2A	245	31	0.13	1.20	0.147	0.70	0.031	0.74	1.5
EP-2B	72	22	0.31	1.31	0.191	0.71	0.039	1.24	2.25
O1-1A	370	31	0.08	1.93	0.223	0.97	0.030	0.78	1.5
O1-1B	150	26	0.17	2.26	0.313	1.08	0.036	1.28	2.25
O1-2A	290	36	0.12	1.37	0.174	0.78	0.032	0.80	1.5
O1-2B	160	21	0.13	1.91	0.271	1.03	0.033	1.05	2.25
O1-3A	430	32	0.07	2.26	0.259	1.10	0.029	0.80	1.5
O1-3B	200	28	0.14	2.76	0.379	1.27	0.035	1.30	2.25
O1-4A	230	32	0.14	1.10	0.138	0.66	0.032	0.74	1.5
O1-4B	150	30	0.20	1.52	0.229	0.86	0.036	1.15	2.25
O2-1A	425	52	0.12235	1.85	0.256	1.00	0.033	0.99	1.5
O2-1B	100	20	0.2	2.09	0.316	1.06	0.037	1.37	2.25
O2-2A	585	50	0.08547	2.72	0.352	1.31	0.031	1.01	1.5
O2-2B	140	22	0.15714	3.03	0.436	1.37	0.036	1.48	2.25
O2-2C	65	5	0.07692	3.26	0.475	1.62	0.031	1.14	2.25
O2-3A	405	52	0.1284	1.75	0.244	0.96	0.033	0.98	1.5
O2-3B	125	24	0.192	2.07	0.319	1.08	0.037	1.36	2.25
O2-4A	420	52	0.12381	1.83	0.253	0.99	0.033	0.99	1.5
O2-4B	125	24	0.192	2.13	0.328	1.10	0.037	1.38	2.25
O2-5A	410	52	0.12683	1.78	0.247	0.97	0.033	0.98	1.5
O2-5B	135	27	0.2	2.10	0.328	1.09	0.037	1.40	2.25

6.4 Rock Cover Protection Calculations

The rock protection provided for the covered tailings area is divided into the two categories of channel rock and rock mulch. This distinction is made on the basis of the methods for calculating rock size. Channel rock size is sized according to estimates of peak flow from the HEC-1 modeling using Manning's equation. The rock mulch is sized according to the unit discharge estimates in Tables 6-2-Cell-1 and 6-2-Cell-2.

6.4.1 Rock Quality

Four sources of rock are within a practical distance of the site and all three sources appear to be of common origin with very similar properties. These four sources include: the quarry (samples designated with the prefix QU) south of the mill area, the rock on the tailings dam face (samples designated with the prefix DS), the rocky soil cover (samples designated with the prefix RSC) which was used as a protective cover for the tailings cell clay liner and exists over the area northeast of the north dike, and the original borrow areas for the mill construction which was the source for the rocky soil. Of these rock sources, only the quarry rock, original borrow area rock, and possibly the dam rock will be used for rock mulch and channel rock with the exception of possible collection of large stones (>200 lbs.) from former borrow areas and the rocky soil cover. The quarry will be used to produce intermediate sized rock for rock mulch, large rock for channels, and the finer fraction from rock processing may be used in the upper cover layer for the tailings. If necessary, the rock production will expand to the original borrow areas to generate rock products similar to those produced from the quarry area. The rock from the dam face will be used primarily for the large channel rock, although a suitable rock mulch product may also be generated from the processing.

The samples from the three sampled rock sources consist of two types of rock in very similar proportions. Since the original borrow area was the source of much of the rock and rocky soil that is in place in the tailings area, the original borrow area is represented by these same samples. Approximately 36% of each rock source is made up of rock identified as an andesite porphyry, while the remainder is sandstone. Seven rock samples were taken with three from the quarry area, two from the dam and two from the rocky soil cover. The average percentages of porphyry in the samples were 35%, 36.5% and 36% for the quarry, dam and rocky soil cover samples, respectively. All samples were taken from rock that ranged in size from one inch to approximately six inches. Durability testing on these samples has revealed that the porphyry is of relatively good quality while the quality of the sandstone is marginal. It is likely that the proportion of porphyry or other more durable stones in larger rocks (diameter of one foot or greater) will be significantly larger than the average 36% for smaller rock and this was confirmed with rock counting estimates of rock proportions. However, the composite quality for rock of all sizes was assumed to be represented by the samples from the rock mulch sized rock. A sample of the porphyry and a sample of the sandstone were also subjected to petrographic analysis, which revealed that there was no smectite or other expansive clays in the rock. The results of the durability testing and petrographic analysis are included in Appendix C. The results of an earlier durability test (done in 1997) are also included in Appendix C. The durability results for this earlier sample were reasonably consistent with those for recent samples, but the proportions of rock type for this earlier sample are estimates.

The rock quality results and scoring for the rock samples are presented in Table 6-3. A composite rock quality score for the quarry rock and the dam rock was calculated using the individual NRC rock scoring method for the porphyry and the sandstone, and then using the proportions of each rock type to composite the score. The results reveal composite scores of 63.3 and 51.8 for the quarry and dam rock respectively. The RSC rock will not be used in the rock mulch or channel rock with the possible exception of larger stones (>200 lbs). With rock quality scores less than 80, the rock requires oversizing of 16.7% for the quarry rock and 28.2% for the dam rock. In order to overcome concerns for the rock quality, a minimum oversizing of 40% was established for all rock mulch and channel rock. This oversizing will result in a corresponding minimum overthickening of at least 40%. It should be noted that the marginal score for the dam rock was due largely to the marginal quality of the sandstone. The dam rock will be used primarily for channel riprap with a diameter ranging from approximately 6 inches to approximately 36 inches. As mentioned in a preceding paragraph, there is a strong likelihood that this bigger rock on the dam has a significantly higher percentage of the more durable rock, which would result in a much better composite score. However it is not possible to perform the quality testing on riprap of this size, and only a preliminary assessment of rock proportions is possible until some rock retrieval and processing is underway. A rock counting technique was used to assess proportions of rock types and this procedure and the results are discussed in Appendix C. Hence, the established minimum oversizing and overthickening of 33% will likely be even more conservative than indicated by the oversizing for present quality concerns.

The rock scores do not meet the minimum score of 65 for frequently saturated areas. However, the environment at the Shootaring site is arid with an estimated annual precipitation of 7 inches. Snowfall is very infrequent and the entire tailings facility is located on a massive sandstone formation. Hence, the designation of channels and rock toes as “frequently saturated” is not applicable to this site. With the drainage provided by the sandstone, rock filter and rock, the potential for saturation of the rock is limited to that occurring during and immediately after catastrophic events.

TABLE 6-3. ROCK QUALITY AND SCORING

Quarry Rock Quality Results:

Quarry Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.532	5.64	9	50.8	90
Absorp, %	1.6	3.8	2	7.6	20
Sod. Sulf., %	1.91	9.545	11	105.0	110
L.A. Abr., %	3.7	8.65	1	8.7	10
			Totals	172.0	230
				Percentage Score:	**74.8%**

Quarry Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.445	3.9	6	23.4	60
Absorp, %	2.13	2.74	5	13.7	50
Sod. Sulf., %	4.33	8.335	3	25.0	30
L.A. Abr., %	5.1	7.94118	8	63.5	80
			Totals	125.6	220
				Percentage Score:	**57.1%**

Quarry Composite:

Percent Andesite Porphyry	35%
Percent Sandstone	65%
Composite Score =(.748*.35)+(.571*.65) =	**63.3%**

Shootaring Dam Rock Quality Results:

Dam Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.529	5.58	9	50.2	90
Absorp, %	1.63	3.74	2	7.5	20
Sod. Sulf., %	4.16	8.42	11	92.6	110
L.A. Abr., %	3.9	8.55	1	8.6	10
			Totals	158.9	230
				Percentage Score:	**69.1%**

Dam Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.392	2.84	6	17.0	60
Absorp, %	2.25	2.5	5	12.5	50
Sod. Sulf., %	12.86	3.856	3	11.6	30
L.A. Abr., %	7.7	6.375	8	51.0	80
			Totals	92.1	220
				Percentage Score:	**41.9%**

Dam Composite:

Percent Andesite Porphyry	36.5%
Percent Sandstone	63.5%
Composite Score =(.691*.365)+(.419*.635) =	**51.8%**

Rock Soil Cover Quality Results:

Rock Soil Cover Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.475	4.5	9	40.5	90
Absorp, %	2.16	2.68	2	5.4	20
Sod. Sulf., %	8.46	5.90588	11	65.0	110
L.A. Abr., %	5.5	7.70588	1	7.7	10
			Totals	118.5	230
				Percentage Score:	**51.5%**

Rock Soil Cover Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.356	2.12	6	12.7	60
Absorp, %	3.1	0.8	5	4.0	50
Sod. Sulf., %	13.48	3.608	3	10.8	30
L.A. Abr., %	9.9	5.05882	8	40.5	80
			Totals	68.0	220
				Percentage Score:	**30.9%**

6.4.2 Channel Rock Sizing

The HEC-1 modeling described in a previous section was used to determine peak flows, which were then used in sizing of the rock for channels. The HEC-1 input files for the Cell 1 and Cell 2 reclamation configurations are included in Appendix J, along with the flow schematic and hydrographs for selected sections. Figures 6-9-Cell-1 and 6-9-Cell-2 present the hydrologic channel sections where the channel configuration and rock sizing were established. The common Cell 1 drainage system to the cross valley berm allows continuation of the hydrologic channel section numbering through the Cell 2 reclamation area. Therefore, the flow characteristics and rock sizing for both reclamation configurations are presented in Table 6-4. Manning's equation was used to determine hydraulic flow characteristics with a uniform Manning's n of 0.035 for rock sections. The Abt/Johnson method presented in NUREG-1623 was used to size the channel rock because it is applicable over a wide range of slope conditions. The rock and design methodology meets the criteria in NUREG-1623 for using the Abt/Johnson method with the exception of the specific gravity. The composite specific gravity of the composite rock is approximately 2.5 as opposed to the recommended minimum of 2.65. However, this is a deficiency of only 6% while the rock is being oversized by at least 46%. As discussed earlier, the rock is substantially oversized and overthickened to alleviate any concerns on suitability of the rock. Both the Manning's equation and the Abt/Johnson method are discussed in Appendix K.

The channel rock is divided into three sizes to fit various channel rock hydraulic characteristics. The primary channel rock has a minimum D_{50} of 14 inches (1.17 feet). This rock is used in sections HC-2, HC-5, HC-6, HC-10, and the porous rock ledge at section HC-3 as shown on Figures 6-9-Cell-1 and 6-9-Cell-2 and presented in Table 6-4. Based on the required rock size in Table 6-4, this large riprap is oversized by a minimum of 50%. The rock will be placed at a minimum thickness of 21 inches (1.75 feet). The large rock will be underlain by a filter layer consisting 6 inches (0.5 feet) of either rock mulch which in turn will be underlain by 6 inches (0.5 feet) of the quarry or other borrow area rocky soil material. The second rock size will be riprap with a minimum D_{50} of 6 inches (0.5 feet). This rock will be used in the moderately sloping channel reach represented by section HC-9 and will also be used as a rock apron at the toe of the reclaimed cross valley berm in the Cell 1 reclamation configuration. The minimum oversizing provided for this rock in the east Cell 2 channel section is 46%.

6.4.3 Overland Flow Rock Sizing

The overland flow rock sizing is presented in Tables 6-2-Cell-1 and 6-2-Cell-2 along with the flow characteristics for the flow paths. Like the channel rock sizing, the rock mulch sizing was done with the Abt/Johnson method. Two rock mulch sizes are indicated in Tables 6-2-Cell-1 and 6-2-Cell-1 with the smaller rock mulch having a design D_{50} of 1.5 inch while the larger rock mulch has a design D_{50} of 2.25 inch. The minimum overland flow oversizing for the small rock mulch is 49% and the minimum oversizing for the large rock mulch is 52% in the Cell 1 and Cell 2 reclamation configurations. Both rock mulches will be placed to a minimum thickness of 4 inches. Overthickening of the rock mulch will be allowed to accommodate larger stones provided a uniform surface is produced. Figure 6-10 presents the rock apron configuration for the downstream edge of rock mulch areas where the discharge is to the native surface.

TABLE 6-4. CHANNEL CONVEYANCE AND ROCK SIZING.

Hydrologic Cross-Section	Base Width (ft)	Right Side Slope (?H:1V)	Left Side Slope (?H:1V)	Bottom Slope (ft/ft)	Discharge (cfs)	Normal Flow Depth (ft)	Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)
HC-1	20	3	3	0.0017	148	2.202	58.6	33.93	1.73
HC-2	20	3	3	0.0360	521	1.897	48.7	32.00	1.52
HC-3	20	3	3	0.0029	514	3.733	116.5	43.61	2.67
HC-4	17	3	3	0.0026	568	4.310	129.0	44.26	2.91
HC-5	10	3	3	0.1100	208	1.166	15.7	17.37	0.91
HC-6	30	3	3	0.0710	733	1.537	53.2	39.72	1.34
HC-7	7	5	5	0.0015	203	3.346	79.4	41.12	1.93
HC-8	30	3	3	0.0093	928	3.133	123.4	49.82	2.48
HC-9	25	3	3	0.0028	299	2.477	86.5	45.46	1.90
HC-10	30	3	3	0.0320	1181	2.537	95.4	46.04	2.07

Hydrologic Cross-Section	Flow Velocity (fps)	Top Width (ft)	Froude Number	Average Unit Discharge (cfs/ft)	Abt/Johnson Rock D50 (ft)	Rock Type +	Target Riprap D50 (ft)	Rock Oversizing (%)
HC-1	2.53	33.21	0.34	5.56	0.073	MLCH	0.188	156
HC-2	10.69	31.38	1.51	20.28	0.563	LRG	1.170	108
HC-3	4.41	42.40	0.47	16.47	0.170	LRG	1.170	590
HC-4	4.40	42.86	0.45	18.98	0.174	INT	0.500	187
HC-5	13.22	17.00	2.42	15.41	0.780	LRG	1.170	50
HC-6	13.78	39.22	2.09	21.18	0.772	LRG	1.170	51
HC-7	2.56	40.46	0.32	8.55	0.089	MLCH	0.188	112
HC-8	7.52	48.80	0.83	23.55	0.342	INT	0.500	46
HC-9	3.46	44.82	0.44	8.57	0.116	MLCH	0.188	62
HC-10	12.38	45.22	1.50	31.40	0.68	LRG	1.17	71

\+ - Rock Type INT = Intermediate Rock
LRG = Large Rock
MLCH = Large Rock Mulch

6.4.4 Channel Rock Toe

A rock toe or apron will be placed at the terminus of the major discharge channel just downstream of the cross valley berm for the Cell 1 reclamation and at the discharge point for the major east Cell 2 channel for the Cell 2 reclamation. In addition to the stilling basin formed by the extension of the channel rock beyond the break in slope, very large stones will be placed in an apron across the swale as shown in Figure 6-9-Cell-1 and Figure 6-9-Cell-2. These stones will be selected with a D_{50} of 24 inches or greater and will be placed in a toe protection to a thickness of 48 inches or more. Figure 6-11 presents a cross-section schematic to illustrate the placement of the rock toe.

6.4.5 Porous Rock Ledge

Figure 6-12 presents a schematic with a longitudinal section of the porous rock ledge discussed in Section 6.3. The ledge serves to restrict peak flows during a PMF level event. Figure 6-13 presents a cross section of the rock porous rock ledge. The rock ledge is primarily an above grade structure located in a very mildly sloped channel section. Discharge through the rock ledge will be a combination of flow through the voids in the rock and overfall discharge at flow depths of more than 3.5 feet. With the exception of relatively small discharges that occur through the gap in the ledge, the submergence of the structure will only occur with catastrophic runoff events approaching the PMF.

6.4.6 Rock Filters

A rock filter will be used under the channel rock to prevent erosion of the underlying materials through the rock. The filter system for the large channel rock will consist of 6 inches of the rock mulch underlain by 6 inches of the quarry area or similar material, which may be unsorted with the exception of removal of the +6-inch fraction. The filter for the intermediate (0.5 foot D_{50}) rock and will consist of 6 inches of the quarry area material or similar material which may be unsorted with the exception of removal of the +6 inch fraction. One of the rock mulch products may also be used in a dual filter configuration for the intermediate rock in critical areas. No specific filter system will be placed under the rock mulch or the portions of the channel rock over the covered tailings area because the upper two feet of the cover consists of the quarry area material from which the +9 inch fraction has been removed. The presence of this rocky material on the covered tailings area negates the need for an additional filter.

6.4.7 Sediment and Debris Impacts

The drainage design for the covered tailings area is not subject to detrimental effects from sediment deposition. Runoff from unprotected areas outside of the tailings is captured in perimeter channels and prevented from flowing across the covered tailings surface. The drainage channel configuration allows accumulation of substantial depths of sediment with no plausible potential for diversion or blockage of the channel. It is possible that a few inches or even a few feet of sediment could accumulate in the mildly sloping sections of the swales and channels, but since the side slopes of the channel in these areas continue on up to provide effective channel depths of several feet, there is really no plausible overtopping scenario. The sediment will be quickly scoured out of the channels if a very severe event occurs, and in the absence of a severe runoff condition, the depth of sediment will eventually reach a pseudo-steady condition based upon the grade to convey smaller runoff flows. These depths will be far below those that will have detrimental effects on the channel.

Sediment accumulation on the rock mulch covered tailings surface will not adversely affect the overland drainage pattern. With the simple drainage pattern at mild to moderate slopes, the potential sediment-caused diversions on the rock mulch surface area are limited to very local flow concentrations occurring over a distance of a few feet. The rock mulch is sufficiently oversized and overthickened to withstand local flow concentrations under PMF conditions.

The potential for detrimental debris and talus accumulation on the western side of the reclaimed Cell 1 and Cell 2 tailings area is very small. The perimeter bench and channel configurations on the west side of the tailings area provide a buffer zone and a trap area for large stones that may come off the bluff. A typical buffer zone width between the native surface and the covered tailings is 40 feet or more. The accumulation of sediment or debris in the perimeter channel will not adversely affect the tailings because any water impounded by the resulting minor blockage of the channel will be outside of the covered tailings area. The below grade depressions on the west side of Cell 2 should serve to trap stones, sediment, and other debris.

6.5 Dam Breach

The current Shootaring Canyon dam will be breached for the Cell 1 reclamation configuration to provide materials for the tailings cover construction and to prevent accumulation of excessive quantities of water behind the dam. The dam will be breached to a depth of approximately 4374 ft. above MSL which leaves a small depression upstream of the dam with an estimated bottom elevation of 4364 ft. above MSL. This depression will act as a surge pond during extreme events. Due to the permeability of the sandstone on which the facility was constructed, it is unlikely that significant long-term ponding of runoff will occur in this depression. However, this small depression will likely prevent significant runoff through the dam breach for all but very severe events. This small depression will trap sediment from larger runoff events. Some of the rock currently on the downstream face of the dam will be placed to form an outfall from the breach on the downstream side of the reclaimed dam. The tailings dam and the downstream rock outfall are located nearly 1000 feet from the rock toe of the channel from the covered tailings area and thus the dam breach is not an integral part of the tailings erosion protection. However this breach configuration should provide a stable downstream channel section and allow return of this off-tailings area to other beneficial use.

6.6 Landslide Impacts

The predominant feature along the west side of the tailings facility is a rock bluff. This rock bluff is composed of the native sandstone bedrock which underlies the tailings facility. The nearly vertical cliff areas on this bluff are between one hundred (100) and two hundred (200) feet high. The base or toe of the nearly vertical cliff is set back from the edge of the reclaimed tailings contact area a minimum of one hundred and fifty (150) feet and in most areas over two hundred (200) feet. At the base or toe of the sandstone cliff areas the ground slopes to the tailings cell area at roughly a 2:1 H/V slope. Scattered on the surface of the side slopes are an assortment of small and large blocks of weathered sandstone from past landslide and rock fall events. In the event of a landslide in which sandstone rocks and boulders come off the top or sides of the cliffs, this material would first impact on the sandstone slopes at or near the base of the cliff above the tailings cap. The side slopes and not the tailings cap would first absorb the kinetic energy of the falling material. The weathered sandstone rocks or boulders would have a tendency to fracture into smaller sizes. The fractured and weathered sandstone rocks would then slide or tumble into the previously fallen sandstone material further reducing the kinetic energy. Fragments of the boulders may continue to slide or tumble down the side slope towards the reclaimed tailings cell but it is unlikely that they will be large enough or retain enough energy to traverse the flat channel or bench buffer area and make it to covered tailings area.

6.7 Erosion Protection – Rock Materials and Placement

6.7.1 Responsibilities

Construction work under this specification will be performed under an earthwork or rock placement contract or by PRL's manpower.

Quality control testing/inspection will be done by PRL using a vendor soil testing service.

6.7.2 Performance Standards

1. All rock used for erosion protection shall be obtained in the designated borrow areas adjacent to the site as shown on Figure 6-14 or from the original borrow areas for mill and dam construction.

2. The rock shall be processed to produce those sizes and gradations as calculated in the erosion protection section of the specifications.

3. The quality of rock shall be not less than a weighted score of 50 for all applications of erosion protection. The rock has been oversized by a factor of 33% or more in the design process.

4. The rock used for covers on the tailings cell and riprap used in the channels shall be sized to provide a minimum D_{50} as follows:

Small rock mulch for tailings surface	D_{50} = 1.5 inch
Large rock mulch for tailings surface	D_{50} = 2.25 inches
Intermediate channel riprap	D_{50} = 6 inches
Large channel riprap	D_{50} = 14 inches
Rock toe riprap	D_{50} = 24 inches

5. Rock covers and riprap shall be 90% - 125% of the following thickness:

Rock mulch for tailings surface	0.33 feet
Intermediate channel riprap	1.0 feet
Large channel riprap	1.75 feet
Rock toe riprap	4.0 feet

6. Filter and bedding materials and riprap shall be 90% - 125% of the following thickness:

Intermediate channel riprap general filter	0.50 feet
Large channel riprap upper filter	0.50 feet
Large channel riprap lower filter	0.50 feet

7. Rock covers and riprap shall be placed by dumping and spreading with heavy equipment to:

a) maintain the acceptable gradation ranges listed above and avoid segregation of sizes
b) create a uniform cover surface free of visible high or low spots or ridges that could result in flow diversion. The surface irregularities for the large channel rock should not exceed 10% of the rock thickness over distances of several feet. The surface irregularities for the rock mulch and small channel rock are controlled by the thickness tolerance which limits irregularities to a few inches.

8. The excavation and/or shaping of the rock cut, transition protection and toe protection will be to the required dimensions as calculated in the erosion protection section of the specifications. The bedding material and coarse riprap will be placed to the design thicknesses and heights.

6.7.3 Testing and Inspection

1. Daily visual inspection of rock delivered and placed during construction shall be performed by PRL or its designee. The visual inspection shall be performed to ensure rock is being placed in conformance to the specifications.

2. Prior to placement of rock, the top of the soil cover layer shall be surveyed for as-built information and to serve as baseline or bottom of the rock cover layer. Once the rock cover layer has been placed, it shall be resurveyed and compared against the top of soil cover layer for thickness verification of the placed rock material. This method does not negate or substitute for rock thickness testing procedures being performed by the use of a tape measure as the cover advances. As a guideline, this procedure should be performed on a regular basis to ensure that placement is to the specified thickness.

3. Testing procedures and frequencies of the rock cover materials shall be as follows:

   a. During production and placement of the riprap and bedding materials PRL or its designee will define the locations and materials to be tested in the field. Gradation tests for each material type shall be performed a minimum of four times during production. During the preliminary stages of production a sample shall be obtained and tested. This will be followed by additional samples when approximately one-third and two-thirds of the total volume has been produced. A final sample shall be obtained and tested near the completion of production. Should the total quantity of materials to be produced be less than 30,000 cubic yards, samples shall be taken near production startup, near the one-third points of production and near completion of production for each type. If the total volume of material is greater than 30,000 cubic yards, a gradation test shall be performed for each additional 10,000 cubic yards or fraction thereof. The following gradation tests shall be performed during production of the rock cover materials:

TEST METHOD	TEST
ASTM C 117, ASTM C 136	Gradation
ASTM D 5519	Particle Size Analysis of Natural and Man-made Riprap Materials

b. The durability of the rock cover material produced shall be 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 composite "rating" or "score" resulting from this evaluation must exceed 50 for acceptance of the rock material. Durability tests for each material type shall be taken at the same frequency intervals as gradation testing, once during the initial phase of production, near the one-third and two-thirds points of production and near the completion of production. Should the total quantity of materials to be produced be less than 30,000 cubic yards, samples shall be taken near production startup, near the one-third points of production and near completion of production for each type. If the total volume of material is greater than 30,000 cubic yards, a gradation test shall be performed for each additional 10,000 cubic yards or fraction thereof. Testing procedures shall be as follows:

TEST METHOD	**TEST**
ASTM C 127	Specific Gravity (Saturated surface dry basis)
ASTM C 127	Absorption
ASTM C 88 (5 cycles)	Soundness
ASTM C 131 (100 revolutions)	Abrasion

Petrographic examination of the rock has been performed and will not be repeated.

In the event that unforeseen rock types are encountered during production, a complete set of durability tests will be run and the material re-scored.

c. The suitability of the rock on the dam face to be processed for large channel rock will be evaluated in the field by a professional geologist or by personnel who have been trained by the Geologist in inspection/selection procedures. Rocks that have joints or planes of weakness at a spacing less than the established D50, or have excessive porosity, or have significant variation in grain size, or have undesirable shape and dimensions, or have other characteristics that render the rock inferior will be clearly marked and excluded from the rock to be placed in the tailings area channel. Striking of the rocks with a rock hammer or testing with a Schmidt hammer may be used to evaluate rock hardness at the direction of the Geologist or Engineer. The inspection/selection process will be done on all rock to be placed as large channel riprap in the tailings area channel.

d. The riprap placed in the channels will be visually inspected to insure that no significant quantities of inferior rock are placed within the channel. The rock will be removed and replaced in areas where the rock is deficient in size, shape or durability.

e. The surface of the large channel riprap will be surveyed and visually inspected to confirm the thickness of riprap and to insure that there are no local surface irregularities that could result in a flow diversion or constitute a significant deviation from design grades. Thickness of the riprap must be within 90% to 125% of design thickness. In addition, differences in thickness measured over a representative area (15 square feet or greater) cannot exceed 10% of the rock thickness over distances of up to 15 feet. The survey data will include channel centerline locations at a 100 foot interval supplemented by a minimum of three other survey points across the channel within each 100 foot interval. The thickness of rock riprap and filter may also be verified by excavation and direct measurement at selected locations.

f. The surface of the rock mulch will be surveyed and visually inspected to confirm the thickness of riprap and to insure that there are no local surface irregularities that could result in diversion of flows. The survey data will include a minimum of one survey point per 10,000 square feet of surface area. . The thickness of rock mulch may also be verified by excavation and direct measurement at selected locations.

6.7.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of rock and bedding placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

6.7.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

6.7.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

6.8 Excavation and Shaping of Channel Cut and Transition Protection

6.8.1 Responsibilities

Construction work under this specification will be performed under an earthwork or rock placement contract or by PRL's forces.

Quality control testing/inspection will be done by PRL using a vendor soil testing service.

6.8.2 Performance Standards

1. Channel cuts, transition protection, and toe protection will be constructed to the lines, grades and dimensions as determined. The control points needed for the establishment of the construction staking of the work will be provided by PRL or their representative. Actual construction staking may be performed by PRL by their own forces if they elect or by a qualified firm for contract construction.

2. The material obtained from the channel cut excavation may be utilized as interim cover prior to placing the radon barrier. Excess material from the channel cut may be disposed of in approved locations.

3. All embankments outside of the tailings shall be placed in a maximum of eight (8) inch lifts and compacted by wheel rolling of equipment or other methods as directed by PRL. Placement of embankment and fill materials within the tailings area is described in section 5.

4. No fill materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. PRL shall determine when these adverse conditions exist.

5. Excavation of the channel cut will not be performed by means of blasting without the written permission of PRL. It must be demonstrated that any blasting performed will not jeopardize the stability of or the performance of the cross valley berm. All liabilities for the damage by blasting will be born by the contractor performing the excavation work.

6. All survey books used in the staking and checking of the ditches will be turned over to PRL for review as requested and at termination of the project given to PRL for their permanent records.

6.8.3 Testing and Inspection

1. Daily visual inspection of the construction activity shall be performed by PRL. Verification of lines, grades and dimensions will be performed by use of survey equipment appropriate for verification needs.

6.8.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the quantities and locations of ditch excavation and embankment and significant events or conditions that affect the placement and properties of the materials.

2. Vendor soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to PRL.

6.8.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

6.8.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

6.9 Regrading and Shaping of Disturbed Borrow Areas

6.9.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by PRL's forces.

Quality control testing/inspection will be done by PRL using a vendor soil testing service.

6.9.2 Performance Standards

1. All borrow areas shall be graded after all other construction activities have been completed and before revegetation activities of the affected area begins.

2. All slopes in the borrow areas will be regraded to a maximum slope of 4:1 horizontal to vertical after all materials required from such borrow area is obtained. The oversize, reject or excess processed material will be placed or scattered along any working face prior to the flattening of the slopes. The entire disturbed site will be regraded to maintain the directions and gradients of ground surfaces that existed prior to the borrow areas development, if practical.

3. After grading is complete, topsoil removed (if any) will be replaced in preparation of seeding.

4. Site seeding will follow topsoil placement (if any) and conform to the latest technologies for establishment of plant growths in arid regions. Seed certification slips as to type, species, and germination will be given to and retained by PRL for permanent record requirements.

5. No seeding will be allowed while the ground is frozen or during times of freezing temperatures.

6.9.3 Testing and Inspection

1. Daily visual inspection of the regrading and seeding activities shall be performed by PRL.

6.9.4 Documentation and Reporting

1. PRL shall maintain a daily construction activity log, recording the regrading, topsoil placement, and seeding activities. An aerial photography survey will be performed of the entire site after completion of the final grading of all disturbed areas, tailings, and mill site. The resulting topographic map will be submitted as documentation of the adequacy of final lines and grades.

6.9.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the PRL representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

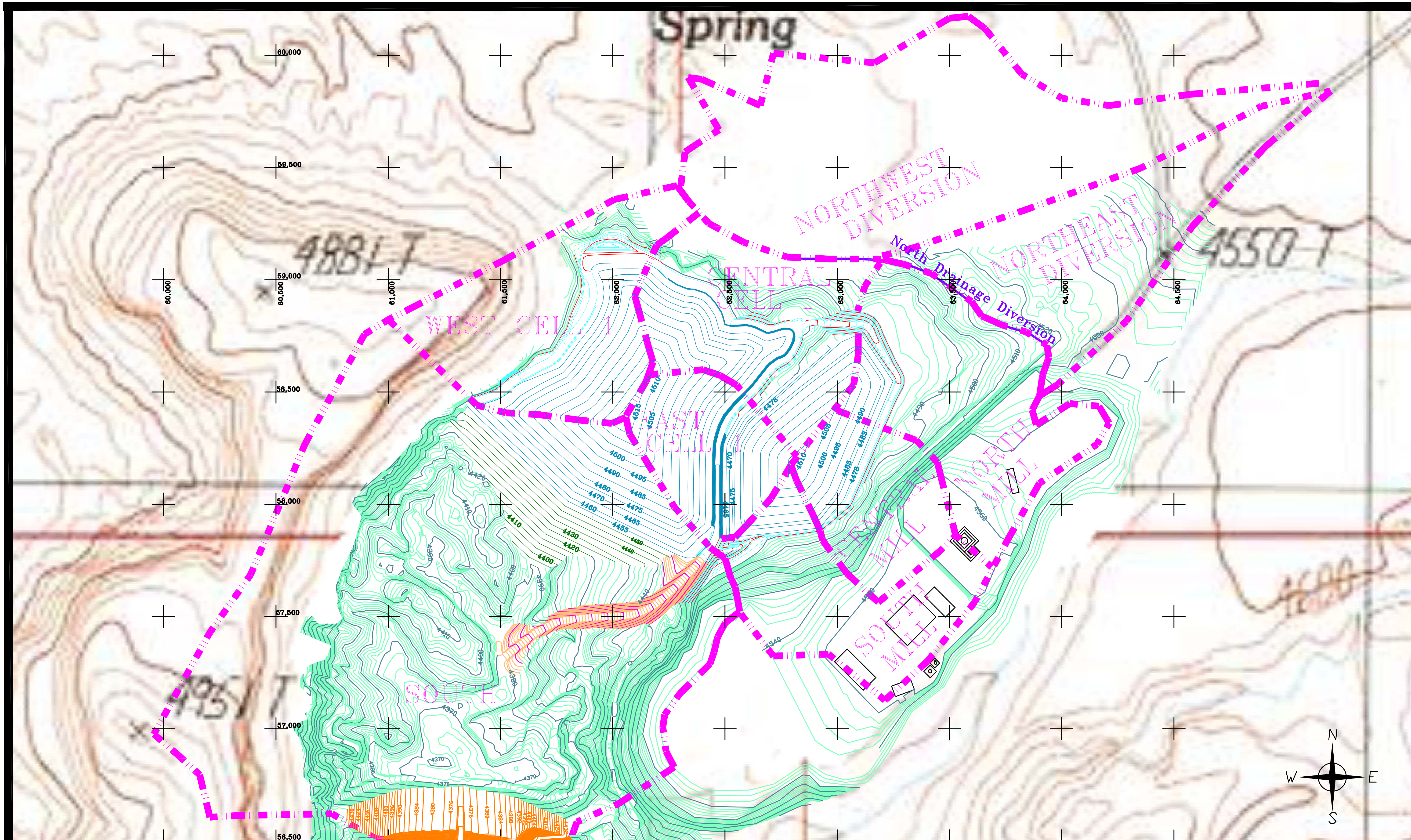
2. The designated corrective action will be implemented before additional related work is permitted. PRL will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by PRL for any nonconformance that, in PRL's judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

6.9.6 Records

1. A daily project journal will be maintained by PRL's representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. PRL will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.



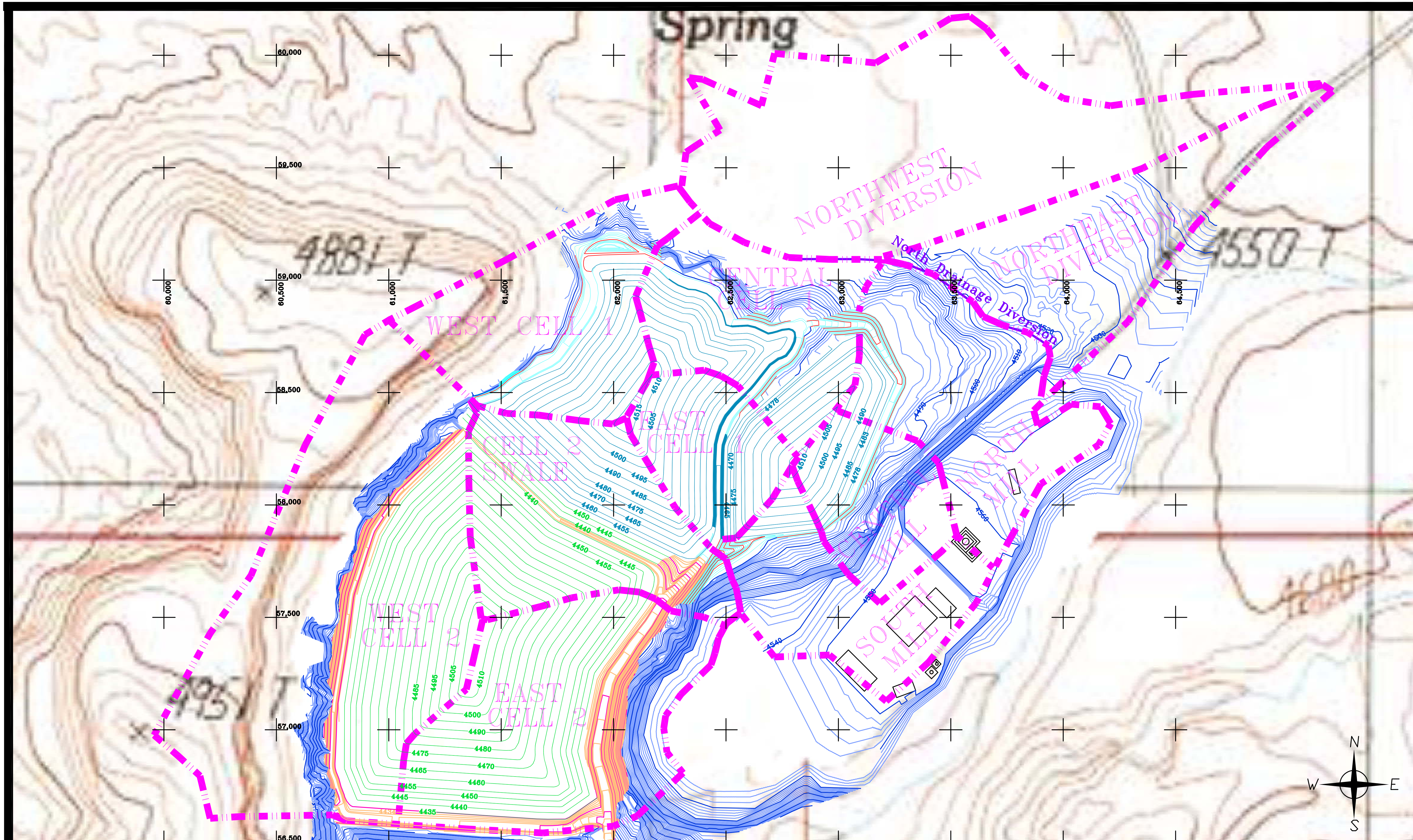
LEGEND

DRAINAGE DIVIDE

PLATEAU RESOURCES Ltd.

FIGURE 6-1-CELL-1. CELL 1 TAILINGS RECLAMATION DRAINAGE BASINS

DATE: 12-2005	RECWORK05.DWG	SCALE: 1"=400'
Page: 6-22	HYDRO-ENGINEERING L.L.C.	



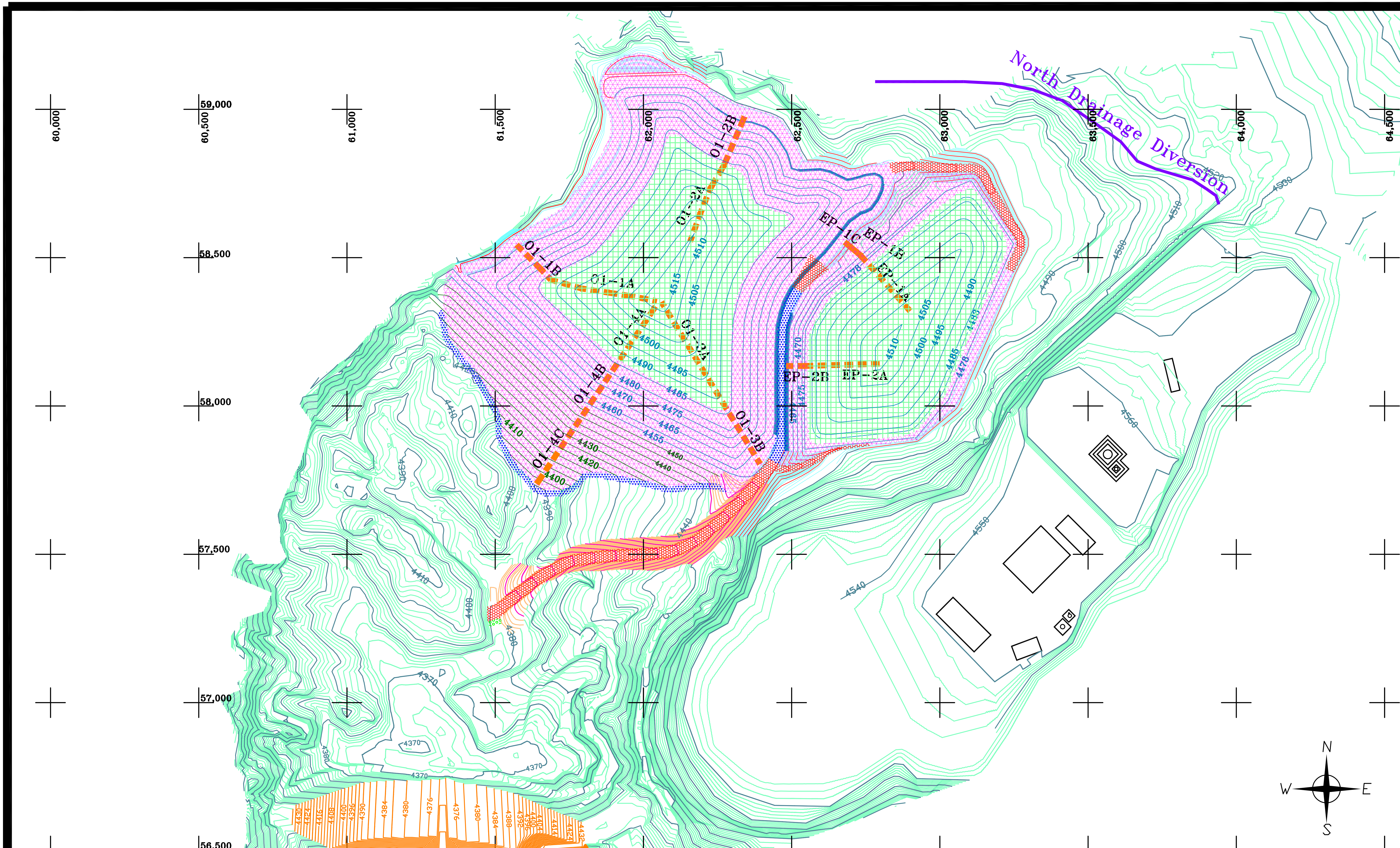
LEGEND

DRAINAGE DIVIDE

PLATEAU RESOURCES Ltd.

FIGURE 6-1-CELL-2. CELL 2 TAILINGS RECLAMATION DRAINAGE BASINS

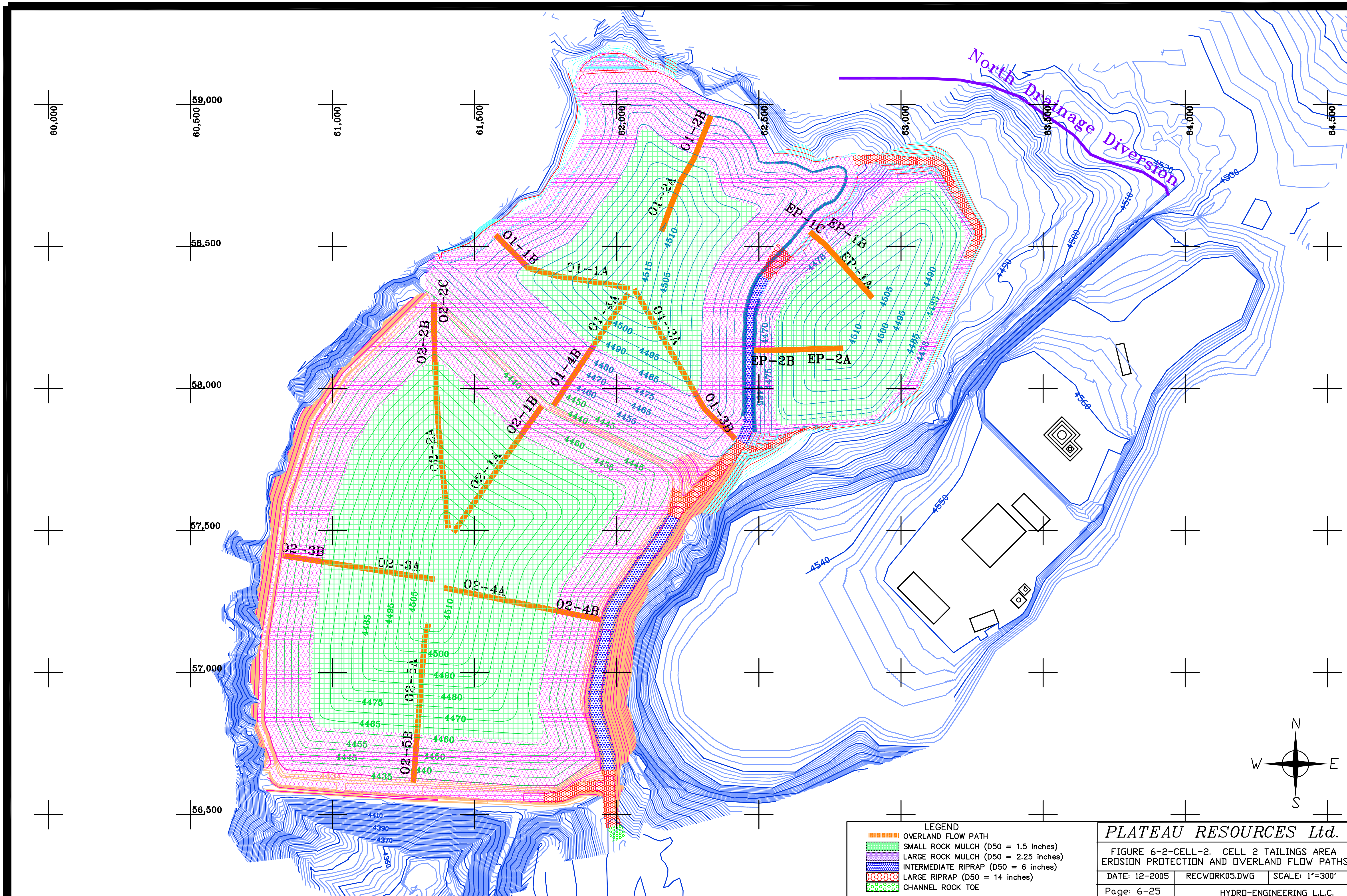
DATE: 12-2005	RECWORK05.DWG	SCALE: 1"=400'
Page: 6-23	HYDRO-ENGINEERING L.L.C.	

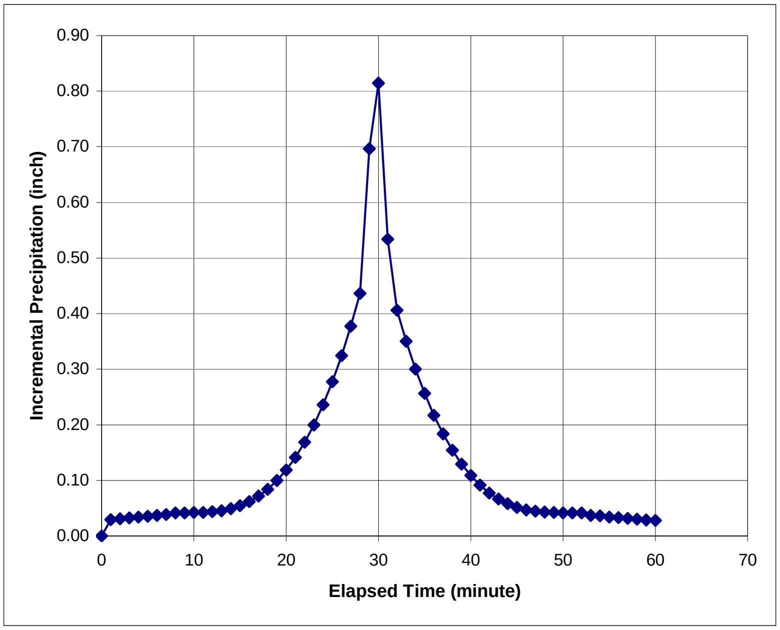


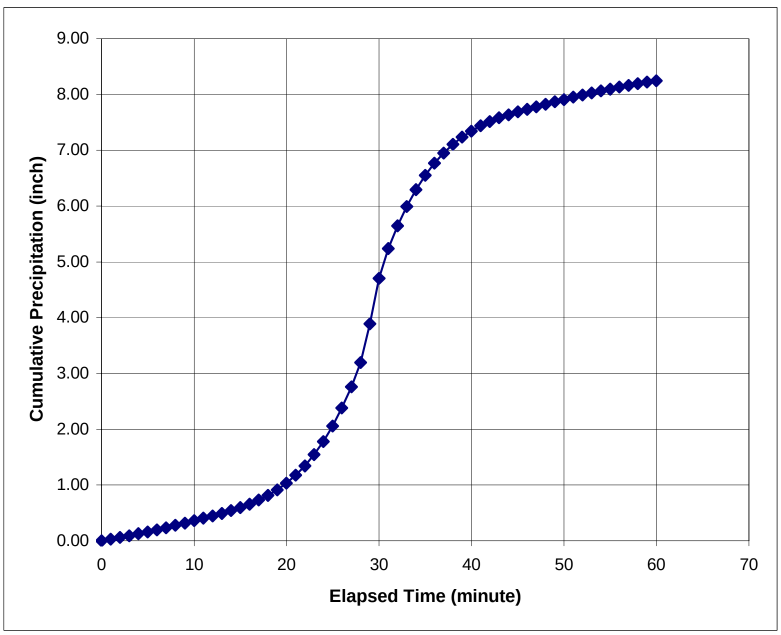
PLATEAU RESOURCES Ltd.

FIGURE 6-2-CELL-1. CELL 1 TAILINGS AREA EROSION PROTECTION AND OVERLAND FLOW PATHS

DATE: 12-2005	RECWORK05.DWG	SCALE: 1"=300'
Page: 6-24	HYDRO-ENGINEERING L.L.C.	

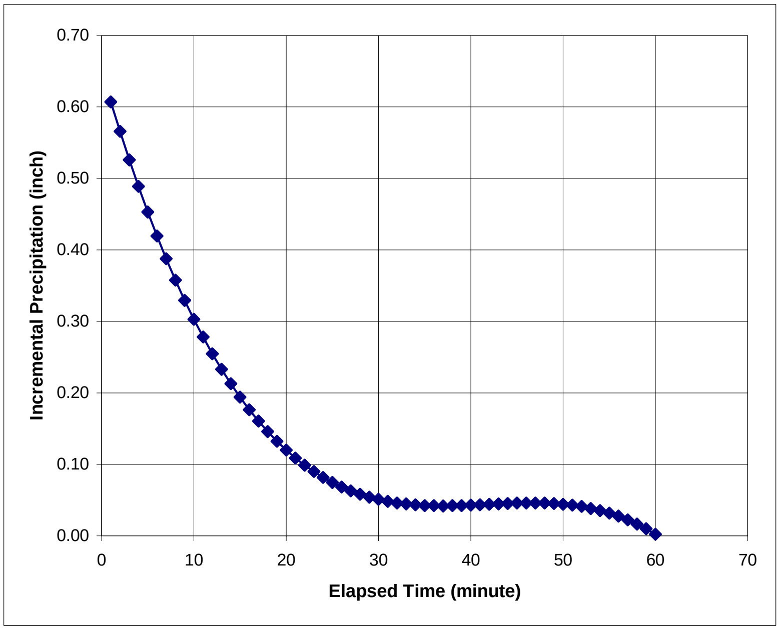

North Drainage Diversion
60,000
60,500
61,000
61,500
62,000
62,500
63,000
63,500
64,000
64,500
59,000
58,500
58,000
57,500
57,000
56,500
01-1A
01-1B
01-2A
01-2B
01-3A
01-3B
01-4A
01-4B
02-1A
02-1B
02-2A
02-2B
02-2C
02-3A
02-3B
02-4A
02-4B
02-5A
02-5B
EP-1A
EP-1B
EP-1C
EP-2A
EP-2B
N
W
E
S
LEGEND
OVERLAND FLOW PATH
SMALL ROCK MULCH (D50 = 1.5 inches)
LARGE ROCK MULCH (D50 = 2.25 inches)
INTERMEDIATE RIPRAP (D50 = 6 inches)
LARGE RIPRAP (D50 = 14 inches)
CHANNEL ROCK TOE
PLATEAU RESOURCES Ltd.
FIGURE 6-2-CELL-2. CELL 2 TAILINGS AREA
EROSION PROTECTION AND OVERLAND FLOW PATHS
DATE: 12-2005
RECWORK05.DWG
SCALE: 1"=300'
Page: 6-25
HYDRO-ENGINEERING L.L.C.

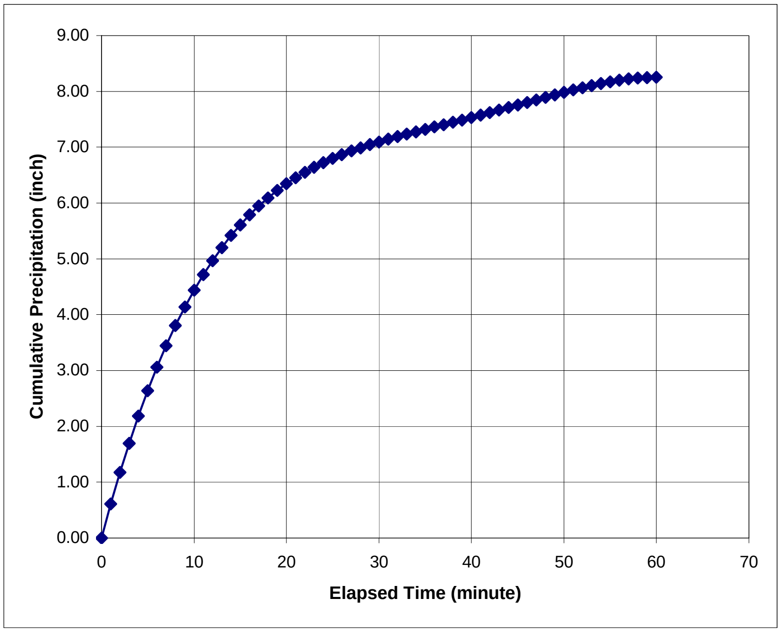




Time (minute)	Incremental Precipitation (inch)	Cumulative Precipitation (inch)
0	0.0000	0.0000
1	0.0293	0.0293
2	0.0308	0.0601
3	0.0323	0.0924
4	0.0337	0.1261
5	0.0352	0.1613
6	0.0367	0.1980
7	0.0382	0.2362
8	0.0417	0.2779
9	0.0418	0.3197
10	0.0420	0.3617
11	0.0424	0.4041
12	0.0435	0.4476
13	0.0457	0.4933
14	0.0493	0.5426
15	0.0544	0.5970
16	0.0618	0.6588
17	0.0715	0.7303
18	0.0840	0.8143
19	0.0996	0.9139
20	0.1186	1.0325
21	0.1414	1.1739
22	0.1683	1.3422
23	0.1998	1.5420
24	0.2361	1.7781
25	0.2775	2.0556
26	0.3244	2.3800
27	0.3774	2.7574
28	0.4363	3.1937
29	0.6968	3.8905
30	0.8145	4.7050
31	0.5338	5.2388
32	0.4061	5.6449
33	0.3501	5.9950
34	0.3003	6.2953
35	0.2561	6.5514
36	0.2173	6.7687
37	0.1835	6.9522
38	0.1543	7.1065
39	0.1295	7.2360
40	0.1086	7.3446
41	0.0914	7.4360
42	0.0774	7.5134
43	0.0663	7.5797
44	0.0579	7.6376
45	0.0516	7.6892
46	0.0472	7.7364
47	0.0445	7.7809
48	0.0429	7.8238
49	0.0421	7.8659
50	0.0419	7.9078
51	0.0418	7.9496
52	0.0415	7.9911
53	0.0374	8.0285
54	0.0360	8.0645
55	0.0344	8.0989
56	0.0330	8.1319
57	0.0316	8.1635
58	0.0300	8.1935
59	0.0286	8.2221
60	0.0279	8.2500

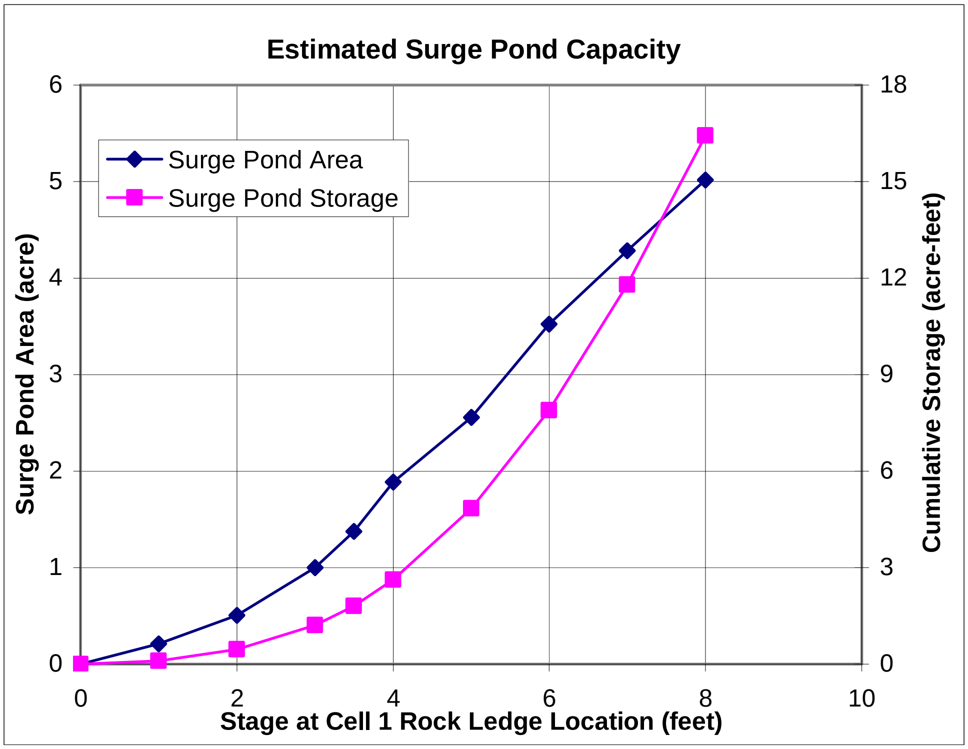
FIGURE 6-3. INCREMENTAL AND CUMULATIVE 1-HOUR, 1-SQUARE MILE PMP PRECIPITATION DISTRIBUTIONS FOR HEC-1 ANALYSIS





Time (minute)	Incremental Precipitation (inch)	Cumulative Precipitation (inch)
0	0.0000	0.0000
1	0.6073	0.6073
2	0.5657	1.1730
3	0.5261	1.6991
4	0.4886	2.1877
5	0.4530	2.6407
6	0.4193	3.0600
7	0.3876	3.4476
8	0.3576	3.8051
9	0.3294	4.1345
10	0.3028	4.4373
11	0.2780	4.7153
12	0.2547	4.9700
13	0.2330	5.2031
14	0.2128	5.4159
15	0.1941	5.6100
16	0.1767	5.7867
17	0.1607	5.9474
18	0.1460	6.0934
19	0.1325	6.2258
20	0.1202	6.3460
21	0.1090	6.4550
22	0.0989	6.5540
23	0.0899	6.6438
24	0.0818	6.7256
25	0.0746	6.8003
26	0.0684	6.8687
27	0.0629	6.9316
28	0.0582	6.9898
29	0.0543	7.0440
30	0.0509	7.0950
31	0.0483	7.1432
32	0.0461	7.1894
33	0.0445	7.2339
34	0.0433	7.2772
35	0.0426	7.3198
36	0.0422	7.3619
37	0.0420	7.4040
38	0.0422	7.4462
39	0.0425	7.4887
40	0.0430	7.5317
41	0.0436	7.5752
42	0.0442	7.6194
43	0.0448	7.6641
44	0.0453	7.7094
45	0.0457	7.7551
46	0.0459	7.8010
47	0.0460	7.8470
48	0.0457	7.8927
49	0.0451	7.9378
50	0.0442	7.9820
51	0.0428	8.0248
52	0.0409	8.0657
53	0.0385	8.1042
54	0.0355	8.1397
55	0.0319	8.1715
56	0.0276	8.1991
57	0.0225	8.2216
58	0.0166	8.2382
59	0.0099	8.2481
60	0.0023	8.2504

FIGURE 6-4. INCREMENTAL AND CUMULATIVE 1-HOUR, 1-SQUARE MILE PMP PRECIPITATION DISTRIBUTIONS FOR OVERLAND FLOW ANALYSIS



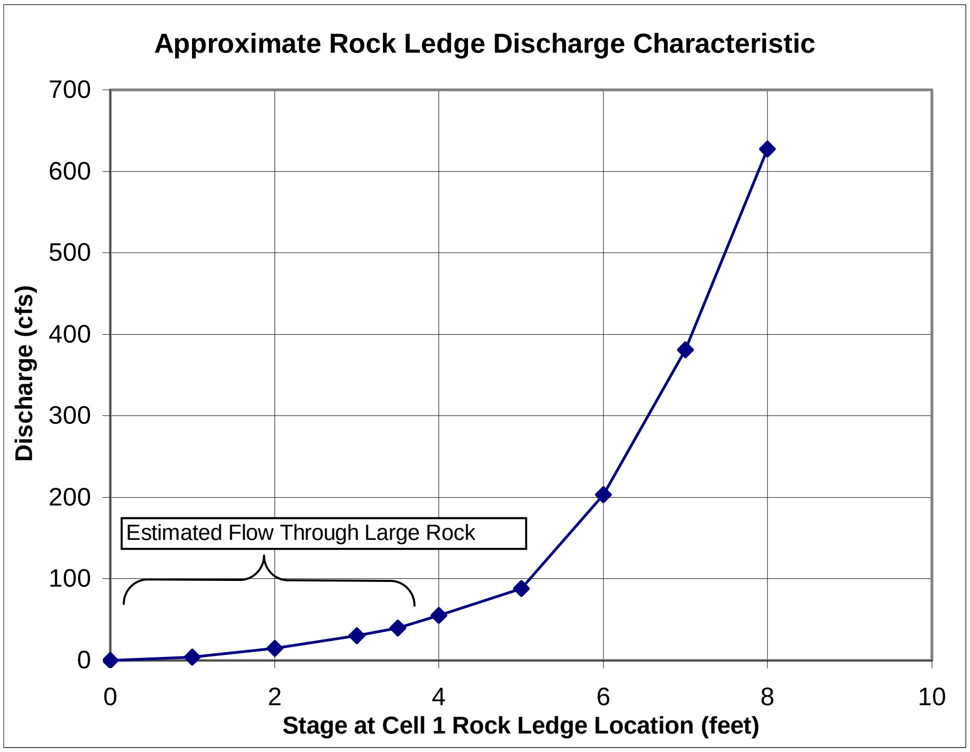
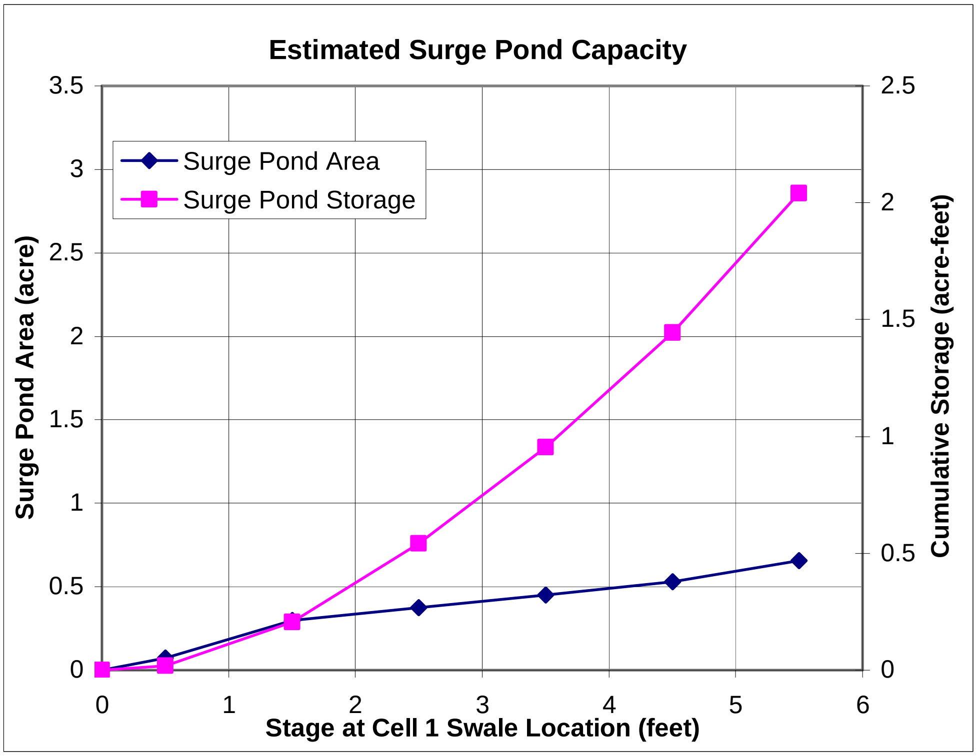


Figure 6-5. Surge Pond Storage and Porous Rock Ledge Discharge Characteristic



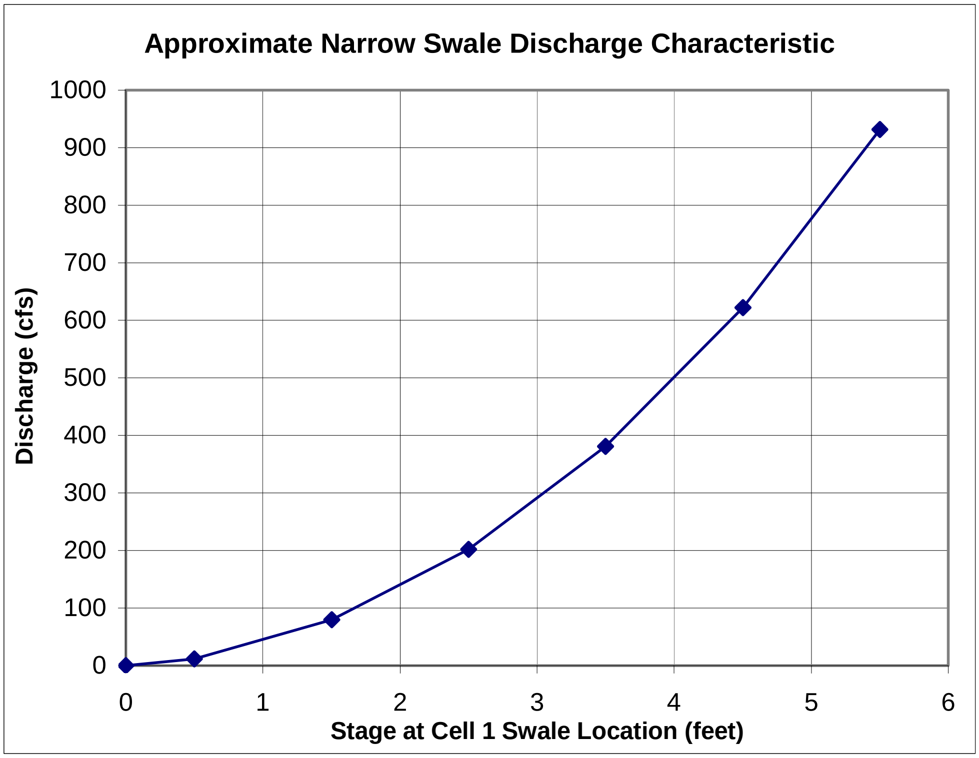
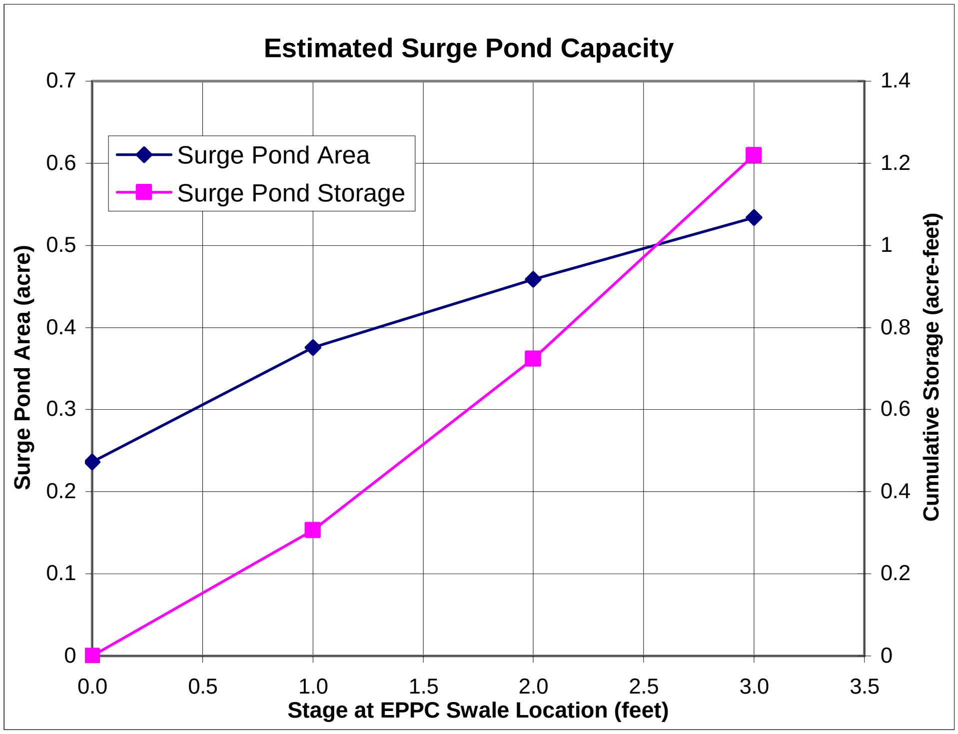


Figure 6-6. Cell 1 Swale Surge Pond Storage and Discharge Characteristic



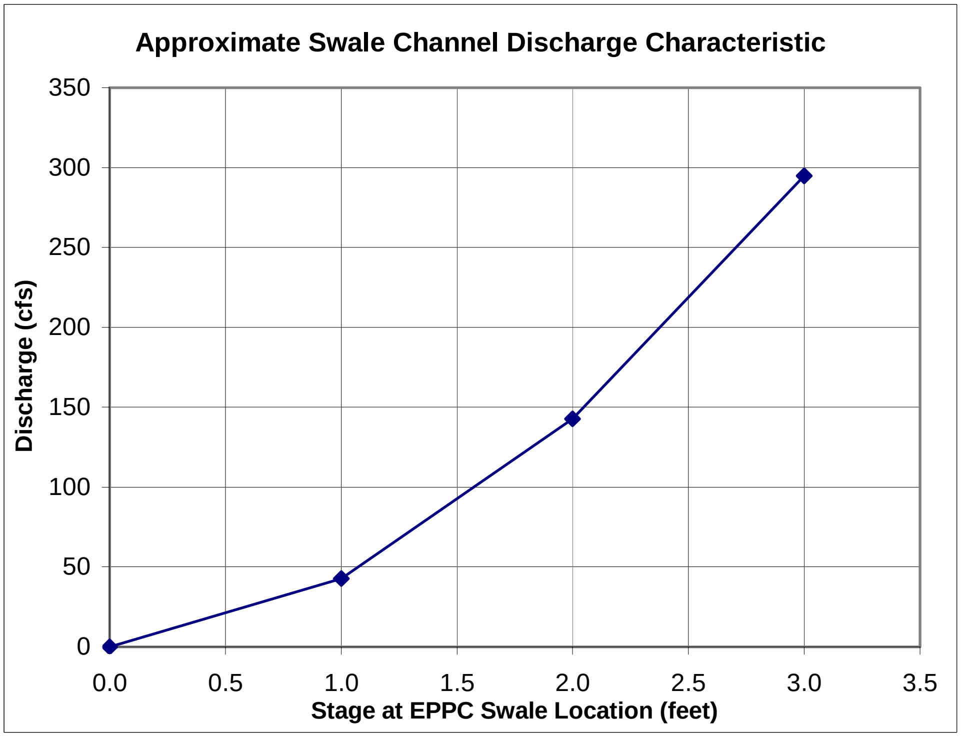
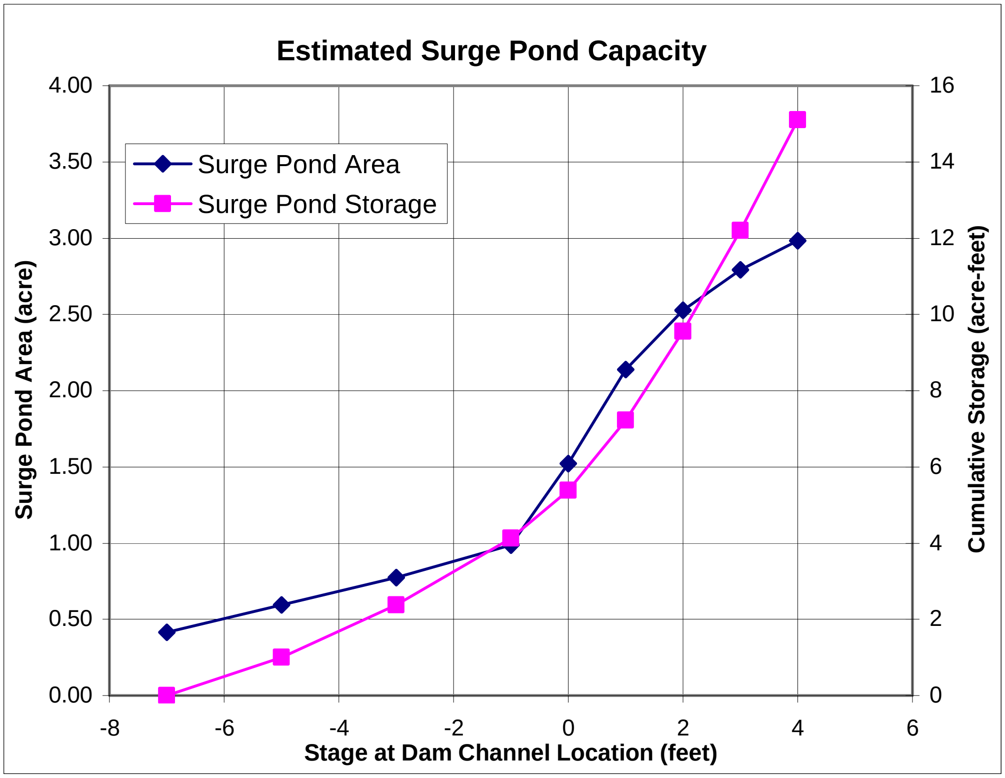


Figure 6-7. Surge Pond Storage and EPPC Swale Discharge Characteristic



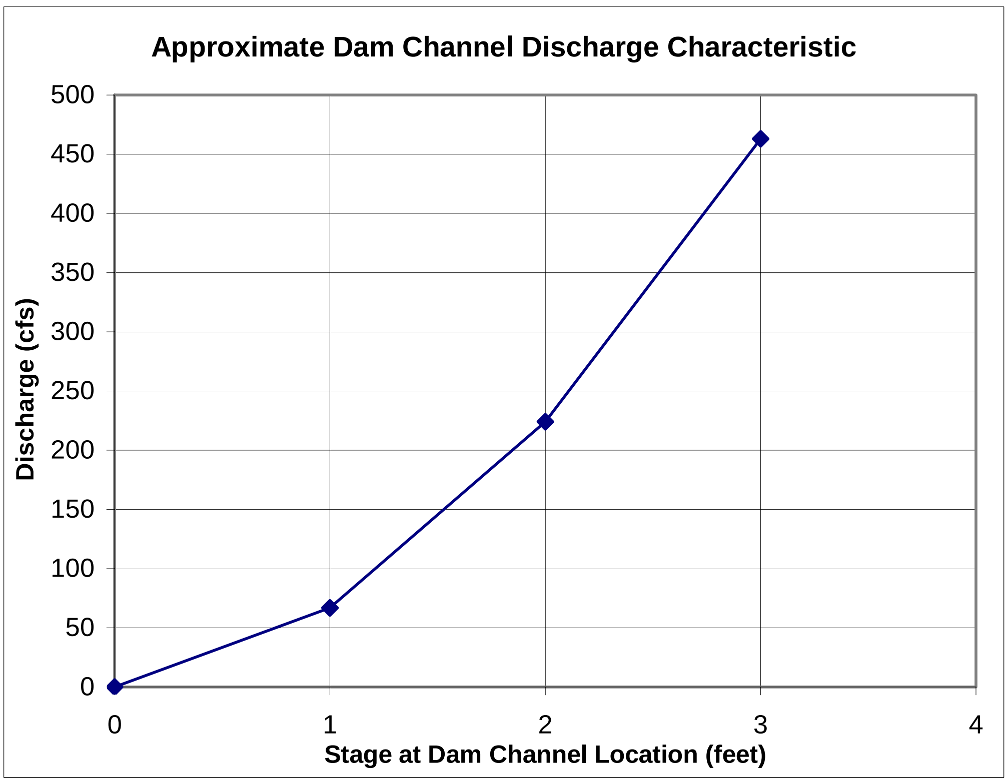
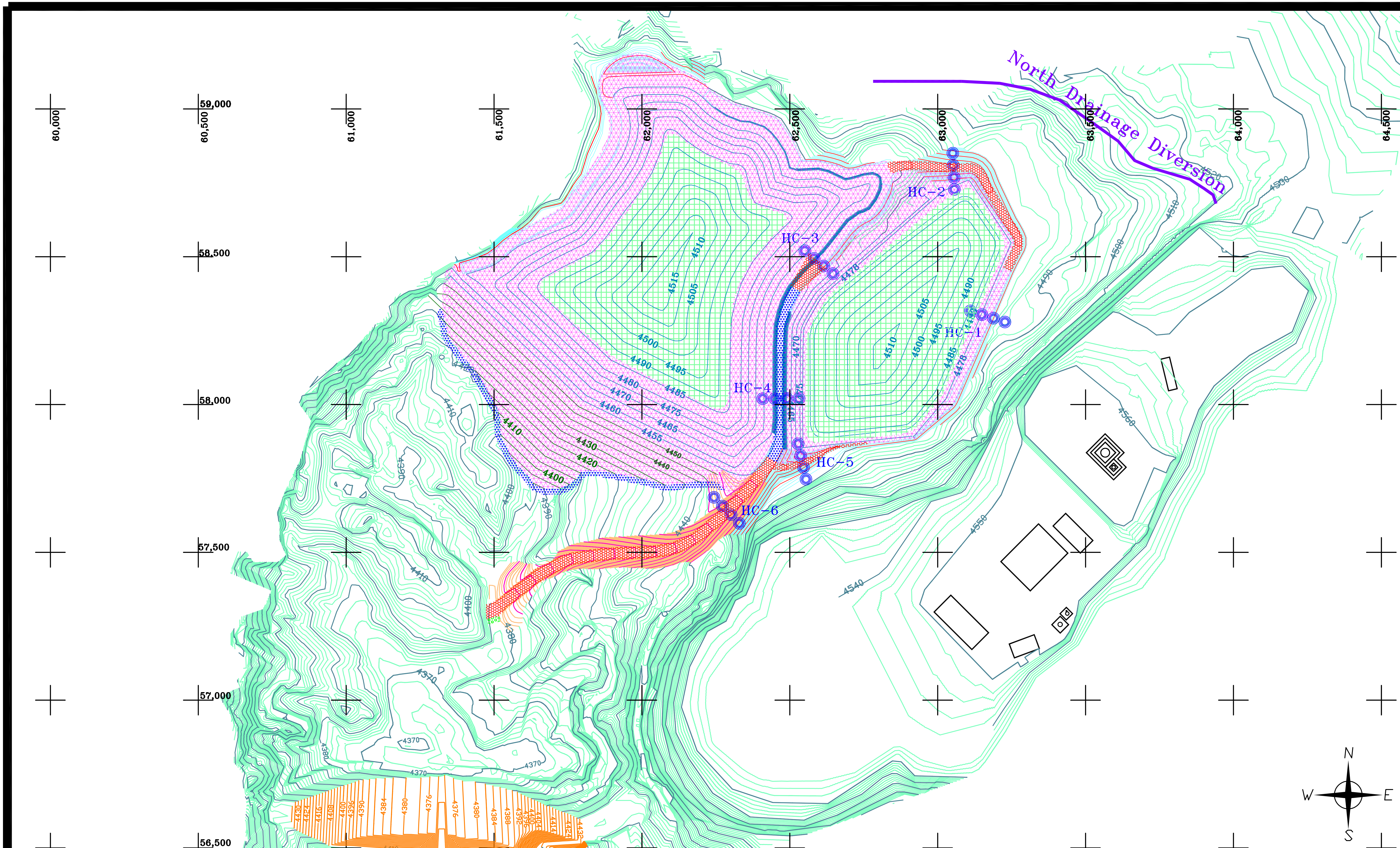


Figure 6-8. Surge Pond Storage and West Cell 2 Channel Discharge Characteristic

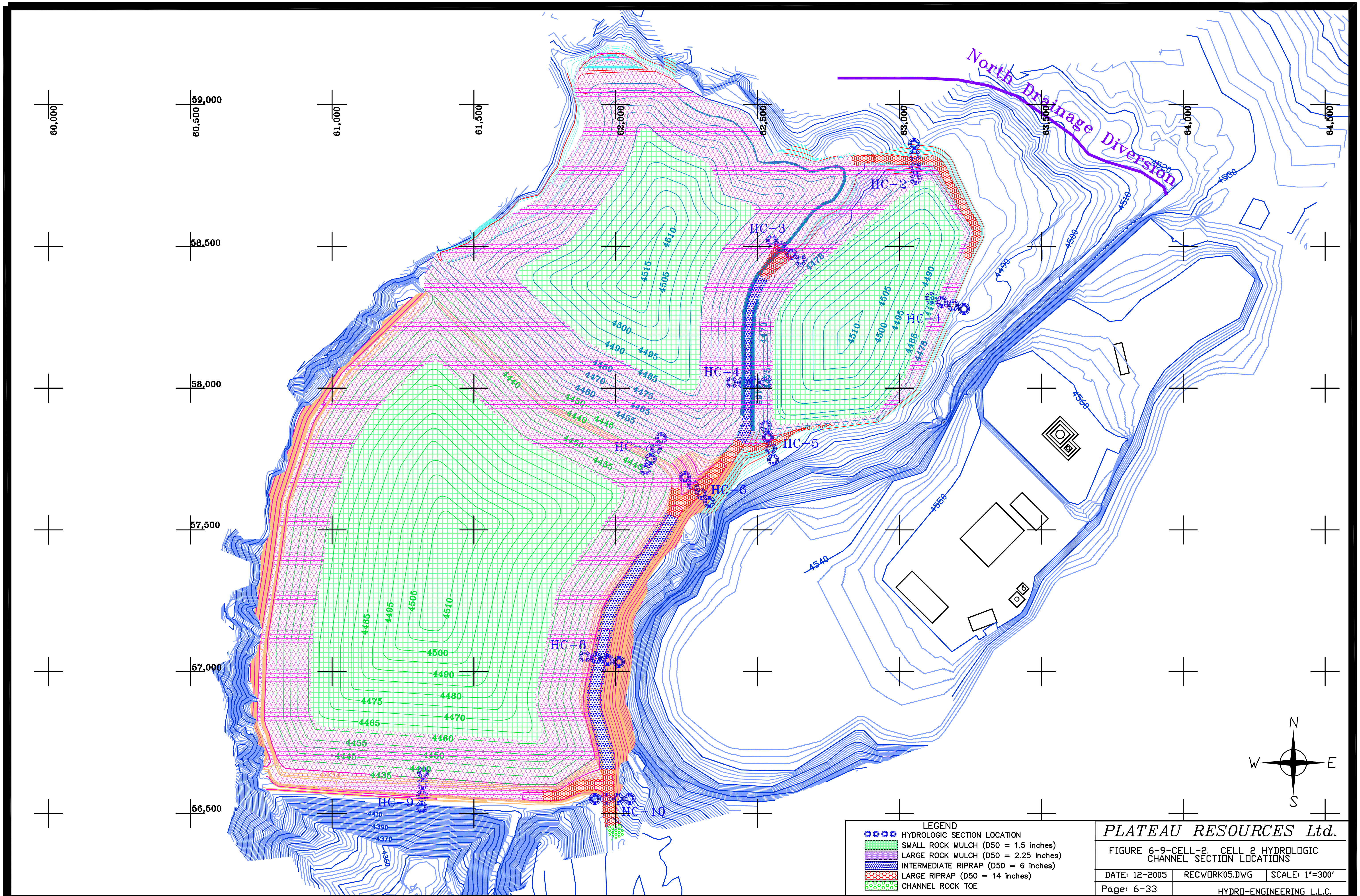


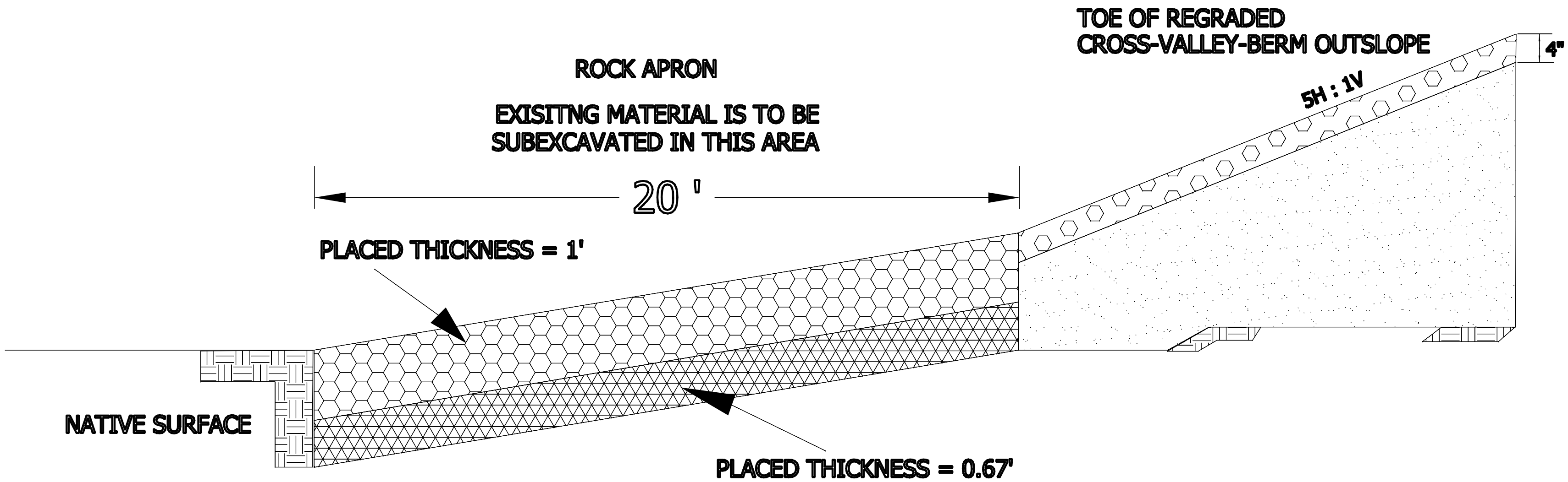
LEGEND
HYDROLOGIC SECTION LOCATION
SMALL ROCK MULCH (D50 = 1.5 inches)
LARGE ROCK MULCH (D50 = 2.25 inches)
INTERMEDIATE RIPRAP (D50 = 6 inches)
LARGE RIPRAP (D50 = 14 inches)
CHANNEL ROCK TOE
RIPRAP OUTFALL

PLATEAU RESOURCES Ltd.

FIGURE 6-9-CELL-1. CELL 1 HYDROLOGIC CHANNEL SECTION LOCATIONS

DATE: 12-2005	RECWORK05.DWG	SCALE: 1"=300'
Page: 6-32	HYDRO-ENGINEERING L.L.C.	


North Drainage Diversion
HC-1
HC-2
HC-3
HC-4
HC-5
HC-6
HC-7
HC-8
HC-9
HC-10
60,000
60,500
61,000
61,500
62,000
62,500
63,000
63,500
64,000
64,500
59,000
58,500
58,000
57,500
57,000
56,500
N
S
E
W
LEGEND
HYDROLOGIC SECTION LOCATION
SMALL ROCK MULCH (D50 = 1.5 inches)
LARGE ROCK MULCH (D50 = 2.25 inches)
INTERMEDIATE RIPRAP (D50 = 6 inches)
LARGE RIPRAP (D50 = 14 inches)
CHANNEL ROCK TOE
PLATEAU RESOURCES Ltd.
FIGURE 6-9-CELL-2. CELL 2 HYDROLOGIC CHANNEL SECTION LOCATIONS
DATE: 12-2005
RECWORK05.DWG
SCALE: 1"=300'
Page: 6-33
HYDRO-ENGINEERING L.L.C.



NOTE: SLOPE OF THE ROCK APRON WILL VARY TO TRANSITION TO THE EXISITING LAND SURFACE

HORIZONTAL SCALE: 1" = 5'
VERTICAL SCALE: 1" = 2.5'

6" D50 ROCK MATERIAL

ROCK FILTER MATERIAL

ROCK MULCH

ROCKY SOIL FILL

PLATEAU RESOURCES, LTD.
RIVERTON, WYOMING

SHOOTARING CANYON URANIUM MILL SITE
TICABOO, UTAH

FIGURE 6-10. DETAIL OF TYPICAL ROCK MULCH APRON PROTECTION

HYDRO-ENGINEERING, L.L.C.
4685 EAST MAGNOLIA
CASPER, WY. 82604

DATE:	12-2005
REVISED	
REVISION BY:	

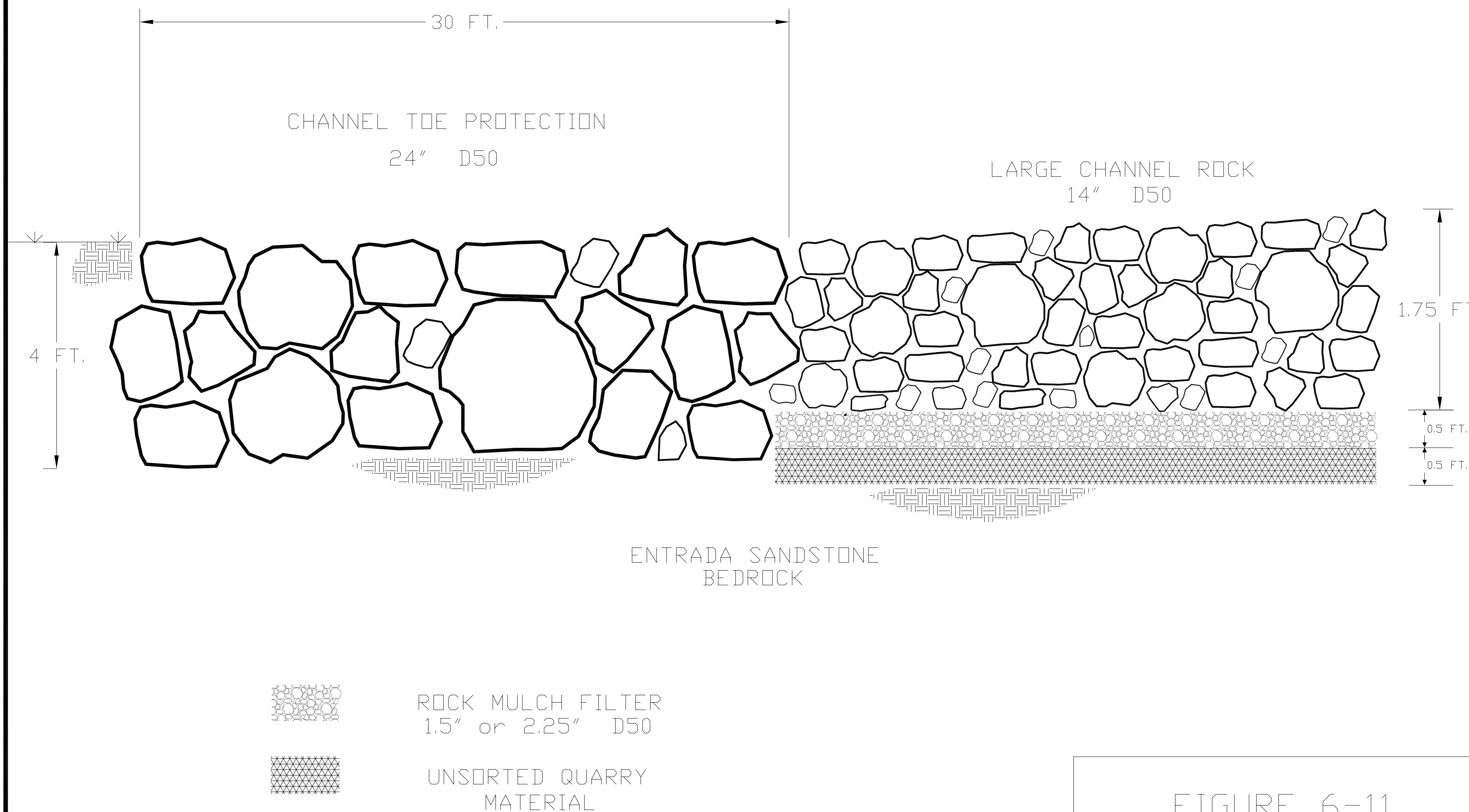
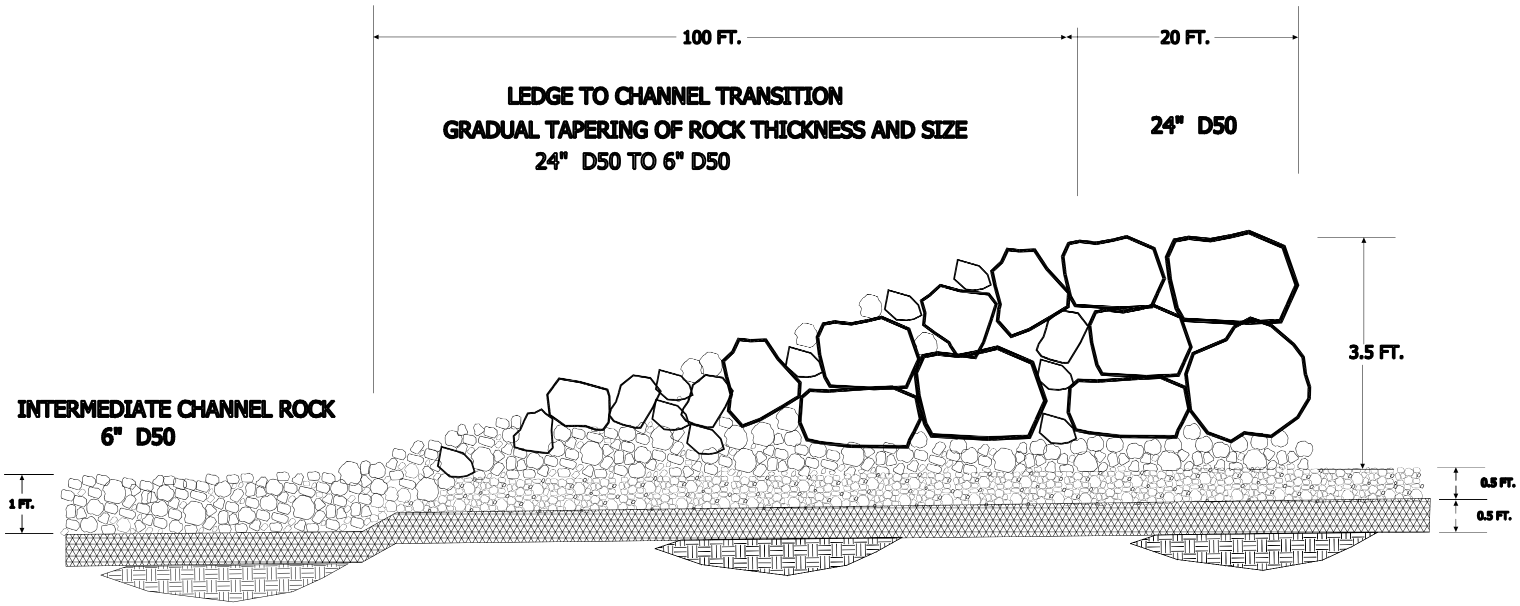


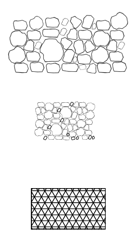
FIGURE 6-11.
CHANNEL ROCK
TOE SCHEMATIC

HYDRO-ENGINEERING, L.L.C.

DATE: 12-2005



NOT TO SCALE



SMALL CHANNEL ROCK
6" D50

ROCK MULCH FILTER
1.5" or 2.25" D50

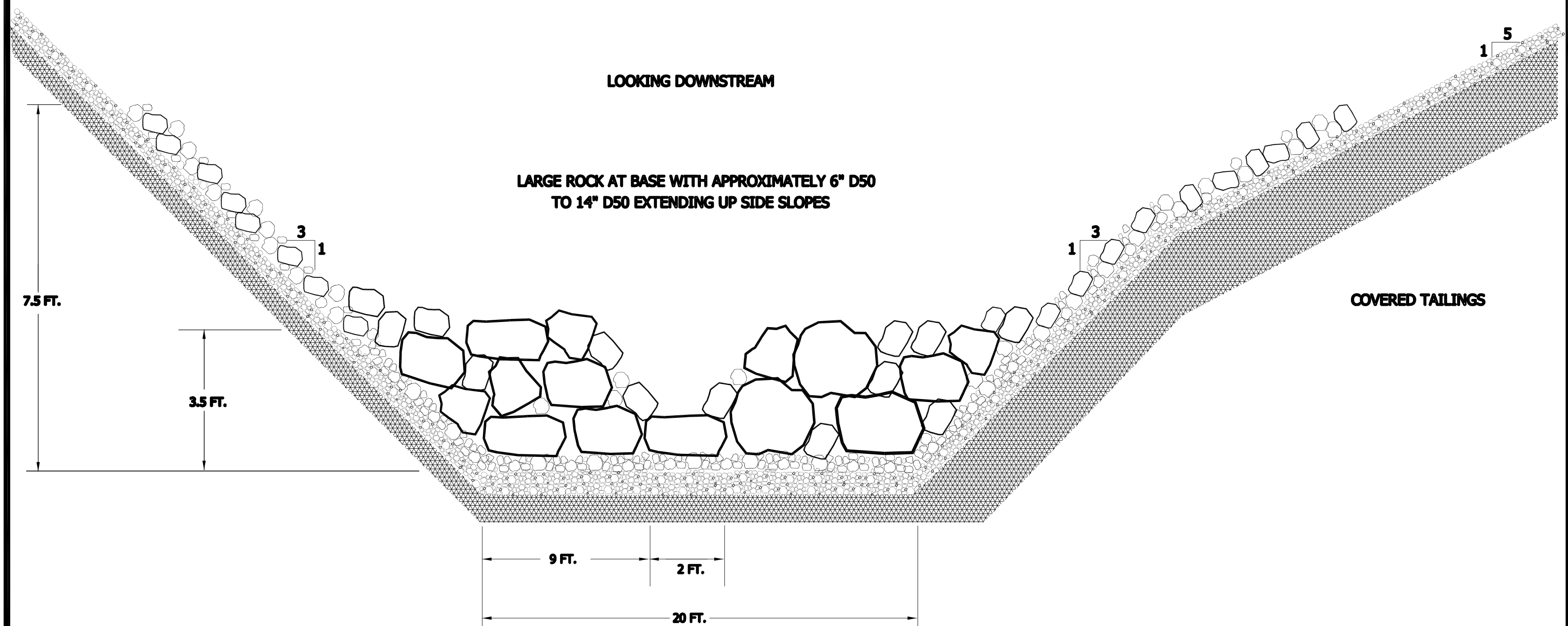
UNSORTED QUARRY
MATERIAL

PLATEAU RESOURCES, LTD.
RIVERTON, WYOMING

SHOOTARING CANYON URANIUM MILL SITE
TICABOO, UTAH

FIGURE 6-12. LONGITUDINAL POROUS ROCK LEDGE SECTION

HYDRO-ENGINEERING, L.L.C. 4685 EAST MAGNOLIA CASPER, WY. 82604	DATE:	12-2005
	REVISED	
	REVISION BY:	



SMALL CHANNEL ROCK
6" D50

ROCK MULCH FILTER
1.5" or 2.25" D50

UNSORTED QUARRY
MATERIAL

NOT TO SCALE

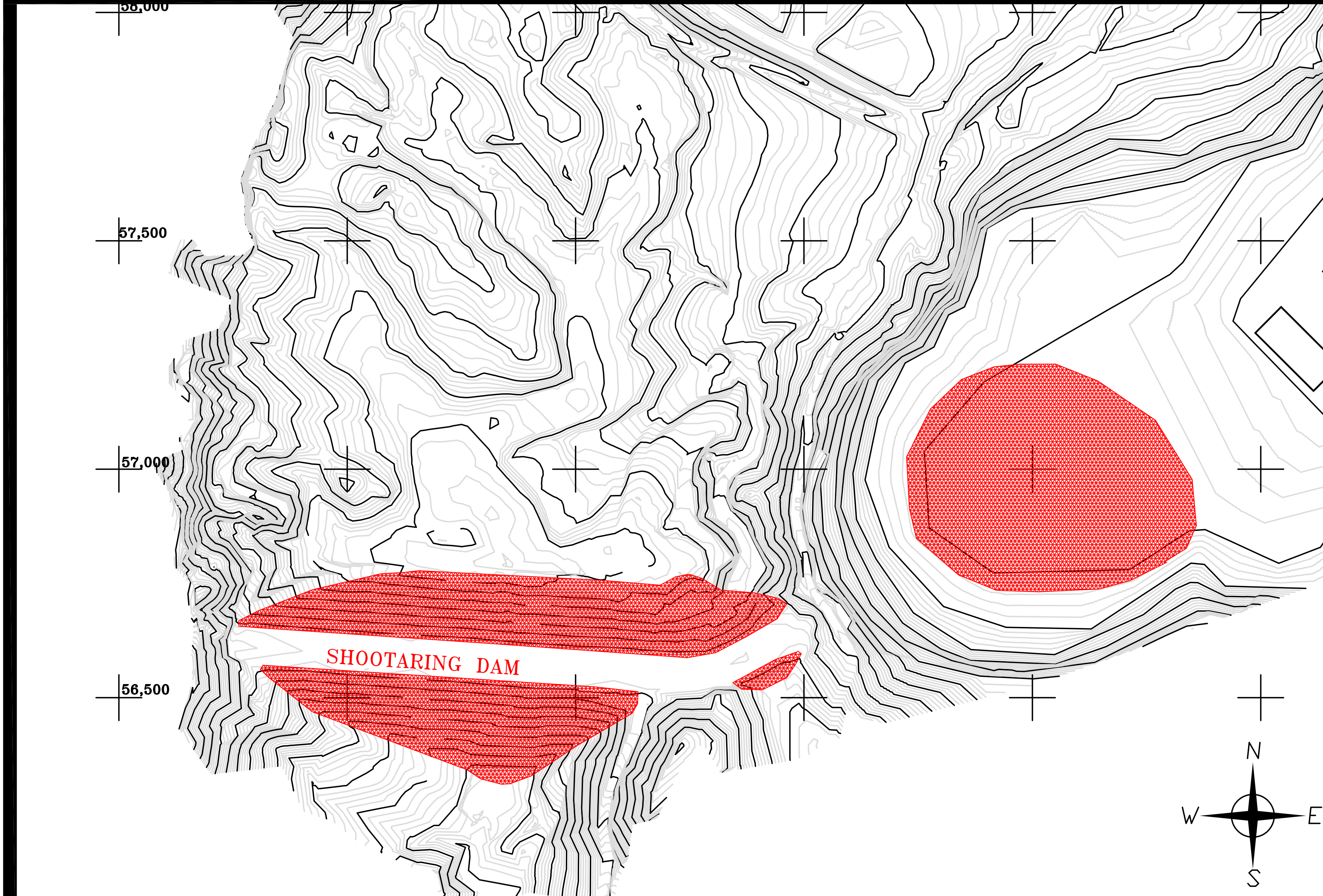
PLATEAU RESOURCES, LTD.
RIVERTON, WYOMING

SHOOTARING CANYON URANIUM MILL SITE
TICABOO, UTAH

FIGURE 6-13. POROUS ROCK LEDGE
CROSS SECTION

HYDRO-ENGINEERING, L.L.C.
4685 EAST MAGNOLIA
CASPER, WY. 82604

DATE:	12-2005
REVISED	
REVISION BY:	



LEGEND

POTENTIAL ROCK SOURCES

PLATEAU RESOURCES Ltd.

FIGURE 6-14. POTENTIAL ROCK SOURCE LOCATIONS

DATE: 12-2005	FIG6-14.DWG	SCALE: 1"=300'
	HYDRO-ENGINEERING L.L.C.	

7.0. WATER RESOURCE PROTECTION

The ground water conditions at this site have been defined in the initial Woodward-Clyde investigations and updated in Hydro-Engineering, LLC (1998, 1999, 2000 and 2005). Additional ground water monitoring data are presented in Hydro-Engineering, LLC (2001 and 2002). The uppermost ground water in the area of the tailings cell is in the Entrada sandstone with water levels approximately 140 feet below the land surface below the tailings cell area. The water quality in the Entrada aquifer is generally good. The ground water has not been affected by the Shootaring tailings site; therefore, no corrective action has been necessary at this site.

7.1 Groundwater

The tailings management plan for the Shootaring Canyon uranium project has been developed to prevent contamination of groundwater underlying the tailings disposal area. A clay lining system generally consisting of 24 inches minimum clay base was placed over the natural sandstone in the impoundment area to limit or prevent contaminant migration from the tailings impoundment into the foundation rock. At this time, the tailings area is dewatered of the drainable water except for a very small quantity that is draining at a very low rate.

Figure 7-1 presents the locations of wells in the Shootaring tailings area. The wells that are completed in the upper portion of the Entrada are shown in red while wells that are completed in the middle and lower portions of the Entrada sandstone are shown in blue. Additional Upper Entrada wells were drilled on the downgradient side of the cross valley berm southeast and northwest of well RM7. New wells RM18 and RM19 were completed in the upper portion of the Entrada aquifer downgradient of the cross valley berm. Well RM20 was completed adjacent to RM8 also in the upper portion of the Entrada aquifer. Table 7-1 presents the completion information for these new wells. Shallow wells RM21 and RM22 were completed adjacent to deep wells RM18 and RM19 to determine if the ground water mound observed in wells RM8 and RM9 extended northward to the toe of the Cell 1 tailings area. Table 7-1 also presents the completion information for RM21 and RM22, which are dry. The neutron and gamma logs for new wells RM18, RM19 and RM20 are presented in Figures 7-1A, 7-1B and 7-1C, respectively. The neutron logs for wells RM18 and RM19 did not show a strong indication of saturation above the water table in the Entrada aquifer at these two locations. Shallow wells RM21 and RM22 were drilled while the driller was on site to conclusively show whether saturation exists above the Entrada water table in these areas. These neutron logs did not indicate the presence of a low permeability lense above the Entrada water table at these two wells. The neutron log for well RM20 does show a strong indication of saturation from a depth of 58 to 97 feet. Saturation above the Entrada water table is known to exist in this area based on shallow well RM8 located adjacent to well RM20. Neutron logging was also conducted on well RM14 to update the neutron log after the deepening of this well. Figure 7-1D presents the updated neutron and gamma logs for well RM14. No visual indications of saturation were observed during the drilling of wells RM18 through RM22. Foam typically had to be added to the drilling process at depths of slightly less than 50 feet, which masks any evidence of saturation after its addition. Figure 7-1E presents the neutron and gamma logs for well RM8

TABLE 7-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS.

WELL NAME	NORTH. COORD.	EAST. COORD.	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-lsd)
						WELLS					
OW1A	57140	63730	1.0	300.0	0.2	4472.53	229.2	4243.33	200-300	-	---
OW1B	57140	63730	1.0	798.0	1.9	4474.23	448.2	4026.03	648-798	-	---
OW2	57094	63667	1.0	300.0	0.2	4470.70	222.9	4247.80	200-300	-	---
OW3	57046	63659	1.0	798.0	2.3	4470.78	453.2	4017.58	650-798	-	---
OW4	57035	63707	1.0	570.0	2.3	4472.54	213.5	4258.99	435-570	-	---
RM1	59307	61827	3.0	487.0	2.2	4449.20	176.5	4272.67	220-480	157-487	106
* RM2	57731	63040	3.0	520.0	1.6	4519.76	258.2	4261.51	260-520	250-520	---
RM2R	57924	63142	5.0	300.0	1.2	4504.86	242.6	4262.26	250-300	242-300	273
* RM3	57193	60647	6.0	540.0	1.8	4461.32	214.8	4246.52	230-540	190-540	246
* RM4	56472	61099	3.0	500.0	3.5	4395.50	155.8	4239.70	190-490	115-500	176
* RM4R	56358	61086	5.0	160.0	1.0	4368.32	128.6	4239.72	110-160	105-160	157
* RM5	56416	61286	3.0	440.0	3.6	4379.12	140.3	4238.82	150-430	130-440	172
* RM6	56348	61481	3.0	460.0	2.3	4374.57	136.5	4238.07	175-455	110-460	174
RM7	57904	61645	3.0	219.5	2.0	4395.86	140.5	4255.33	187-217	177-217	200
RM8	57204	61576	3.0	79.1	3.1	4381.77	58.25	4323.52	57-77	47-77	---
* RM9	56767	61363	3.0	82.8	1.2	4369.31	61.30	4308.01	62-82	52-82	---
* RM10	56286	61272	5.0	99.0	2.0	4343.57	95.30	4248.27	57-97	53-97	---
* RM11	56594	60769	5.0	240.0	2.0	4436.14	184.7	4251.44	140-180	5-180	203
									180-240#	-	
RM12	59477	61791	5.0	157.0	1.3	4415.95	142.7	4273.22	117-157	110-157	156
* RM13	56648	61996	5.0	270.0	2.0	4434.81	189.6	4245.21	140-180	5-180	219
									180-270#	-	
RM14	58419	61368	5.0	260.0	1.5	4450.84	192.2	4258.61	134-174	127-174	253
									174-260#	-	
* RM15	56311	61354	5.0	460.0	1.9	4343.75	107.7	4236.05	379-459	95-459	157
* RM16	56615	60772	5.0	296.0	1.2	4434.95	194.6	4240.35	246-296	240-296	255
* RM17	56636	61993	5.0	290.0	0.7	4433.58	190.0	4243.58	240-290	235-290	248
RM18	57833	61851	5.0	243.3	1.3	4421.56	164.4	4257.15	162-242	149-242	232
RM19	58077	61524	5.0	236.3	1.3	4409.50	152.7	4256.74	155-235	139-235	219
RM20	57208	61592	5.0	212.6	1.6	4380.83	129.9	4250.93	131-211	120-212	201
RM21	57843	61851	5.0	141.3	1.3	4421.64	Dry	4281.64	110-140	100-140	---
RM22	58088	61513	5.0	120.8	0.8	4410.52	Dry	4290.52	90-120	80-120	---
WW1	57144	63677	6.0	870.0	-2.8	4454.79	---	---	635-870#	-	---
WW2	56562	63086	6.0	1000.	-3.4	4471.61	---	---	602-1000	-	---
					TAILINGS WELLS						
T4	58456	61953	2.0	20.0	1.2	4431.20	Dry	4411.20	12.9-17.9	10-18	---
T5	58371	61891	2.0	10.0	2.5	4425.00	Dry	4415.00	2.5-7.5	0.7-8	---
T6	58133	61801	2.0	11.7	2.9	4429.00	Dry	4417.30	3.8-8.8	1-9	---
						PIEZOMETERS					
PZ1	56598	61022	1.0	87.0	2.0	4434.51	---	---	75-85	2-85	---
PZ2	56580	61327	1.0	88.0	2.0	4434.74	---	---	76-86	3-86	---
PZ3	56564	61575	1.0	88.0	2.0	4435.34	---	---	76-86	3-86	---
* PZ4	56271	61383	1.0	25.0	2.0	4347.17	Dry	4320.92	13-23	2-23	---
* PZ5	56301	61275	1.0	25.0	2.0	4344.79	Dry	4318.49	13-23	1-23	---

TABLE 7-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS. (cont.)

WELL NAME	NORTH. COORD.	EAST. COORD.	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-lsd)
* PZ6	56332	61167	1.0	25.0	2.0	4362.50	Dry	4336.90	13-23	2-23	---

NOTE: Wells RM1 through RM6, RM15 through RM17, OW1A and OW2 are completed in the Entrada Aquifer
Wells RM2R, RM4R, RM7 through RM14 and PZ4 through PZ6 are completed in the Upper Entrada Sandstone
Wells WW1, WW2, OW1B and OW3 are completed in the Navajo Aquifer
Well OW4 is completed in the Carmel Aquitard
Piezometers PZ1 through PZ3 are Dam Piezometers
mp = measuring point; lsd = land surface datum; msl = mean sea level
# = open hole
* = Abandoned Well
Above data compiled from physical measurements, records and site surveys.

which are similar to the neutron log from RM20 until the probe reaches the water level in well RM8. The three geologic cross-sections that were included in the 1998 Ground-Water Hydrology report were updated and are presented in this section. Figure 7-1 shows the location of these cross-sections. Cross-section 1-1' which is presented in Figure 7-2 is along the downstream side of the Shootaring Dam. Cross-section 2-2' goes across the downstream side of the cross valley berm adjacent to the tailings cell and down to monitoring well RM3. Figure 7-3 presents geologic cross-section 2-2'. This cross-section was extended on the east up to new shallow monitoring well RM2R and the alignment was adjusted to go along the cross valley berm from well RM18 to RM7 to RM19 to RM14 and then south to monitoring well RM3. This adjustment was made to allow the presentation of wells RM14, RM18 and RM19 on this cross-section. The new neutron log for well RM14 replaced the original log for well RM14 on Figure 7-3 because this well was deepened after the initial logging. None of the neutron logs of the wells (RM18, RM7, RM19 and RM14) along the cross valley berm indicate the presence of a low permeability zone above the Entrada water table in this area. Cross-section 3-3' goes from the downstream edge of the Shootaring Dam through the cross valley berm and the tailings cell and to the background monitoring wells RM1 and RM12 (see Figure 7-4). The log of new well RM20, which is adjacent to RM8, replaces the RM8 log because the log for well RM20 is deeper. Figure 7-1 shows the location of the limits of the existing tailings (blue line). Figure 7-4 shows the design reclamation surface in red and orange lines for both reclamation configuration and the northern and southern limits of the designed tailings cell on this cross-section. The top of the existing clay liner below the tailings is shown in blue in the tailings cell area. These geologic cross-sections show neutron logs at two different scales. The neutron log below the water table is printed in red at an expanded scale (see scale definition on the log). The range of the two scales for the logs for wells RM6 and RM12 are different than the remainder of the logs. The areas of lower permeability (K) sandstone were interpreted from the neutron logs. A magenta pattern is shown where the lower permeability sandstone is indicated by the neutron logs. This lower permeability sandstone exists in the Shootaring Dam area and upstream of the dam but does not extend up to well RM20 or up to the cross valley berm and tailings cell. A thin lower permeability lense is thought to cause the saturation in well RM8 based on the well RM20 log. Some lower permeability sandstone also exists in the area of upgradient monitoring well RM1 but does not extend to well RM12. The neutron log for well RM1 indicates that this material does not have a permeability as low as the sandstone at well RM15. The small head difference between wells RM1 and RM12 also indicates that the upper sandstone at RM1 is more permeable. No lower permeability material was interpreted in the area of cross-section 2-2' which is near the cross valley berm and tailings cell area. Tailings well T4 is shown on the cross-section in Figure 7-4 and this well illustrates that the existing tailings thickness is very small.

The well depth is shown with a vertical yellow line with the slotted or open hole interval shown with short black horizontal line pattern. The limits of the higher water-level elevations in the upper Entrada were defined prior to the deepening of wells RM11, RM13 and RM14. Wells RM13 and RM14 were dry prior to deepening these wells. A note has been added to the geologic cross-section to show the depth of these wells prior to deepening. Well RM11 contained a very few feet of water in the well prior to deepening this well. Higher water-level elevation, therefore, does not exist in wells RM14, RM21 and RM22 as it does in wells RM8 and RM9.

The piezometric surface for 2004 was updated on the three cross-sections. A cyan water-level elevation line is shown for the Entrada aquifer. The green piezometric surface line is shown on the cross-sections for the upper lower permeability Entrada. The higher water level in the Upper Entrada is approaching the Entrada aquifer piezometric surface at RM10 but is seventy feet higher in elevation upstream of the Shootaring Dam. The Upper Entrada head approaches the Entrada aquifer head between wells RM8 and RM7 (see Figure 7-4). Figure 7-5 also presents the water-level elevation for the Upper Entrada and the Entrada aquifer for 2004. The blue contours show that the piezometric surface in the Entrada aquifer is highest at upgradient well RM1 at slightly above 4272 ft-msl and lowest downstream of the Shootaring Dam at less than an elevation of 4240 ft-msl. Water-level elevation of the upper lower permeability Entrada is shown in red on the Figure 7-5. This piezometric surface shows a mound around wells RM8 and RM9 with steep gradients extending outward from these two wells. The Upper Entrada saturation zone is very thin at wells RM10, RM11 and RM13. Water levels in the Upper Entrada wells RM7, RM12, RM14, RM18, RM19, RM20 and RM2R fit the main Entrada piezometric surface showing that the Upper Entrada and the main aquifer have very similar heads in the tailings cell area.

The latest 2004 water-quality data is also presented on the three cross-sections. The water-quality data is listed on the cross-section for wells shown on the cross-section and are listed in the same order as presented on the cross-section. For example, Figure 7-4, cross-section 3-3' presents the water quality for wells RM8, RM20, RM7, RM1 and RM12. Quality of water is generally good with TDS varying from a low of 176 at well RM19 to a high of 348 mg/l from well RM7. As expected, chloride concentrations are very low in this water, ranging from a low of 3 at well RM19 to a high of 17 mg/l at well RM12. Background well RM12 has the highest concentration for chloride which has been useful in defining the upper range of natural concentrations of this constituent. The arsenic concentration is slightly higher in wells RM8 and RM20. The chloride concentrations and other conservative ions at these three wells are well within the natural range and therefore these arsenic concentrations are also thought to be natural. The 2004 water-quality data does not indicate any impacts from the Shootaring tailings. Future concentrations along with previous 20 years of data from all of the Shootaring wells are important in defining the range of background concentrations at this site.

At the project site, net evaporation from exposed water surfaces will average approximately 70 inches (178 cm) per year, which is equivalent to approximately 3.6 gallons (13.6 l/min) per minute per acre of exposed surface.

Since the tailings management plan provides a means for drainage of all excess tailings liquids, no significant amount of free tailings liquid will remain in the impoundment at project termination. Presently, no permanent free tailings liquid has been measured in the four tailings wells in the existing tailings. Also, after the project is terminated, normal evaporation from the tailings cap system will dispose of the incident precipitation, including runoff. Under present conditions with a land surface with a depression and without a clay cap, the drainage system collects only a very small rate of water after rainfall events (see Section 3.2 for details). Therefore, only a very limited potential exists for ground-water contamination from this project, and the requirements for surveillance of the ground-water in the area will be minimal. The monitoring wells located immediately downgradient of the Cell 1 disposal perimeter (RM7, RM14, RM18, RM19 and RM23) will be maintained and be available for subsequent ground-water monitoring with the Cell 1 reclamation configuration. Proposed monitoring wells RM23, RM25, RM26, RM27, RM28, RM29, RM30, RM31 and RM32 will be maintained and be available for ground-water monitoring if reclamation occurs after the usage of Cell 2.

7.1.1 Drainage Through Liner

The Entrada sandstone underlying the disposal system has a high calcite (calcium carbonate) content and an average horizontal hydraulic conductivity (permeability) of 7 x 10-5 cm/sec (0.2 ft/day, see Hydro-Engineering 1998), as computed from field test data. The vertical hydraulic conductivity is probably less than the horizontal, perhaps less than one tenth of the horizontal value. This high calcite content has neutralized any acidic (pH 1-2) tailings solution that may have contacted the calcite. Monitoring well data indicates that the acidic tailings solution has not penetrated the underlying sandstone. Natural neutralization raises the pH, which in turn precipitates the radionuclides and heavy metals present in the tailings liquids. However, a high TDS is generally not significantly reduced by neutralization. Major-constituent monitoring does not indicate any water quality impact. For a more complete discussion on the geology and chemical properties of the underlying material, refer to Woodward-Clyde Consultants (1978a and 1979) studies in the preliminary and final geotechnical studies of the area. The ground-water monitoring at the tailings site does not show effects from the existing tailings. The ground-water quality is generally good in the Entrada aquifer in the tailings area (see Hydro-Engineering 2002 and 2005). The water quality concentrations in the Entrada aquifer have not changed enough to indicate any impact and reflect only background variations. The potential for impact will be reduced even further with the addition of the clay cap over the tailings cell.

The area north of the existing cross valley berm has been lined with a clay blanket of generally not less than two-feet thickness. The clay blanket has been overlain with sandy material covered with gravel, which is designed to prevent intrusion of slimes. Within the sand layer and adjacent to the clay liner are drainage pipes which drain to a collection sump to prevent the development of static head on the clay liner. The collection sump, located downstream of the cross valley berm, is equipped with a pump. The liquid in the sump is pumped to lined surface evaporation ponds placed on top of tailings within the impoundment. The existing tailings cell will be replaced by tailings Cell 1 which will also be equipped with a solution collection system as well as a leak detection system. These systems will be operated until the tailings cells are drained and are scheduled for reclamation.

7.1.2 Monitoring Threshold Values

The State of Utah has selected the following threshold values: Arsenic = 0.022 mg/l, Chloride = 40 mg/l, Selenium = 0.022 mg/l, and pH = 6.8 standard units. Uranium is compared to the State Ad hoc ground water quality standard of 0.03 mg/l. The up-gradient well RM1 is located immediately north of the tailings impoundment. The compliance wells are RM7, RM18 and RM19. Well RM20 is located adjacent to well RM8 and is completed in the upper portion of the Entrada aquifer and used with well RM8 to define the vertical gradient in this area. The vertical head difference between wells RM8 and RM20 is 72.6 feet. This indicates an average gradient between the center of these two well screens of 0.69 feet/feet (72.6/104). Figure 7-1 also shows the locations of two new wells, RM21 and RM22, adjacent to wells RM18 and RM19. The neutron logs from wells RM18 and RM19 did not show a strong indication of a saturated mound above the Entrada piezometric surface, but the two shallow wells were added while the driller was on site to confirm the lack of saturation. Wells RM21 and RM22 are dry.

The Shootaring Canyon ground-water monitoring program is proposed to consist of semi-annual sampling for the following parameters:

PARAMETER LISTING

pH (field)	Conductivity (field)	Total Dissolved Solids
Chloride	Sulfate	Arsenic
Barium	Cadmium	Chromium
Copper	Lead	Mercury
Molybdenum	Selenium	Silver
Zinc	Ammonia	Fluoride
Nitrate plus Nitrite	Uranium	

Ground-water sampling at the Shootaring site is still being used to define the variation in natural concentrations at this site. The following wells will be used with wells RM7, RM18 and RM19 to continue to define the background concentrations:

WELL NAME

RM1	RM2R	RM8
RM12	RM14	RM20
RM21	RM22	

Upgradient wells RM1 and RM12 are very useful in defining upgradient concentrations at this site but these additional wells will also define variation in natural concentrations. They will also be used to determine whether the tailings cell has any effect on the Entrada aquifer.

Wells RM4, RM4R, RM5, RM6, RM9, RM10, RM11, RM13, RM15, RM16 and RM17 were abandoned in October of 2003. Well RM2 was abandoned because it was not possible to pump a sample from the well, and it was located near well RM2R which is included in the monitoring program. Well RM3 was also abandoned due to its distance from the tailings cell. Piezometers PZ4, PZ5 and PZ6, which were completed in the upper shallow portion of the Entrada sandstone, were also abandoned. No saturation has been detected in these wells and it is extremely unlikely that saturation will occur due to the shallow completion of the wells. These wells were completed for the Shootaring Dam stability monitoring program. Figure 7-1 shows which wells have been abandoned.

7.2 Surface Water

After the site has been reclaimed, the clay barrier and cover will prevent surface water from coming into contact with the contaminated material. In addition, much of the surface water will be diverted away from the tailings disposal cell. Therefore, the water quality of the surface runoff should be the same as the runoff water quality outside of the cell area.

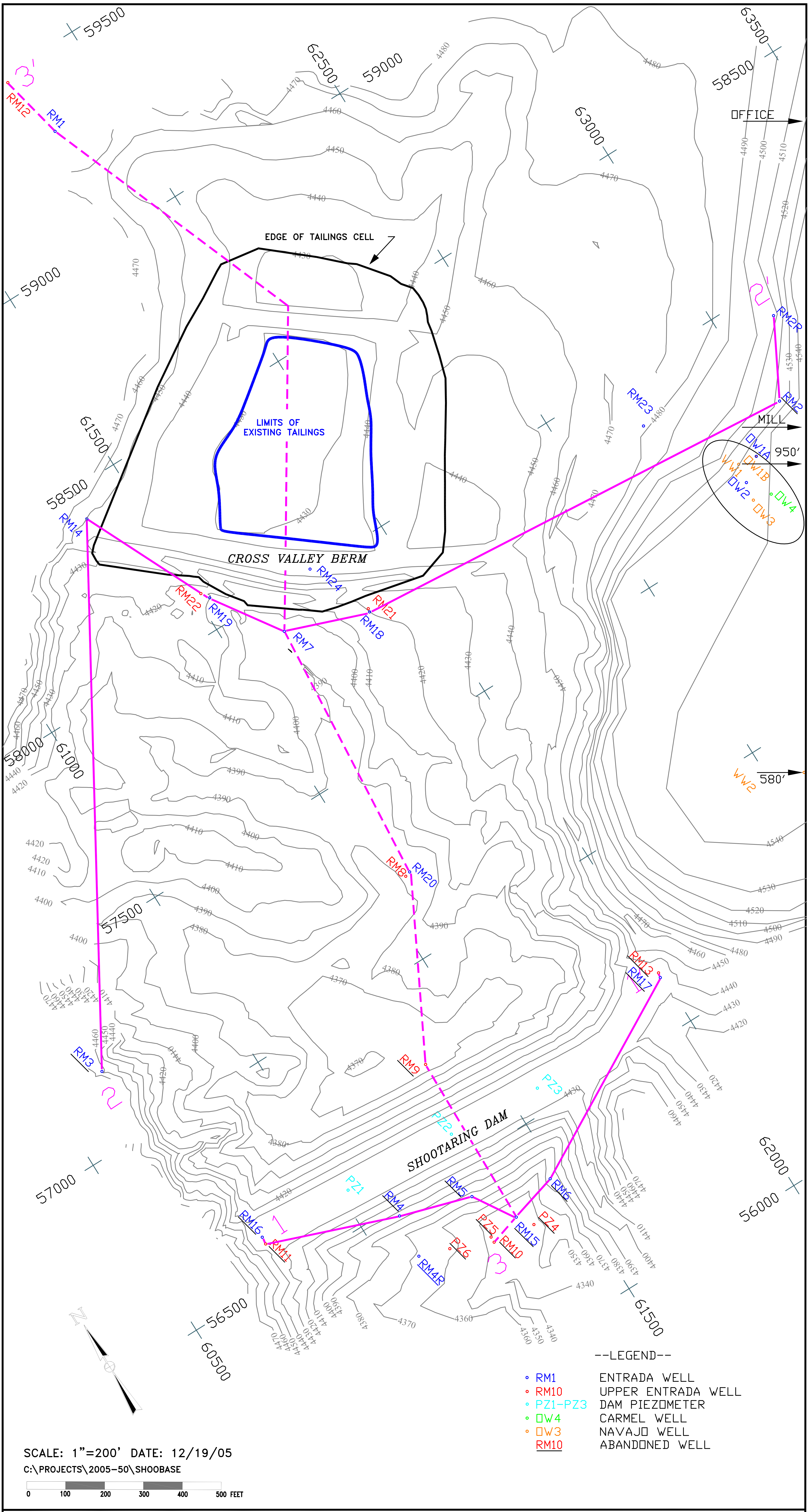


FIGURE 7-1. LOCATION OF WELLS AND GEOLOGIC CROSS SECTIONS

FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-18
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES
NONE

LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION	K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM	D.F.
DRILLING MEAS. FROM			G.L.

DATE	10-27-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	242 FT	LEVEL	164 FT
DEPTH-LOGGER	243.5 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	243 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	Q. FROST		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	242 FT	5"	PVC	SURFACE	242 FT

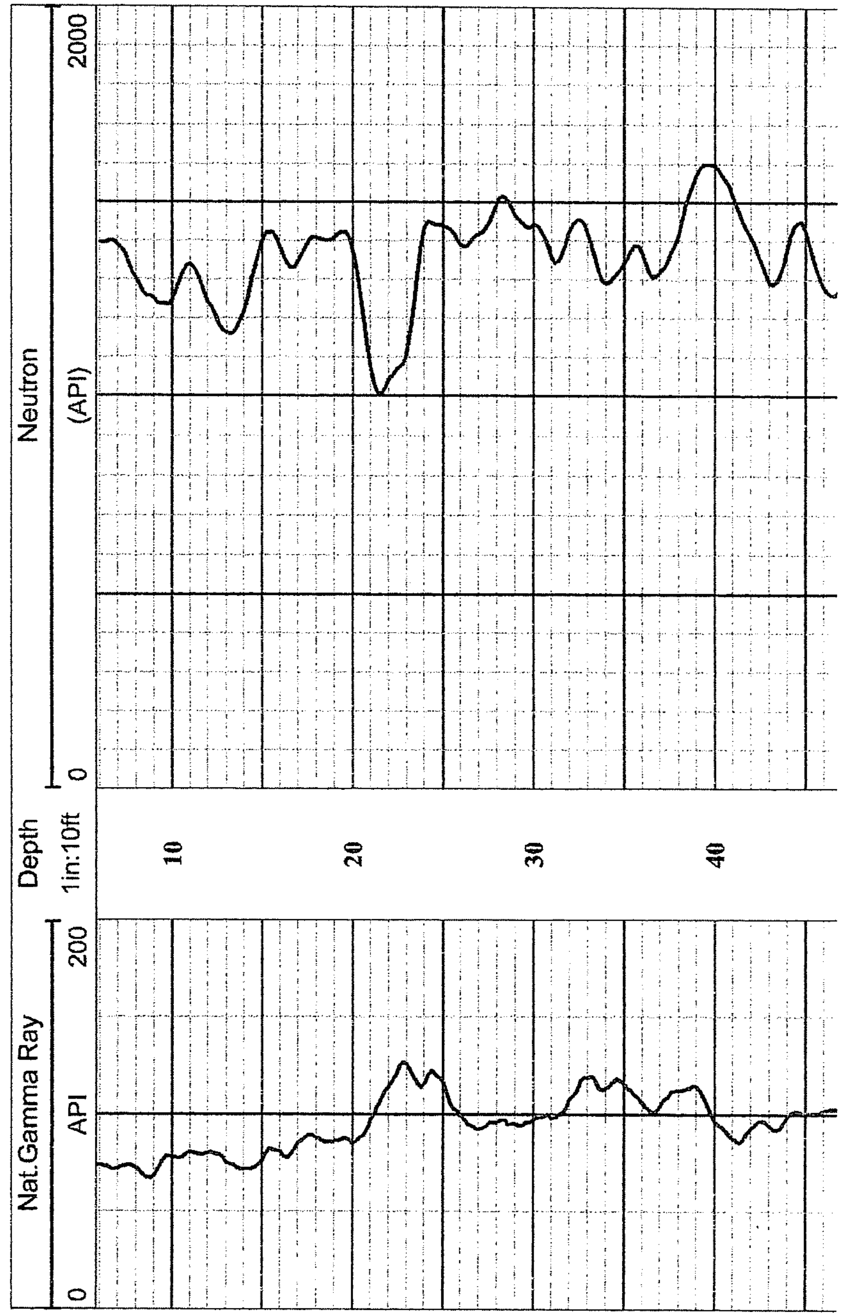


FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18, (continued).

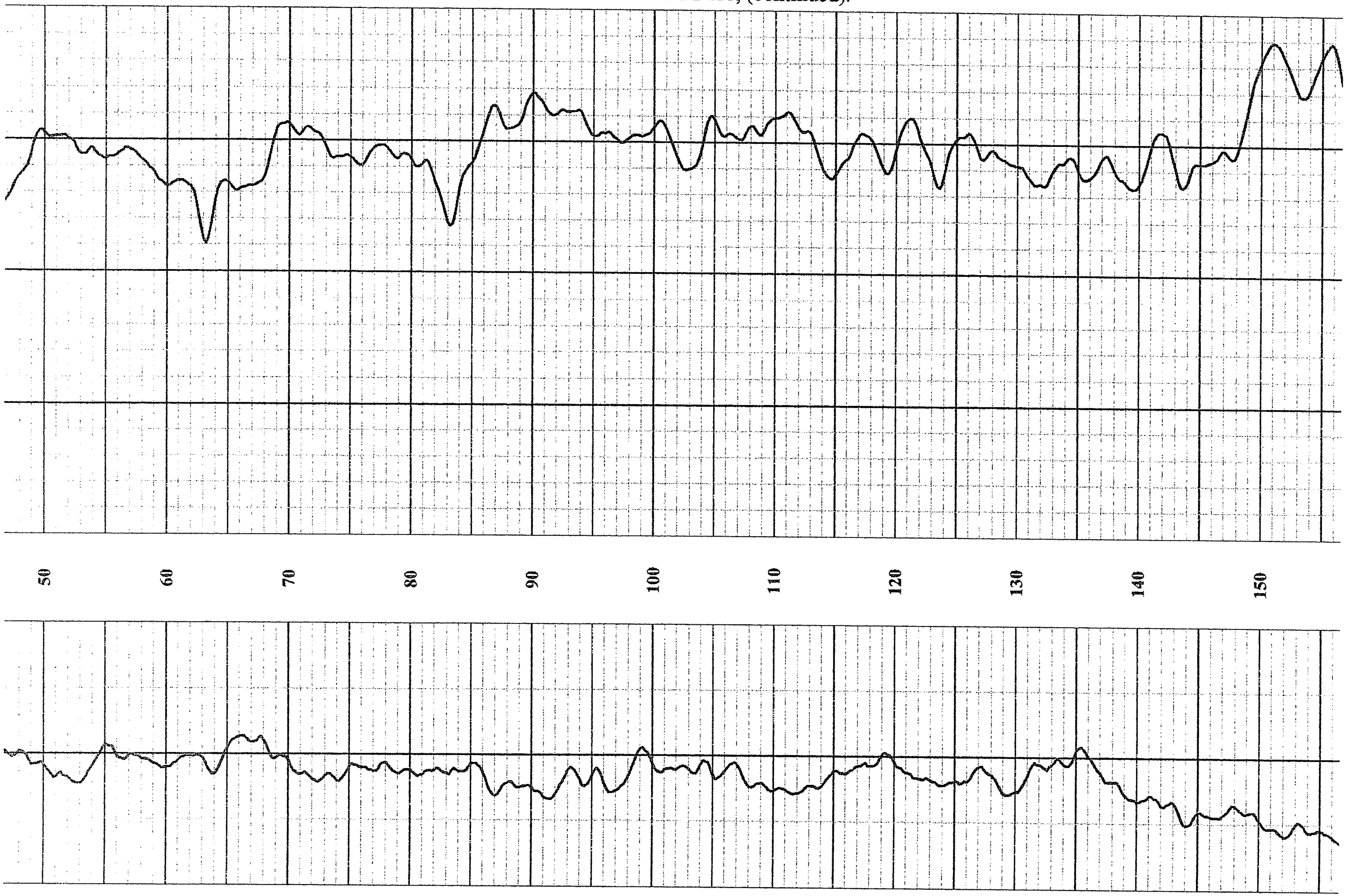


FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18, (continued).

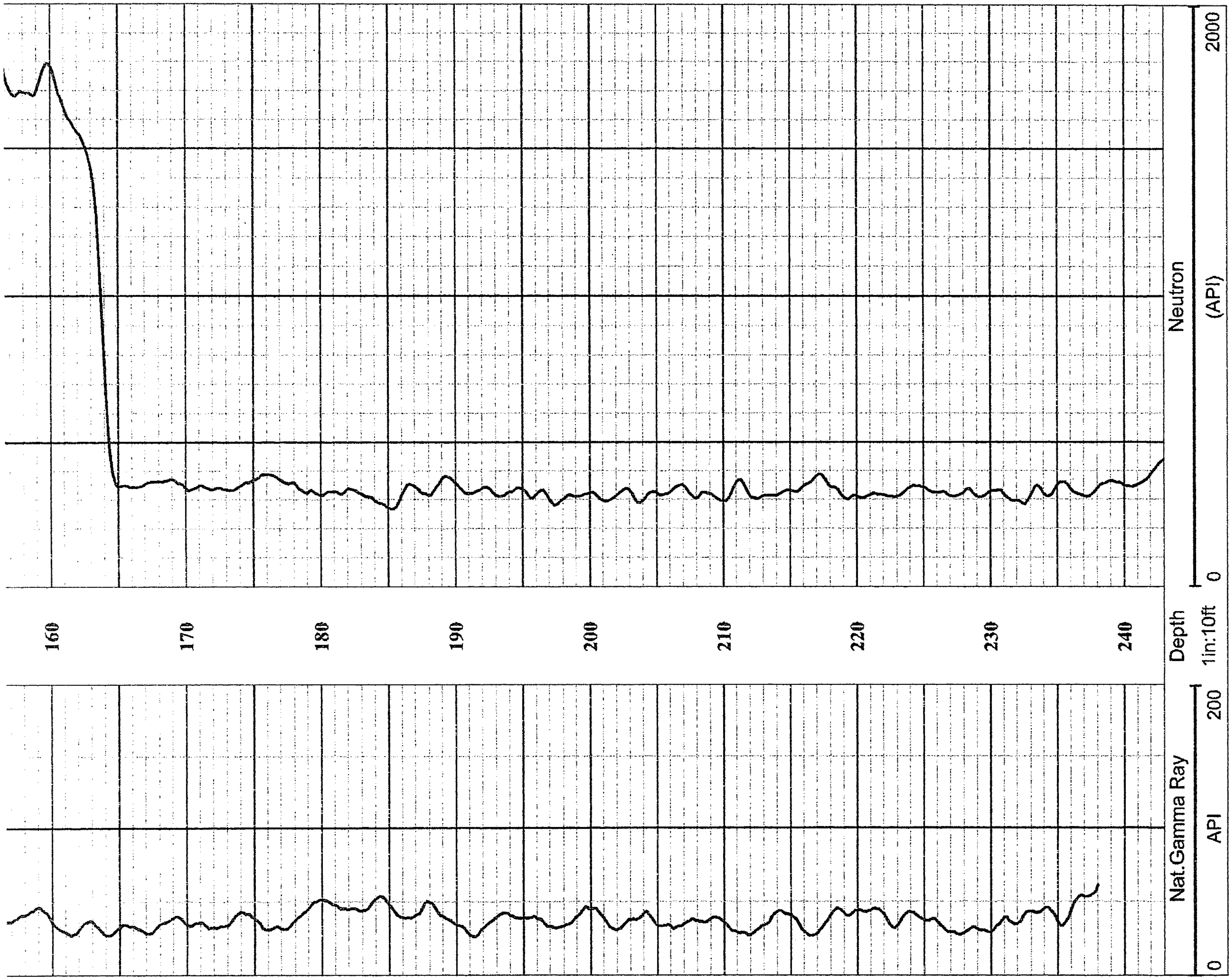


FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-19
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES
NONE

LOCATION

SEC TWP RGE

PERMANENT DATUM ELEVATION K.B.
LOG MEAS. FROM GROUND LEVEL ABOVE PERM. DATUM D.F.
DRILLING MEAS. FROM G.L.

DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	235 FT	LEVEL	154 FT
DEPTH-LOGGER	235 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	235 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	TOTAL DEPTH	5"	PVC	SURFACE	TOITAL DEPTH

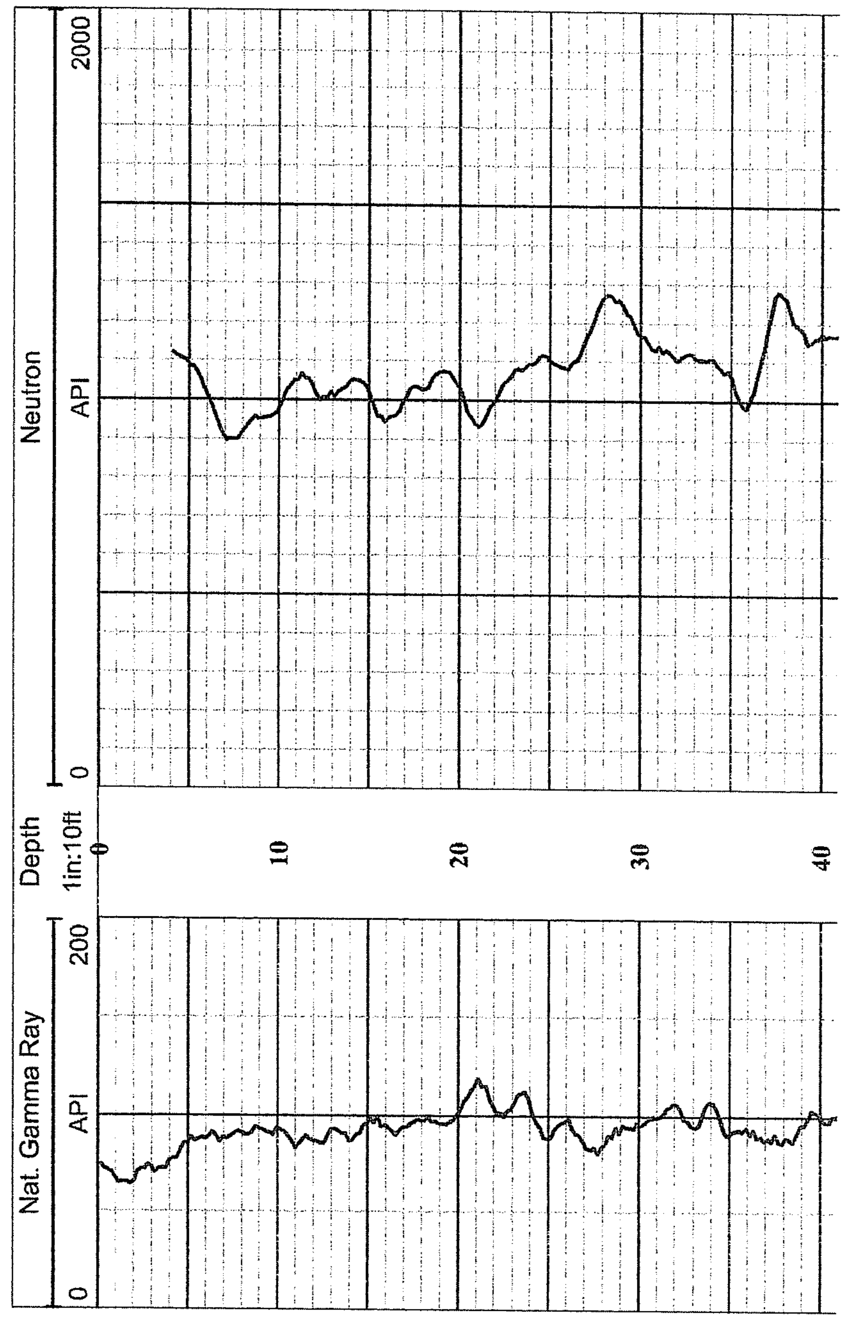


FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19, (continued).

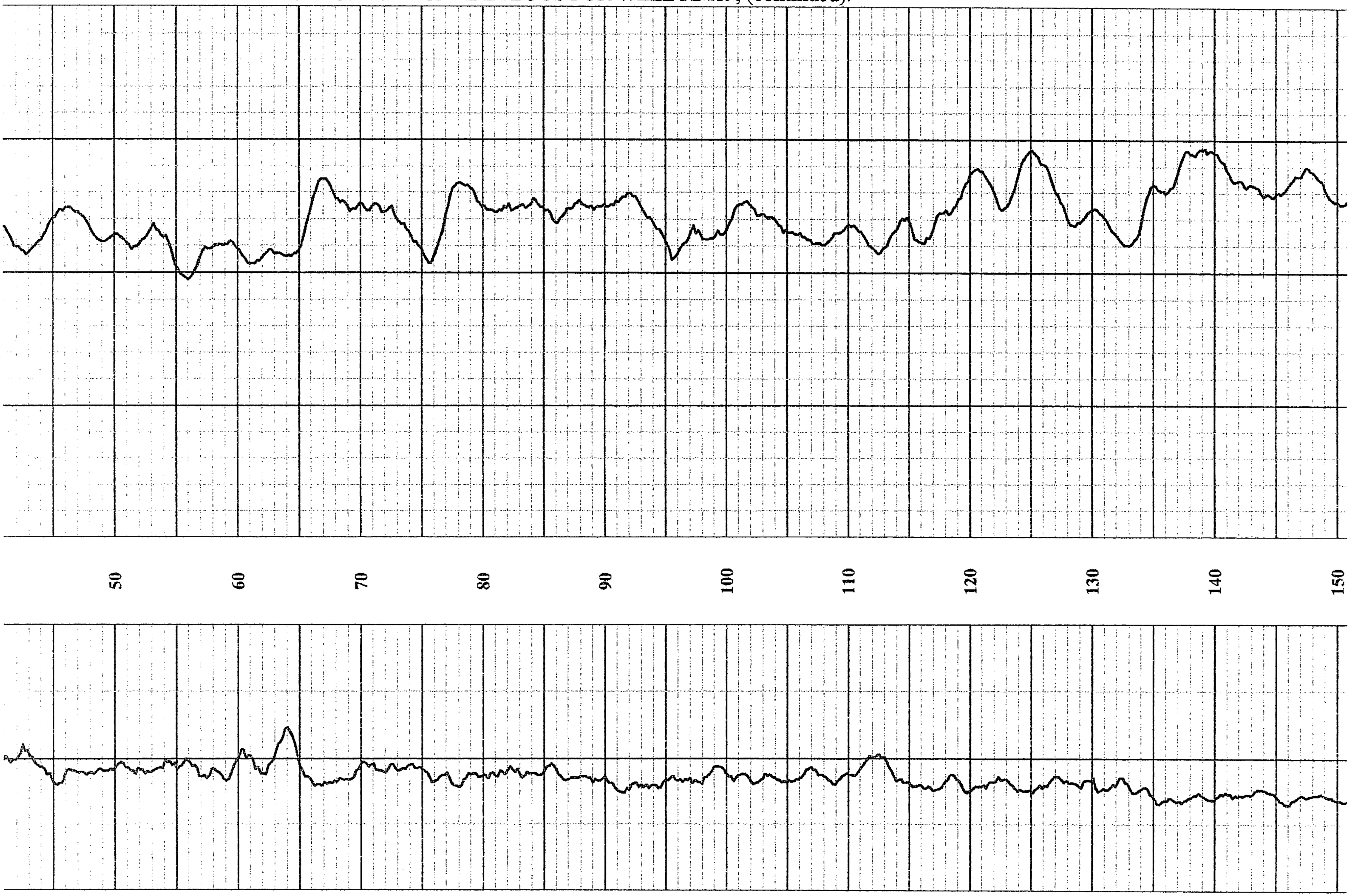


FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19, (continued).

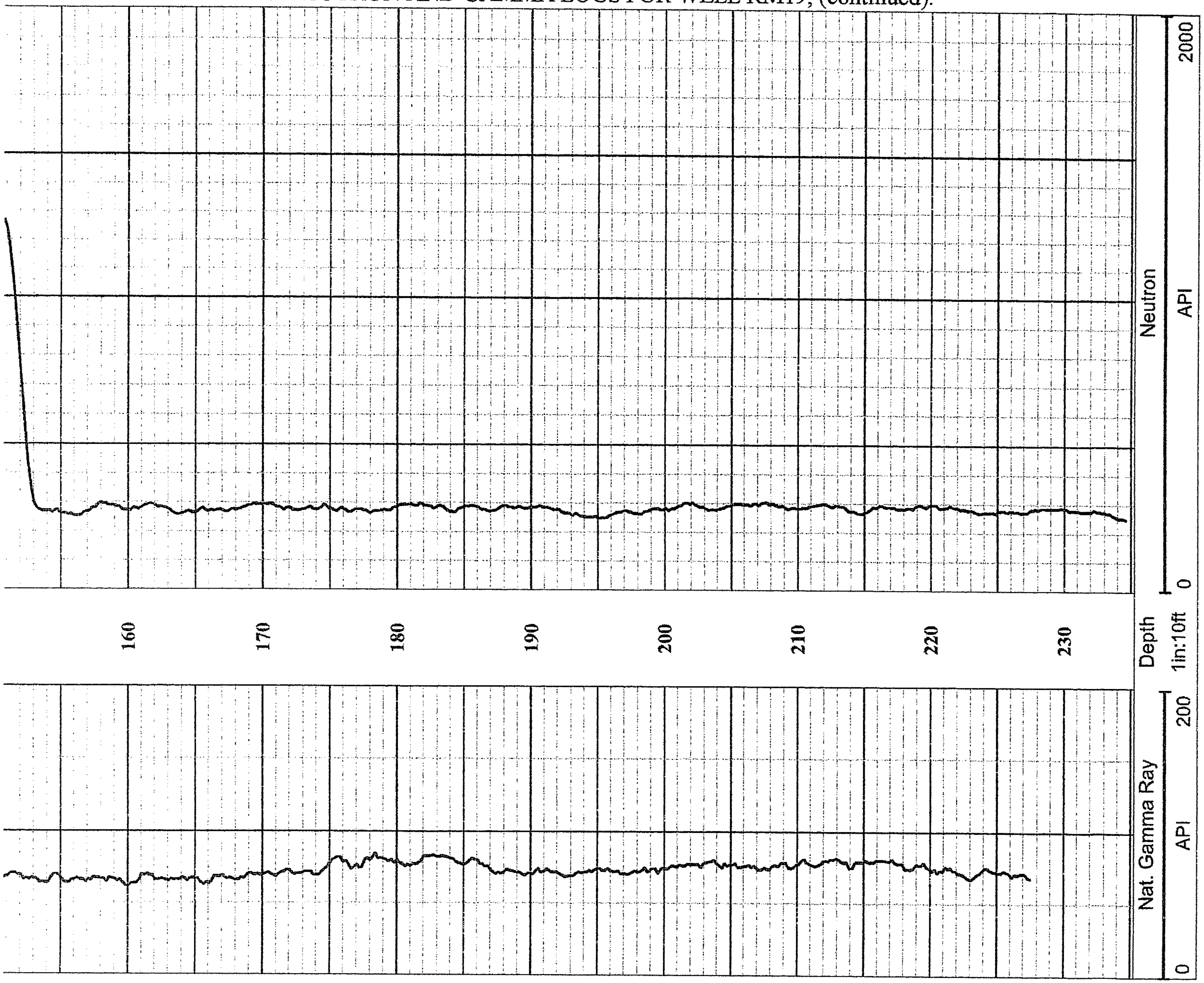


FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20.

Southwest Geophysical Services, Inc.

COMPANY	PLATEAU RESOURCES
WELL ID	RM-20
FIELD	SHOOTARING MILL
COUNTY	GARFIELD
STATE	UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES: NONE

LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION		K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM		D.F.
DRILLING MEAS. FROM				G.L.

DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	211 FT	LEVEL	127 FT
DEPTH-LOGGER	211 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	211FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	TOTAL DEPTH	5"	PVC	SURFACE	TOTAL DEPTH

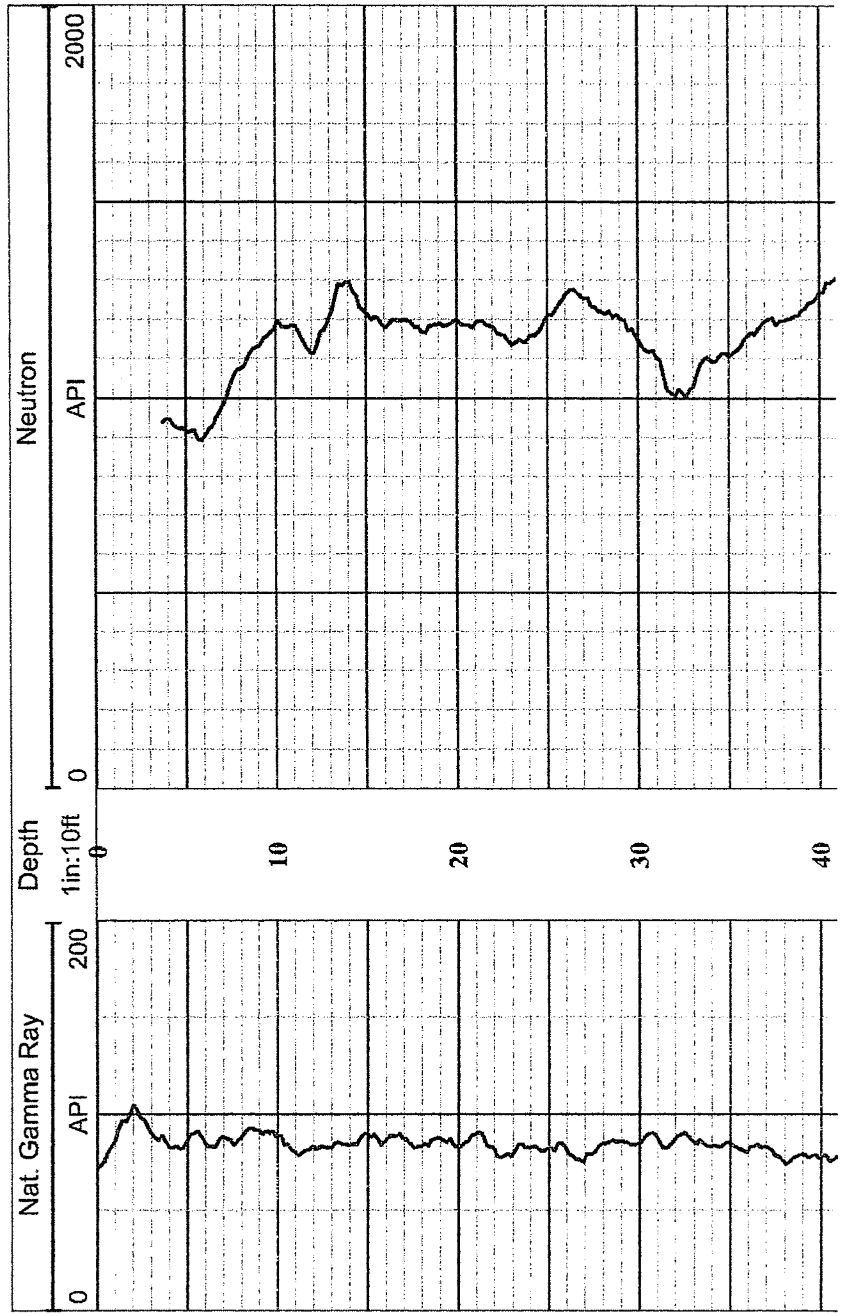


FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20, (continued).

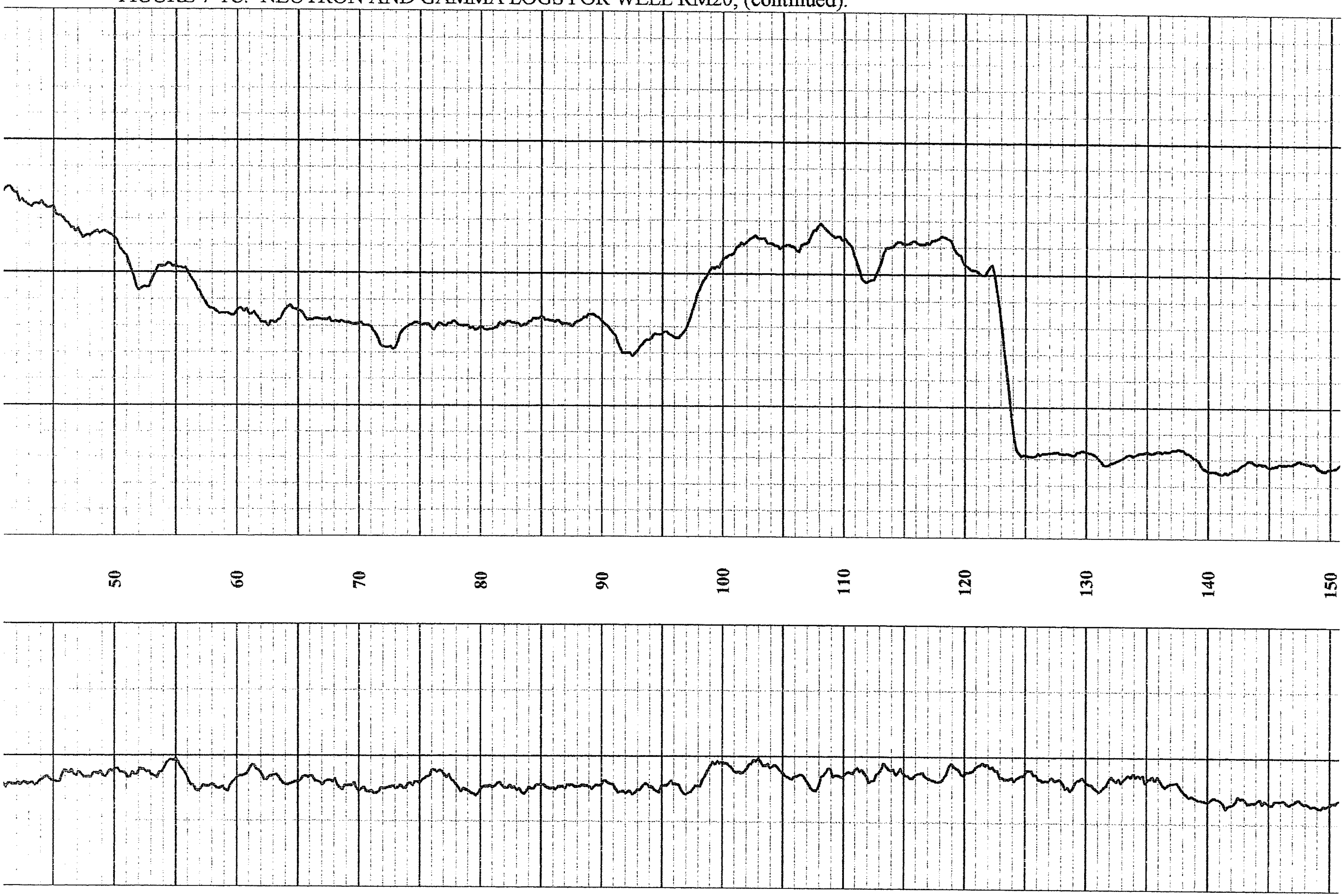


FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20, (continued).

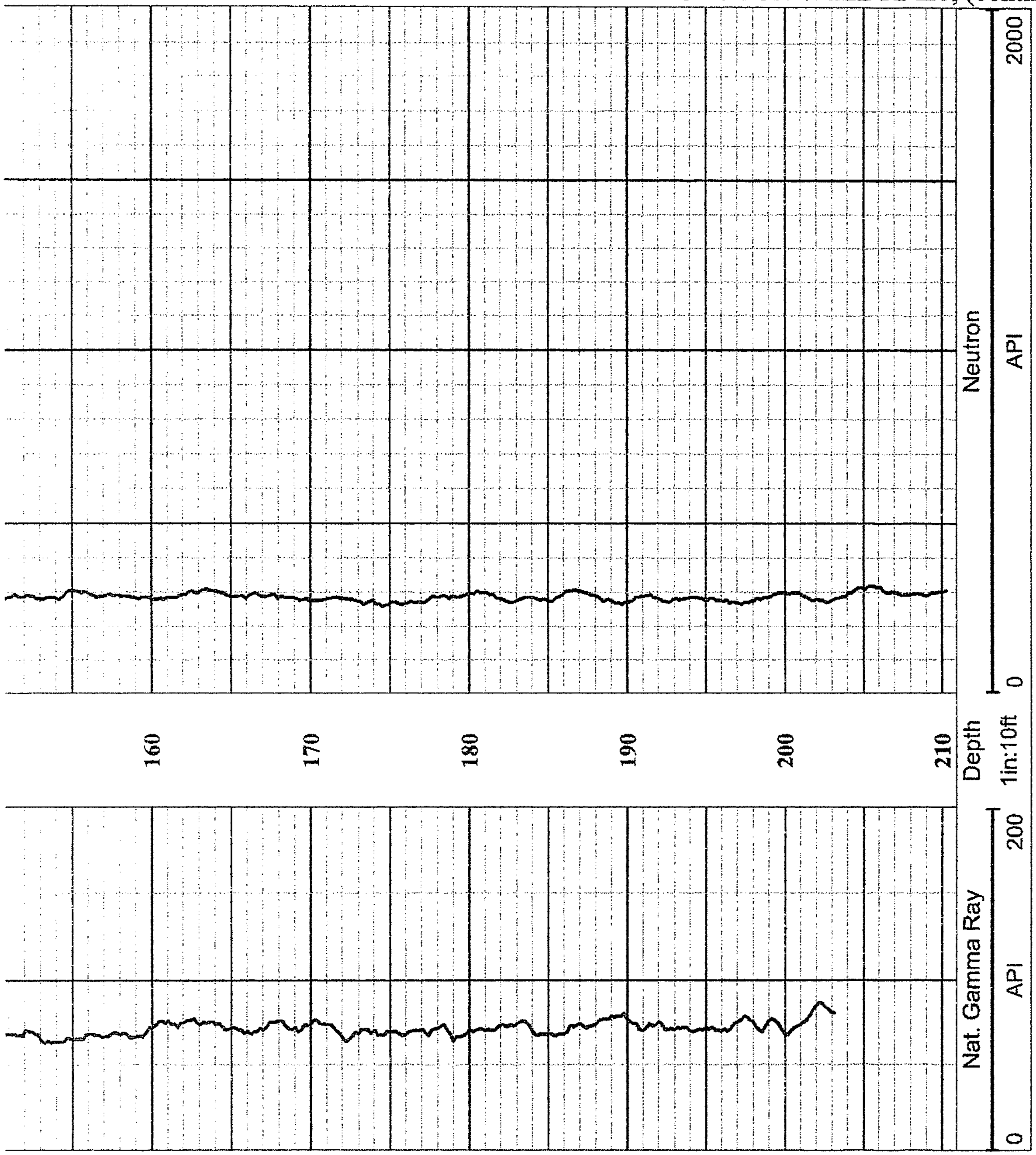


FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-14
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES
NONE

LOCATION

SEC TWP RGE

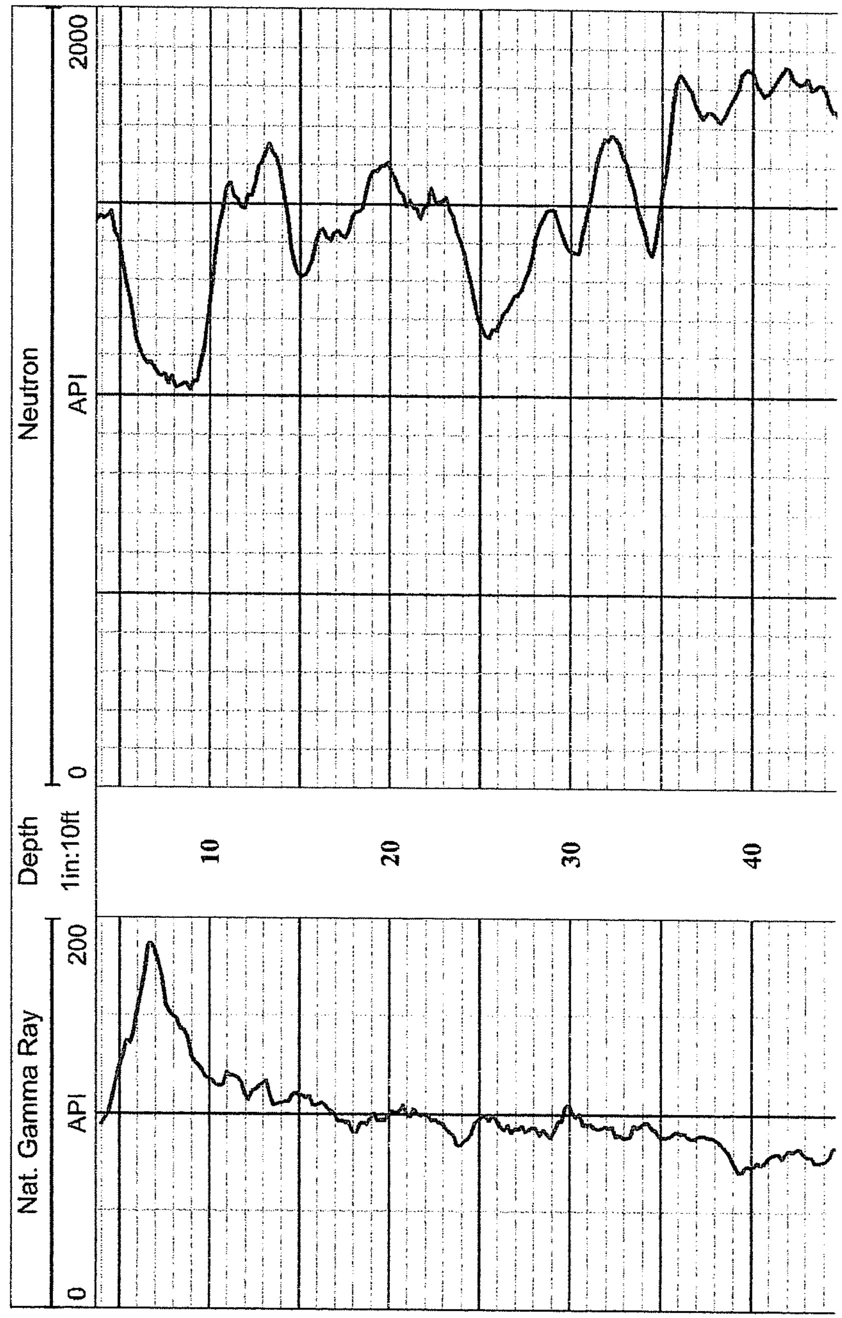
PERMANENT DATUM ELEVATION K.B.

LOG MEAS. FROM GROUND LEVEL ABOVE PERM. DATUM D.F.

DRILLING MEAS. FROM G.L.

DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	260 FT	LEVEL	195 FT
DEPTH-LOGGER	260 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	260 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	160 FT	5"	PVC	SURFACE	160 FT
2	4 3/4"	160 FT	TOTAL DEPTH				



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December 2005

FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14, (continued).

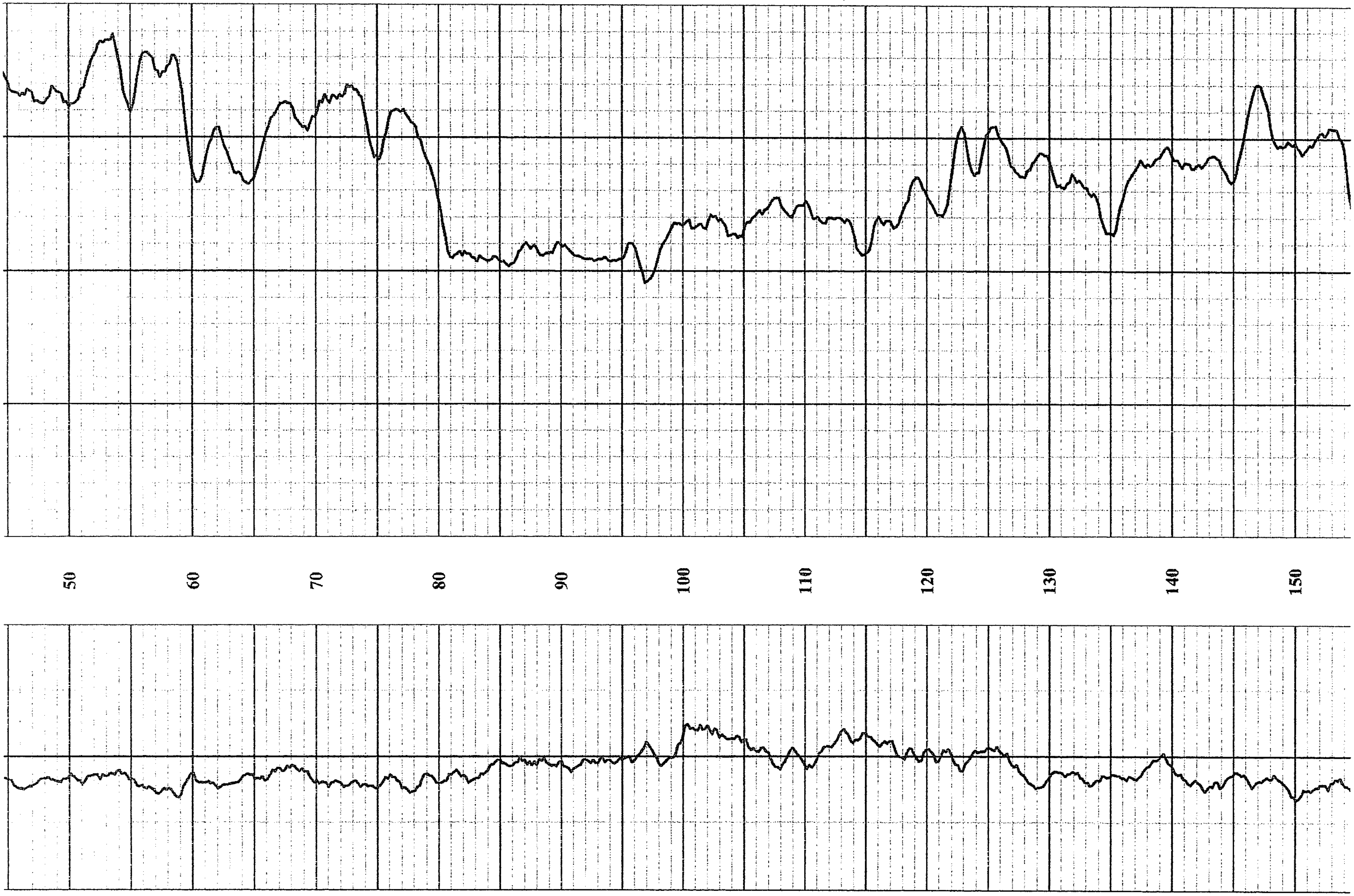
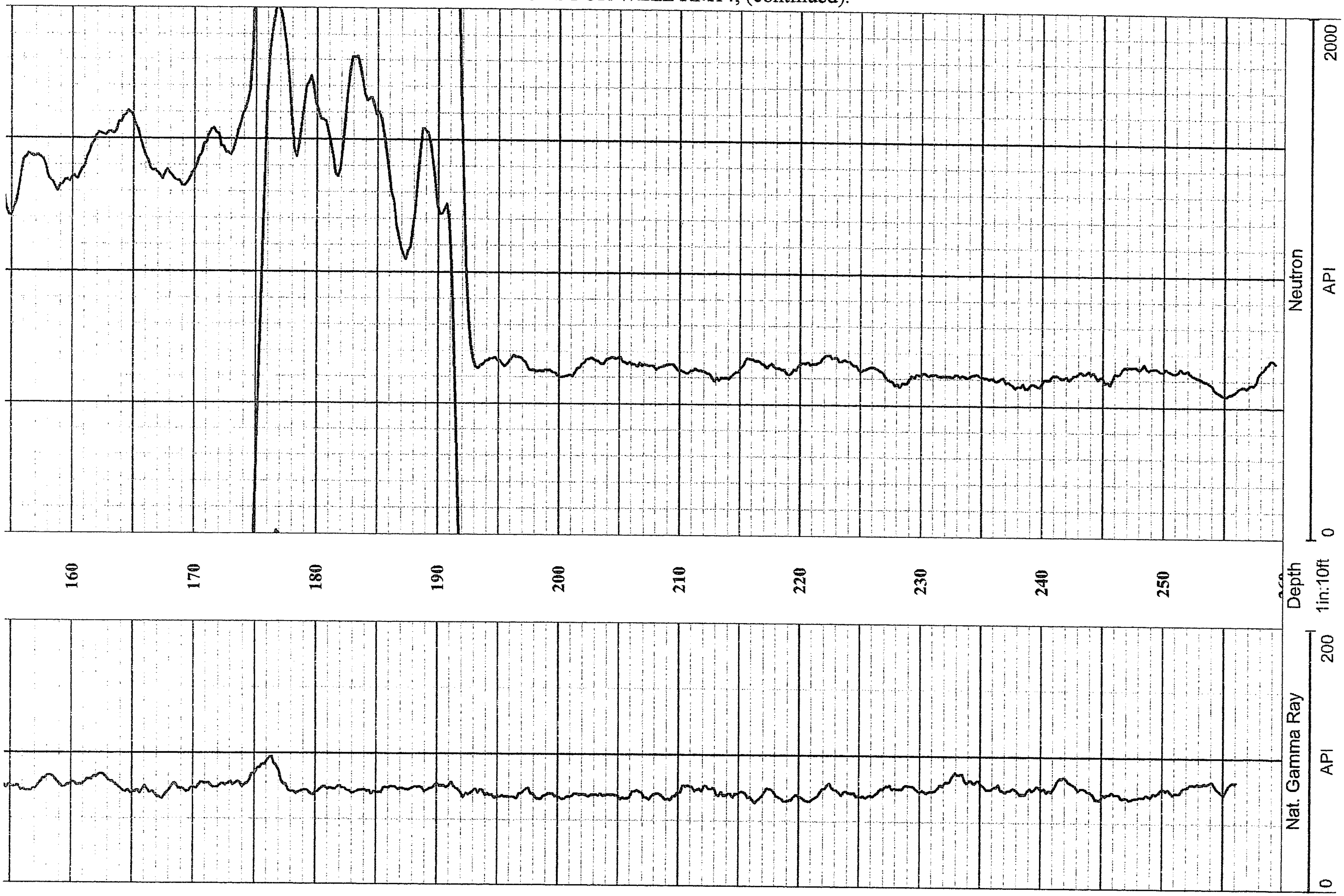


FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14, (continued).



Southwest Geophysical Services, Inc.

GEOPHYSICAL WELL LOG: NATURAL GAMMA RAY NEUTRON	**PERM. DATUM:** TOP OF CASING **LOG MEASURED FROM:** T. O. C. **ELEVATION:**	**OTHER SERVICES:**

COMPANY: PLATEAU RESOURCES
PROJECT/FIELD: TICABOO TAILINGS PILE
WELL: RM-8
LOCATION: SEC: **T:** **R:**
NORTH= **EAST=**
COUNTY: GARFIELD **STATE:** UTAH

ELEVATION KB:
DF:
GL:

COMPANY: PLATEAU RESOURCES
WELL: RM-8

	RUN NO. 1		RUN NO. 1
DATE	2/25/98	FLUID LEVEL	56 FT
DEPTH DRILLER	90 FT	FLUID NATURE	FORMATION FLUID
DEPTH LOGGER	78 FT	FLUID VISCOSITY	
BOTTOM LOGGED	77 FT	FL. RESISTIVITY	
TOP LOGGED INT.	SURFACE	FL. RES. @ B.H.T.	
CASING LEVEL	ALL	CIRCULATION TEMP.	
CASING SIZE	3 IN ID	BOT HOLE TEMP.	
CASING SIZE	PVC	TOOL #	HS
BIT SIZE		LOGGED BY:	SHERRY MILLER
BIT SIZE		WITNESSED BY:	CHUCK JOHNSON

REMARKS:

THANK YOU

FIGURE 7-1E. NEUTRON AND GAMMA LOGS FOR WELL RM8.

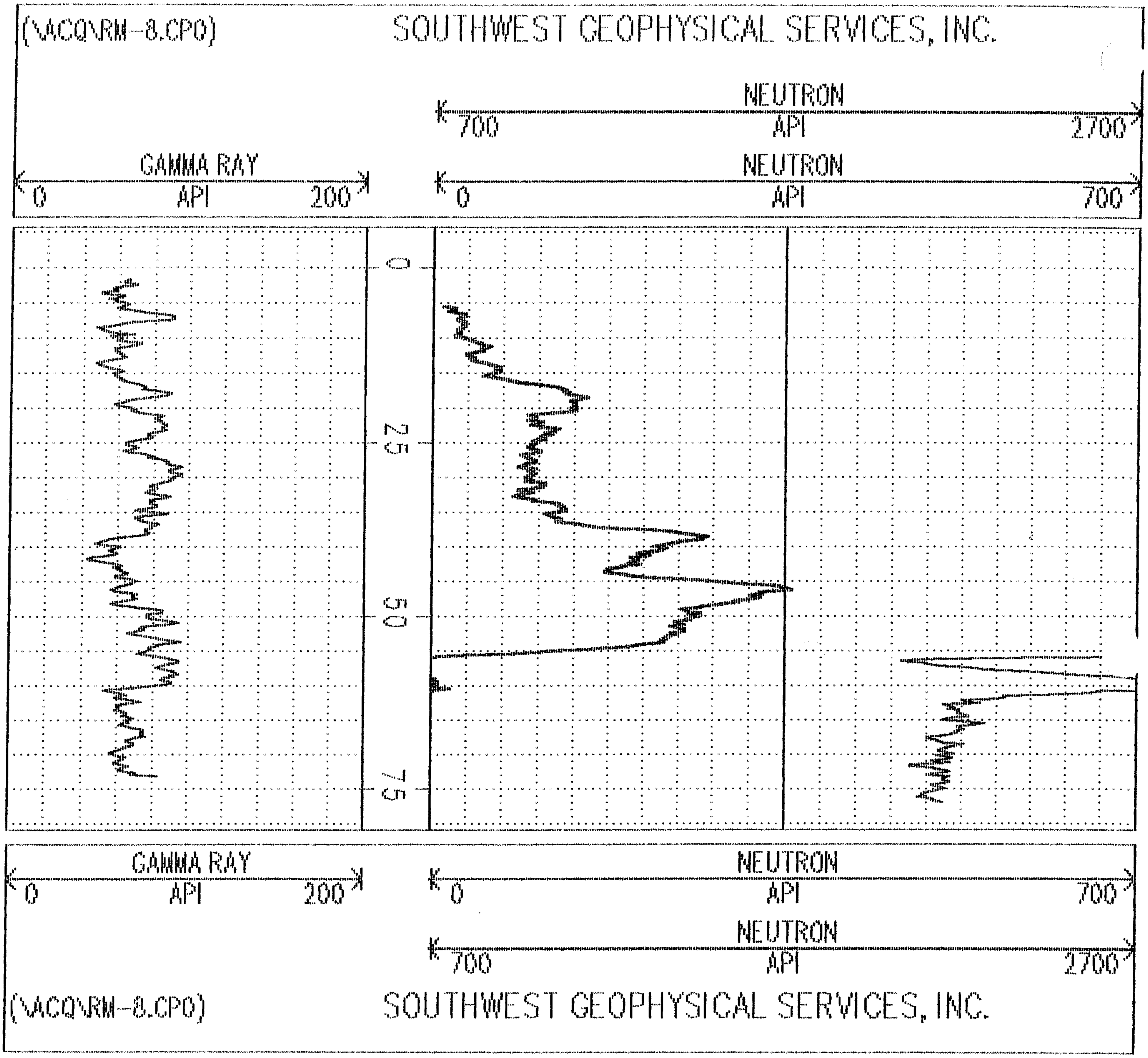
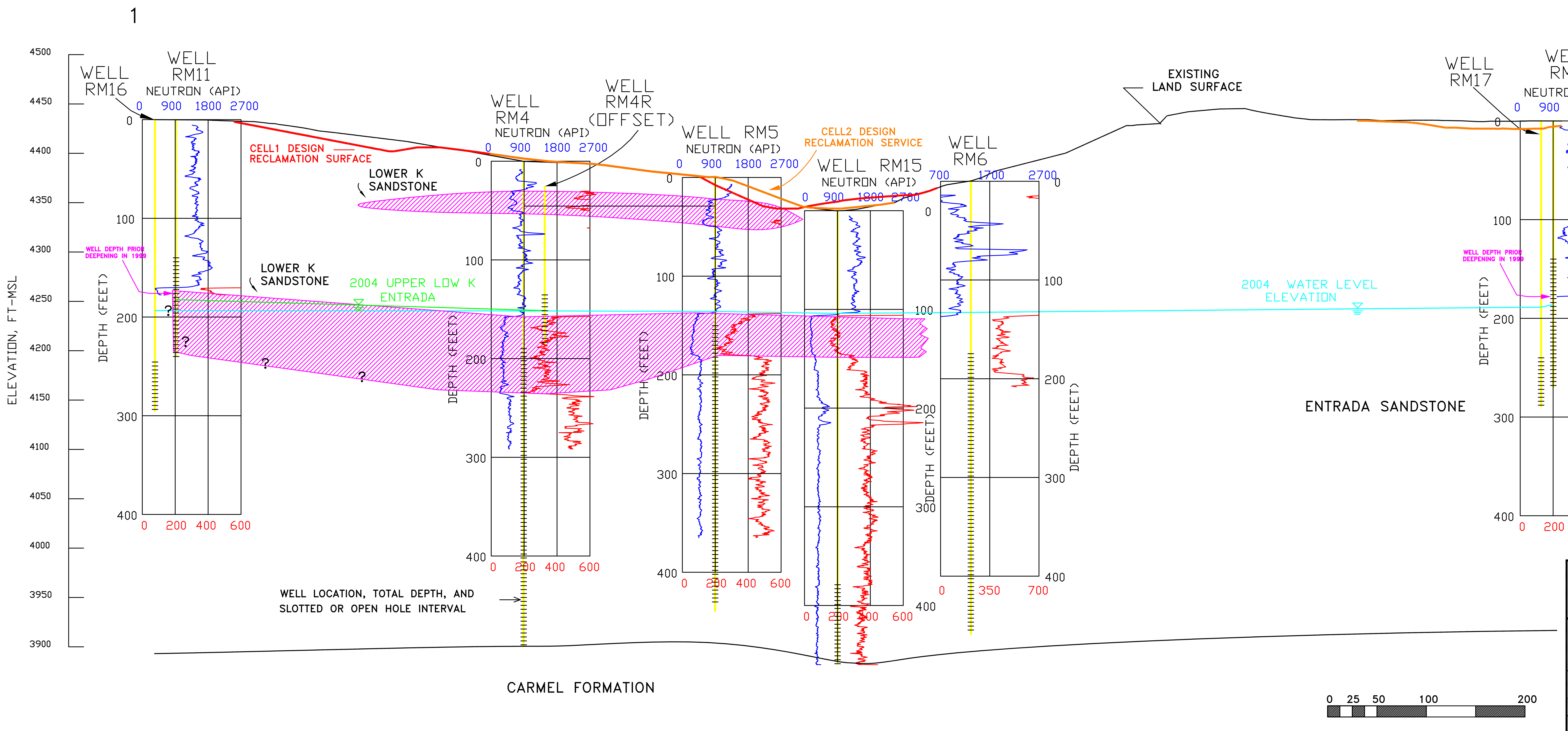


FIGURE 7-1E. NEUTRON AND GAMMA LOGS FOR WELL RM8, (continued).



PLATEAU RESOURCES, LTD.
SHOOTARING CANYON MILL

FIGURE 7-2.
GEOLOGIC CROSS SECTION 1-1'

SCALE: HORIZ. 1"=80' VERT. 1"=50'	HYDRO-ENGINEERING, LLC CASPER, WYO
DATE: 12/18/05	

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2004 WATER QUALITY

CONSTITUENT	WELLS RM14	RM19	RM7
Ammonia, Dissolved	<0.05	<0.05	<0.05
Arsenic, Dissolved	<0.003	<0.003	<0.003
Barium, Dissolved	<0.1	0.1	0.1
Cadmium, Dissolved	<0.001	<0.001	<0.001
Chloride, Dissolved	9	3	4
Chromium, Dissolved	<0.01	<0.01	<0.01
Conductivity, Field @ 25C	383	354	361
Copper, Dissolved	<0.01	<0.01	<0.01
Flouride, Dissolved	0.2	0.2	0.2
Lead, Dissolved	<0.002	<0.002	<0.002
Mercury, Dissolved	<0.001	<0.001	<0.001
Molybdenum, Dissolved	<0.005	<0.005	<0.005
Nitrate + Nitrite, Dissolved	1.8	1.3	1.3
pH, Field	7.34	7.39	7.21
Selenium, Dissolved	<0.005	<0.005	<0.005
Silver, Dissolved	<0.005	<0.005	<0.005
Sulfate, Dissolved	27	22	22
Temperature Celsius	21.4	21	22.8
Total Dissolved Solids	245	176	189
U-Nat, Dissolved	0.0037	0.0029	0.0029
Water Level	191.3	152.3	140.3
Zinc, Dissolved	<0.01	<0.01	<0.01

Note: All units are in mg/l except conductivity in umhos/cm, pH in Standard Units and water level in depth below measuring point in feet.

2004 WATER QUALITY

CONSTITUENT	WELLS RM18	RM2R
Ammonia, Dissolved	<0.05	<0.05
Arsenic, Dissolved	<0.003	<0.003
Barium, Dissolved	0.10	0.10
Cadmium, Dissolved	<0.001	<0.001
Chloride, Dissolved	8.0	13.0
Chromium, Dissolved	<0.01	<0.01
Conductivity, Field @ 25C	361	379
Copper, Dissolved	<0.01	<0.01
Flouride, Dissolved	0.200	0.200
Lead, Dissolved	<0.002	<0.002
Mercury, Dissolved	<0.001	<0.001
Molybdenum, Dissolved	<0.005	<0.005
Nitrate + Nitrite, Dissolved	1.4	1.5
pH, Field	7.87	6.99
Selenium, Dissolved	<0.005	<0.005
Silver, Dissolved	<0.005	<0.005
Sulfate, Dissolved	23	29
Temperature Celsius	20.2	20.6
Total Dissolved Solids	201	208
U-Nat, Dissolved	0.0030	0.0030
Water Level	163.8	243.4
Zinc, Dissolved	<0.01	<0.01

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SHOOTARING CANYON MILL

FIGURE 7-3.
GEOLOGIC CROSS SECTION 2-2'

SCALE: HORIZ. 1"=160' VERT. 1"=80'
DATE: 12/18/05
HYDRO-ENGINEERING, LLC
CASPER, WYO

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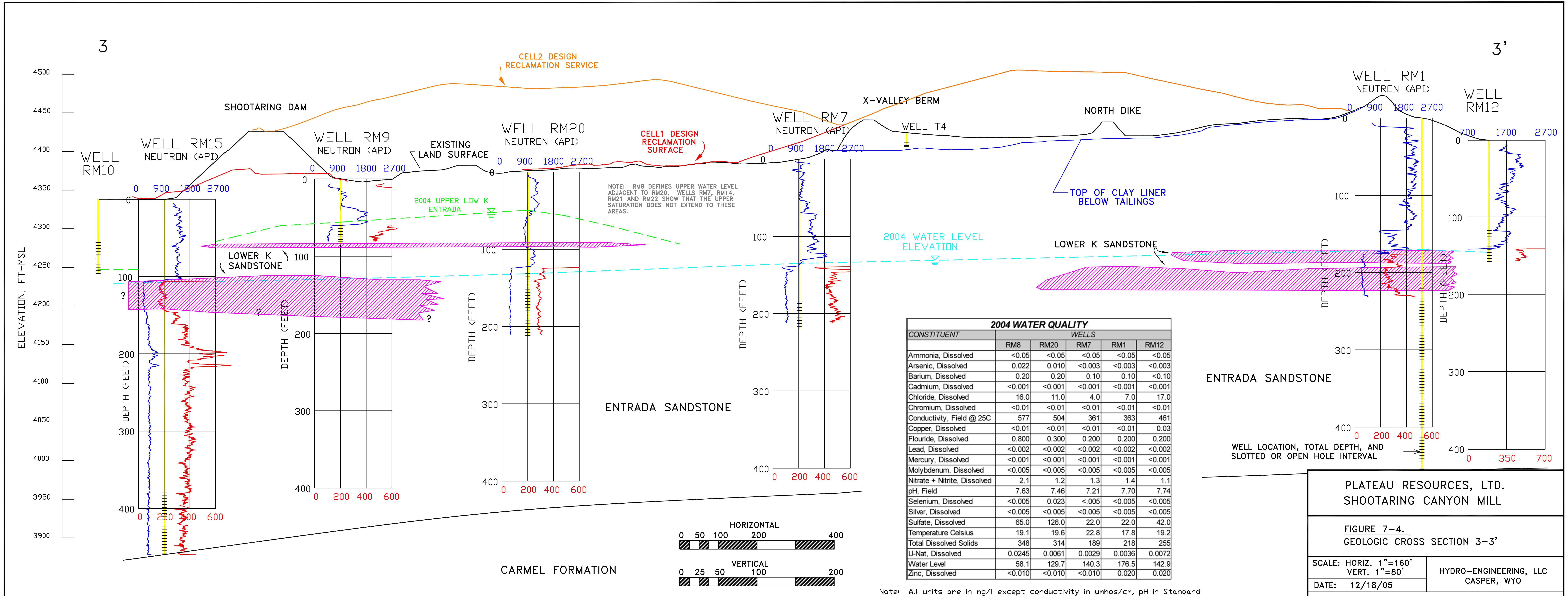

2004 WATER QUALITY

CONSTITUENT	WELLS				
	RM8	RM20	RM7	RM1	RM12
Ammonia, Dissolved	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic, Dissolved	0.022	0.010	<0.003	<0.003	<0.003
Barium, Dissolved	0.20	0.20	0.10	0.10	<0.10
Cadmium, Dissolved	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride, Dissolved	16.0	11.0	4.0	7.0	17.0
Chromium, Dissolved	<0.01	<0.01	<0.01	<0.01	<0.01
Conductivity, Field @ 25C	577	504	361	363	461
Copper, Dissolved	<0.01	<0.01	<0.01	<0.01	0.03
Flouride, Dissolved	0.800	0.300	0.200	0.200	0.200
Lead, Dissolved	<0.002	<0.002	<0.002	<0.002	<0.002
Mercury, Dissolved	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, Dissolved	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate + Nitrite, Dissolved	2.1	1.2	1.3	1.4	1.1
pH, Field	7.63	7.46	7.21	7.70	7.74
Selenium, Dissolved	<0.005	0.023	<.005	<0.005	<0.005
Silver, Dissolved	<0.005	<0.005	<0.005	<0.005	<0.005
Sulfate, Dissolved	65.0	126.0	22.0	22.0	42.0
Temperature Celsius	19.1	19.6	22.8	17.8	19.2
Total Dissolved Solids	348	314	189	218	255
U-Nat, Dissolved	0.0245	0.0061	0.0029	0.0036	0.0072
Water Level	58.1	129.7	140.3	176.5	142.9
Zinc, Dissolved	<0.010	<0.010	<0.010	0.020	0.020

Note: All units are in mg/l except conductivity in umhos/cm, pH in Standard Units and water level in depth below measuring point in feet.

PLATEAU RESOURCES, LTD.
SHOOTARING CANYON MILL

FIGURE 7-4.
GEOLOGIC CROSS SECTION 3-3'

SCALE: HORIZ. 1"=160'
VERT. 1"=80'

DATE: 12/18/05

HYDRO-ENGINEERING, LLC
CASPER, WYO

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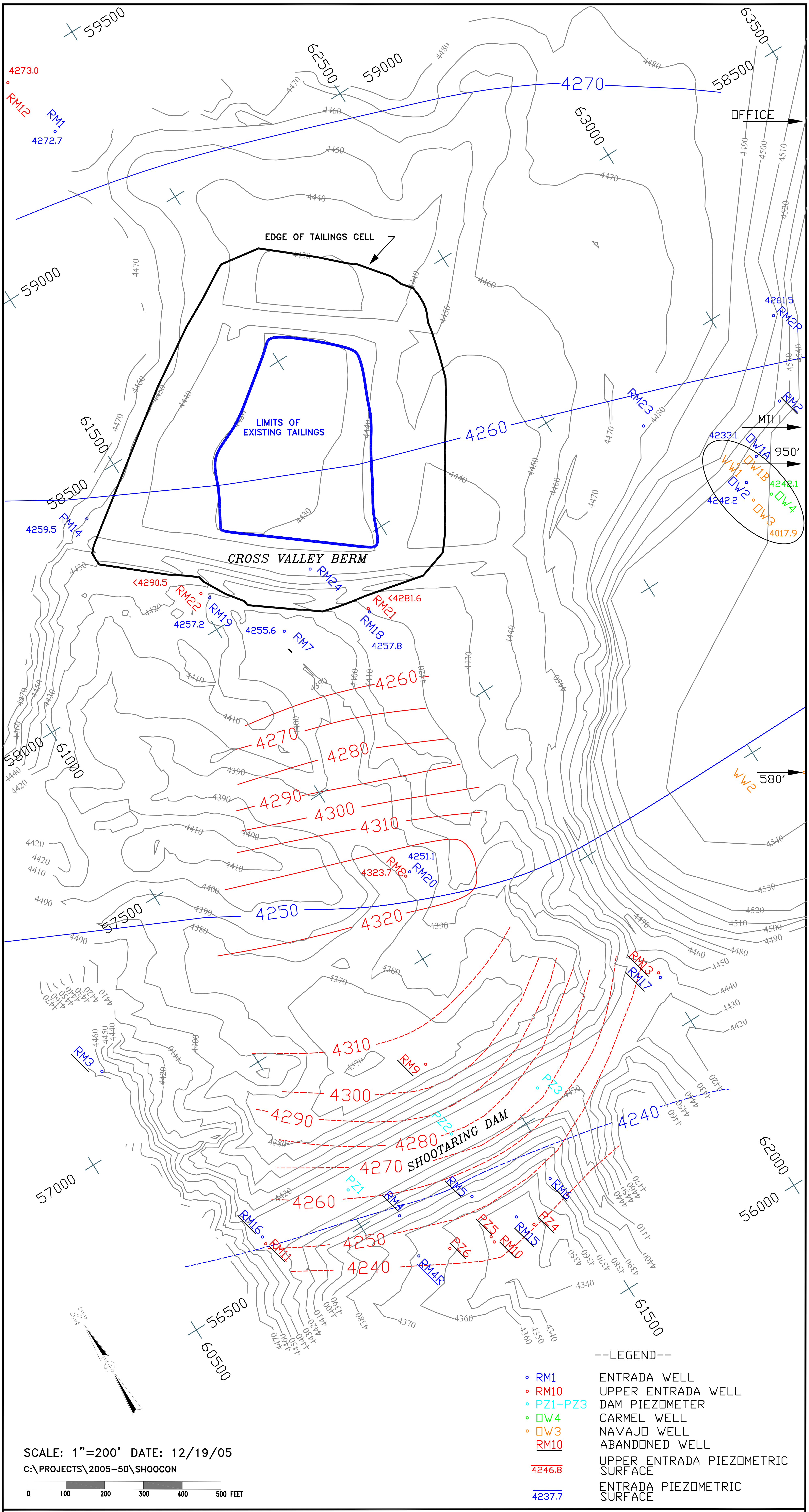


FIGURE 7-5. WATER-LEVEL ELEVATION IN THE UPPER ENTRADA AND ENTRADA AQUIFER, 2004, FT-MSL

8.0. MILL DECOMMISSIONING AND SITE CLEANUP

PRL intends to decontaminate salvageable equipment for unrestricted release. Equipment and structures having no net salvageable value will be removed and placed in the tailings cell. Contaminated soils and contaminated residues will be consolidated with the tailings and stabilized in the EPPC. Disturbed areas will then be graded and seeded for growth of native vegetation.

The mill site consists of the following:

Main Office Building	Truck Scales	Maintenance Shop
Ore Storage Area	Bucking Room	Warehouse
Grizzly - Dump Pocket	Acid Tank	Environmental Lab
Fuel Oil Tank	Potable Water Tank	Analytical Lab-Stacks
Raw Water Tank	Wet Scrubber - Stack	Reagent Storage
Conveyor - Tunnel	Seal Water Tank	Generator Buildings- Stacks
Pump House	De-Mister Stack	Vanadium Circuit Building
Grinding Leach Area		
Counter Current Decantation Area		
Precipitation - Drying - Packaging Area - Stack		

Plans for contaminated soil removal and decontamination or demolition of the structures are presented in the following sections.

8.1 Regulatory Requirements

All decommissioning activities will be done in accordance with the applicable requirements in Title 10 of the Code of Federal Requirements, the current license, and other applicable regulatory requirements. The work will be done as soon as practical in conformance with 10CFR 40.42(g) and Utah Admin. Rule R313-24.

The performance-based State of Utah license requires reviews of all operations and procedures to assure that radiation exposure to workers and the public will be maintained as low as reasonably achievable. At this time, it is believed that only one activity, the decommissioning of the yellowcake building, has the potential to result in exposures exceeding that from normal mill operations. Engineering controls, including the application of a fixative agent to control the release of uranium, will be reviewed and approved by the Safety and Environmental Review Panel (SERP). In addition to special engineering and administrative controls, standard management controls will govern the decommissioning activities, including the use of Standard Operating Procedures, Radiation Work Permits, and other administrative and engineering controls utilized by the Environmental and Radiological Health Supervisor (ERHS), site management; Safety and Environmental Review Panel (SERP), and corporate management. Worker exposure concentrations will be measured utilizing one or more of the following methods: Bioassay, TLD and/or air sampling as conditions warrant.

PRL will conform to the recordkeeping requirements in 10 CFR 40.36(f) and relevant requirements in Utah Admin. Rule R313-24, where all records related to the decommissioning will be maintained for review and transfer to the State of Utah. This includes current records related to spills or releases and any known buried material or material outside of the radiation control area. Records will be kept at the Corporation main offices at 877 North 8th West, Riverton, WY.

The environmental and occupational safety impact of decommissioning the mill will be minimal with the controls that have been outlined in the cleanup. See Appendix I for a list of Titles of Standard Operating Procedures that are in place and will be utilized and/or updated or modified as needed during the site reclamation and decommissioning. Standard Operating Procedures have been added, updated or modified to reflect the requirements of the reclamation plan. See Section 3.3 for additional discussion on Radiation health and safety. The consolidation of the contaminated soil and materials and placement in the capped tailings cells will eliminate this as a potential source of release to the environment. Impacts to plants and animals should be negligible due to the small surface area of disturbance and a relatively short reclamation schedule. The impact to the water quality will be positive in that all contaminated materials will be placed into a designed long-term disposal cell, making it less available for transport to surface and groundwater. Negative impacts include increased water use for dust control and soil conditioning and short-term degradation of the air quality during reclamation.

8.2 Disassemble and Dispose of Contaminated Equipment and Structural Materials

All materials and plant equipment unsuitable for unrestricted release will be placed in the tailings impoundment for disposal. This includes contaminated residues from tanks or vessels identified for decontamination to release criteria levels.

Table 8-1 lists the equipment anticipated for disposal. This equipment will not be decontaminated. Non-degradable material will be placed into a tailings pit and flowable fill added to fill the voids. The flowable fill to be utilized in reducing voids in and around mill demolition material placed into the tailings cell is designed to reduce voids only and not provide support or have strength after drying. The flowable fill is made up of cement, fly ash (class F or C), water and onsite soil material. The ratio of the mixture will depend upon type of soil, water and fly ash available. The mixture will be mixed onsite and poured into the demolition cell to the top of the debris. The wood or other degradable material will be placed in single lifts no greater than 6-inches thick and covered with sandy fill material. A limited number of small items, such as the sump pump, will be buried with compacted fill prior to the placement of the cap. Pipe will be cut into manageable lengths and placed in the disposal pit to be filled with flowable fill. A minimum of three debris disposal pits are planned on top of the EPPC.

TABLE 8-1. List of Equipment Anticipated for Disposal into Tailings Facility

Equipment	Construction Material
Ore grizzly	Steel
Wet Scrubber	Steel
Sulfuric acid tank	Steel
Leach feed tanks w agitator	Rubber coated steel
Leach 1st stage w agitator	Rubber coated steel
Leach 2nd stage w agitator	Rubber coated steel
Primary thickener 1st stage	Rubber coated steel
Clarifier thickener 2nd stage	Rubber coated steel
Sand filters	Steel
Counter current decantation concrete pad	Concrete
Reagent mix tanks	Steel
Sodium chlorate tank	Steel
Solvent extraction tanks, mixers	Fiberglass
Solvent extraction scrubber	Fiberglass
Precipitation solution tank	Fiberglass
Yellow Cake precipitation tanks	Rubber coated steel
Yellow Cake thickener	Rubber coated steel
Yellow Cake drum filters	Steel
Yellow Cake calciner	Masonry & steel
Yellow Cake impact crusher	Steel
Yellow Cake Scrubber	Steel
Tailings slurry line	HDPE pipe
Dust/fume collector	Steel, fiberglass
Pumps, piping, electric motors and other misc.	Steel, rubber coated steel, fiberglass, copper
Vanadium Circuit	
Misc. concrete and rebar	Concrete, steel
Contaminated yard area	Steel, fiberglass

8.3 Decontamination of Tools, Equipment and Buildings for Unconditional Use

All tools, equipment, and structures considered for unrestricted release will be decontaminated prior to monitoring. This includes all building surfaces classified as MARSSIM Class 1 and Class 2 (as defined in Appendix H). Decontamination methods include a combination of washing, high-pressure sprays, or steam cleaning. No hazardous waste constituents will be used in the decontamination process. The surfaces will be air dried prior to radiological monitoring.

Table 8-2 is a list of equipment and buildings that are anticipated to be cleaned and released. Any of the equipment and buildings on this list may be moved to the disposal list if cleanup efforts are not beneficial or the cost of cleanup exceeds the salvage value.

TABLE 8-2. List of Equipment/Buildings Anticipated for Unrestricted Release

Equipment	Size	Construction Materials
Office building	25'x80'	metal frame with metal siding, wood and gypsum board interior
Desks, file chairs		
Guard station		wood frame with wood siding and gypsum board
Scale		steel and wood
Sample preparation building		steel
Ore Hopper		steel
Conveyor apron feed		steel
Conveyor structure		steel
Belt		rubber composite
Fresh water tanks –2 tanks		steel
Pump/fire house building	20'x50'	concrete, steel frame and steel siding
Temporary gensets		
Powerhouse building	60'x90'	steel frame and steel siding
3-gensets complete		
2-air compressors		
Control panels		
Dry (change rooms)		
Diesel fuel tank		steel
Electric switchgear		
Transformers		
SAG mill		
Controls		
Screens		
Vanadium building		
Mill control room instrumentation		
Mill office area		wood/sheet rock
Counter current decantation tanks		rubber lined steel
Ammonia tank		steel
Unloading pump		
Kerosene tank		steel
Pumping system		
Laboratory building	45'x85'	metal frame with metal siding, wood and gypsum board interior
Lab equipment		
Maintenance shop building	75'x120'	steel frame and steel siding
Equipment		
Warehouse building	70'x75'	metal frame with metal siding, wood and gypsum board interior
Main mill building		steel frame and steel siding
Solvent extraction	70'x100'	
Precipitation	40'x70'	
Reagent	40'x70'	
Grinding and leach	70'120'	

8.3.1 Monitoring and Release of Tools, Equipment and Buildings

Tools and equipment with potential radiological contamination will be monitored prior to release using existing standard operating procedures. Tools and equipment meeting the criteria in NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use of Termination of Licenses for Byproduct, Source, or Special Nuclear Material, dated May 1987" will be released for unrestricted use.

Release criteria have been developed for building surfaces following NRC Regulation in 10 CFR 40, Appendix A and 10 CFR 20 and related sections of Utah Admin. Rule R313-24. The code, RESRAD-Build, was used to calculate the total effective dose equivalent (TEDE) to future occupants of the buildings when exposed to surface contamination from yellowcake and process liquids. It was assumed that the buildings will be used for industrial purposes and that workers occupying the buildings are the critical group. Appendix G presents the results of the TEDE modeling where a gross alpha contamination limit of 700 dpm/100 cm^2 is proposed. This limit conforms to the 10 CFR 20 TEDE limit of 25 mrem/y. The State of Utah requires the use of the Benchmark Approach for uranium recovery facilities, where the TEDE was calculated in Appendix E to be 34 mrem/y. This would have allowed approximately 950 dpm total alpha contamination levels. Because of ALARA considerations, the 700 dpm/100 cm^2 limit will be used.

The dose modeling presented in Appendix G showed that the dose from yellowcake was very similar to the dose from process liquids, if normalized to the gross alpha emission rate. Therefore a gross alpha contamination limit of 700 dpm/ 100 cm^2 will be applied to all buildings surfaces. The removable limit was established as 20 percent of the total limit, based on existing mill building surface contamination levels for total and removable.

A MARSSIM-based characterization and verification plan was developed and presented in Appendix H. This plan will be followed to demonstrate compliance with the surface contamination limits for building surfaces. Buildings will be monitored and released according to the monitoring procedures and release criteria presented in Appendices G and H. Areas within buildings showing evidence of possible penetration of process solutions will be evaluated for possible subsurface contamination. Based upon exposure of the building or area of the building to process solution that could be carried below the concrete floor, coring will be conducted in the SX, grinding, leaching and yellowcake sump areas. The cored concrete will be tested for process contamination (i.e. retained uranium and Ra-226) and the soil beneath the concrete should be tested in fifteen (15) centimeter intervals to determine if it has been contaminated. If the buildings, slabs and soils beneath the slabs are not contaminated, the buildings shall be released for unrestricted use, provided the building surfaces meet the release criteria and radiological monitoring requirements in Appendices G and H, respectively. Otherwise, the buildings will be demolished, the slabs removed, and the underlying soils removed (if contaminated) and all contaminated materials shall be placed in the tailings impoundment. Releasable concrete slabs may be covered with two (2) feet of clean native borrow soils in lieu of removal and disposal in the impoundment area.

8.3.2 Disposal of Non-radiological or Laboratory Chemicals

All reagents and laboratory chemicals remaining on site will be disposed of in conformance with all applicable federal and state regulations pertaining to the transport and disposal of hazardous material, where applicable. Potentially contaminated reagents and chemicals will be tested for byproduct contamination before transfer. Laboratory chemicals that did not come in contact with the uranium recovery process, and are not contaminated with radionuclides, will be transferred off site.

Two non-radiological hazards on the site are sodium chlorate and sulfuric acid. These hazards will be encountered during the decommissioning of the sodium chlorate and sulfuric acid storage tanks and distribution lines. PRL has identified an outside consultant with experience in handling these two chemicals under uranium mill site conditions and PRL will utilize his services.

8.3.3 Disposal of Decontamination Wash Water

The facility slabs are constructed to allow drainage of liquids to a sump. All decontamination water will drain to these sumps. Decontamination water will be disposed of in the tailings cell. This water will be used for dust and moisture control for the tailings reclamation and also used in the flowable fill mixing.

8.4 Contaminated Soil Cleanup

Section 3 presents the results of a recent radiological characterization survey that shows areas of the site where soil contamination exists. The survey shows that soil contamination is limited to areas of known spills and the ore storage area. The exact boundaries of the areas cannot be defined at this time since most of the areas were influence by gamma shine from nearby building components, ore piles, or tailings. The affected areas will be remediated using more sensitive survey equipment to assure compliance with the cleanup criteria. In order to assure that the extent of the area has been defined, a 10-meter buffer area (considered Class II and Class III in MARSSIM terminology) contiguous to each contaminated area will be evaluated for potential contamination. The buffer zone for the ore storage area will be 20-meters wide. The site cleanup criteria and procedures are presented in the following subsections.

8.4.1 Cleanup Limits for Soils

The contaminants on the site have been determined to be uranium ore, process solution residuals, Th-230, and to a lesser extent, uranium tailings. No evaporation ponds currently exist at this site except for the very small lined pit on the tailings where the cross valley berm sump water is pumped. This lined pit is normally dry. The cleanup criteria for tailings is given in 10 CFR 20, Appendix A and referenced in Utah Admin. Rule R313-24. The criteria require the cleanup of Ra-226 to 5 pCi/g above background, averaged over the surface 15-cm depth layer and an area of 100 m^2. The limit for subsurface layers is 15 pCi/g.

For radionuclide mixes that are different than uranium tailings, the cleanup criteria are to be based on the Benchmark Approach, where the site specific TEDE (Benchmark Dose) to the critical receptor is calculated using Ra-226 at 5 pCi/g in surface soils. The site-specific contaminant levels are then adjusted so that the TEDE does not exceed the Benchmark Dose.

The radionuclide mix of process solution residuals and uranium ore are identical, based on process knowledge. Therefore the Benchmark Approach was used to develop the cleanup criteria using a radionuclide mix of U-238 and U-235 with the progeny in secular equilibrium and assuming the natural abundance ratios for the uranium isotopes. The analysis, presented in Appendix E, limits the natural uranium contamination in soil to 9.1 pCi/g (13.4 mg/kg). This corresponds to a Ra-226 concentration of 4.4 pCi/g above background. For subsurface layers, it is assumed that the Ra-226 concentration limit would be 3 times the surface layer (similar to that of tailings), or 13 pCi/g above background levels. ALARA considerations require that an effort be made to reduce these concentrations to as low as reasonably achievable levels.

The area shown as "F" in Figure 3-3A consists of approximately 6.5 acres and is potentially contaminated by Th-230 from a tailings water spill. Because the contaminants were originally deposited within the pool of fugitive solution, the distribution of Th-230 at the time of the spill was likely fairly uniform within the pool area. Some cleanup of the 6.5 acres affected by the fluid had been done shortly after the spill, and there is currently less than one acre exhibiting elevated surface gamma-ray exposure rates, attributable to Ra-226 contamination. The measured Ra-226 and Th-230 concentrations in soil samples taken from this small area were less than 35 and 200 pCi/g, respectively. The field gross alpha method will be applied to areas previously determined to be free of gamma-emitting radionuclides. Therefore alpha emissions above natural background levels should be attributable primarily to the decay of Th-230. Prior to applying the method at Shootaring, a set of data will be obtained using soil samples collected from the affected area and comparing the on-site Th-230 analyses to that of a vendor laboratory. This will result in site specific performance parameters (efficiency and MDA) for the gross alpha method. After reclamation, this area will be a sediment catch basin formed by the base of the Shootaring Dam for Cell 1 reclamation or part of the Cell 2 reclamation. The dam will be cut to an elevation where sediment will be retained for the Cell 1 reclamation plan. The water dissipates by evaporation and seepage into the vadose zone. Over time, several feet of sediment will collect above Area F. Because of the undesirability of this area as a building or camping site, no people are likely to spend time there. This situation therefore does not lend itself to developing cleanup criteria using the Benchmark Approach since even short-time occupation of the area is unlikely since it is in the flood plain for the Cell 1 reclamation plan. Under the Cell 2 reclamation plan, the entire area will be beneath the reclaimed tailings Cell 2.

Since cleanup criteria for Th-230 contaminated soils do not exist, the Benchmark approach and an alternative calculation comparing Rn-222 releases were considered for establishing the cleanup criteria. The Benchmark method limits the residual radionuclide concentrations such that the dose is no larger than the dose from occupancy of the site if the surface soils were contaminated with Ra-226 at 5 pCi/g. The dose from radon emissions is specifically excluded. Several exposure scenarios for developing Th-230 cleanup criteria for this area were considered. For scenarios where short-term occupancy of the site is probable (camper, hunter, or hiker) the direct exposure as well as airborne particulate exposure to occupants would be very high if the surface soils were contaminated at 5 pCi/g Ra-226, compared to the exposures from Th-230 contamination lying beneath a 46-cm soil cover. Another exposure route considered was the use of water from an aquifer beneath the site as drinking water for nearby residents. However, it is widely known that Th-230 is immobile in near-neutral pH water. These exposure pathways lead to an unreasonably high Th-230 cleanup criterion. Thus the Benchmark dose assessment method was not applied at this site. The only significant exposure pathway from residual Th-230 results from Rn-222 releases from the in-growth of Ra-226. Since 10 CFR Part 40, Appendix A already has a standard for subsurface Ra-226, PRL proposes to limit the existing Th-230 concentrations in any 15-cm layer and 100-m^2 area to that which would result in a maximum of 15 pCi/g of Ra-226 above background at any time during the next 1,000 years. This proposed approach is an alternate calculation for meeting the existing Ra-226 standard.

A minimum of 46 cm (18 in.) thick clean soil cover will be applied to the entire area to limit airborne erosion from this area until covered by sediment for the Cell 1 reclamation plan. If only Th-230 exists as a contaminant, then an additional 42 pCi/g of Th-230 will result in 15 pCi/g of Ra-226 at the end of 1,000 years.

The current Th-230 concentrations are much higher than the Ra-226 concentrations and therefore the Bateman equations show that the maximum Ra-226 concentration will occur at the end of the 1,000-year period. Therefore, PRL will limit the Ra-226 to 15 pCi/g above background, where the Ra-226 concentration is calculated by the equation

$$\text{Ra-226 (pCi/g)} = 0.65\ \text{Ra-226}_E\ \text{(pCi/g)} + 0.35\ \text{Th-230}_E\ \text{(pCi/g)}$$

where the subscript "E" indicates currently existing concentrations.

A statistical analysis of the preoperational natural background data is presented in Appendix F. Recommended mean background level for U-nat is of 0.51 pCi/g, for Th-230 is 0.54 pCi/g, and for Ra-226 is 0.34 pCi/g.

8.4.2 Gamma Action Level

Gamma surveys will be used to guide the soil remediation efforts. The surveys will identify soil contamination that exceeds the cleanup criteria and will be used to guide the cleanup efforts. After cleanup, the surveys will be used, in conjunction with surface soil sample analyses, to verify cleanup to the site cleanup criteria. A gamma action level, defined as a gamma count-rate level corresponding to the soil cleanup criterion, is used in the interpretation of the data. Normally the action level is conservatively developed to allow only a five percent error rate of exceeding the cleanup criteria at the 95% confidence level.

Conditions are not suitable at this time to develop an action level since the ore storage area contains ore piles and the most of the areas potentially contaminated by process solutions are in gamma shine areas. Therefore an action level will be determined after most of the contaminated material has been removed. An action level will be established by developing a correlation between Ra-226 concentrations and gamma-ray count rate using the appropriate statistical approach to estimate the 95% confidence level. The action level will correspond to a gamma-ray count rate that conservatively predicts that the Ra-226 in soil may be above the cleanup criterion. One action level will be required for use where process materials or uranium ore is the principal contaminant. Another action level will be required for areas affected by uranium tailings. These action levels are expected to be similar but will be checked for accuracy during the excavation of material.

Twenty or more locations within the contaminated area will be chosen where the Ra-226 concentrations do not exceed 25 pCi/g. Measurements will be made in locations where the gamma-ray levels are uniform. A 2-inch by 2-inch NaI detector will be placed at the normal monitoring height above the point and a count-rate determination made. A 5-point composite soil sample will be taken within a 3-ft diameter area to represent the average concentration within the circular area. The detector height of 45 cm will be used since at this height, a majority of the above-background counts should arise from gamma-rays originating from the 3-ft diameter area. This method of determining the action level has been shown to be equivalent to averaging the gamma count rate over a larger area (100 m^2) and performing a five point sampling of the grid blocks, (Pathfinder Mines Corporation, Site Cleanup and Verification Plan for the Shirley Basin Mill Site). Correlations developed using smaller areas are necessary when there are no large uniformly contaminated areas. The gamma-ray count rates per pCi/g in the soil are, however, theoretically slightly smaller, resulting in a more conservative gamma-ray action level. The gamma action level(s) will be developed as soon as practical after the decision is made to proceed to reclamate and will be provided to the State of Utah at that time. The data and correlation(s) will also be included in the Completion Report. A correlation between gamma count rate and Ra-226 activity will also be developed using the final verification sampling results for the grid blocks. This correlation should confirm that the gamma action level was appropriate and resulted in compliance with the cleanup criteria. The final sampling and this correlation will be done while excavation equipment is still available on site. Correlation and sampling data will be supplied to the regulator as soon as practicable. The final correlation will also be presented in the Completion Report.

8.4.3 Gamma Surveys for Characterization and Verification

Two methods are proposed for conducting site gamma surveys, the first is the use of the GPS-based radiological survey system and the second is the use of the equivalent conventional method using a Ludlum 2221 rate-meter/scaler and Model 44-10 detector. Since the methods differ only by data recording and management, there are no apparent differences in the accuracy of the results. The surveys are described and PRL will decide which method to employ.

Gamma Surveys and Mapping Using Global Positioning System

The GPS-based radiological survey will be done using equivalent equipment to that used in the correlation studies. The gamma-mapping system consists of digital gamma-ray monitoring equipment coupled to a Ludlum Model 44-10, a 2-inch by 2-inch NaI(Tl) detector. The digitized radiological count rate data are recorded once every two seconds by transmission to a Trimble ProXR GPS receiver (or equivalent), which automatically tags the data with the coordinates at the time the data count rate is received. The ProXR, manufactured by Trimble Navigation, is state-of-the-art land surveying equipment, employing the use of satellite global positioning system (GPS) technology. The accuracy of the coordinates is better than one meter while collecting data. The data are collected in a data logger and later downloaded into a computer. The data are then loaded into the ArcView GIS or other software for mapping and developing isocontours.

A gamma survey will be done over the extent of the affected areas and buffer areas. Gamma count rate isocontour lines at the action level will be used to define where remediation is required. After the remediation, the area will be resurveyed and the new data added to the database. This iterative procedure will be applied until all areas are determined to meet the action levels.

In the verification phase, the average count rate over each 100-m^2 grid block is calculated by downloading the data into a database management computer application. The data records within each grid block are counted, averaged, and assessed as to whether the grid block meets verification criteria.

Function checks for the equipment will be performed at the beginning of each work shift using standard operating procedures. In addition, standard operating procedures will be used for operating the GPS-based radiological survey equipment as well as processing the data.

<u>Radiological Surveys and Mapping Using Conventional Methods</u>
Gamma surveys may be conducted using the same type of radiological survey equipment described above, other than the data will be recorded manually and presented on maps with isocontours using computer assisted means. Grid blocks of 33-ft by 33-ft (approximately 100 m^2) will be established over the affected area. In order to determine the average gamma count rate within a grid block, the Ludlum Model 2221/Model 44-10 combination will be used to integrate the count rate while a technician walks the area for one minute. Correlation studies at other mill sites have demonstrated that this results in a good correlation with the Ra-226 in the soil.

8.4.4 Excavation Control Monitoring

Remediation of contaminated soils will be done by excavation. The purpose of excavation control monitoring is to guide the removal of contaminated material to the point where it is highly probable that an area meets the cleanup criteria. Monitoring equipment and action levels developed in the calibration studies will be used for excavation control monitoring. A technician will monitor the soil after the removal of layers of soil until the instrumentation shows that the levels are below the action level. The detector is held close to the ground so that small “hot spots” will be identified and removed. This will lead to each grid block having a uniformly contaminated surface soil layer. This reduces sampling error and will provide additional assurance that the average measured concentration meets the cleanup criterion. No documentation of the results is done since the verification data will serve to demonstrate compliance with the cleanup standards. For large areas, a GPS based survey may be performed periodically to predict the progress of the excavation.

For areas exhibiting contamination below the top six inches, excavation control monitoring will be done using the same detector as used in the calibration study, considering the appropriate action level and adjusting for geometry factors. The cleanup limit for deep excavations in tailings affected areas where backfill is applied is 15 pCi/g above background for Ra-226. For ore or process material contaminated areas, the subsurface criterion for Ra-226 is 13.2 pCi/g (or 27.3 pCi/g U-nat) developed in the Benchmark Dose Assessment.

Excavation control for the Th-230 contaminated areas will be done using a gross alpha procedure. The soil sample will be dried and pulverized and placed in a ZnS-coated container. The container will be counted in a Lucas Cell Counter. The counter will be calibrated using soil samples collected from the site and analyzed for Th-230 by a vendor laboratory using isotopic thorium procedure, EPA-970. The measured gross-alpha MDA for this procedure is 14 pCi/g. All soils with elevated uranium or radium concentrations will be removed by excavating soils with elevated gamma-ray emissions. Samples will be taken throughout the area and the sample locations determined by GPS. Additional soil will be removed from areas exceeding the cleanup criteria for Th-230. Standard Operating Procedure HP-24, Soil Screening Method for Th-230 in Soil, provides details for this method. Samples will be taken throughout the area based upon the concentration of Th-230 and physical spacing of the previous Th-230 sampling. Should the physical terrain change (i.e. from flat to sloping), the frequency of sampling will increase so as to predict the Th-230 activity more accurately.

8.4.5 Soil Cleanup Verification Survey and Sampling Plan

A final gamma survey of the affected area and buffer zone will be performed using the GPS-based equipment or conventional equipment as described above. For the GPS-based survey, a minimum of 10 data records in each 100-m^2 grid block will be used to obtain the average gamma count rate for the affected areas of the site. For conventional surveys, a 1-minute integrated count while walking the area will be used as the average count rate.

For all grid blocks where the average count rate (bare Ludlum 44-10 detector) exceeds the action level, the grid blocks will either be cleaned to below the action level or the grid blocks will be sampled to assure compliance with the cleanup criteria. The five-point soil sampling procedure is given in SOP HP-22. The sample will be analyzed to assure that the Ra-226 and uranium concentration complies with the cleanup criteria.

All verification samples will be analyzed by a vendor laboratory according to specified QA/QC procedures. Standard Operating Procedures HP-21, HP-22 AND HP-23 include details of the soil cleanup verification surveys and sampling plans for surface and subsurface contaminated areas.

For the Th-230 contaminated area (Area F), all areas exhibiting elevated gamma levels will be cleaned to near background levels. Soil samples will be taken from Area F and analyzed on-site until evidence shows that the area meets the 42 pCi/g above background Th-230 limit. Documentation of the sampling locations and the results will be included in the completion report.

The area will then be divided into 100 m^2 (33-ft by 33-ft) grid blocks. Thirty percent of the grid blocks will be randomly selected for sampling and analysis at the vendor laboratory for Ra-226 and Th-230. If all grid blocks do not meet the criterion, an additional 30 percent of the grid blocks will be sampled and the process repeated until the sampled set meets the cleanup criterion. The sampling method and quality assurance requirements specified in standard operating procedures, HP-21, HP-22, HP-23,.and HP-24 will be applied to this area. PRL will submit field control and verification data for Area F to the regulator before Area F is covered.

8.4.6 Laboratory Quality Assurance

All verification samples will be sent to Energy Laboratories, Inc. (ELI) for analysis for Ra-226. For 90 percent of the samples, the entire sample will be transported to ELI. Ten percent of the samples will be selected at random and split, one part going to ELI and the other part to another vendor laboratory. The analytical methods that will be used for U-nat and Th-230 are EPA Method 6020 and EPA Method 907, respectively.

The results from the two vendor laboratories will be evaluated by assuring that the error bars overlap at the three standard deviation levels for all samples having measured Ra-226 concentrations greater than 1 pCi/g. That is, if the sample results for laboratories A and B are reported as $C_A \pm 3\sigma_A$ and $C_B \pm 3\ \sigma_B$, where σ is the standard deviation, PRL will conduct an investigation if the following condition is not met: $|C_A - C_B| \leq |3\sigma_A + 3\ \sigma_B|$. The investigation may include having one or both laboratories repeat their analysis. The reason for not including the test for results less than 1 pCi/g is that the agreement at these low levels is normally not a good indicator of laboratory quality. For small values, the large relative errors almost always allow the above test to be met. It has been our experience that the above test is very difficult to pass for a large set of samples and therefore we may expect sample results that never agree even after the subsequent investigation and further analyses. We however should expect that no bias exists between the two sets of vendor lab data. The bias will be determined by performing a linear regression between the data pairs. Any bias should be less than the difference between the cleanup limit and the highest value measured in the set of verification samples. Other statistical tests may be performed such as those to identify data outliers prior to assessing the bias.

The widely differing results between laboratories can be explained by the fact that it is difficult to estimate the error for the analysis of a particular sample. It has been our experience that commercial laboratories report an underestimate of their errors, often indicating that the errors are the counting statistical errors only. They ignore the larger, often unknown, other statistical and systematic errors associated with the analysis. These include a systematic bias of up to five to ten percent due to errors in the calibration standards, errors associated with determining the chemical extraction yield for radiochemical analysis, and the potentially very large error associated with taking an aliquot from the larger sample. In order to assess these errors accurately, it would be necessary to perform analyses on several aliquots taken from the same large sample. This is costly and almost never done. We therefore, as indicated above, expect several samples to not meet the criterion for agreement even after the investigation has been completed. We believe that the overall QA program will, however, provide confidence that the analyses are acceptable and that the site meets the cleanup goals.

Should it be discovered that a bias exists between the two laboratories that would be expected to result in the failure of grid blocks using the primary laboratory results, the failed grid blocks will either be further decontaminated and sampled or a third laboratory will be used in order to better understand the source of the bias.

PRL management will check all aspects of data collection and input to verify that procedures are being followed. The collection and handling of samples from the mill decommissioning, soil cleanup, ore pad cleanup, Area F cleanup, and other radiological cleanup areas will be reviewed and approved by management. Laboratory results for these samples will be evaluated for completeness and consistency. Other aspects of the reclamation including adherence to the SOPs and adherence to the reclamation plan will be evaluated by PRL management on a daily basis. The construction process will be monitored to confirm that appropriate physical and radiological safety procedures are followed. Excavation processes will be monitored to ensure that contaminated materials are not handled carelessly and that any spillage is collected and contained. The conveyance of contaminated materials to the tailings area will be monitored to prevent dispersal of these materials in the environment. Construction and sampling activities will be documented and reviewed throughout the reclamation process.

8.5 Land Restoration

After the mill site, ore stockpile, and Th-230 contaminated areas have been verified as meeting the cleanup criteria, a completion report will be prepared and submitted to the State of Utah for approval. Upon approval, PRL will grade the area to prevent excessive erosion and to blend the site with the natural topography, to the extent practical. Native site soils will be added where practical to help establish natural vegetation. Some areas will only be graded for commercial use while other areas having no commercial use will be seeded.

A mixture of 2 pounds each of rabbit brush, crested wheat, alkali salaton, four wing salt brush, shad scale and Indian rice grass seed will be planted at a rate of 12 pounds per acre.

8.6 Quality Assurance and Quality Control

The Radiation Safety Officer is responsible for implementing the Quality Assurance and Quality Program (QA/QC). He (or his designate) will periodically review the program. Items for review include the performance of the personnel, the adequacy and completeness of the records, and the maintenance of the radiological instrumentation.

The QA/QC for the radiological aspects of the decommissioning will be administered through use of trained and qualified personnel, adequate and maintained equipment, documented procedures, a good record keeping system, and internal checks and audits.

Radiation technicians will be qualified by the Radiation Safety Officer (or his designate) to perform specific quality tasks. Quality tasks are those tasks where the quality of the work is related to achieving the performance requirements of the project. This will be accomplished by requiring the technician to demonstrate an understanding of the equipment and SOPs for the task. A list of qualified technicians will be maintained for each quality task. Periodic reviews of each technician's performance will be made by the RSO (or his designate).

All monitoring equipment will have current calibrations. Functions checks will be done before and after daily use.

Chain-of-custody forms will be used for all verification soil samples, which will be analyzed by an off-site vendor laboratory. A fraction of these samples will be split and submitted to another vendor laboratory for analysis. The details of the Laboratory Quality Assurance program are given in Section 8.4.6.

9.0. TAILINGS RECLAMATION

9.1 Description of Tailings Reclamation

Tailings reclamation will include the regrading of the tailings surface within the synthetic-lined cells, covering of the tailings with an infiltration/radon barrier and erosion protection rock mulch, and construction of a drainage system to convey runoff. The mill demolition material will be placed in disposal pits within the EPPC, Cell 1 or Cell 2 and the voids will be filled with flowable fill. The disposal area will then be reshaped and covered in the same manner as the general tailings cell(s)

Figure 9-1 presents the present topography and reclamation cross section locations for the tailings cell area. Figures 9-2-Cell-1 and 9-2-Cell-2 present the topography of the constructed tailings Cells to the top of the upper synthetic liner with Figure 9-2-Cell-1 presenting Cell 1 only and Figure 9-2-Cell-2 presenting both Cell 1 and Cell 2. Figures 9-3-Cell-1 and 9-3-Cell-2 present the planned topography of the reclaimed tailings cells to the top of the uppermost cover, rock mulch or riprap layer. The cross section locations are also shown on Figure 9-3-Cell-1, which presents topography for the Cell 1 reclamation, and on Figure 9-3-Cell-2, which presents topography for the Cell 1 and Cell 2 reclamation configuration.

The present topography for the Cell 1 area includes the existing tailings and other contaminated material. This material including the existing tailings will be excavated and placed in the lined EPPC prior to the construction of the lined Cell 1. The liner system for Cell 1, the EPPC, and Cell 2 will include a clay underliner with two HDPE liners and leak detection system. Each disposal cell will also include a drainage system consisting of a perforated pipe collection system embedded in a three-layer permeable drainage blanket. The reclamation configuration for each disposal cell consists of regrading to a steepest slope of 5H:1V over the covered tailings with a general radially outward flow pattern and perimeter channel system.

The planned cover for the tailings cells includes a sandy interim/grading layer, a compacted clay layer, a second sandy layer, and an upper rocky soil layer. The erosion protection layer will be a rock mulch layer and will be placed over the upper rocky soil layer. The clay for the barrier cap for the Cell 1 reclamation will be obtained from the Shootaring dam and rocky soil material from the Shootaring dam may be used for the upper rock soil layer in the Cell 1 reclamation. Figure 9-4 shows a cross section through the center of the Shootaring dam. The zone 1 material is the source for the clay barrier while zone 2 material will be used for the rocky soil cover material. Figure 9-5-Cell-1 presents a schematic of the cover configuration for the Cell 1 reclamation configuration. For the reclamation plan including both Cell 1 and Cell 2, the clay will be derived from an alternate off-site source, and the majority of sandy and rocky soil will be excavated from surrounding borrow areas. Figure 9-5-Cell-2 shows a schematic of the disposal cell cover system for the Cell 1 and Cell 2 reclamation plan.

Nine cross section figures have been developed to present existing, tailings cell, and reclamation surfaces for the tailings disposal system. Cross Sections A-A', B-B' and C-C' traverse both the

Cell 1 and Cell 2 tailings areas; Cross Sections D-D', E-E', and F-F' are within the Cell 1 area, and Cross Sections G-G', H-H', and I-I' are with the Cell 2 area. Figure 9-6 presents the reclamation Cross Section A-A' with a vertical to horizontal exaggeration of 10:1 (see Figures 9-1, 9-2-Cell-1, 9-2-Cell-2, 9-3-Cell-1 and 9-3-Cell-2 for locations of the cross sections). The cross sections present the existing surface in brown, the constructed Cell 1 surface in cyan, the constructed Cell 2 surface in red, the Cell 1 reclamation surface in blue, and the Cell 1 and 2 reclamation surface in green. The descriptive text on the cross section figures is also color coded. In addition, the areas where the Cell 1 liner and Cell 1 drainage layer are present area indicated with segmented yellow lines. The presence of the Cell 2 liner and Cell 2 drainage layer are indicated with segmented light orange lines. The thickness of these lines does not reflect the true thickness of the corresponding liner or drainage layers. The low area in the tailings Cell 2 surface approximately 400 feet from the southern end of Cross Section A-A' is the corner of a collection sump for the southern Cell 2 drainage system (see Figure 9-6). The very southern end of the cross section also shows the dam breach that is included in the Cell 1 reclamation configuration to facilitate drainage from the Shootaring Canyon area. For the Cell 1 and 2 reclamation configuration, the Shootaring dam is left in place.

Figure 9-7 shows the reclamation Cross Section B-B' which is through the middle of the general tailings area from the southwest to the northeast. The relatively large elevation differential between the existing surface the Cell 1 liner surface in the area of station 200 feet reflects the required removal of the existing tailings and other contaminated material prior to the construction of Cell 1.

Figure 9-8 shows the reclamation Cross Section C-C'. There is a significant cut of the native surface in the central Cell 2 area in order to construct Cell 2. This cross section also shows the dramatic reconfiguration of the cross valley berm in order to construct Cell 1.

Cross Section D-D' has a northwest to southeast orientation along the northern edge of Cell 1 (see Figure 9-2-Cell-1). The tailings thickness will be relatively small on this northern edge of Cell 1 (see Figure 9-9). There will be a significant cut in the native surface to create the EPPC.

Figure 9-10 presents Cross Section E-E' which runs generally through the center of Cell 1 and the southern end of the EPPC. This cross section illustrates the large potential thickness of tailings in the central Cell 1 area.

Cross Section F-F' runs roughly parallel to the cross valley berm approximately 200 feet north of the cross valley berm. Figure 9-11 presents Cross Section F-F' and the location of the two Cell 1 drainage collection sumps is evident near the center of the section.

Cross Section G-G' has a northwest to southeast orientation along the northern end of Cell 2 (see Figure 9-2-Cell-2). The cross section passes through the two northern drainage collection sumps in Cell 2 (see Figure 9-12). There is also a significant cut in the native surface to construct Cell 2.

Figure 9-13 presents Cross Section H-H' which runs generally through the center of Cell 2. The potential tailings thickness at this section may exceed 100 feet.

Cross Section I-I' runs across Shootaring Canyon immediately upstream of the Shootaring dam. The cross section passes through the corner of one of the south Cell 2 drainage collection sumps at roughly the lowest point in the planned tailings disposal area.

9.2 Tailings and Other Sources of Contaminated Fill

Tailings Cell 1 and Cell 2 will contain the future production of uranium tailings. Thickness of these tailings may exceed 100 feet, and the planned reduced moisture placement is expected to produce a relatively homogeneous tailings material. It is not anticipated that significant quantities of other contaminated materials will be placed in Cell 1 or Cell 2. The existing contaminated materials within the tailings area will be transferred to the lined EPPC prior to construction of Cell 1. These materials include: the existing tailings, the ore on top of the cross valley berm, 11.e(2) waste materials in the north and east tailings dikes, and the contaminated soils at the toe of the Shootaring dam. At the time of decommissioning, the mill equipment and other contaminated materials will be placed in the EPPC or in one of the tailings cells.

9.2.1 Existing Tailings

The existing tailings will be excavated and placed within the EPPC. The estimated volume of the existing tailings is approximately 83,000 cubic yards.

9.2.2 Ore and 11e(2) Waste Materials

Approximately two feet of ore was placed on the cross valley berm for protection of erosion of the Entrada sand that was used to construct the berm. This ore will be removed and placed within the EPPC. An estimate of 6700 cubic yards are planned to be excavated from the berm and placed in the cell. The 11.e(2) material in the north and east tailings dikes will also be excavated and placed within the EPPC. The estimated volume of this material is around 50,000 cubic yards.

9.2.3 Toe of the Shootaring Dam

The gamma survey defined an area upstream of the Shootaring dam that contains elevated radionuclide concentrations. This contaminated soil will be picked up and placed in the EPPC. The lowermost portion of the rock protection on the tailings dam and the soil in the pool area contains the volume of contaminated soil. The rock will have to be removed and separated from the soil to be excavated and placed in the EPPC. The volume of material to be placed in the EPPC from the toe of the Shootaring dam is estimated to be 18,000 cubic yards.

9.2.4 Mill Decommissioning

Equipment from the mill decommissioning that is unsuitable for decontamination will be placed in the disposal cell. The equipment will be placed in pits in the tailings cell and then filled with a flowable fill to fill the voids. Wood boards will be placed in the cell with a thickness no greater than 6 inches and covered with sandy material.

9.3 Barrier Cap

The barrier cap will consist of four layers including: a thick sandy interim/grading cover, a compacted clay layer, a second thin sandy layer, and a two foot layer of sand, silt and rock. A rock mulch erosion protection layer placed on the rocky soil layer. Figure 9-5-Cell-1 presents a detail of the disposal cell cover system for the Cell 1 reclamation configuration. Figure 9-5-CELL-2 presents a detail of the disposal cell cover system for the Cell 1 and Cell 2 reclamation configuration. Table 9-1 presents a summary of the estimated volumes for the two reclamation configurations. For the Cell 1 reclamation configuration, much of the cover layer materials will be extracted from the Shootaring dam (see Figures 9-15 and 9-16 for present and design topography, respectively). For the Cell 1 and Cell 2 reclamation configuration, most of the cover system materials will be taken from off-site borrow areas.

9.4 Disposal of Excess Clean Material

The borrow of clay and rocky soil from the Shootaring dam and the creation of the dam breach for the Cell 1 reclamation configuration may result in an excess of zone 1 (clay), zone 2 (rocky soil) or zone 3 (very fine sand) materials. This material may be used as general fill in the tailings reclamation or be disposed of on the upstream side of the Shootaring dam. At this time, it is not anticipated that significant volumes of excess material will be generated, and therefore, the only restriction on disposal areas for the excess materials is that they be located off-channel to avoid any blockage of the drainage through the breach in the Shootaring dam. The channel cut on the east side of the tailings cell may also generate some excess fine sand material. This material may also be placed in the most convenient location that does not result in blockage of the general drainage system. Possible disposal locations are shown in Figure 9-17.

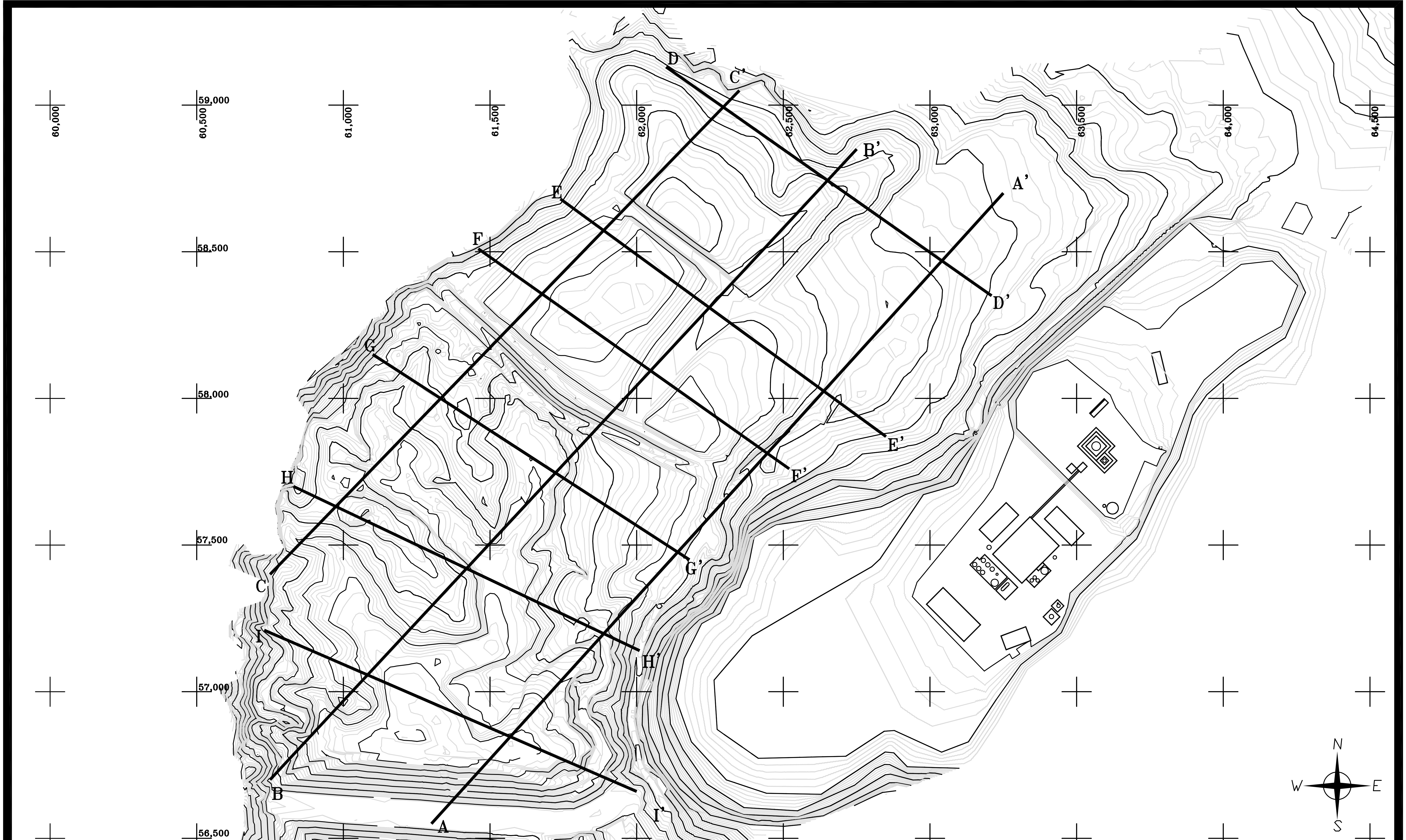
9.5 Environmental Impacts

The reclamation of the tailings will result in the encapsulation of the radioactive material, significantly decreasing the potential for radiation exposure at the site. Based on our analysis, the erosion protection system will protect the encapsulated material for at least 1000 years and thereby decrease the potential for future exposure. The cap also should decrease infiltration to such a low level that no potential future impacts to the ground water should occur. Erosion protection and the cover system should also prevent any exposure of the cell material to surface water.

Table 9-1. Reclamation Volume Estimates

Cell 1 Reclamation Area Designation	Area (ft^2)	Area (acre)	Thickness (inch)	Thickness (feet)	Area Scaling Factor	Volume (ft^3)	Volume (cu. yd.)
Radon Cover Area							
Interim/Grading Cover	1,274,896	29.27	40.0	3.33	1.03	4,377,143	162,116
Dam Clay Cover	1,274,896	29.27	18.0	1.50	1.03	1,969,714	72,952
Sand Cover	1,274,896	29.27	6.0	0.50	1.03	656,571	24,317
Rocky Soil Cover	1,274,896	29.27	24.0	2.00	1.03	2,626,286	97,270
Small Rock Mulch Cover Area	735,612	16.89	4.0	0.33	1.03	252,560	9,354
Large Rock Mulch Cover Area	1,083,088	24.86	4.0	0.33	1.03	371,860	13,773
Intermediate Riprap	46,822	1.07	12.0	1.00	1.03	48,227	1,786
Filter	46,822	1.07	12.0	1.00	1.03	48,227	1,786
Large Riprap	75,971	1.74	21.0	1.75	1.03	136,938	5,072
Filter	75,971	1.74	12.0	1.00	1.03	78,250	2,898
Rock Ledge Riprap	7,109	0.16	30.0	2.50	1.03	18,306	678
Filter	7,109	0.16	12.0	1.00	1.03	7,322	271
Rock Toe	803	0.02	48.0	4.00	1.00	3,212	119
Dam Breach Rock	4,071	0.09	20.0	1.67	1.03	6,989	259
Filter	4,071	0.09	12.0	1.00	1.03	4,193	155

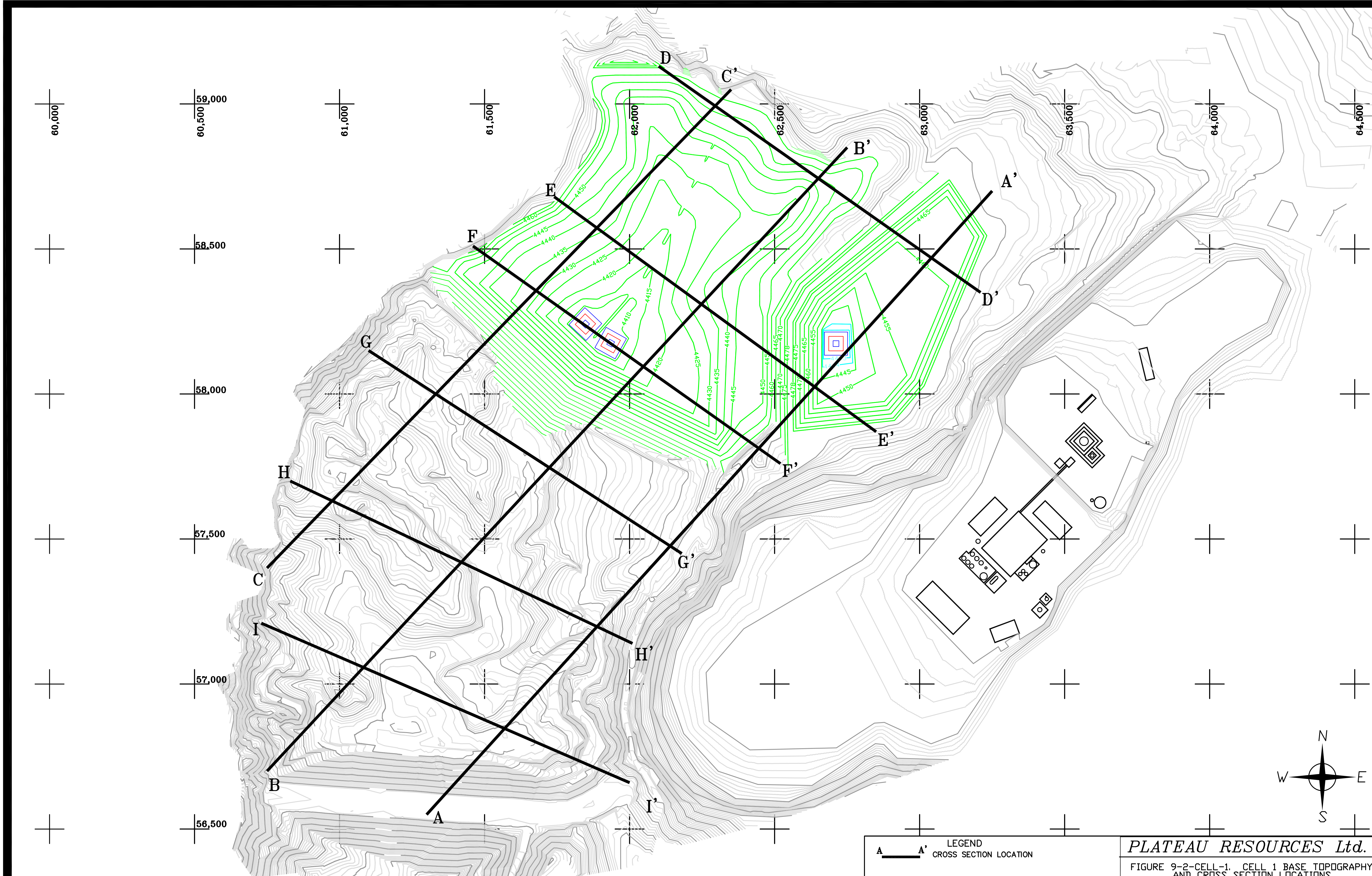
Cell 1 and 2 Reclamation Area Designation	Area (ft^2)	Area (acre)	Thickness (inch)	Thickness (feet)	Area Scaling Factor	Volume (ft^3)	Volume (cu. yd.)
Radon Cover Area							
Interim/Grading Cover	2,718,444	62.41	62.0	5.17	1.03	14,466,653	535,802
Alternate Clay Cover	2,718,444	62.41	18.0	1.50	1.03	4,199,996	155,555
Sand Cover	2,718,444	62.41	6.0	0.50	1.03	1,399,999	51,852
Rocky Soil Cover	2,718,444	62.41	24.0	2.00	1.03	5,599,995	207,407
Small Rock Mulch Cover Area	1,707,211	39.19	4.0	0.33	1.03	586,142	21,709
Large Rock Mulch Cover Area	1,794,353	41.19	4.0	0.33	1.03	616,061	22,817
Intermediate Riprap	69,966	1.61	12.0	1.00	1.03	72,065	2,669
Filter	69,966	1.61	12.0	1.00	1.03	72,065	2,669
Large Riprap	63,115	1.45	21.0	1.75	1.03	113,765	4,214
Filter	63,115	1.45	12.0	1.00	1.03	65,008	2,408
Rock Ledge Riprap	7,109	0.16	30.0	2.50	1.03	18,306	678
Filter	7,109	0.16	12.0	1.00	1.03	7,322	271
Rock Toe	2,502	0.06	48.0	4.00	1.00	10,008	371



PLATEAU RESOURCES Ltd.

FIGURE 9-1. PRESENT TOPOGRAPHY AND CROSS SECTION LOCATIONS

DATE: 12-2005	CROSS-SECTIONS.DWG	SCALE: 1"=300'
Page: 9-6	HYDRO-ENGINEERING L.L.C.	



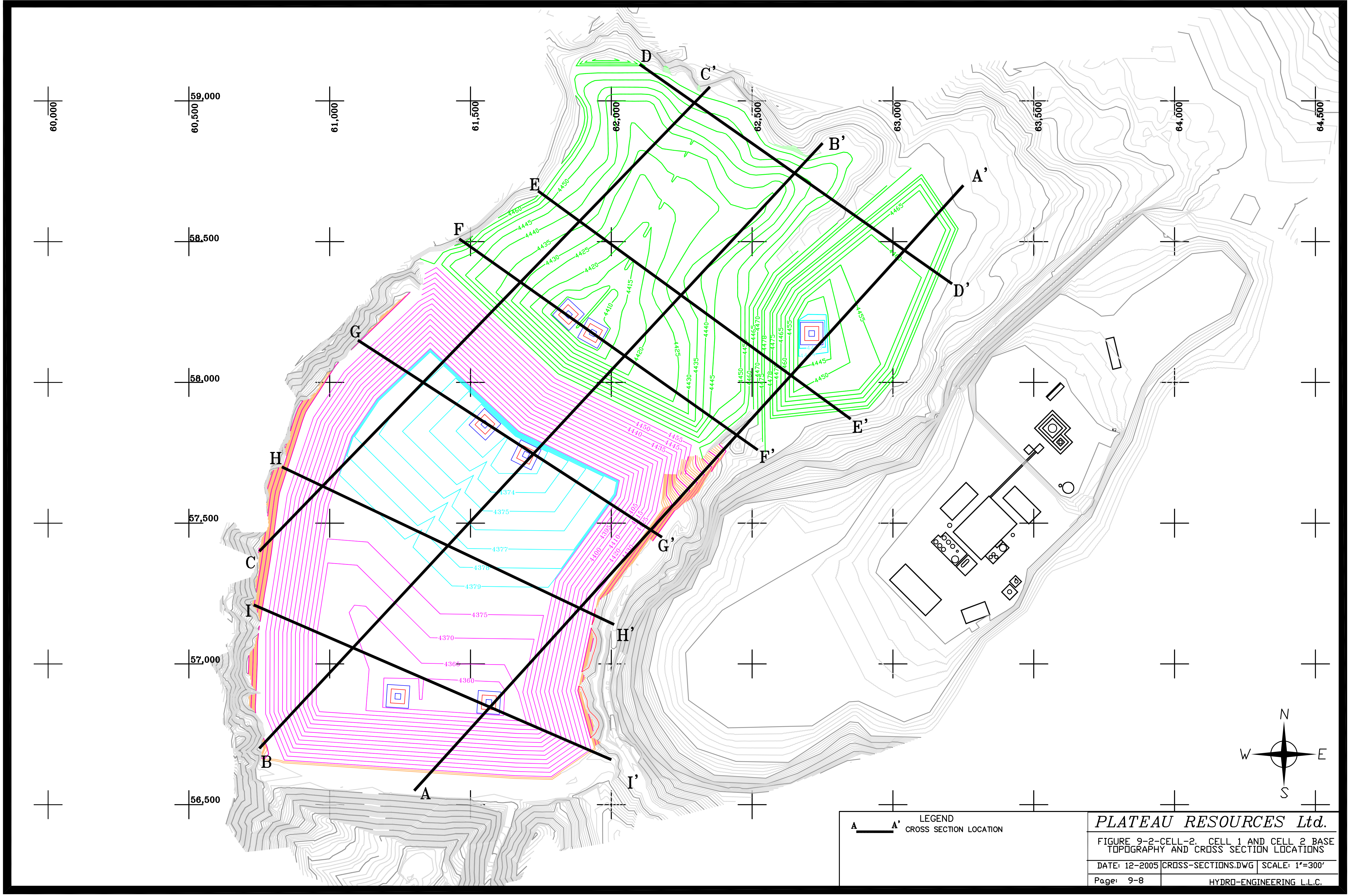
LEGEND

A — A' CROSS SECTION LOCATION

PLATEAU RESOURCES Ltd.

FIGURE 9-2-CELL-1. CELL 1 BASE TOPOGRAPHY AND CROSS SECTION LOCATIONS

DATE: 12-2005	CROSS-SECTIONS.DWG	SCALE: 1"=300'
Page: 9-7	HYDRO-ENGINEERING L.L.C.	



PLATEAU RESOURCES Ltd.
FIGURE 9-2-CELL-2. CELL 1 AND CELL 2 BASE TOPOGRAPHY AND CROSS SECTION LOCATIONS
DATE: 12-2005
CROSS-SECTIONS.DWG
SCALE: 1"=300'
Page: 9-8
HYDRO-ENGINEERING L.L.C.
LEGEND
A A'
CROSS SECTION LOCATION
N
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W
60,000
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61,000
61,500
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62,500
63,000
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59,000
58,500
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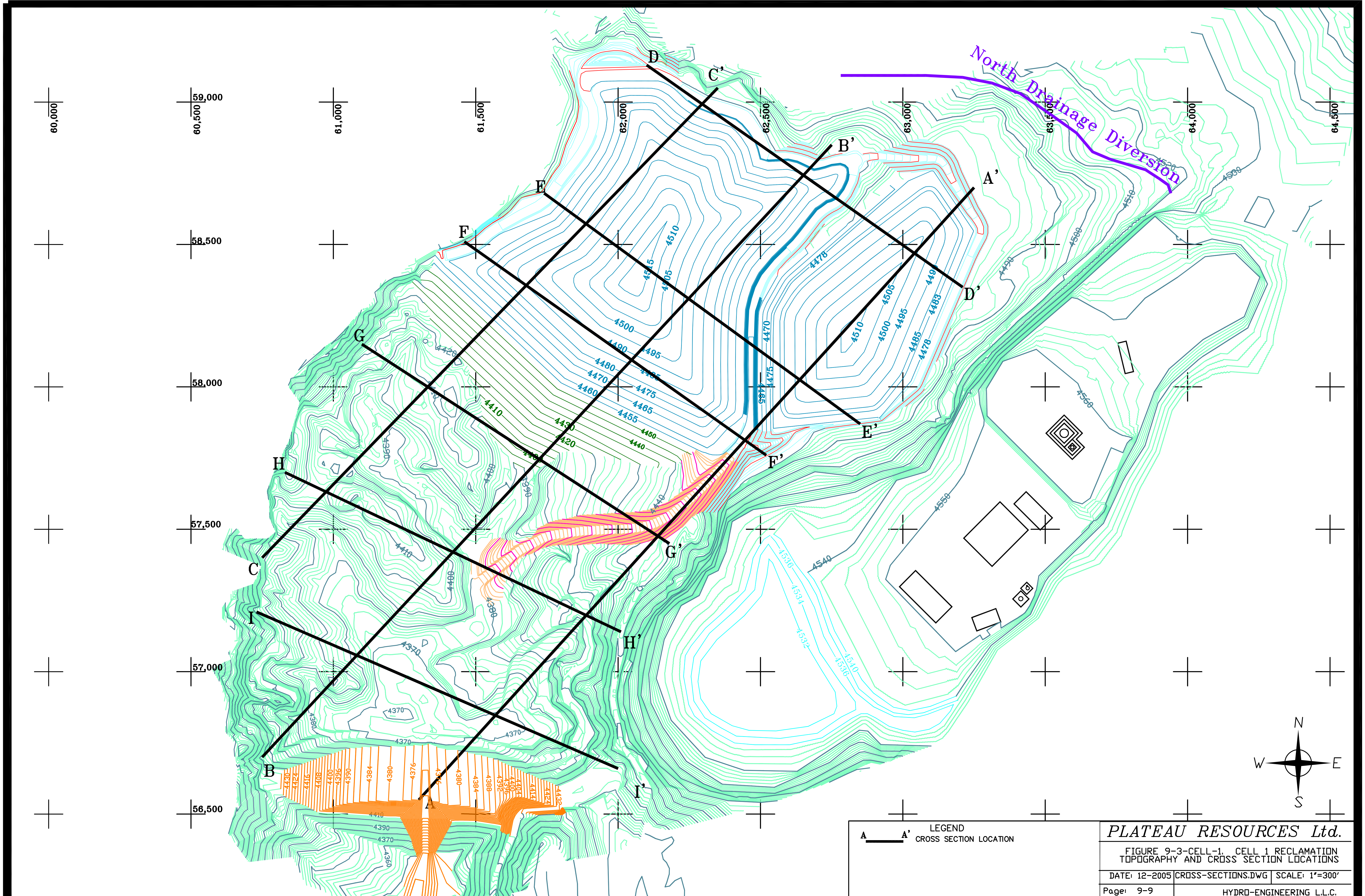
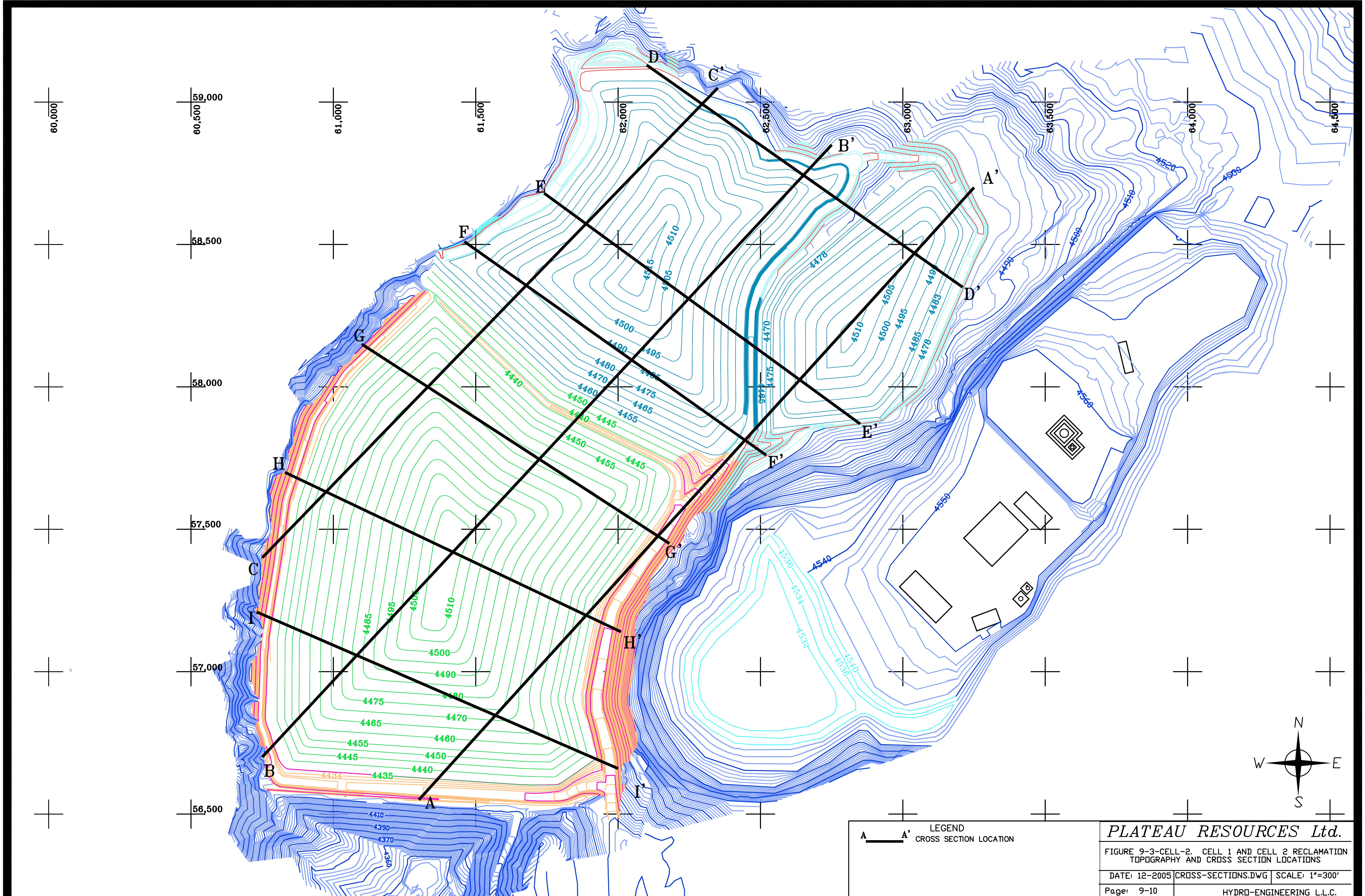
57,500
57,000
56,500
A
A'
B
B'
C
C'
D
D'
E
E'
F
F'
G
G'
H
H'
I
I'



PLATEAU RESOURCES Ltd.

FIGURE 9-3-CELL-1. CELL 1 RECLAMATION TOPOGRAPHY AND CROSS SECTION LOCATIONS

DATE: 12-2005	CROSS-SECTIONS.DWG	SCALE: 1"=300'
Page: 9-9	HYDRO-ENGINEERING L.L.C.	



LEGEND
A A' CROSS SECTION LOCATION
PLATEAU RESOURCES Ltd.
FIGURE 9-3-CELL-2. CELL 1 AND CELL 2 RECLAMATION TOPOGRAPHY AND CROSS SECTION LOCATIONS
DATE: 12-2005
CROSS-SECTIONS.DWG
SCALE: 1"=300'
Page: 9-10
HYDRO-ENGINEERING L.L.C.
N
S
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59,000
58,500
58,000
57,500
57,000
56,500
60,000
60,500
61,000
61,500
62,000
62,500
63,000
63,500
64,000
64,500

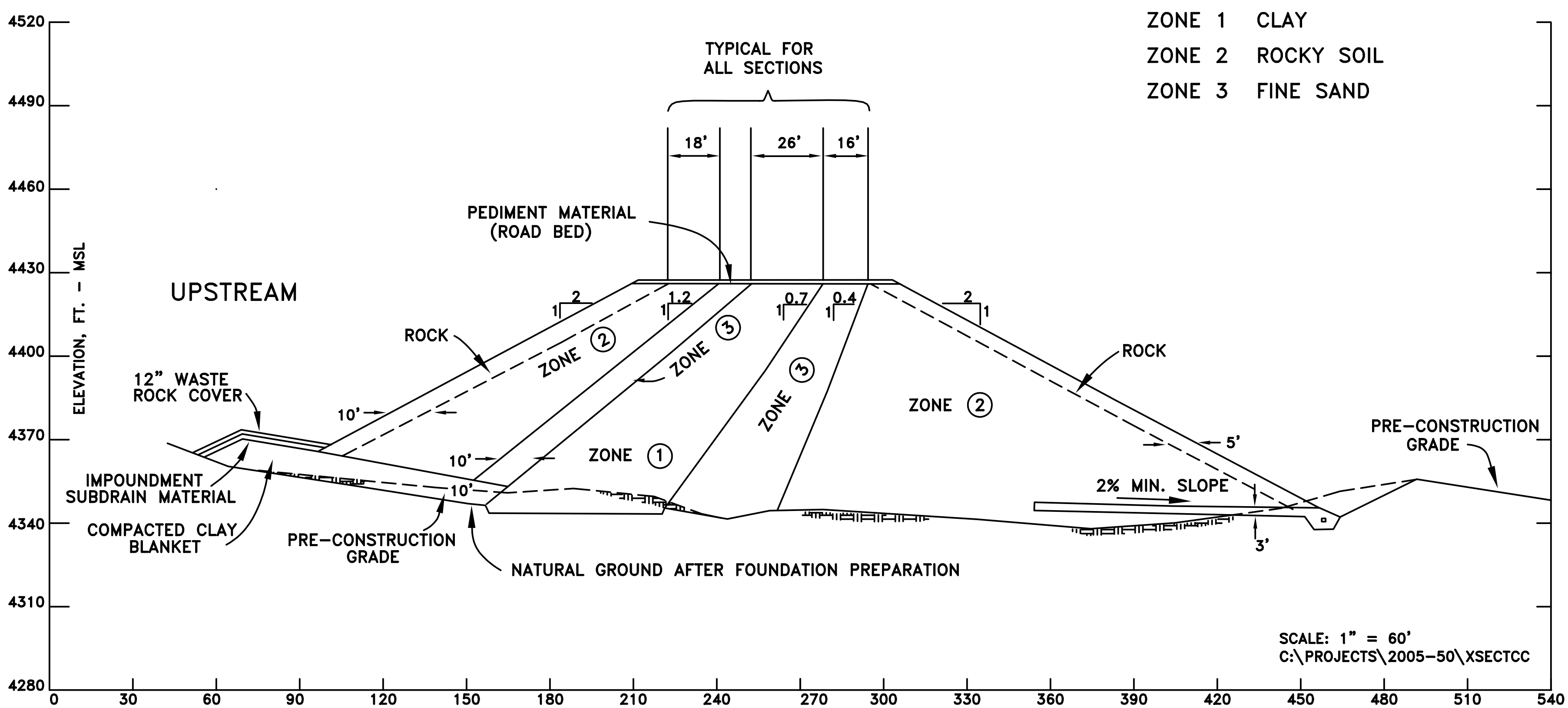
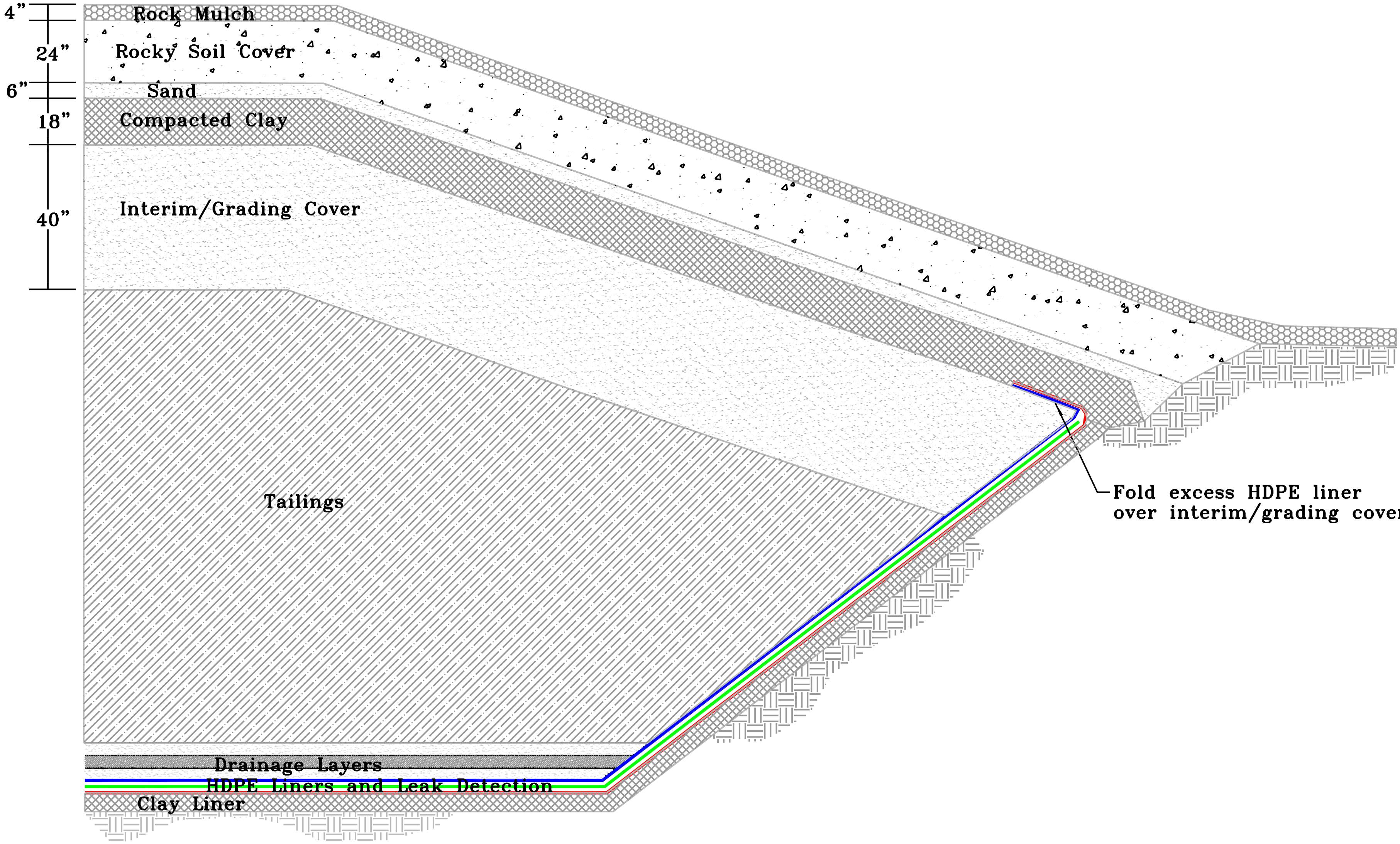
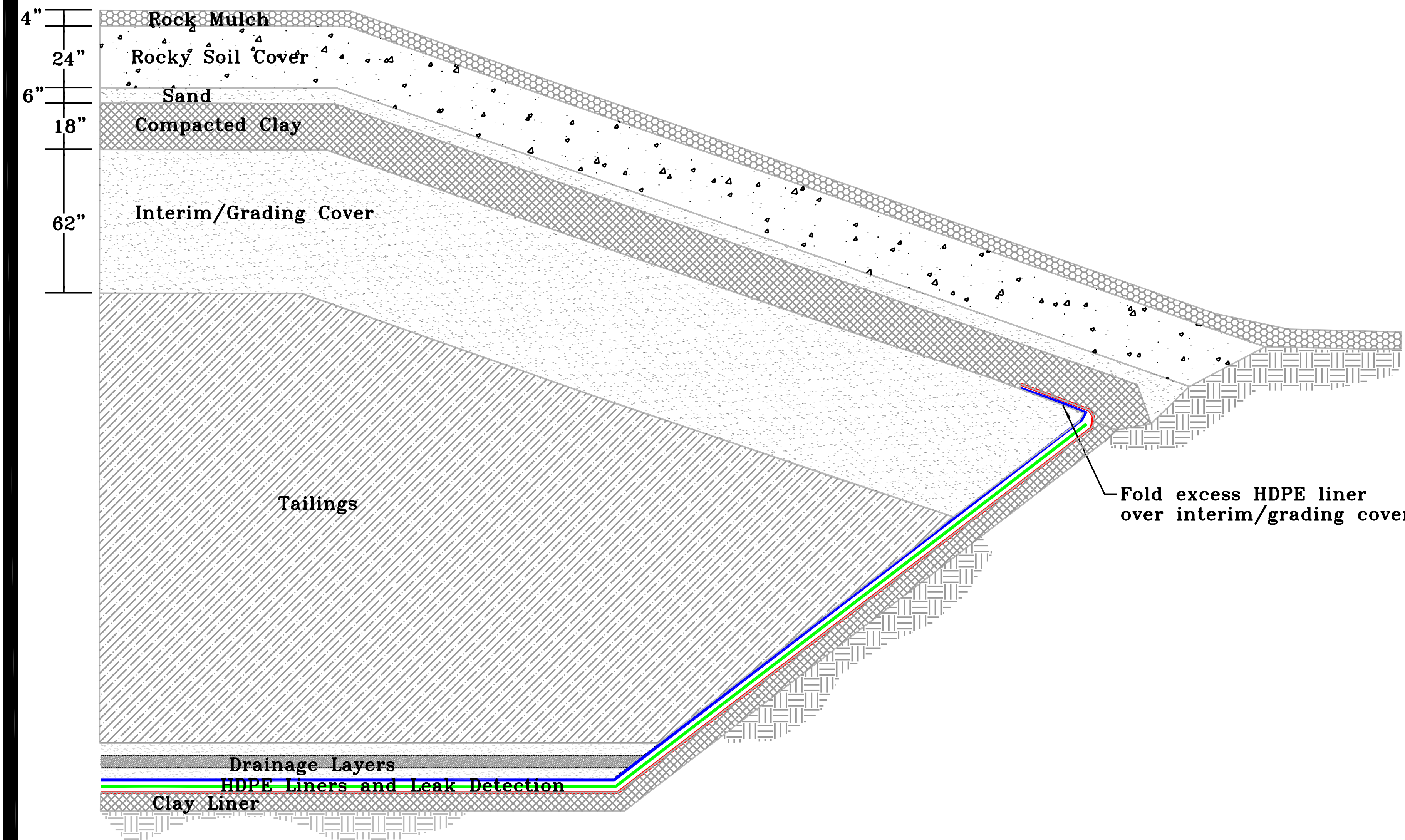


FIGURE 9-4. CENTER CROSS SECTION THROUGH SHOOTARING DAM



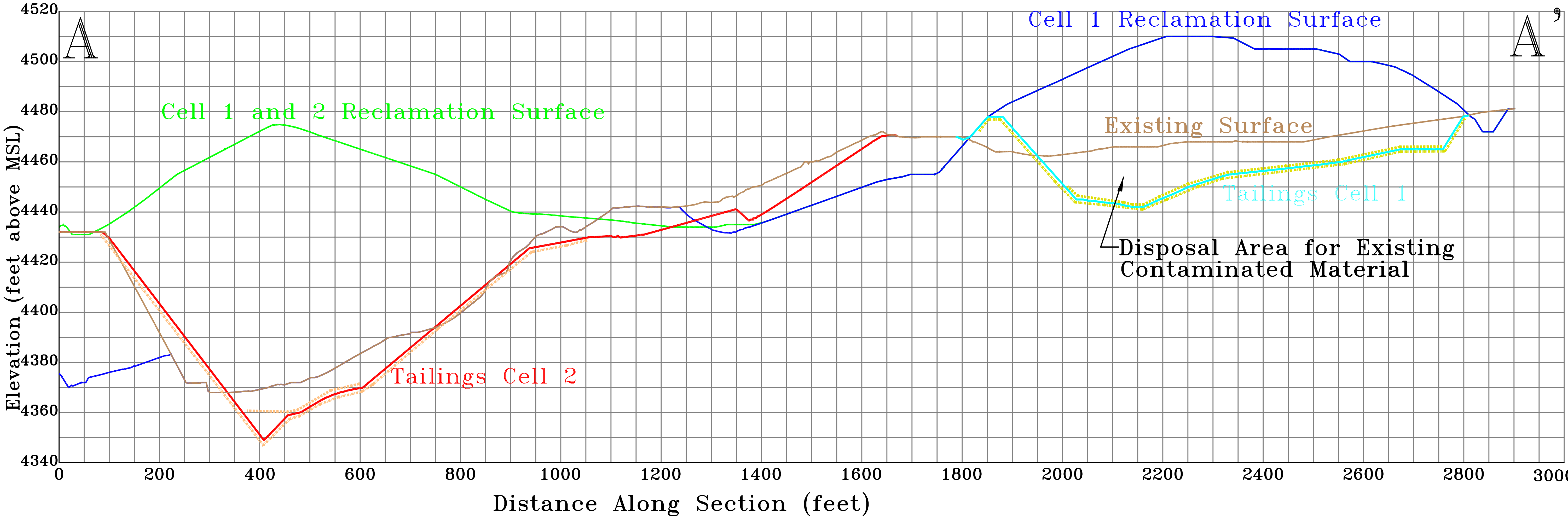
PLATEAU RESOURCES Ltd.		
Figure 9-5-Cell-1. Cell 1 Reclamation Cover System		
DATE: 11-2005	Fig9-5.dwg	NOT TO SCALE
Page: 9-12	HYDRO-ENGINEERING L.L.C.	



PLATEAU RESOURCES Ltd.

Figure 9-5-Cell-2. Cell 1 and Cell 2 Reclamation Cover System

DATE: 11-2005	Fig9-5.dwg	NOT TO SCALE
Page: 9-13	HYDRO-ENGINEERING L.L.C.	



Scale: Horiz. 1"= 200'
Vert. 1"= 40'

LEGEND
- CELL 1 LINER
- CELL 1 DRAINAGE LAYER
- CELL 2 LINER
- CELL 2 DRAINAGE LAYER

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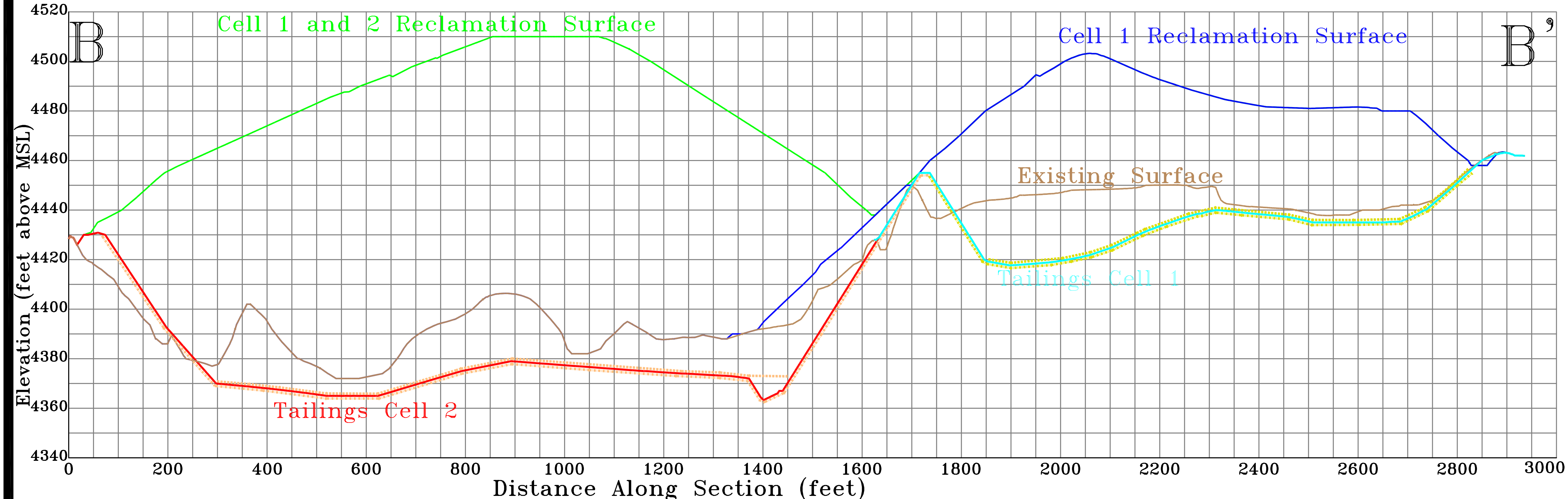
FIGURE 9-6. RECLAMATION CROSS SECTION A-A'

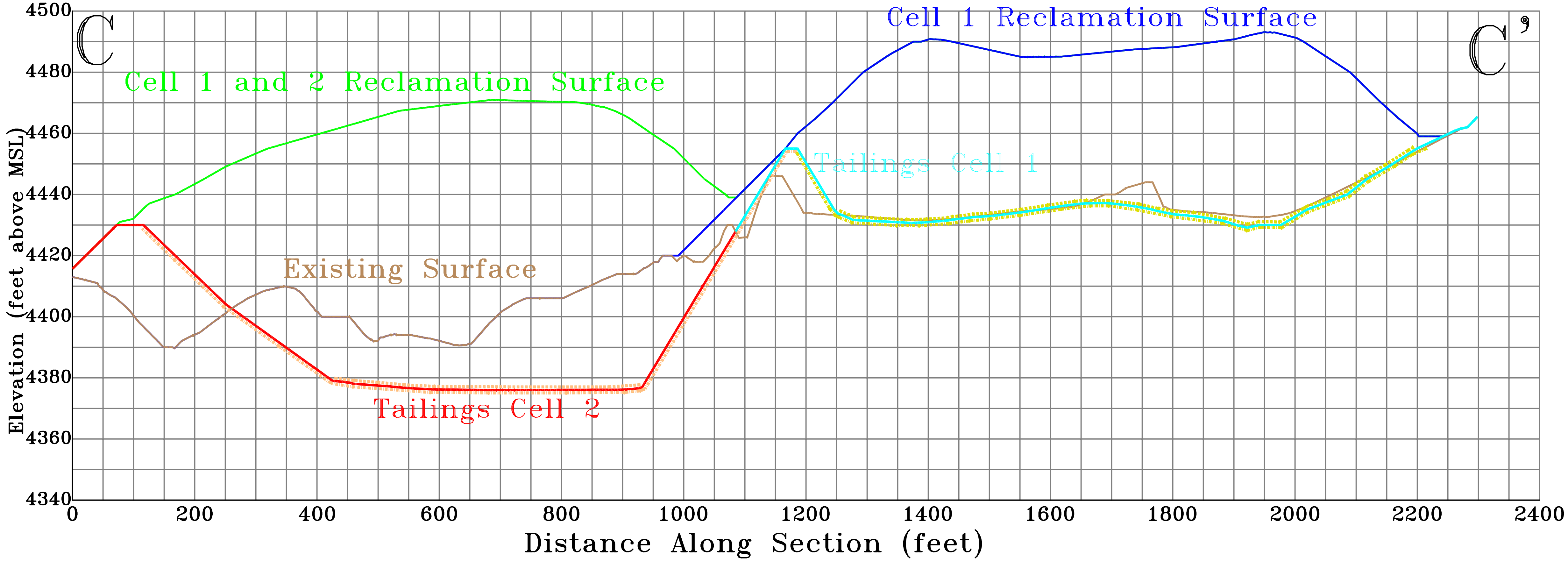
DATE: 12-2005	CROSS-SECTIONS.DWG
Page: 9-14	HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 200'
Vert. 1"= 40'

LEGEND
CELL 1 LINER
CELL 1 DRAINAGE LAYER
CELL 2 LINER
CELL 2 DRAINAGE LAYER

PLATEAU RESOURCES Ltd.	
FIGURE 9-7. RECLAMATION CROSS SECTION B-B'	
DATE: 12-2005	CROSS-SECTIONS.DWG
Page: 9-15	HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 200'
Vert. 1"= 40'

LEGEND
CELL 1 LINER
CELL 1 DRAINAGE LAYER
CELL 2 LINER
CELL 2 DRAINAGE LAYER

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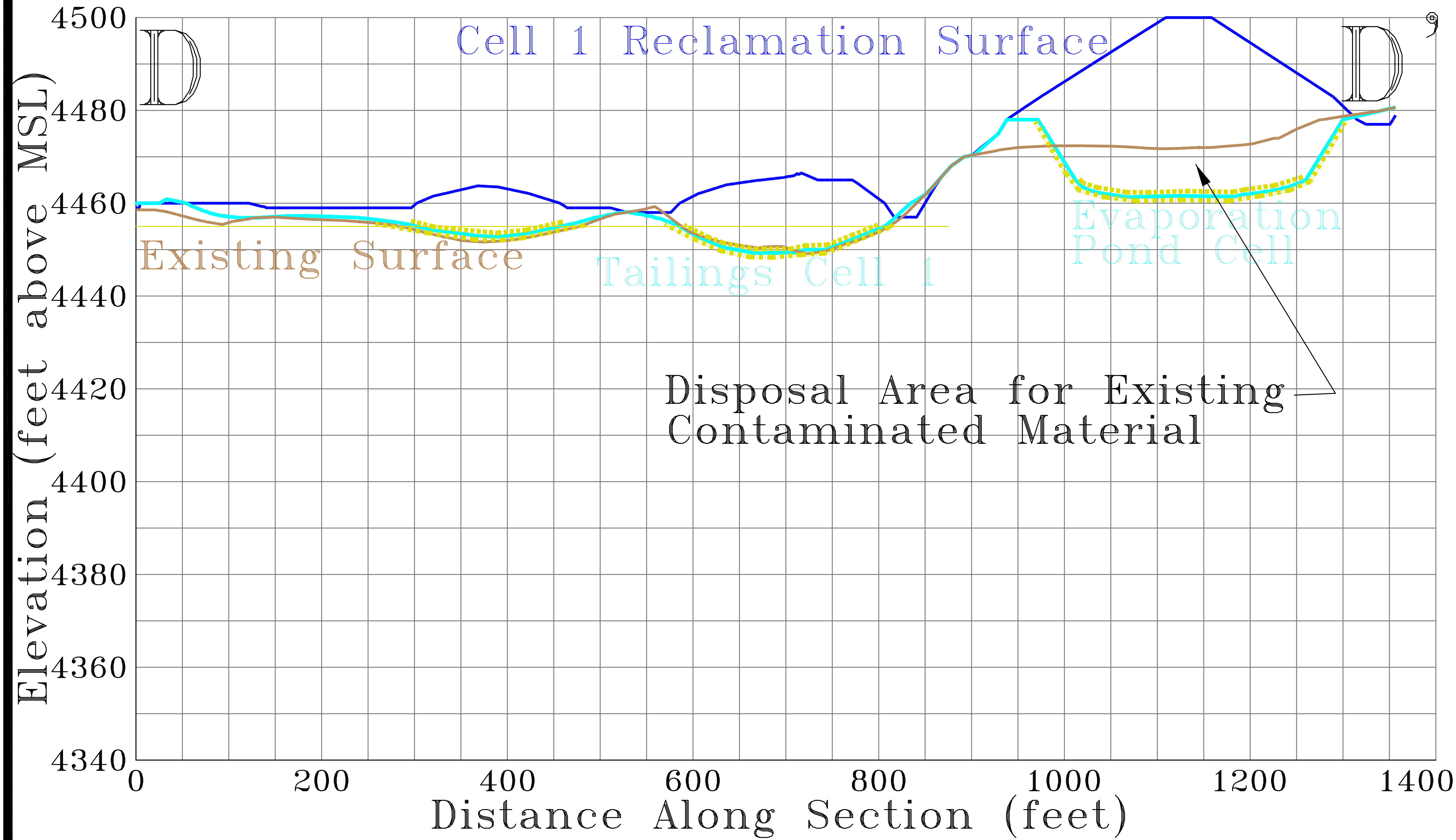
FIGURE 9-8. RECLAMATION CROSS SECTION C-C'

DATE: 12-2005 CROSS-SECTIONS.DWG

Page: 9-16

HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 1 LINER
CELL 1 DRAINAGE LAYER

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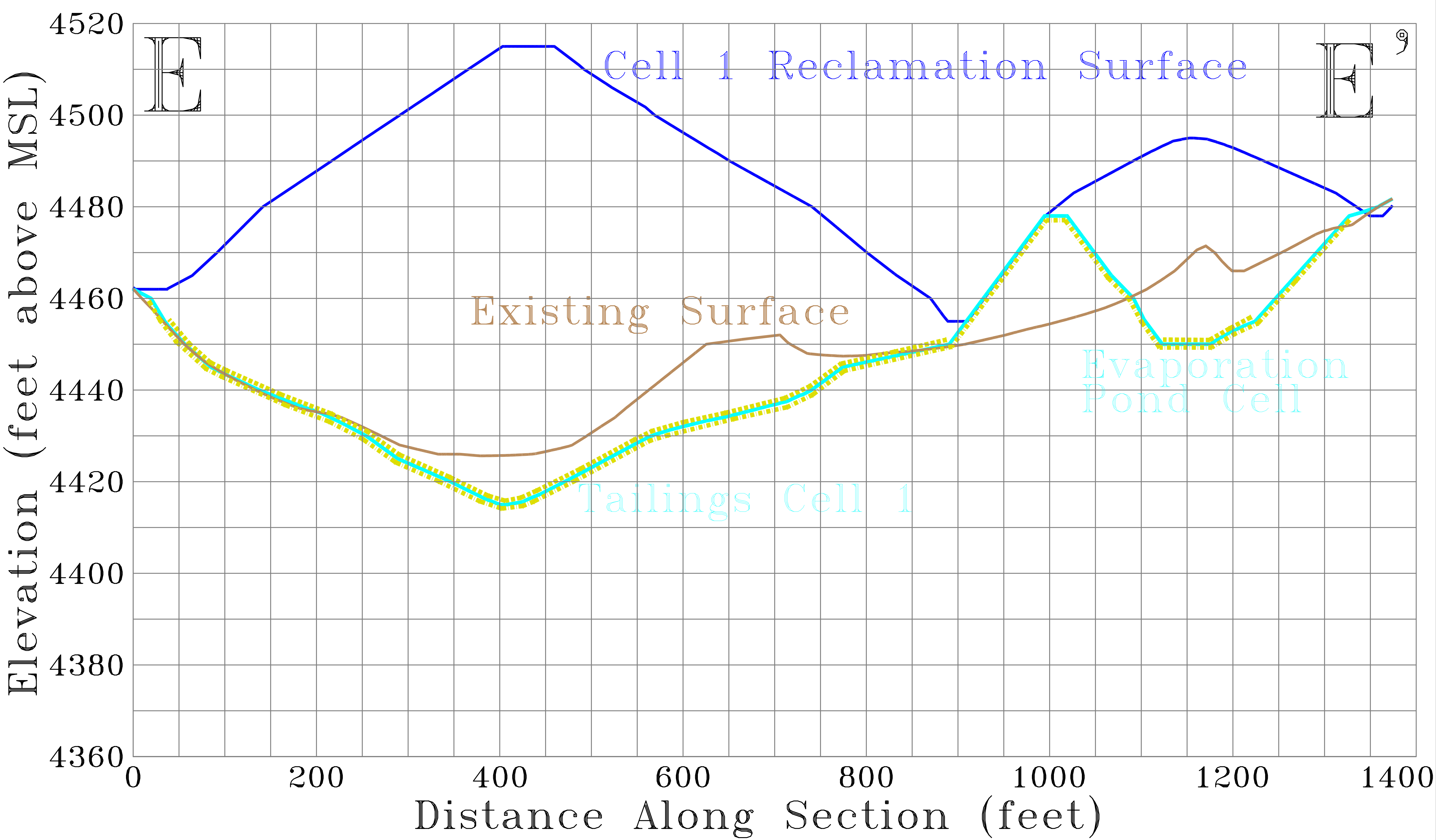
FIGURE 9-9. RECLAMATION CROSS SECTION D-D'

DATE: 12-2005	CROSS-SECTIONS.DWG
Page: 9-17	HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 1 LINER
CELL 1 DRAINAGE LAYER

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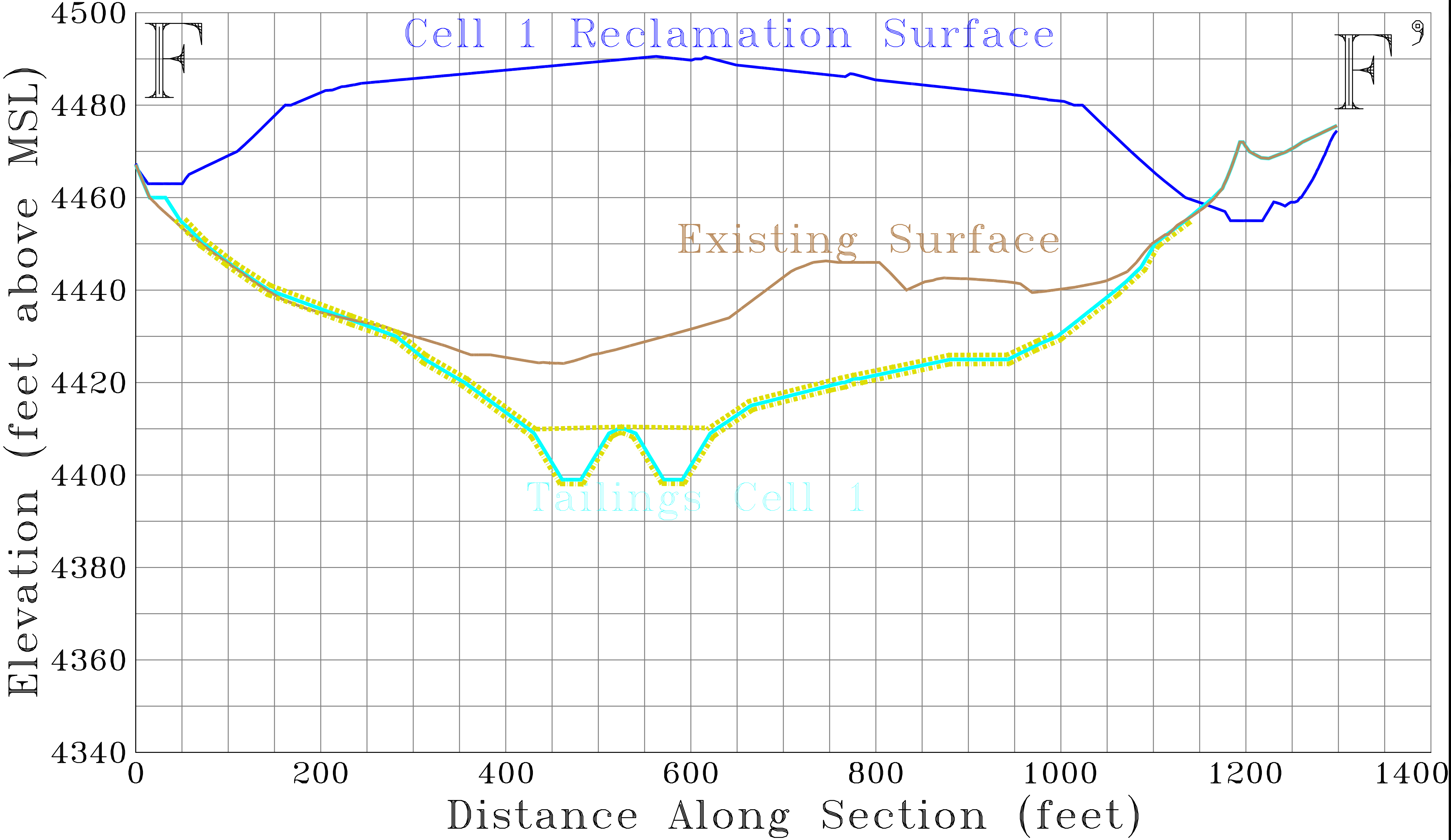
FIGURE 9-10. RECLAMATION CROSS SECTION E-E'

DATE: 12-2005 | CROSS-SECTIONS.DWG

Page: 9-18 | HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 1 LINER
CELL 1 DRAINAGE LAYER

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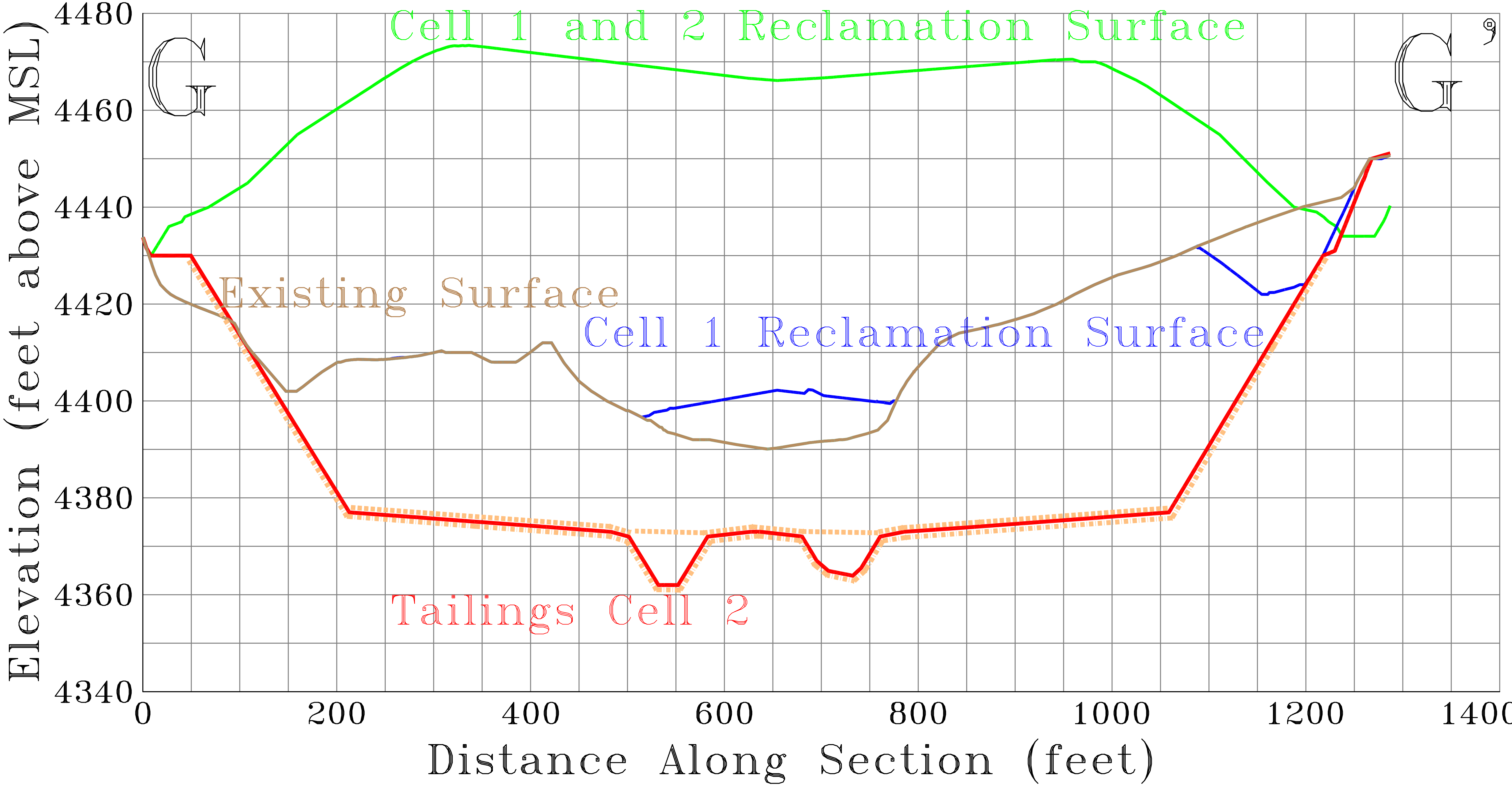
FIGURE 9-11. RECLAMATION CROSS SECTION F-F'

DATE: 12-2005 CROSS-SECTIONS.DWG

Page: 9-19 HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 2 LINER
CELL 2 DRAINAGE LAYER

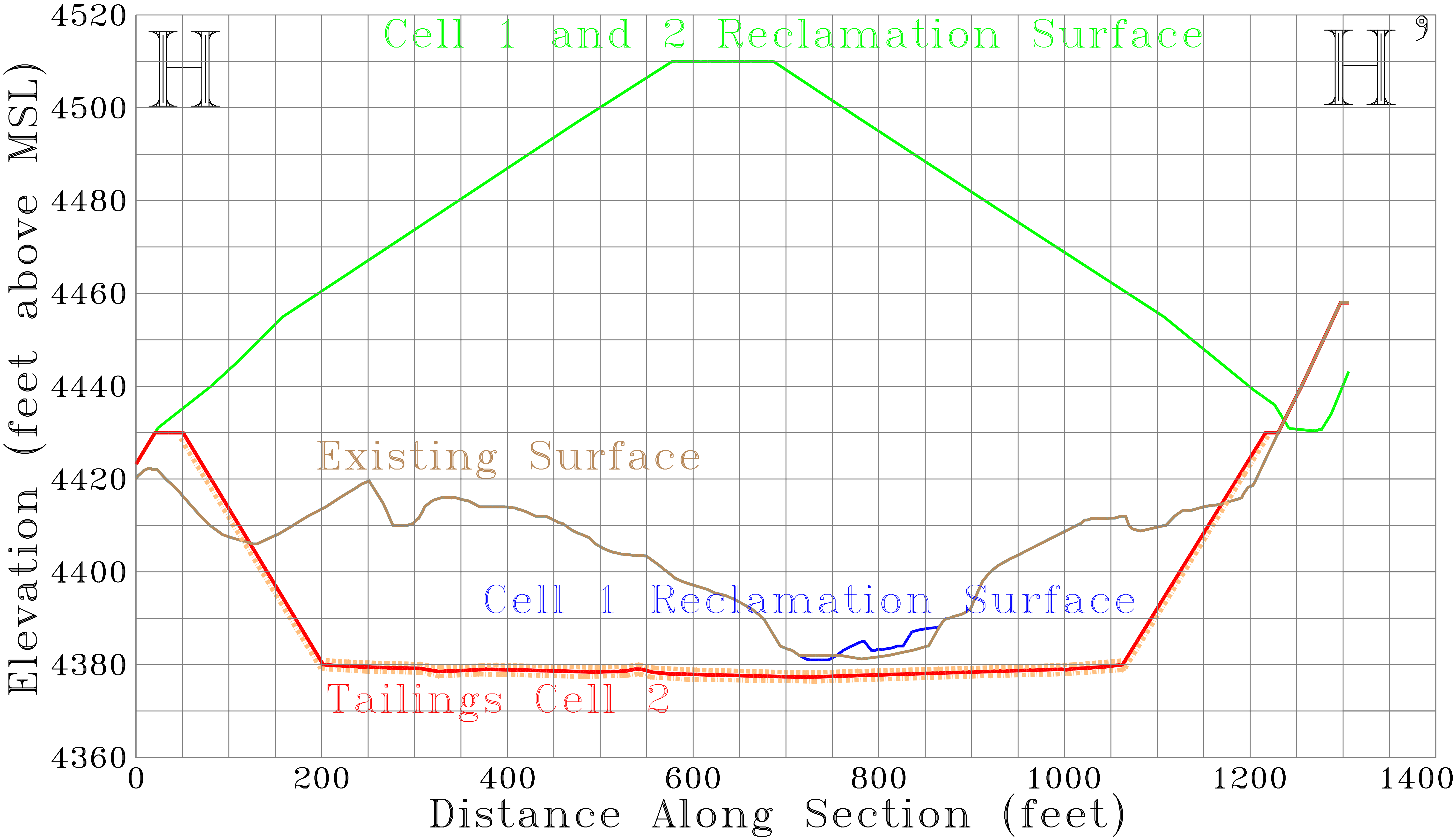
PLATEAU RESOURCES Ltd.

FIGURE 9-12. RECLAMATION CROSS SECTION G-G'

DATE: 12-2005 CROSS-SECTIONS.DWG

Page: 9-20

HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 2 LINER
CELL 2 DRAINAGE LAYER

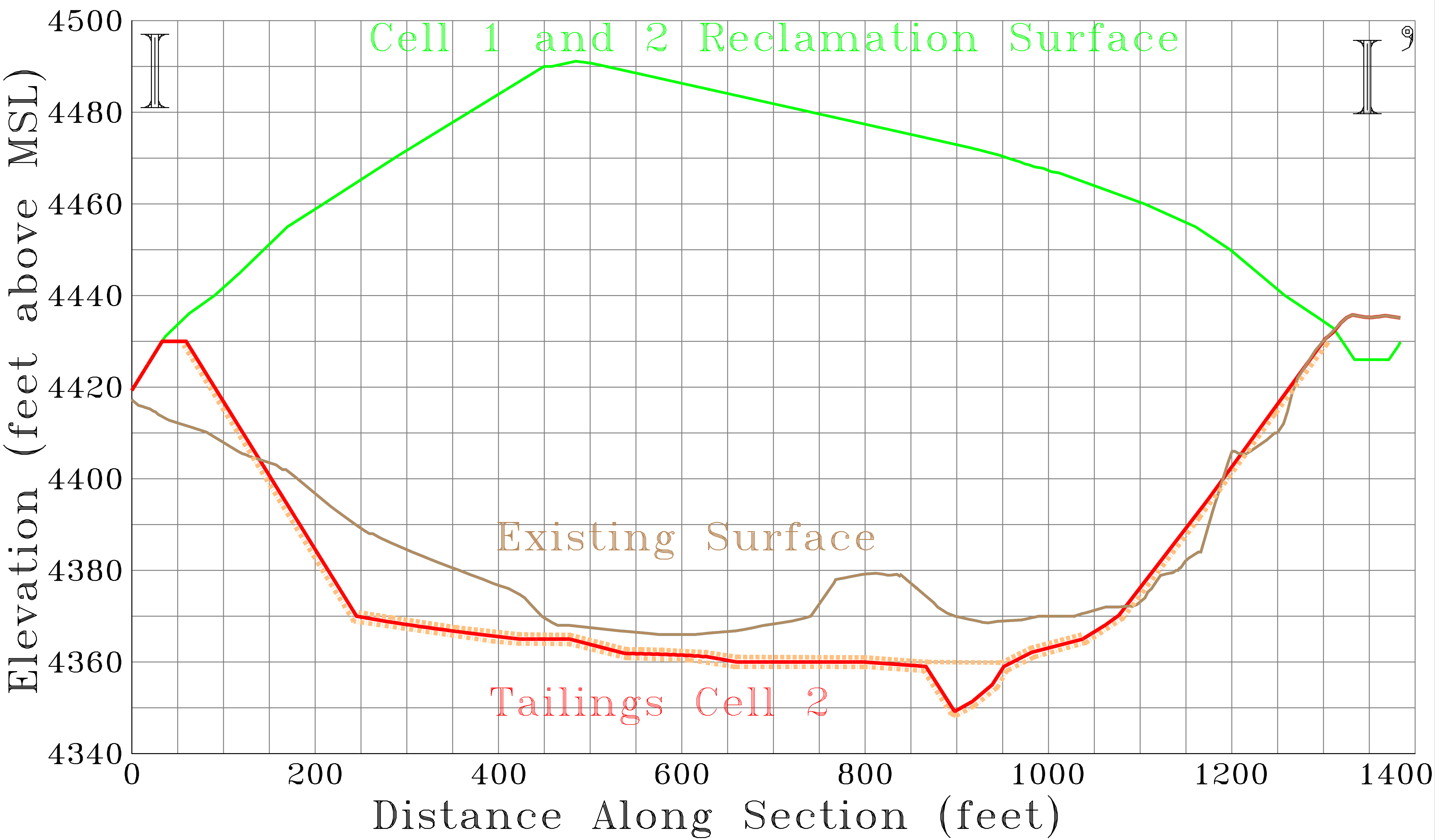
PLATEAU RESOURCES Ltd.

FIGURE 9-13. RECLAMATION CROSS SECTION H-H'

DATE: 12-2005 CROSS-SECTIONS.DWG

Page: 9-21

HYDRO-ENGINEERING L.L.C.



Scale: Horiz. 1"= 100'
Vert. 1"= 20'

LEGEND
CELL 2 LINER
CELL 2 DRAINAGE LAYER

PLATEAU RESOURCES Ltd.

FIGURE 9-14. RECLAMATION CROSS SECTION I-I'

DATE: 12-2005 | CROSS-SECTIONS.DWG

Page: 9-22

HYDRO-ENGINEERING L.L.C.

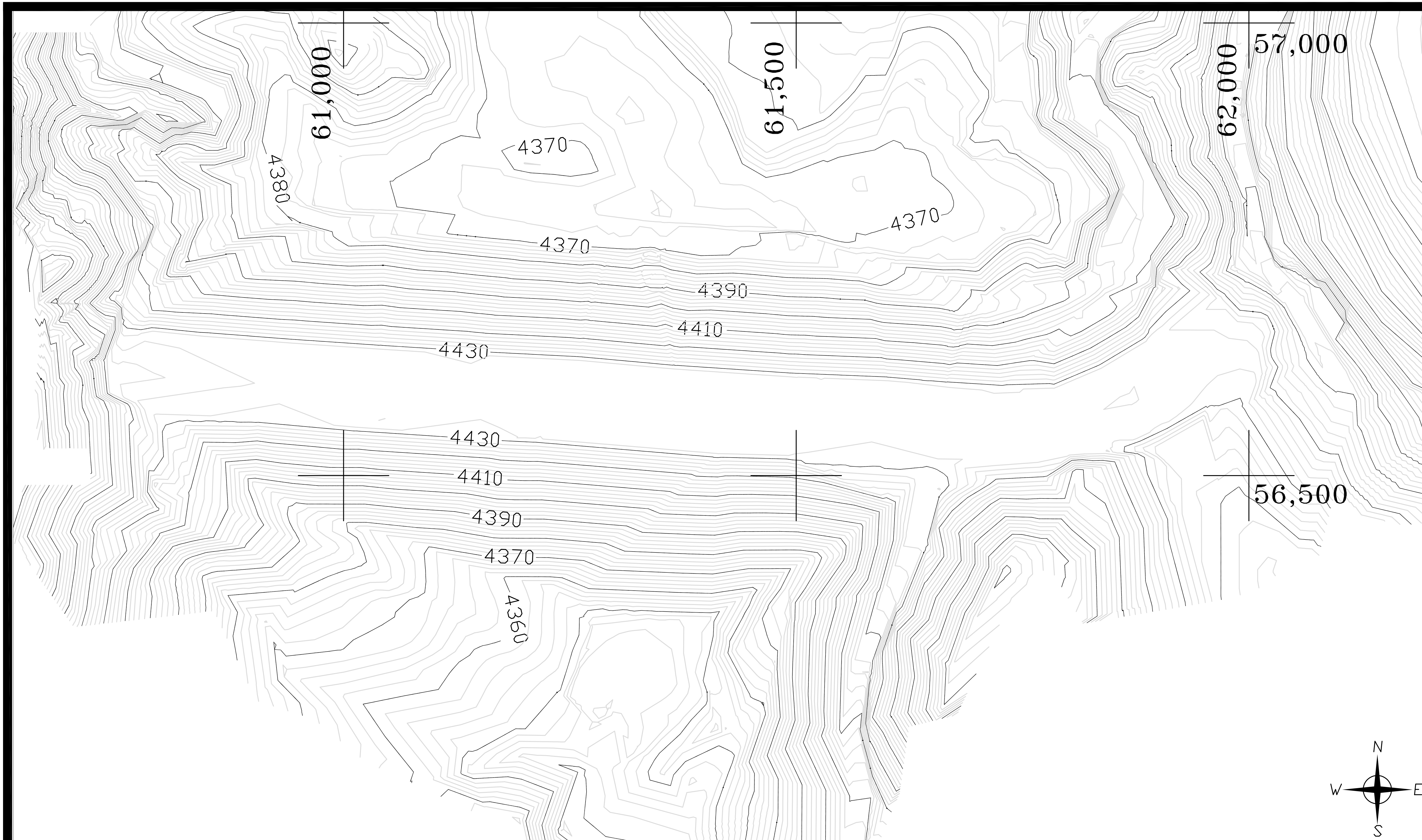


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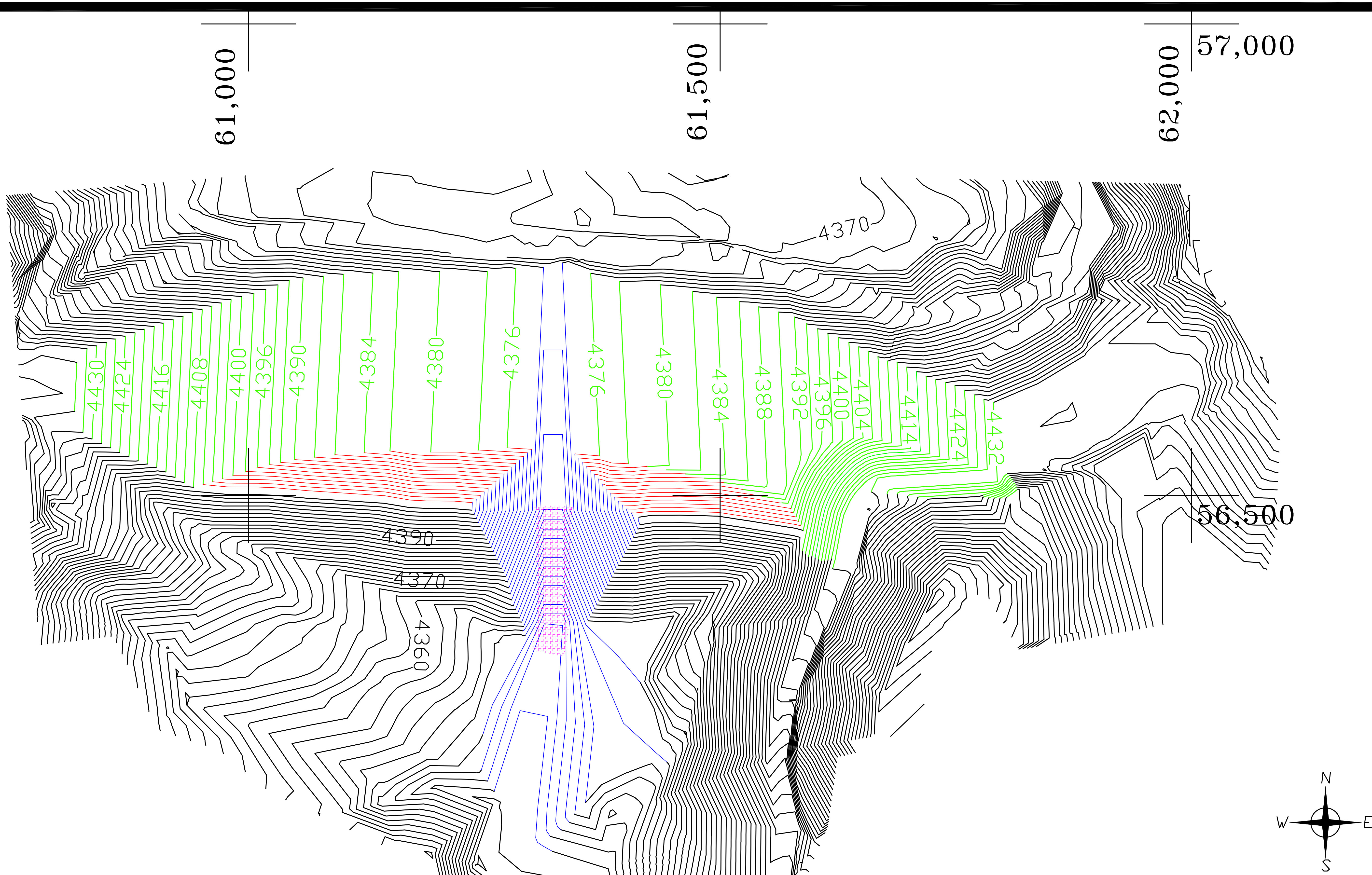
FIGURE 9-15. SHOOTARING DAM PRESENT TOPOGRAPHY

DATE: 12-2005	FIG9-15.DWG	SCALE: 1"=100'
Page: 9-23	HYDRO-ENGINEERING L.L.C.	



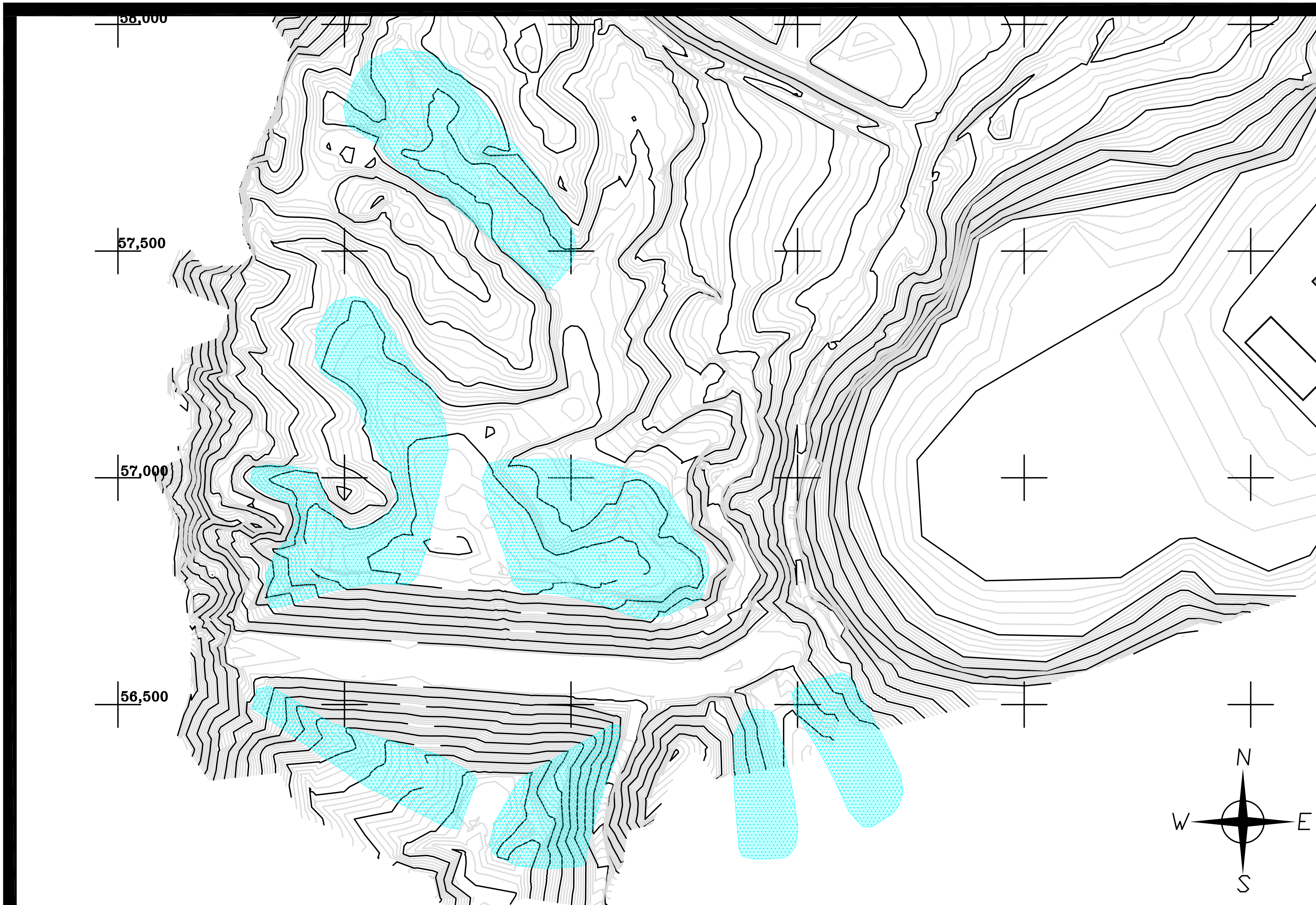
LEGEND

RIPRAP OUTFALL

PLATEAU RESOURCES Ltd.

FIGURE 9-16. SHOOTARING DAM DESIGN
TOPOGRAPHY FOR CELL 1 RECLAMATION

DATE: 12-2005	FIG9-15.DWG	SCALE: 1"=100'
Page: 9-24	HYDRO-ENGINEERING L.L.C.	



LEGEND

POSSIBLE DISPOSAL LOCATION

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FIGURE 9-17. POSSIBLE LOCATIONS FOR DISPOSAL OF EXCESS FILL

DATE: 12-2005	FIG9-17.DWG	SCALE: 1"=300'
Page: 9-25	HYDRO-ENGINEERING L.L.C.	

10.0. DECOMMISSIONING AND TAILING RECLAMATION SCHEDULE

The decommissioning activities objective is to perform the tasks continuously once begun but may extend beyond the 20 month period for the Cell 1 reclamation and beyond the 26 month period for the Cell 1 and Cell 2 reclamation. Figures 10-1-Cell-1 and 10-1-Cell-2 illustrates major activities and estimated time frames for completion. Radiation safety and monitoring programs shall continue throughout the decommissioning and tailings reclamation process.

Figure 10-1-Cell-1 presents the schedule of reclamation activities at the Shootaring site for the plan that includes proceeding to reclamation with only Cell 1 constructed and utililized. The decommissioning schedule for the Shootaring Canyon Mill has a six (6) month interval for salvage of milling components that have commercial value and are able to be released for unrestricted use. Table 8-2 presents a list of equipment anticipated for release during this period. This time interval can vary, as the components are made available for release. The mill decommissioning is planned to start during the early stages of the reclamation project. With this, there is the presumption that all excess fluids in the EPPC can be evaporated or otherwise disposed of within the salvage period. Time frames are estimated for each of the individual major tasks in the mill decommissioning with the total decommissioning estimated to last six months. The total Cell 1 reclamation plan is for 20 months but could be extended significantly if significant gaps between some of the reclamation stages are required. Weather delays could result in a longer period of time between the start and finish of the reclamation. Also, laboratory and completion reports with regulatory review and approval could also require additional time between some reclamation tasks.

Figure 10-1-Cell-2 presents the schedule of reclamation activities at the Shootaring site for the plan that includes utilization of both the Cell 1 and Cell 2 tailings disposal impoundments. The decommissioning schedule for the Shootaring Canyon Mill is common for both the Cell 1 and Cell 1 and 2 reclamation plans. The total Cell 1 and Cell 2 reclamation plan is for 26 months but could be extended significantly if significant gaps between some of the reclamation stages are required. Weather delays could result in a longer period of time between the start and finish of the reclamation. Also, laboratory and completion reports with regulatory review and approval could also require additional time between some reclamation tasks.

FIGURE 10-1-CELL-1. Schedule of Reclamation Activity at the Shootaring Canyon Site for Cell 1 Reclamation

	Time	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20
GRAPHICAL EVENTS FOR RECLAMATION OF THE MILL SITE	Days																				
SECTION 11.1: MILL DECOMMISSIONING & SHAPING																					
11.1.0 SALVAGE OF MILL COMPONENTS	180																				
11.1.1 GAMMA-SOIL RADIONUCLIDE RELATIONSHIP	4																				
11.1.2 AMMONIA TANK CONVERSION	1																				
11.1.3 TRUCK SCALE CLEANUP AND BUILDING DEMO	1																				
11.1.4 ORE HOPPER DEMO	10																				
11.1.5 ACID TANK & FOUNDATION DEMO	2																				
11.1.6 CCD CIRCUIT DEMO	12																				
11.1.7 MILL DEMO	20																				
11.1.8 VANADIUM CIRCUIT DEMO	7																				
11.1.9 TANKS AND FOUNDATIONS E. OF MILL DEMO	3																				
11.1.10 SODIUM CHLORATE TANK, FOUND. DEMO	2																				
11.1.11 CONCRETE TRENCH DEMO	3																				
11.1.12 TAILINGS CONVEYANCE SYSTEM DEMO	2																				
11.1.13 REMOVAL OF CONTAMINATED SOILS FROM AROUND BUILDINGS	3																				
11.1.14 REMOVAL OF CONTAMINATED SOILS FROM ORE PAD AREA	10																				
11.1.15 RADIOACTIVE CONTAINMENT STORAGE AREA CLEANUP	5																				
11.1.16 SOIL VERIFICATION	3																				
11.1.17 RECONTOURING, SHAPING AND SEEDING MILL SITE AND BORROW	5																				
11.1.18 MANAGEMENT, REPORTING, TESTING & MONITORING	103																				
11.1.19 MOBILIZATION & DEMOBILIZATION	10																				
SECTION 11.2: RECLAMATION OF TAILINGS CELL 1																					
11.2.1 MILL DEMO DISPOSAL	79																				
11.2.2 CONTOURING CELL 1 TAILINGS SURFACE	10																				
11.2.3 DRAINAGE SYSTEM GRADING	15																				
11.2.4 SANDY INTERIM/GRADING MATERIAL	40																				
11.2.5 CLAY COVER MATERIAL	40																				
11.2.6 ROCKY SOIL COVER MATERIAL	35																				
11.2.7 ROCK COVER MATERIALS	60																				
11.2.8 MONITORING WELL ABANDONMENT	20																				
11.2.9 MANAGEMENT, REPORTING, TESTING & MONITORING	299																				

Note: Schedule subject to change due to weather or other unforeseable circumstances, or contractor effieciency.

Plateau Resources Limited

Operation and

Reclamation Schedule

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FIGURE 10-1-CELL-2. Schedule of Reclamation Activity at the Shootaring Canyon Site for Cell 1 and Cell 2 Reclamation

GRAPHICAL EVENTS FOR RECLAMATION OF THE MILL SITE	Time Days	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24	Month 25	Month 26
SECTION 11.1: MILL DECOMMISSIONING & SHAPING																											
11.1.0 SALVAGE OF MILL COMPONENTS	180																										
11.1.1 GAMMA-SOIL RADIONUCLIDE RELATIONSHIP	4																										
11.1.2 AMMONIA TANK CONVERSION	1																										
11.1.3 TRUCK SCALE CLEANUP AND BUILDING DEMO	1																										
11.1.4 ORE HOPPER DEMO	10																										
11.1.5 ACID TANK & FOUNDATION DEMO	2																										
11.1.6 CCD CIRCUIT DEMO	12																										
11.1.7 MILL DEMO	20																										
11.1.8 VANADIUM CIRCUIT DEMO	7																										
11.1.9 TANKS AND FOUNDATIONS E. OF MILL DEMO	3																										
11.1.10 SODIUM CHLORATE TANK, FOUND. DEMO	2																										
11.1.11 CONCRETE TRENCH DEMO	3																										
11.1.12 TAILINGS CONVEYANCE SYSTEM DEMO	2																										
11.1.13 REMOVAL OF CONTAMINATED SOILS FROM AROUND BUILDIN	3																										
11.1.14 REMOVAL OF CONTAMINATED SOILS FROM ORE PAD AREA	10																										
11.1.15 RADIOACTIVE CONTAINMENT STORAGE AREA CLEANUP	5																										
11.1.16 SOIL VERIFICATION	3																										
11.1.17 RECONTOURING, SHAPING AND SEEDING MILL SITE AND BO	5																										
11.1.18 MANAGEMENT, REPORTING, TESTING & MONITORING	103																										
11.1.19 MOBILIZATION & DEMOBILIZATION	10																										
SECTION 11.3: RECLAMATION OF TAILINGS CELLS 1 AND 2																											
11.3.1 MILL DEMO DISPOSAL	79																										
11.3.2 CONTOURING CELL 1 AND CELL 2 TAILINGS SURFACE	15																										
11.3.3 DRAINAGE SYSTEM GRADING	45																										
11.3.4 SANDY INTERIM/GRADING MATERIAL	120																										
11.3.5 CLAY COVER MATERIAL	80																										
11.3.6 ROCKY SOIL COVER MATERIAL	60																										
11.3.7 ROCK COVER MATERIALS	60																										
11.3.8 MONITORING WELL ABANDONMENT	20																										
11.3.9 MANAGEMENT, REPORTING, TESTING & MONITORING	479																										

Note: Schedule subject to change due to weather or other unforeseable circumstances, or contractor effieciency.

Plateau Resources Limited

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11.0. COST ANALYSIS FOR MILL DECOMMISSIONING AND TAILINGS RECLAMATION

Cost breakdown of the areas of work:

11.1 Cost Estimate for Mill Site Decommissioning

As presented, the decommissioning and reclamation activities are expected to take approximately two years to complete. PRL prepared a cost estimate for the mill decommissioning, which includes the following assumptions:

1. The on-site work force is expected to consist of the following labor components:
   1 - Radiation Safety Officer
   3 - Radiation Technician
   1 - Lab Technician
   1 - Clerk
   1 - Demolition Superintendent/Foreman
   7 - Equipment Operators
   1 - Equipment Mechanic
   1 - Oiler
   5 - Laborers
   21

Personnel may be increased or decreased depending on the project activity or other specialists required for certain high risk areas. The number of personnel listed represents a typical or average work force.

2. The on-site equipment force is expected to consist of the following components:
   1 - Shear/Concrete Attachment/Excavator
   1 - Front End Loader
   1 - Grapple/Excavator
   2 - End Dump Trucks
   2 - Water Wagons
   1 - Fuel/Lube Truck
   1 - Motor Grader
   1 – Welder
   1 – Farm Tractor w/ Accs.
   2 - Scrapers
   13

Additional equipment may be added or removed depending on the project activity, contractor preference or other special requirements.

11.1.0 Salvage of Mill Components: 180 days $0

Salvage of mill components is planned for the first six months of the reclamation operation:

TOTAL =	**$0**	**$0**

11.1.1 Gamma-Soil Radionuclide Relationship: 4 days $10,904

Develop relationships between gamma readings and radium-226, natural uranium, and thorium-230 concentrations. For costing it is estimated to take four days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
2 EA Radiation Technicians	26	64	1,664	
Misc. Hand Tools	10	24	240	
Soil Samples				
	30 samples @ $300/ea =		9,000	
	TOTAL =		**$ 10,904**	**$10,904**

11.1.2 Ammonia Tank Conversion: 1 day $ 176

Remove and dispose of any fluids per state and federal laws. Clean tank and foundation for release. Vent tank, remove all present fittings, and connect propane fittings. For costing it is estimated to take one day to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
1 EA Laborers	12	8	96	
Misc. Hand Tools	10	8	80	
	TOTAL =		**$ 176**	**$11,080**

11.1.3 Truck Scale Cleanup and Building Demo: 1 day $1,300

Requires disassembly of scale building for disposal in tailings cell, and cleaning of the scale for release. For costing it is estimated to take one day to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	4	600	
2 End Dump Trucks w/ Drivers	60	8	480	
1 Water Wagon w/ Operator	55	4	220	
		TOTAL =	**$1,300**	**$12,380**

11.1.4 Ore Hopper Demo: 10 days $22,920

Remove grizzly and wet scrubber and place into the tailings impoundment. Requires disassembly and backfilling of ore dump pocket. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative:
Crawler Excavator w/ Operator	90	40	3,600	
Front End Loader w/ Operator	88	80	7,040	
Welder & Truck	45	40	1,800	
End Dump Truck w/ Driver	60	80	4,800	
Shear w/ Operator	150	8	1,200	
2 EA Laborers	12	240	2,880	
Misc. Hand Tools	20	80	1,600	
		TOTAL =	**$22,920**	**$ 35,300**

11.1.5 Acid Tank and Foundation Demo: 2 days $1,652

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks and foundations for placement into the tailings impoundment. For costing it is estimated to take two days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	4	600	
Front End Loader w/ Operator	88	4	352	
2 End Dump Trucks w/ Drivers	60	8	480	
Water Wagon w/Operator	55	4	220	
		TOTAL =	**$1,652**	**$36,952**

11.1.6 CCD Circuit Demo: 12 days $19,360

Remove tanks and foundations for placement into the tailings impoundment. Remove and dispose of top 1 foot of soil beneath the foundation. For costing it is estimated to take two and a half weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	80	12,000	
2 End Dump Truck w/ Drivers	60	80	4,800	
2 EA Laborers	12	80	960	
Misc. Hand Tools	20	80	1,600	
		TOTAL =	**$19,360**	**$56,312**

11.1.7 Mill Demo: 20 days $99,340

Remove equipment for placement into the tailings impoundment. For costing it is estimated to take four weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	160	24,000	
Grapple w/ Operator	150	160	24,000	
Front End Loader w/ Operator	88	130	11,440	
Welder and Truck	45	150	6,750	
2 End Dump Truck w/ Driver	60	290	17,400	
Water Wagon w/ Operator	55	160	8,800	
2 EA Laborers	12	640	7,680	
Misc. Hand Tools	20	160	3,200	
		TOTAL =	**$99,430**	**$155,742**

11.1.8 Vanadium Circuit Demo: 7 days $35,032

Remove equipment for placement into the tailings impoundment. For costing it is estimated to take one and a half weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	56	8,400	
Grapple w/ Operator	150	56	8,400	
Front End Loader w/ Operator	88	46	4,048	
Welder and Truck	45	56	2,520	
2 End Dump Truck w/ Driver	60	102	6,120	
Water Wagon w/ Operator	55	56	3,080	
2 EA Laborers	12	112	1,344	
Misc. Hand Tools	20	56	1,120	
		TOTAL =	**$35,032**	**$190,774**

11.1.9 Tanks and Foundations E. of Mill: 3 days $16,152

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks, sand filters and foundations for placement into the tailings impoundment. For costing it is estimated to take three days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	24	3,600	
Grapple w/ Operator	150	24	3,600	
Front End Loader w/ Operator	88	34	2,992	
End Dump Truck w/ Driver	60	40	2,400	
Water Wagon w/ Operator	55	24	1,320	
1 EA Laborers	12	120	1,440	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$16,152**	**$206,926**

11.1.10 Sodium Chlorate Tank, Found. Demo: 2 days $14,712

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks and foundations for placement into the tailings impoundment. For costing it is estimated to take 2 days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	16	2,400	
2 End Dump Truck w/ Drivers	60	30	1,800	
1 EA Laborers	12	16	192	
Misc. Hand Tools	20	16	320	
Neutralization of Residual	1	LS	10,000	
		TOTAL =	**$14,712**	**$221,638**

11.1.11 Concrete Trench Demo: 3 days $9,768

Remove concrete trenches and cut piping for placement into the tailings impoundment. For costing it is estimated to take three days to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Excavator w/ Operator	90	20	1,800	
Shear w/ Operator	150	20	3,000	
Water Wagon w/ Operator	55	24	1,320	
2 End Dump Truck w/ Drivers	60	48	2,880	
1 EA Laborers	12	24	288	
Misc. Hand Tools	20	24	480	
TOTAL =			**$9,768**	**$231,406**

11.1.12 Tailings Conveyance System Demo: 2 days $1,920

Cut pipe into manageable sections for placement into the tailings impoundment. For costing it is estimated to take two days to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Front End Loader w/ Operator	88	16	1,408	
1 EA Laborers	12	16	192	
Misc. Hand Tools	20	16	320	
		TOTAL =	**$1,920**	**$233,326**

11.1.13 Removal of Contaminated Soils From Around Buildings:

3 days $16,580

Remove approximately 1 foot of soil from contaminated areas identified within the mill area for placement into the tailings impoundment. For costing it is estimated to take half of one week to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA. Scraper w/ Operators	148	40	5,920	
Motor Grader w/ Operator	85	20	1,700	
Crawler Excavator w/ Operator	90	20	1,800	
Front End Loader w/ Operator	88	20	1,760	
2 End Dump Truck w/ Drivers	60	40	2,400	
Water Wagon	55	40	2,200	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$16,580**	**$249,906**

11.1.14 Removal of Contaminated Soils From Ore Pad Area:

10 days $48,720

Remove approximately 1 foot of soil from ore pad area for placement into the tailings impoundment. Also includes removal of fence in area. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA. Scraper w/ Operators	148	160	23,960	
Motor Grader w/ Operator	85	80	6,800	
Crawler Excavator w/ Operator	90	40	3,600	
Front End Loader w/ Operator	88	40	3,520	
2 End Dump Truck w/ Drivers	60	80	4,800	
Water Wagon	55	80	4,400	
2 EA. Laborers	12	60	720	
Misc. Hand Tools	20	60	1,200	
		TOTAL =	**$48,720**	**$298,626**

11.1.15 Radioactive Containment Storage Area Cleanup: 5 days $13,800

Includes removal of all material and 3" of soil of entire area for placement into the tailings impoundment. For costing it is estimated to take one week to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA Scraper w/ Operator	148	20	2,960	
Motor Grader w/ Operator	85	20	1,700	
Water Wagon w/ Operator	55	20	1,100	
2 End Dump Trucks	60	40	2,400	
Front End Loader w/ Operator	88	30	2,640	
Shear w/ Operator	150	20	3,000	
		TOTAL =	**$13,800**	**$312,426**

11.1.16 Soil Verification: 3 days $10,248

Areas where soil cleanup was performed are to be scanned and verified to be cleaned to the approved standards. For costing it is estimated to take three days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
2 EA Radiation Technicians	26	48	1,248	

Soil Samples

30 samples @ $300/ea = 9,000

TOTAL = $ 10,248 $322,674

11.1.17 Recontouring, Shaping and Seeding Mill Site and Borrow:

5 days $18,920

Grade site to match the surrounding area. Place soils and seeding where required for establishment of plant growth. For costing it is estimated to take one week to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Front End Loader w/ Operator	88	40	3,520	
Water Wagon w/ Operator	55	40	2,200	
2 End Dump Truck w/ Drivers	60	80	4,800	
Farm Tractor & Acc. w/ Operator	65	40	2,600	
2 EA Laborers	25	80	2,000	
Seed, Fertilizer & Mulch Cost				
10 Acres - $300 / Acre			3,000	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$18,920**	**$341,594**

11.1.18 Management, Reporting, Testing & Monitoring: 103 days $1,078,300

The following is the cost to have on staff or on site the following people and or equipment & facilities during decommissioning activities. The time required is matched to the above mill site decommissioning items, which is twenty-six weeks. The personnel below will be performing the daily paper work, reporting, management of decommissioning activities, environmental and radiological surveys and testing, quality control testing, soil verification, monitoring and any other safeguards and requirements to establish a site which will meet the unrestricted use parameters. The average radon flux will be determined on the disposal cell based on 100 canister readings. Note the time allowed in this matches the time to perform the work in the decommissioning of the mill facility. These people will also be used in the reclamation of the tailings impoundment and the additional time and expense for them will be accounted for in that section. The cost to perform independent testing and monitoring is also given below, along with an estimate on preparing a detailed decommissioning plan and completion report.

Crew:	Cost / Month	Months	Extension	Cumulative
Radiation Safety Officer	5,300	6	31,800	
Radiaton Technician 3 EA	25,950	6	155,700	
Lab Technician for Testing	4,200	5	21,000	
Labor 3 EA	9,000	6	54,000	
Clerical	3,600	6	21,600	
Demolition Superintendent	4,500	6	27,000	
Utility Cost (Phone, Elec. , ect.)	8,000	6	48,000	
Living Costs for Crew (21 people)	52,500	6	315,000	
Misc. Office Supplies	500	6	3,000	
Mechanic	3,000	6	18,000	

Oiler	2,200	6	13,200	
Environmental, Radiological & Other Required or Needed Quality Control & Testing Equipment Allowance	40,000	4	160,000	
Preparing a Detailed Completion for Decommissioning and Reclamation Report	1	LS	100,000	
Outside Analytical, testing and Calibration Costs	1	LS	80,000	
Facility Setup Costs	1	LS	30,000	
		TOTAL =	**$1,078,300**	**$1,419,894**

11.1.19 Mobilization & Demobilization: 10 days $63,500

Move equipment to the site and then move off site. For costing assume equipment may have to come in from a total of 500 miles away. Therefore see the following cost estimate:

13 Pieces of Equipment @ 500 Miles X 2 Ways X $4.50 /Mile	=	$58,500	
Misc. Mobilization Items -- 1 LS @ $5,000.00	=	$ 5,000	
	TOTAL =	**$63,500**	**$1,483,394**

11.2 COST ANALYSIS FOR TAILINGS CELL 1 RECLAMATION

As presented, the decommissioning and reclamation activities for the Cell 1 reclamation are expected to take approximately twenty months to complete. PRL prepared a cost estimate for the tailings reclamation, which includes the following assumptions:

1. The on-site work force will consist of the following estimated labor components:
   1 - Radiation Safety Officer
   3 – Radiation Technicians
   1 - Lab Technician
   1- Clerk
   1 – Construction Superintendent/Foreman
   12 - Equipment Operators
   1 - Equipment Mechanic
   1 - Oiler
   5 - Laborers
   26

Personnel may be increased or decreased depending on the project activity or other specialist required for certain high risk areas. The number of personnel listed represents a typical or average work force.

2. The on-site equipment force is expected to consist of the following components:
   3 - Front End Loader
   2 - Crawler Excavator
   6 – Off-Road Trucks
   2 - Water Wagons
   1 - Fuel/Lube Truck
   2 - Motor Grader
   1 – Crawler Dozer
   2 – Compactor
   1 – Screening Plant
   1 – Farm Tractor w/ Accs.
   6 - Scrapers
   27

Additional equipment may be added or removed depending on the project activity, contractor preference or other special requirements.

11.2.1 Mill Demo Disposal: 79 days $293,020

The mill area demolition is all to be placed in the tailings impoundment. Cost includes placement only. The total volume for disposal from the Mill Demo and Mill soil cleanup is approximately 26,000 C.Y., all of which is to be disposed of in the tailings cell. To prevent settlement after placement of the mill demo material, all voids will be filled with a flowable fill. For costing it is estimated to take sixteen weeks to complete with the following crew:

Flowable Fill: 7,020 C.Y. @ $35.00 / C.Y. = **$245,700**

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	260	38,740	
Water Wagon w/ Operator	55	52	2,860	
Compactor w/ Operator	55	104	5,720	
		TOTAL =	**$293,020**	**$ 293,020**

11.2.2 Contouring Cell 1 Tailings Surface: 10 days $27,520

The contouring of the tailings surface will include grading to produce a central pile with relatively uniform outslopes. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	80	11,920	
Water Wagon w/ Operator	55	80	4,400	
Motor Grader w/ Operator	85	80	6,800	
Compactor w/ Operator	55	80	4,400	
		TOTAL =	**$27,520**	**$320,540**

11.2.3 Drainage System Grading: 15 days $87,600

The drainage system grading includes earthwork to create perimeter channels around Cell 1 and the EPPC. Portions of the channel cut volume may be placed as interim/grading cover. The proximity of the tailings and channel cut area allows placement in the tailings area without additional haul distance. For costing it is estimated to take three weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	120	17,880	
Water Wagon w/ Operator	55	120	6,600	
Motor Grader w/ Operator	85	120	10,200	
Crawler Excavator w/ Operator	90	120	10,800	
2 EA Off-Road Trucks w/ Drivers	148	120	17,760	
2 EA Scraper w/ Operator	148	120	17,760	
Compactor w/ Operator	55	120	6,600	
		TOTAL =	**$87,600**	**$408,140**

11.2.4 Sandy Interim/Grading Material: 40 days $623,120

Costing for the sandy interim/grading cover material includes royalty, mining, loading, hauling, and placing. For costing it is estimated to take eight weeks to complete with the following crew:

Tailings Area:	Estimated Volume =	186,400 CY
	Sand Royalty @ $1.00/CY =	**$186,400**

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 Crawler Dozer w/ Operator	149	640	95,360	
Water Wagon w/ Operator	55	320	17,600	
Motor Grader w/ Operator	85	320	27,200	
Crawler Excavator w/ Operator	90	320	28,800	
4 EA Off-Road Truck w/ Operator	148	1280	189,440	
2 EA Loader with Operator	88	640	56,320	
Compactor w/ Operator	55	320	17,600	
Farm Tractor w/ Disc	55	80	4,400	
		TOTAL =	**$623,120**	**$1,031,260**

11.2.5 Clay Cover Material: 40 days $519,920

Costing for the clay cover material includes loading, hauling, and placing. For costing it is estimated to take eight weeks to complete with the following crew:

Tailings Area: Estimated Volume = 73,000 CY

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA Crawler Dozer w/ Operator	149	640	95,360	
Water Wagon w/ Operator	55	320	17,600	
2 EA Motor Grader w/ Operator	85	640	54,400	
Crawler Excavator w/ Operator	90	320	28,800	
6 EA Scraper w/ Operator	148	1920	284,160	
2 EA Compactor w/ Operator	55	640	35,200	
Farm Tractor w/ Disc	55	80	4,400	
		TOTAL =	**$519,920**	**$1,551,180**

11.2.6 Rocky Soil Cover Material: 35 days $428,880

Costing for the rocky soil cover material includes loading, hauling, and placing. For costing it is estimated to take seven weeks to complete with the following crew:

Tailings Area: Estimated Volume = 97,300 CY

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA Crawler Dozer w/ Operator	149	560	83,440	
Water Wagon w/ Operator	55	280	15,400	
2 EA Motor Grader w/ Operator	85	480	40,800	
Crawler Excavator w/ Operator	90	280	25,200	
6 EA Scraper w/ Operator	148	1,680	248,640	
Compactor w/ Operator	55	280	15,400	
		TOTAL =	**$428,880**	**$1,980,060**

11.2.7 Rock Cover Materials: 60 days $300,045

Process, load, haul and place rock cover materials to the required thickness above the soil cover and on slopes.

ROCK PRODUCTION AND PLACEMENT CREW:

2 EA	EXCAVATOR	@	$ 114 / HR / EA
2 EA	DOZER	@	$ 149 / HR / EA
3 EA	LOADER	@	$ 88 / HR / EA
1 EA	SCREEN	@	$ 100 / HR / EA
1 EA	BLADE	@	$ 85 / HR / EA
2 EA	WATER TRUCK	@	$ 40 / HR / EA
6 EA	OFF-ROAD TRUCK	@	$ 148 / HR / EA
1 EA	MECHANICS	@	$ 40 / HR / EA
1 EA	OILERS	@	$ 20 / HR / EA
2 EA	LABORERS	@	$ 12 / HR / EA
1 LS	MISC. EXP.	@	$ 20 / HR / EA
	TOTAL $ / HR	=	***$ 1,751 / HR***

Expect 2 rounds / HR / Truck	=	4 EA x 30 CY/Load x 2 Loads / HR x 8 HR/Day
	=	1,920 CY/Day

Therefore:	(8 HR/Day x $ 1,751 / HR) / 1,920 CY/Day	=	$ 7.30 / CY
	Royalty Payment @ $ 1.00 /CY	=	$ 1.00 / CY
	TOTAL $ / CY	=	**$ 8.30 / CY**

Cost for Tailings Portion

Filter Material	- 5,110 C.Y.	x	$ 8.30 / CY	=	$42,413	
Rock Products	- 31,040 C.Y.	x	$ 8.30 / CY	=	$257,632	
			TOTAL	=	**$300,045**	**$2,280,105**

11.2.7.1 Additional Cost Analysis Break Down of Rock Cover Materials:

The rock cover materials will be processed from the existing borrow shown on Figure 6-9 and possibly from surrounding borrow areas. The smaller riprap and rock mulch products (<6" D50) material will be processed from the quarry and Shootaring Dam, and the larger material (>6" D50) will be processed from the quarry, the upstream and downstream faces of the Shootaring Dam, and original borrow areas for the mill and dam. The material is in sufficient quantity and sizes within the borrow areas. No blasting or crushing will be required to produce the rock cover material as designed, rather only separation of the different sizes out of the borrow material will be required. This material from the quarry will be produced by the use of the following types of equipment working together in the production and placement of the material. A Cat D9 size dozer will strip a very limited depth of soil medium and push the borrow material to a two (2) to three (3) cubic yard size excavator. The excavator will be loading the borrow material onto the screening plant which will separate the required rock sizes from the borrow material. The product and the waste material will be stockpiled and/or loaded onto haul trucks for delivery to the tailings disposal facility for placement. The loading and stockpiling will be performed by the use of two (2) five (5) cubic yard size loaders. This will enable them to keep up with the production rates and haulage of the materials. As the pits advance, the dozer will shape and clean behind the operation. The material from the dam face will be produced using a Cat D9 or larger dozer to push the material from the top of the dam face to the bottom where it will be picked through with an excavator with a thumb attachment to sort out the large material. The excavator will then load the trucks for hauling to the placement site.

The product materials will be hauled to the site by the use of thirty (30) to fifty (50) cubic yard off-road trucks. The number of trucks will depend on the production rate and placement of the product materials. For costing, at this time, four (4) trucks will be used in the calculation at a cycle rate of two (2) rounds per hour per truck. The distance hauled will generally be under one (1) mile and as such, better cycle times may be attained, thus reducing the number of haul trucks required. The haul road will be maintained by the use of a motor grader or blade in conjunction with a water truck for dust control.

At the location of final placement of the rock products, the material will be dumped and spread by the use of an excavator. This will limit the amount of rock material pushed into the underlying medium and will reduce disturbance of the rock surface. A low ground pressure dozer may also be used to spread rock products, but for this analysis, the excavator was included in the costing.

In addition to the machine time cost, the cost of a support maintenance crew to the rock production cost. This crew includes a mechanic, oiler, and two (2) laborers.

In this analysis, there was no consideration of simultaneous production of two or more product materials. It is likely that multiple products can be produced at the same time which will ultimately reduce unit rock costs. The cost analysis includes stripping, production, hauling, placing, maintenance and clean up operations involved in production of each required rock size. The estimated cost of $ 8.30/ CY of rock material produced, hauled and placed is likely conservative because multiple rock products may be produced with the same inputs, and the royalty cost will not be applicable for some of the rock sources.

11.2.8 Monitoring Well Abandonment: 20 days $48,758

Includes abandonment of 24 sand packed wells. For costing it is estimated to take four weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Drill Rig w/ Crew	100	160	16,000	
2 Laborers	55	320	17,600	
Misc. Hand Tools	20	160	3,200	
			36,800	

Materials:	Cost / L.F.	L.F.	Extension	
Grout	2	5,979	11,958	
		TOTAL =	**$48,758**	**$2,328,863**

11.2.9 Management, Reporting, Testing & Monitoring:

299 days $2,356,100

The following is the cost to have on staff or on site the following people and or equipment & facilities during reclamation activities. The time required is matched to the above tailings site reclamation items, which is approximately seventy weeks. The personnel below will be performing the daily paper work, reporting, management of reclamation activities, environmental and radiological surveys and testing, quality control testing, monitoring and any other safeguards and requirements to establish a site which is stable and requires no further monitoring care. Note that these people are also used in the decommissioning of the mill site and the additional time and expense for them will be accounted for in that section. The cost to perform independent testing and monitoring is also given below, along with an estimate on preparing a detailed completion report.

Crew	Cost / Month	Months	Extension	
Radiation Safety Officer	5,300	14	74,200	
Radiation Technicians 3 EA.	25,950	14	363,300	
Lab Technician for Testing	4,200	14	58,800	
Labor 3 EA	9,000	14	126,000	
Clerical	2,200	14	30,800	
Construction Superintendent	4,500	14	63,000	
Utility Cost (Phone, Elec., etc.)	8,000	14	112,000	
Living Costs for Crew (25 people)	65,000	14	910,000	
Misc Office Supplies	2,000	14	28,000	
Environmental, Radiological & Other Required or Needed Quality Control & Testing Equipment Allowance	30,000	14	420,000	
Completion Report	1	LS	100,000	
Radon Flux Testing	1	LS	15,000	
Outside Analytical, testing and Calibration Costs	1	LS	55,000	
	TOTAL =		**$2,356,100**	**$4,684,963**

11.2.10 Additional Mobilization and Demobilization: 10 days $76,500

17 Pieces of Equipment: 500 Miles X 2 Ways X $4.50/Mile = $76,500

TOTAL = $76,500 $4,761,463

11.3 COST ANALYSIS FOR TAILINGS CELL 1 AND CELL 2 RECLAMATION

As presented, the decommissioning and reclamation activities for tailings Cell 1 and Cell 2 are expected to take approximately twenty-six months to complete. PRL prepared a cost estimate for the tailings reclamation, which includes the following assumptions:

1. The on-site work force will consist of the following estimated labor components:
   1 - Radiation Safety Officer
   3 – Radiation Technicians
   1 - Lab Technician
   1- Clerk
   1 – Construction Superintendent/Foreman
   15 - Equipment Operators
   1 - Equipment Mechanic
   1 - Oiler
   5 - Laborers
   29

Personnel may be increased or decreased depending on the project activity or other specialist required for certain high risk areas. The number of personnel listed represents a typical or average work force.

2. The on-site equipment force is expected to consist of the following components:
   3 - Front End Loader
   2 - Crawler Excavator
   6 – Off-Road Trucks
   2 - Water Wagons
   1 - Fuel/Lube Truck
   3 - Motor Grader
   2 – Crawler Dozer
   2 – Compactor
   1 – Screening Plant
   1 – Farm Tractor w/ Discs
   6 - Scrapers
   29

Additional equipment may be added or removed depending on the project activity, contractor preference or other special requirements.

11.3.1 Mill Demo Disposal: 79 days $293,020

The mill area demolition is all to be placed in the tailings impoundment. Cost includes placement only. The total volume for disposal from the Mill Demo and Mill soil cleanup is approximately 26,000 C.Y., all of which is to be disposed of in the tailings cell. To prevent settlement after placement of the mill demo material, all voids will be filled with a flowable fill. For costing it is estimated to take sixteen weeks to complete with the following crew:

Flowable Fill: 7,020 C.Y. @ $35.00 / C.Y. = **$245,700**

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	260	38,740	
Water Wagon w/ Operator	55	52	2,860	
Compactor w/ Operator	55	104	5,720	
		TOTAL =	**$293,020**	**$ 293,020**

11.3.2 Contouring Cell 1 and Cell 2 Tailings Surface: 15 days $41,280

The contouring of the tailings surface will include grading to produce a central pile with relatively uniform outslopes. For costing it is estimated to take three weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	120	17,880	
Water Wagon w/ Operator	55	120	6,600	
Motor Grader w/ Operator	85	120	10,200	
Compactor w/ Operator	55	120	6,600	
		TOTAL =	**$41,280**	**$334,300**

11.3.3 Drainage System Grading: 45 days $165,120

The drainage system grading includes earthwork to create perimeter channels around Cell 1, Cell 2, and the EPPC. Portions of the channel cut volume may be placed as interim/grading cover. The proximity of the tailings and channel cut area allows placement in the tailings area without additional haul distance. For costing it is estimated to take nine weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	149	360	53,640	
Water Wagon w/ Operator	55	360	13,200	
Motor Grader w/ Operator	85	120	10,200	
Crawler Excavator w/ Operator	90	240	21,600	
2 EA Off-Road Trucks w/ Drivers	148	240	35,520	
2 EA Scraper w/ Operator	148	120	17,760	
Compactor w/ Operator	55	240	13,200	
		TOTAL =	**$165,120**	**$499,420**

11.3.4 Sandy Interim/Grading Material: 120 days $2,316,420

Costing for the sandy interim/grading cover material includes royalty, mining, loading, hauling, and placing. For costing it is estimated to take eight weeks to complete with the following crew:

Tailings Area: Estimated Volume = 587,700 CY
Sand Royalty @ $1.00/CY = **$587,700**

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 EA Crawler Dozer w/ Operator	149	1920	286,080	
Water Wagon w/ Operator	55	960	52,800	
2 EA Motor Grader w/ Operator	85	1920	81,600	
Crawler Excavator w/ Operator	90	960	86,400	
6 EA Off-Road Truck w/ Operator	148	5760	852,480	
2 EA Loader with Operator	88	1920	168,960	
2 EA Compactor w/ Operator	55	1920	105,600	
Farm Tractor w/ Disc	55	240	13,200	
		TOTAL =	**$2,316,420**	**$2,815,840**

11.3.5 Clay Cover Material: 80 days $4,206,920

Costing for the clay cover material includes loading, hauling, and placing. For costing it is estimated to take sixteen weeks to complete with the following crew:

Tailings Area: Estimated Volume = 155,600 CY
Clay Royalty @ $1.00/CY = **$155,600**

Mining Crew:	Cost / Hour	Hours	Extension	Cumulative
2 Crawler Dozer w/ Operator	149	1200	178,800	
Water Wagon w/ Operator	55	600	33,000	
Motor Grader w/ Operator	85	600	51,000	
Crawler Excavator w/ Operator	90	600	54,000	
Front End Loader w/ Operator	88	600	52,800	
Farm Tractor w/ Disc	55	200	11,000	
Hauling:				
Highway Trucking (60 mile round trip) Cost/CY		$21.60	3,360,960	
Placement Crew:				
Crawler Dozer w/ Operator	149	640	95,360	
Water Wagon w/ Operator	55	640	35,200	
2 EA Motor Grader w/ Operator	85	1280	108,800	
2 EA Compactor w/ Operator	55	1280	70,400	
		TOTAL =	**$4,206,920**	**$7,022,760**

11.3.6 Rocky Soil Cover Material: 60 days $861,120

Costing for the rocky soil cover material includes loading, hauling, and placing. For costing it is estimated to take twelve weeks to complete with the following crew:

Tailings Area: Estimated Volume = 207,407 CY
Rocky Soil Royalty @ $1.00/CY = **$207,407**

Crew:	Cost / Hour	Hours	Extension	Cumulative
2 Crawler Dozer w/ Operator	149	1920	286,080	
Water Wagon w/ Operator	55	480	26,400	
Motor Grader w/ Operator	85	480	40,800	
Crawler Excavator w/ Operator	90	960	86,400	
6 EA Scraper w/ Operator	148	1,920	284,160	
2 EA Loader w/ Operator	88	960	84,480	
2 EA Compactor w/ Operator	55	288	52,800	
		TOTAL =	**$861,120**	**$7,883,880**

11.3.7 Rock Cover Materials: 60 days $479,806

Process, load, haul and place rock cover materials to the required thickness above the soil cover and on slopes.

ROCK PRODUCTION AND PLACEMENT CREW:

2 EA	EXCAVATOR	@	$ 114 / HR / EA
2 EA	DOZER	@	$ 149 / HR / EA
3 EA	LOADER	@	$ 88 / HR / EA
1 EA	SCREEN	@	$ 100 / HR / EA
1 EA	BLADE	@	$ 85 / HR / EA
2 EA	WATER TRUCK	@	$ 40 / HR / EA
6 EA	OFF-ROAD TRUCK	@	$ 148 / HR / EA
1 EA	MECHANICS	@	$ 40 / HR / EA
1 EA	OILERS	@	$ 20 / HR / EA
2 EA	LABORERS	@	$ 12 / HR / EA
1 LS	MISC. EXP.	@	$ 20 / HR / EA
	TOTAL $ / HR	=	***$ 1,751 / HR***

Expect 2 rounds / HR / Truck = 4 EA x 30 CY/Load x 2 Loads / HR x 8 HR/Day
= 1,920 CY/Day

Therefore: (8 HR/Day x $ 1,751 / HR) / 1,920 CY/Day = $ 7.30 / CY
Royalty Payment @ $ 1.00 /CY = $ 1.00 / CY
TOTAL $ / CY = $ 8.30 / CY

Cost for Tailings Portion

Filter Material	- 5,348 C.Y.	x	$ 8.30 / CY	=	$44,388	
Rock Products	- 52,460 C.Y.	x	$ 8.30 / CY	=	$435,418	
			TOTAL	**=**	**$479,806**	**$8,363,686**

11.3.7.1 Additional Cost Analysis Break Down of Rock Cover Materials:

The rock cover materials will be processed from the surrounding borrow areas and from the existing borrow shown on Figure 6-9. The smaller riprap and rock mulch products (<6” D50) material will be processed from the surrounding borrow areas, quarry and Shootaring Dam, and the larger material (>6” D50) will be processed from the surrounding borrow areas, quarry, and the upstream and downstream faces of the Shootaring Dam. The material is in sufficient quantity and sizes within the borrow areas. No blasting or crushing will be required to produce the rock cover material as designed, rather only separation of the different sizes out of the borrow material will be required. This material from the quarry will be produced by the use of the following types of equipment working together in the production and placement of the material. A Cat D9 size dozer will strip a very limited depth of soil medium and push the borrow material to a two (2) to three (3) cubic yard size excavator. The excavator will be loading the borrow material onto the screening plant which will separate the required rock sizes from the borrow material. The product and the waste material will be stockpiled and/or loaded onto haul trucks for delivery to the tailings disposal facility for placement. The loading and stockpiling will be performed by the use of two (2) five (5) cubic yard size loaders. This will enable them to keep up with the production rates and haulage of the materials. As the pits advance, the dozer will shape and clean behind the operation. The material from the dam face will be produced using a Cat D9 or larger dozer to push the material from the top of the dam face to the bottom where it will be picked through with an excavator with a thumb attachment to sort out the large material. The excavator will then load the trucks for hauling to the placement site.

The product materials will be hauled to the site by the use of thirty (30) to fifty (50) cubic yard off-road trucks. The number of trucks will depend on the production rate and placement of the product materials. For costing, at this time, four (4) trucks will be used in the calculation at a cycle rate of two (2) rounds per hour per truck. The distance hauled will generally be under two (2) miles and as such, better cycle times may be attained, thus reducing the number of haul trucks required. The haul road will be maintained by the use of a motor grader or blade in conjunction with a water truck for dust control.

At the location of final placement of the rock products, the material will be dumped and spread by the use of an excavator. This will limit the amount of rock material pushed into the underlying medium and will reduce disturbance of the rock surface. A low ground pressure dozer may also be used to spread rock products, but for this analysis, the excavator was included in the costing.

In addition to the machine time cost, the cost of a support maintenance crew to the rock production cost. This crew includes a mechanic, oiler, and two (2) laborers.

In this analysis, there was no consideration of simultaneous production of two or more product materials. It is likely that multiple products can be produced at the same time which will ultimately reduce unit rock costs. The cost analysis includes stripping, production, hauling, placing, maintenance and clean up operations involved in production of each required rock size. The estimated cost of $ 8.30/ CY of rock material produced, hauled and placed is likely conservative because multiple rock products may be produced with the same inputs, and the royalty cost will not be applicable for some of the rock sources.

11.3.8 Monitoring Well Abandonment: 20 days $48,758

Includes abandonment of 24 sand packed wells. For costing it is estimated to take four weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Drill Rig w/ Crew	100	160	16,000	
2 Laborers	55	320	17,600	
Misc. Hand Tools	20	160	3,200	
			36,800	

Materials:	Cost / L.F.	L.F.	Extension	
Grout	2	5,979	11,958	
		TOTAL =	**$48,758**	**$8,412,444**

11.3.9 Management, Reporting, Testing & Monitoring:

479 days $3,443,000

The following is the cost to have on staff or on site the following people and or equipment & facilities during reclamation activities. The time required is matched to the above tailings site reclamation items, which is approximately seventy weeks. The personnel below will be performing the daily paper work, reporting, management of reclamation activities, environmental and radiological surveys and testing, quality control testing, monitoring and any other safeguards and requirements to establish a site which is stable and requires no further monitoring care. Note that these people are also used in the decommissioning of the mill site and the additional time and expense for them will be accounted for in that section. The cost to perform independent testing and monitoring is also given below, along with an estimate on preparing a detailed completion report.

Crew	Cost / Month	Months	Extension
Radiation Safety Officer	5,300	20	106,000
Radiation Technicians 3 EA.	25,950	20	519,000
Lab Technician for Testing	4,200	20	84,000
Labor 3 EA	9,000	20	180,000
Clerical	2,200	20	44,000
Construction Superintendent	4,500	20	90,000
Utility Cost (Phone, Elec., etc.)	8,000	20	160,000
Living Costs for Crew (29 people)	72,500	20	1,450,000
Misc Office Supplies	2,000	20	40,000
Environmental, Radiological & Other Required or Needed Quality Control & Testing Equipment Allowance	30,000	20	600,000
Completion Report	1	LS	100,000
Radon Flux Testing	1	LS	15,000
Outside Analytical, testing and Calibration Costs	1	LS	55,000

TOTAL = $3,443,000 $11,855,444

11.3.10 Additional Mobilization and Demobilization: 10 days $85,500

19 Pieces of Equipment: 500 Miles X 2 Ways X $4.50/Mile = $85,500

TOTAL = $85,500 $11,940,944

12.0 SUMMARY OF TOTAL COST FOR BONDING REQUIREMENTS

The total cost estimate for the Shootaring mill decommissioning and tailings reclamation is summarized in Table 12-1-Cell-1 for the Cell 1 reclamation plan. All costs have been rounded to the nearest one hundred dollars. This total cost is $1,483,400 and $4,761,400 for the mill decommissioning and Cell 1 tailings reclamation respectively. The total cost for the reclamation project with a 15% contingency, 10% PRL management overhead and long-term management cost is estimated to be $8,638,600.

The total cost estimate for the Shootaring mill decommissioning and tailings reclamation is summarized in Table 12-1-Cell-2 for the Cell 1 and Cell 2 reclamation plan. All costs have been rounded to the nearest one hundred dollars. This total cost is $1,483,400 and $11,940,900 for the mill decommissioning and Cell 1 tailings reclamation respectively. The total cost for the reclamation project with a 15% contingency, 10% PRL management overhead and long-term management cost is estimated to be $17,720,600.

Table 12-1-Cell-1. Cost Summary for Mill Decommissioning and Tailings Cell 1 Reclamation

Events for Reclamation and Decommissioning of Shootaring Canyon Mill Facility		Cost
Decommission and Site Clean Up of Mill Facility		
11.1.0	Salvage of Mill Components	$ 0
11.1.1	Gamma-Soil Radionuclide Relationship	10,900
11.1.2	Ammonia Tank Conversion	200
11.1.3	Truck Scale Cleanup and Building Demo	1,300
11.1.4	Ore Hopper Demo	22,900
11.1.5	Acid Tank and Foundation Demo	1,700
11.1.6	CCD Circuit Demo	19,400
11.1.7	Mill Demo	99,400
11.1.8	Vanadium Circuit Demo	35,000
11.1.9	Tanks and Foundations E. of Mill	16,200
11.1.10	Sodium Chlorate Tank, Found. Demo	14,700
11.1.11	Concrete Trench Demo	9,800
11.1.12	Tailings Conveyance System Demo	1,900
11.1.13	Removal of Contaminated Soils from Around Buildings	16,600
11.1.14	Removal of Contaminated Soils from Ore Pad Area	48,700
11.1.15	Radioactive Containment Storage Area Cleanup	13,800
11.1.16	Soil Verification	10,200
11.1.17	Recontouring, Shaping and Seeding Mill Site and Borrow	18,900
11.1.18	Management, Reporting, Testing & Monitoring	1,078,300
11.1.19	Mobilization & Demobilization	63,500
	Total Cost for Decommission & Site Cleanup of Mill Area =	**$ 1,483,400**
Reclamation of Tailings Cell 1		
11.2.1	Mill Demo Disposal	293,000
11.2.2	Contouring Cell 1 Tailings Surface	27,500
11.2.3	Drainage System Grading	87,600
11.2.4	Sandy Interim/Grading Material	623,100
11.2.5	Clay Cover Material	519,900
11.2.6	Rocky Soil Cover Material	428,900
11.2.7	Rock Cover Materials	300,000
11.2.8	Monitoring Well Abandonment	48,800
11.2.9	Management, Reporting, Testing & Monitoring	2,356,100
11.2.10	Additional Mobilization & Demobilization	76,500
	Total Cost for Tailings Cell =	**$ 4,761,400**
	SUBTOTAL OF WORK =	**$ 6,244,800**
	15% CONTINGENCY =	**$ 936,700**
	PRL MANAGEMENT OVERHEAD @ 10% =	**$ 718,200**
	(9/05 vs. 11/78 CPI) LONG TERM MAINTENANCE COST =	**$ 738,900**
	TOTAL COST OF MILL DECOMMISSIONING, SITE CLEANUP AND TAILINGS RECLAMATION WORK IS EQUAL TO	**$ 8,638,600**

Table 12-1-Cell-2. Cost Summary for Mill Decommissioning and Cell 1 and Cell 2 Reclamation

Events for Reclamation and Decommissioning of Shootaring Canyon Mill Facility		Cost
Decommission and Site Clean Up of Mill Facility		
11.1.0	Salvage of Mill Components	$ 0
11.1.1	Gamma-Soil Radionuclide Relationship	10,900
11.1.2	Ammonia Tank Conversion	200
11.1.3	Truck Scale Cleanup and Building Demo	1,300
11.1.4	Ore Hopper Demo	22,900
11.1.5	Acid Tank and Foundation Demo	1,700
11.1.6	CCD Circuit Demo	19,400
11.1.7	Mill Demo	99,400
11.1.8	Vanadium Circuit Demo	35,000
11.1.9	Tanks and Foundations E. of Mill	16,200
11.1.10	Sodium Chlorate Tank, Found. Demo	14,700
11.1.11	Concrete Trench Demo	9,800
11.1.12	Tailings Conveyance System Demo	1,900
11.1.13	Removal of Contaminated Soils from Around Buildings	16,600
11.1.14	Removal of Contaminated Soils from Ore Pad Area	48,700
11.1.15	Radioactive Containment Storage Area Cleanup	13,800
11.1.16	Soil Verification	10,200
11.1.17	Recontouring, Shaping and Seeding Mill Site and Borrow	18,900
11.1.18	Management, Reporting, Testing & Monitoring	1,078,300
11.1.19	Mobilization & Demobilization	63,500
	Total Cost for Decommission & Site Cleanup of Mill Area =	**$ 1,483,400**
Reclamation of Tailings Cell 1 and Cell 2		
11.3.1	Mill Demo Disposal	293,000
11.3.2	Contouring Cell 1 Tailings Surface	41,300
11.3.3	Drainage System Grading	165,100
11.3.4	Sandy Interim/Grading Material	2,316,400
11.3.5	Clay Cover Material	4,206,900
11.3.6	Rocky Soil Cover Material	861,100
11.3.7	Rock Cover Materials	479,800
11.3.8	Monitoring Well Abandonment	48,800
11.3.9	Management, Reporting, Testing & Monitoring	3,443,000
11.3.10	Additional Mobilization and Demobilization	85,500
	Total Cost for Tailings Cell =	**$ 11,940,900**
	SUBTOTAL OF WORK =	**$ 13,424,300**
	15% CONTINGENCY =	**$ 2,013,600**
	PRL MANAGEMENT OVERHEAD @ 10% =	**$ 1,543,800**
	(9/05 vs. 11/78 CPI) LONG TERM MAINTENANCE COST =	**$ 738,900**
	TOTAL COST OF MILL DECOMMISSIONING, SITE CLEANUP AND TAILINGS RECLAMATION WORK IS EQUAL TO	**$ 17,720,600**

13.0 FINAL DECOMMISSIONING COMPLETION REPORT

A final decommissioning report will be developed on the cleanup of the mill and the area surrounding the mill. The cleanup in the ore stockpile and ore pad area will also be included with the mill decommissioning completion report.

A reclamation-as-built plan will be included in the completion report for the tailings reclamation. The tailings reclamation completion report will contain the volumes of materials placed in the tailings cell(s) and reclamation of the EPPC.

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APPENDIX A

BACKHOE PIT AND TEST HOLE INFORMATION

APPENDIX A

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TABLES

A.1 BACKHOE PIT AND TEST HOLE INFORMATION

Appendix A presents the lithologic logs obtained from the backhoe pit, drill hole, hand auger, and backhoe-hand auger/drill hole combinations that were obtained during the site evaluation in June of 2002. Also presented in Appendix A are the results of the rock thickness tests that were performed on the Shootaring Dam rock.

Table A-1 presents the lithologic logs from the eleven backhoe pits used in the site evaluation. Table A-2 presents the lithologic logs from the fourteen drill holes used in the site evaluation. Table A-3 presents the lithologic logs from the thirty-six auger holes used in the site evaluation. In some locations, backhoe pits were used in combination with the hand auger or drill hole to determine the lithology. Table A-4 presents the lithologic logs from the twenty-one backhoe pit-auger/drill hole combinations that were used in the site evaluation. Table A-5 presents the results of the ten rock thickness checks that were performed on the upstream and downstream faces of the Shootaring Dam.

TABLE A-1. LITHOLOGIC LOGS OF BACKHOE PITS

LITHOLOGIC LOGS			
	top	***bottom***	
Backhoe Pit	***meas. (in.)***	***meas. (in.)***	***Descriptions***
CV4	0	18	tan sand, rocks and clay
CV4	18	30	very fine red sand, hard
DA1	0	39.6	rock, sand and clay
DA1	39.6	48	brown clay w/little green clay
DD4	0	0	gravel @ surface
DD4	0	17	very fine red sand, some rock
DD5	0	12	gravel & red fine sand
DD5	12	17	large rocks & clay
DD6	0	4	rock & red sand
DD6	4	17	red very fine sand
DD7	0	12	gravel & red sand
DD7	12	17	very fine sand
DD8	0	6	tan very fine sand
DD8	6	12	clay, rock and sand
DD9	0	6	tan, very fine sand
DD9	6	12	clay, rock and sand
ED4	0	12	red sand and clay
ED4	12	48	brown clay
OP33	0	15.6	red very fine sand
OP33	15.6	34.8	gray sand ore
OP33	34.8	40.8	tan fine sand
OP33	40.8	46.8	red very fine sand
T7	0	44.4	red very fine sand
T7	44.4	46.8	tails slimes
T7	46.8		rock layer

TABLE A-2. LITHOLOGIC LOGS OF DRILL HOLES.

LITHOLOGIC LOGS			
	top	***bottom***	
Drill Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
CV1	0	36	tan rock, sand and clay
CV1	36	60	red very fine sand
CV1	60	228	red very fine sand
CV1	228	264	brown clay
CV1	264	324	red very fine
CV2	0	36	tan rock, sand and clay
CV2	36	300	very fine red sand
CV2	300	360	very fine red sand
CV2	360	492	very fine red sand
CV2	492	564	brown clay
CV2	564	588	white very fine sandstone, Entrada
CV2	588	600	red silty, very fine sandstone
CV3	0	30	tan rock, sand and clay
CV3	30	120	red very fine sand, dry
CV3	120	180	red very fine sand w/ little moisture
CV3	180	216	red very fine sand w/ little moisture
CV3	216	258	brown clay, dry
CV3	258	300	red very fine sandstone, Entrada
ED1	0	12	rock, sand and clay
ED1	12	48	red very fine sand
ED1	48	144	tan very fine sand and clay
ED1	144	162	brown clay
ED1	162	180	red very fine sandstone, Entrada
ED3	0	12	rock, sand and clay
ED3	12	53	tan very fine silty sand
ED3	54	72	red very fine sand
ED3	72	102	brown clay
ED3	102	120	red very fine sandstone, Entrada
ND1	0	12	rock, clay and sand
ND1	12	60	tan very fine sand
ND1	60	72	tan & brown very fine sand w/ piece of wood & plastic
ND1	72	84	concrete
ND1	84	108	red very fine sand
ND1	108	126	brown clay
ND1	126	144	red very fine sandstone, Entrada
ND2	0	24	rock, clay and sand
ND2	24	84	very fine sand, clays & rocks
ND2	84	120	tan very fine sand, moist
ND2	120	180	brown sand & clay w/ some rock & wood, plastic
ND2	180	240	very fine tan sand
ND2	240	288	very fine tan sand
ND2	288	312	clay
ND3	0	24	rock, sand and clay
ND3	24	48	brown sand & clay w/ some wood
ND3	48	120	tan fine sand
ND3	120	168	tan fine sand

TABLE A-2. LITHOLOGIC LOGS OF DRILL HOLES. (cont'd.)

LITHOLOGIC LOGS			
	top	***bottom***	
Drill Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
ND3	168	180	red very fine sand
ND3	180	204	brown clay
ND3	204	240	red very fine sand, Entrada
ND3	240		white sandstone
T1	0	60	red very fine sand w/some clay
T1	60	90	very fine tan & brown sand w/ some clay
T1	90	108	rock, sand and clay
T1	108	126	red very fine sand
T1	126	162	brown clay
T1	162	174	red very fine sand
T2	0	18	red very fine sand
T2	18	60	tan very fine sand, tails
T2	60	108	tan very fine sand, tails, some slime
T2	108	120	red very fine sand
T2	120	126	brown sand clay
T2	126	168	brown clay
T2	168	180	light brown very fine sand
T3	0	24	red very fine sand
T3	24	60	tan fine sand, tailings
T3	60	96	tan fine sand, tailings w/little moisture
T3	96	204	tan fine sand, tailings w/little moisture
T3	204	216	red very fine sand
T3	216	234	rock and fine sand
T3	234	270	red very fine sand
T3	270	348	brown clay
T3	348	372	red very fine sand, Entrada
T4	0	18	very fine red sand
T4	18	60	tan tailings sand and slimes
T4	60	120	tan tailings sand
T4	120	156	shelby tube
T4	120	192	tan tailings sand
T4	192	216	rock and red very fine sand
T4	216		top of clay
T5	0	24	very fine red sand
T5	24	54	tailings slime
T5	54	66	rock, sand and clay
T5	66	78	red very fine sand
T5	78		clay
T6	0	18	red very fine sand
T6	18	24	tailings slime
T6	24	72	red very fine sand
T6	72	96	gravel, tan sand
T6	96		clay

TABLE A-3. LITHOLOGIC LOGS OF AUGER HOLES.

LITHOLOGIC LOGS			
	top	***bottom***	
Auger Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
C1	0	12	red clay w/ some white mudstone
C1	12	36	red very fine sandstone, Entrada
C10	0	8	red clay w/some fine sand
C10	8	42	red clay w/green clay
C10	42	59	very fine red sand
C11	0	9	very fine sand and clay
C11	9	38	red very fine sand
C12	0	34	red clay w/some green sandy mudstone
C12	34		red very fine sandstone
C13	0	38	red clay w/ 20% green mudstone
C13	38	41	very fine red sand
C2	0	12	red clay w/approx. 20% white mudstone
C2	12	24	red clay w/approx. 20% white mudstone
C2	24	36	red very fine sandstone, Entrada
C3	0	34	red clay w/20% mudstone, little 1-6" rock
C3	34	38	red very fine sandstone, Entrada
C5	0	18	red clay w/little red & white mudstone
C5	18	24	very fine red sandstone, Entrada
C7	0	15	red clay
C7	15	21	very fine gray sandstone
C7	21	33	very fine sandstone
C7	33	66	red clay
C7	66		rock
C8	0	17	red clay
C8	17	20	very fine red sand
C8	20	69	clay, red
C8	69	84	very fine red sandstone
C9	0	7	red clay
C9	7	14	very fine red sand
C9	14	50	red clay w/ some green clay
C9	50	60	very fine red sandstone
D96	0	42	red sand
D96	42	72	red sand
D96	72	102	red sand
D97	0	54	red sand
D97	54	66	red sand
D98	0	18	red sand
D98	18	30	red sand
D98	30	42	red sand
D99	0	42	red sand
D99	42		white sand
NA1	0	5	rock, sand and clay
NA1	5	21	very fine red sand
NA1	21	43	red clay w/little green clay

TABLE A-3. LITHOLOGIC LOGS OF AUGER HOLES. (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
Auger Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
NA1	43	49	red clay and very fine sand
NA1	49	54	very fine red sand
NA1	54	85	red clay
NA1	85	86	red very fine sand, Entrada
NA10	0	6	rock, sand and clay
NA10	6	27	red sand, very fine
NA10	27	75	clay
NA10	75		sand
NA11	0	12	rock, sand and clay
NA11	12	30	red very fine sand
NA11	30	58	brown clay w/little green mudstone
NA11	58	64	red very fine sandstone, Entrada
NA12	0	10	rock, sand and clay
NA12	10	20	very fine red sand
NA12	20	55	purple clay w/ some green clay
NA12	55	60	very fine red sandstone, Entrada
NA13	0	10	rock, clay and sand
NA13	10	21	red very fine sand
NA13	21	38	purple clay w/ some green clay
NA13	38	40	very fine red sandstone, Entrada
NA14	0	1	very fine red sand w/ small gravel
NA14	1	15	red very fine sand
NA14	15	53	brown clay w/ green clay
NA14	53	59	red very fine sandstone, Entrada
NA15	0	15	sand, rock and clay
NA15	15	22	red sand
NA15	22	68	clay
NA15	68		red sand
NA16	0	10	rock, sand and clay
NA16	10	25	red sand
NA16	25	55	clay
NA16	55		red sand
NA17	0	12	rock, sand and clay
NA17	12	23	red sand
NA17	23	48	clay
NA17	48		sand
NA18	0	11	rock, sand and clay
NA18	11	24	red sand
NA18	24	72	clay
NA18	72		sand
NA19	0	6	rock, clay and sand
NA19	6	16	sand
NA19	16	73	clay
NA19	73		sand

TABLE A-3. LITHOLOGIC LOGS OF AUGER HOLES. (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
Auger Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
NA2	0	15	sand, rock and clay
NA2	15	27	very fine red sand
NA2	27	42	red clay
NA2	42	47	very fine red sand, Entrada
NA20	0	10	rock, clay and sand
NA20	10	22	sand
NA20	22	44	clay
NA20	44		sand
NA3	0	7	rock, sand and clay
NA3	7	20	very fine sand
NA3	20	71	red clay
NA4	0	11	rock, sand and clay
NA4	11	20	fine red
NA4	20	78	clay
NA4	78		red Entrada
NA5	0	4	rock, sand and clay
NA5	4	16	red fine sand
NA5	16	21	clay
NA5	21		red Entrada
NA6	0	12	rock, sand and clay
NA6	12	25	red sand
NA6	25	65	clay
NA6	65		sand
NA7	0	5	rock, sand and clay
NA7	5	25	red sand, fine
NA7	25	59	clay
NA7	59		sand
NA8	0	6	rock, sand and clay
NA8	6	18	very fine red sand
NA8	18	29	red clay w/ little green clay
NA8	29	34	red clay & sandy green mudstone
NA8	34	37	red very fine sandstone, Entrada
NA9	0	3	sand, rock and clay
NA9	3	14	very fine red sand
NA9	14	53	red clay w/ some green silty clay
NA9	53	60	red very fine sandstone, Entrada
OP31	0	8.4	red very fine sand
OP31	8.4	42	ore sand, hit rock

TABLE A-4. LITHOLOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS

LITHOLOGIC LOGS			
	top	bottom	
Auger/Backhoe Pit	***meas. (in.)***	***meas. (in.)***	***Descriptions***
C4	0	60	red clay w/ green & brown mudstone approx. 15% up to 4" size
C4	60	66	sand and clay
C4	66	72	very fine red sand, Entrada
C6	0	12	red clay dry, some rock
C6	12	36	moist clay, red, some white sandstone
C6	36	58	Entrada sandstone
ED2	0	24	rock, sand and clay
ED2	24	54	tan very fine sand
ED2	54	60	red sand
ED2	60	126	very fine to very coarse sand
ED2	126	142	clay
ED2	142	180	very fine red sandstone, Entrada
NP1	0	12	rock, sand and clay
NP1	12	21	Sand
NP1	21	38	clay
NP1	38		Sand
NP10	0	16	clay, sand and rock
NP10	16	28	Sand
NP10	28	100	clay
NP10	100		Sand
NP11	0	20	sand, rock and clay
NP11	20	31	sand
NP11	31	86	clay
NP11	86		sand
NP2	0	10	rock, sand and clay
NP2	10	32	red very fine sand
NP2	32	66	red clay w/ some white clay
NP2	66	72	red very fine sandstone, Entrada
NP3	0	10	rock, sand and clay
NP3	10	22	red sand
NP3	22	40	clay
NP3	40		red sand
NP4	0	12	rock, clay and sand
NP4	12	19	red sand
NP4	19	69	clay
NP4	69		sand
NP5	0	7	rock, sand and clay
NP5	7	23	Sand
NP5	23	85	clay
NP5	85		sand
NP6	0	12	rock, clay and sand
NP6	12	18	sand
NP6	18	27	rock, clay and sand

TABLE A-4. LITHOLOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS (cont'd.)

LITHOLOGIC LOGS			
	top	***bottom***	
Auger/Backhoe Pit	***meas. (in.)***	***meas. (in.)***	***Descriptions***
NP6	27	45	Sand
NP6	45	87	clay
NP6	87		Sand
NP7	0	12	rock, clay and sand
NP7	12	22.5	Sand
NP7	22.5	53.5	clay
NP7	53.5		sand
NP8	0	10	clay, rock and sand
NP8	10	27	sand
NP8	27	64	clay
NP8	64		sand
NP9	0	21	clay, rock and sand
NP9	21	37	sand
NP9	37	71	clay
NP9	71		sand
OP32	0	4.8	very fine red sand
OP32	4.8	44.4	ore sand
OP32	44.4	55.2	red very fine sand
WP1	0	12	rock, clay and sand
WP1	12	30	Sand
WP1	30	54	clay
WP1	54		Sand
WP2	0	6	rock and clay
WP2	6	19	Sand
WP2	19	23	rock and clay
WP2	23	38	Sand
WP2	38	82	clay
WP2	82		Sand
WP3	0	6	rock and clay
WP3	6	18	Sand
WP3	18	28.5	rock, clay and sand
WP3	28.5	42.5	Sand
WP3	42.5	72.5	clay
WP3	72.5		Sand
WP4	0	11	rock, clay and sand
WP4	11	21	Sand
WP4	21	69	clay
WP4	69		Sand
WP5	0	14	rock, clay and sand
WP5	14	28	Sand
WP5	28	45	rock, clay and sand
WP5	48	51	Sand
WP5	51	91	clay
WP5	91		Sand

TABLE A-4. LITHOLOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS (cont'd.)

LITHOLOGIC LOGS			
	top	***bottom***	
Auger/Backhoe Pit	***meas. (in.)***	***meas. (in.)***	***Descriptions***
WP6	0	4	rock, clay and sand
WP6	4	14	Sand
WP6	14	28	rock, clay and sand
WP6	28	45	Sand
WP6	45	62.5	clay
WP6	62.5		Sand

TABLE A-5. TAILINGS DAM ROCK THICKNESS

SAMPLE SITE	THICKNESS (FT.)
DS1	1.9
DS2	2.3
RT1	2.1
RT2	2.2
RT3	2.1
RT4	2.0
RT5	2.3
RT6	2.6
RT7	3.6
RT8	3.8

APPENDIX B

GAMMA SURVEY

APPENDIX B

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TABLES

B. 1 GAMMA Survey

A gamma survey was conducted to define the areas in the Shootaring mill and tailings area with elevated soil concentrations of radionuclides. Table B-1 of Appendix B presents the gamma survey readings. This table includes the site name, the gamma reading in µR/hr and any location information relative to the measurement. Figures 3-2A and 3-2B show the location of the gamma sites for the west and east areas respectively. Figure 3-2C shows the gamma site locations for the east area in the mill area. The gamma values are posted on Figures 3-3A, 3-3B and 3-3C.

Two gamma meters were used to develop the gamma values for the Shootaring site. The first meter was Ludlum model 19 with a serial number of 34944, which was last calibrated on April 11, 2002. The second meter that was used is a Ludlum model 12S with a serial number 92512 and calibrated on May 28, 2002.

Radiation trained personnel did the ground surface gamma survey over two days to identify any areas that could have elevated gamma readings. No action was taken to shield the survey meters from shine caused by known gamma sources, such as, ore pile, mill process equipment, buildings and tailings depositional area. Survey meter calibrations are noted on the data sheets. Gamma survey procedure included function checks on the meter before use. The density of the data was determined based on non-uniformity of the data. For example, when there were rapidly changing exposure rates with distance, more data were recorded compared to areas where the exposure rates were uniform over large distances. As a gamma reading was recorded the hand held global positioning system (GPS) gave a position which was also recorded along with any notable landmarks. The gamma survey meter was carried at approximately one meter height above the ground.

Readings taken below the ground surface were only contact measurements for a qualitative determination only. Readings are used to estimate soil removal depth.

TABLE B-1. GAMMA SURVEY

Site Name	*Gamma Reading* (uR/hr)	*Location*
A1	5	
A10	8	
A11	7	
A12	8	
A13	8	
A14	6	
A15	7	
A16	7	
A17	7	
A18	6	edge of cover
A19	6	divide
A2	6	
A20	6	divide
A21	5	Entrada
A22	5	Entrada
A23	6	Entrada
A24		5 1/16 Bench
A25	6	S33/S34 S250 Entrada
A26	6	
A27	6	wind blown
A28	6	wind blown
A29	6	wind blown
A3	7	
A30	6	wind blown
A31	7	top pipe drain
A32	7	top drain
A33	7	edge rock
A34	7	
A35	7	top drain
A36	7	
A37	8	top ridge
A38	7	
A39	8	top of drain
A4	7	
A40	8	
A41	8	
A42	8	c. of draw
A43	8	
A44	7	
A45	7	edge of rock
A46	6	Entrada
A47	8	Entrada
A48	7	edge of rock
A49	7	
A5	7	
A50	8	
A51	9	N edge NP10
A52	10	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
A53	9	top drain
A54	10	
A55	8	top drain
A56	8	
A57	8	
A58	9	edge of rock
A59	10	edge of rock
A6	7	
A60	10	
A61	10	
A62	46	
A63	88	
A64	165	
A65	130	S side NP11
A66	30	
A67	9	
A68	8	
A69	8	
A7	7	top drain
A70	8	edge of rock
A71	8	Entrada slope break
A72	7	edge of rock
A73	8	
A74	9	
A75	11	edge of rock
A76	10	
A77	9	
A78	9	N side WP1
A79	9	
A8	7	
A80	9	edge of rock
A81	10	edge of rock
A82	10	
A83	10	
A84	10	S side WP3
A85	12	edge of rock
A86	11	edge of rock
A87	12	
A88	11	
A89	11	
A9	7	
A90	11	edge of rock
A91	17	edge of rock
A92	41	
A93	110	
A94	12	
A95	16	edge of rock
B1	14	edge of clay & rock

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
B10	12	edge of rock
B11	12	edge of rock
B12	12	
B13	12	
B14	10	edge of clay
B15	9	toe of road
B16	9	toe of road
B17	10	edge of clay
B18	11	
B19	11	
B2	32	
B20	12	
B21	10	
B22	15	c. of 3 roads
B23	11	
B24	12	
B25	12	
B26	10	auger C1
B27	8	
B28	7	center road
B29	7	center road
B3	14	
B30	6	center road
B31	6	center road
B32	6	RM2
B33	7	toe slope
B34	7	RM2R
B35	7	toe slope
B36	6	
B37	6	
B38	8	
B39	9	edge of clay
B4	11	edge of clay
B40	11	
B41	11	
B42	10	ED4
B43	9	center road
B44	10	
B45	8	edge of clay
B46	7	
B47	7	
B48	7	center road
B49	7	toe slope
B5	9	outlet 6' culvert
B50	8	center road
B51	10	center road
B52	11	center road
B53	8	center road

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
B54	10	center road
B55	10	center road
B56	13	center road
B57	11	center road
B58	11	center road
B59	12	
B6	9	toe of road
B60	13	
B61	15	corner of fence
B62	16	c. of gate
B63	8	fence
B64	10	
B65	9	
B66	9	
B67	9	center road
B68	10	clay
B69	10	clay, some fine sand
B7	10	edge of clay
B70	9	clay and some fine sand
B71	8	clay and some fine sand
B72	8	road
B73	7	
B74	7	
B75	6	road
B76	7	road
B77	7	road
B78	6	
B79	6	
B8	12	
B80	6	
B81	6	
B82	7	
B83	6	
B84	5	
B85	6	
B86	5	
B87	5	
B88	6	
B89	7	
B9	12	
B90	7	
B91	8	
B92	8	
B93	7	
B94	7	
B95	7	
B96	6	
B97	11	draw

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
B98	13	draw
C100	8	
C101	7	
C20	9	c. gate
C21	9	fence
C22	11	fence
C23	11	fence
C24	10	fence bend
C25	11	fence
C26	11	fence
C27	12	fence corner
C28	10	top slope
C29	8	top slope
C30	11	top slope
C31	10	c. road
C32	8	
C33	8	top of slope
C34	7	top of slope
C35	8	top of slope
C36	8	cor. Fence
C37	9	fence
C38	7	
C39	7	
C40	7	
C41	8	
C42	7	cor. Fence
C43	10	fence
C44	8	fence
C45	7	cor. Fence
C46	7	
C47	7	
C48	7	
C49	9	cor. Fence
C50	8	fence
C51	8	fence toe
C52	9	fence
C53	11	c. gate
C54	10	
C55	11	
C56	12	
C57	14	old pit
C58	17	
C59	14	
C60	15	
C61	17	toe
C62	32	toe
C63	16	
C64	14	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
C65	14	
C66	24	
C67	24	
C68	15	
C69	14	
C70	17	
C71	12	
C72	12	
C73	14	
C74	10	
C75	8	
C76	8	
C77	8	cor. shop
C78	10	cor. shop
C79	8	
C80	21	
C81	28	
C82	34	ditch
C83	13	
C84	7	
C85	7	
C86	7	
C87	7	
C88	9	road
C89	11	concrete
C90	11	
C91	7	pond dike
C92	7	pond dike
C93	6	pond dike
C94	7	top slope
C95	7	top slope
C96	6	
C97	5	
C98	7	
C99	7	
CV1	110	drill hole
CV2	90	sand cone & drill hole
CV3	105	drill hole
CV4	85	drill hole
CVB2	125	sand cone hole
D1	28	NW CCD & road
D10	12	SE Ammonia Tank 3 ft. from CCD wall
D11	16	SE side CCD
D12	17	S side CCD
D13	18	S side CCD
D14	22	S side CCD
D15	24	S side CCD
D16	25	S side CCD

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
D17	25	S side CCD
D18	24	S side CCD
D19	20	SW side CCD
D2	50	N side CCD center line of road
D20	18	W side CCD
D21	25	W side CCD at tailing line
D22	24	W side CCD at tailing line
D23	22	W side CCD
D24	26	SW mill building
D25	40	W side mill building
D26	22	W side mill building
D27	25	W side mill building
D28	17	W side mill building
D29	27	W side mill building
D3	35	N side CCD & road
D30	16	W side mill building
D31	16	NW side of switch gear room (mill building)
D32	19	NW side of generator & road
D33	21	SW side of generator/transformer
D34	19	W side of generator/transformer
D35	14	NW side of generator/transformer (8 ft)
D36	16	W conveyor (10 ft)
D37	18	W conveyor
D38	17	NW conveyor
D4	25	N side CCD & road
D40	12	N side generator/transformer (10 ft from fence)
D41	13	NW side power house
D42	11	N side power house
D43	11	N side power house
D44	11	NE side change dry
D45	12	E side change dry
D46	12	SE side change dry
D47	16	S side change dry & road
D48	23	NE side 600 area (& road), S side power house
D49	23	N side 600 area & road
D5	18	N side CCD & road
D50	16	N side 600 area & road
D51	15	N side 600 area & road & N side switch gear
D52	15	N side switch gear
D53	21	NE side 600 area, 15 ft from building
D54	35	E side 600 area & large door
D55	100	E side 600 area on pump hose (preg tank?)
D56	40	E side SX & large door
D57	40	E side thickener outside (material in sump)
D58	26	NE side outside thickener
D59	30	E side thickener , 6 ft from sump
D6	15	NE CCD & road
D60	20	E side thickener (tanks), 6 ft from sump

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
D61	15	SE side tank (thickener), 6 ft from sump
D62	11	NE side shop
D63	11	E side shop
D64	12	SE side shop
D65	8	S side of fence (inside mill yard), 30 ft from east side
D66	8	S side of fence, 30 ft inside
D67	7	S side of fence, 30 ft inside
D68	8	S side of lab air conditioner
D69	9	SE side lab, 5 ft from building
D7	14	NE Ammonia Tank & road
D70	7	E. side lab
D71	8	E. side lab
D72	8	NE side lab
D73	8	N side lab
D74	8	N side lab
D75	9	NW side lab
D76	10	W side lab
D77	9	W side lab
D78	9	W side lab
D79	10	SW side lab
D8	12	NE Ammonia across from Tank
D80	8	S side lab
D81	9	S side lab
D82	9	SW side kerosene tank
D83	8	SW side kerosene tank & inside fence
D84	8	NE side kerosene tank & inside fence & NaChloride tank
D85	9	NW side kerosene tank & NaChloride tank
D86	10	NW side NaChlorate tank
D87	10	NE side NaChlorate tank & fence, 10 ft
D88	12	E side of fence (inside yard) across road from outside thickener
D89	11	E side inside fence
D9	11	SE Ammonia across from Tank
D90	10	E side inside fence
D91	10	E side inside fence, across from pump house
D92	10	E side inside fence, across from water tank
D93	11	E side inside fence, across from water tank road
D94	10	E side inside fence
D95	11	E side fence at guard house
D96	28	3.5' N. Pit old lab
D96	8 - 10	3.5' to 6' check gamma every 6", all red sand, no odor or texture change (sand is a little damp), contact rock at 7'
D96	8 - 9	check gamma every 6", all red sand, no color change
D97	5 - 8	second old pit, 0 - 4.5' (sidewall)
D97	10	5.5', red sand
D98	8 - 10	1.5' to 2.5 '
D98	16	2.5', red color
D98	60	3.5', red color
D99	8 - 9	0' - 3.5', red sand

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
D99	11	3.5', white sand
DD1	7	
DD2	8	
DD3	7	
DD4	12	in pit, gravel @ surface,, 0-1.5' v.f. red sand, some rock
DD5	15	0-1' gravel & red fine sand, 1-1.5' large rocks & cl. Ore
DD6	10	top to bottom, 0-4" rock & red sand, 4"-1.5' red v.f. sand
DD7 (0-6")	16	
DD7 (1)	15	0-1' gravel & red sand, 1-1.5' v.f. red sand
DD8 (0-6")	60	tan v.f. sand
DD8 (6-12")	45	clay, rock & sand
DD9 (0-6")	19	
DD9 (6-12")	16	
E1	12	walk gate
E10	11	NE fuel dike
E11	13	
E12	13	fence
E13	24	fence
E14	17	
E15	23	toe dike
E16	48	
E17	38	NW building
E18	25	Mill Sur. 4
E19	130	near ore
E2	14	
E20	34	
E21	36	SE side
E22	21	
E23	29	NE scale
E24	25	fence cor.
E25	50	fence cor.
E26	34	
E27	33	yellow post
E28	28	
E29	25	
E3	12	
E4	9	
E5	9	top slope
E6	9	cor building
E7	13	top slope
E8	18	
E9	11	SE fuel dike
F1	65	east CVB
F10	12	
F11	14	
F12	14	sump
F13	10	
F14	10	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
F15	14	
F16	23	
F17	22	
F18	14	
F19	42	
F2	24	
F20	17	
F21	40	west CVB
F22	12	above WSC/CVB
F23	9	
F24	8	
F25	11	
F26	8	
F27	9	
F28	8	
F29	8	
F3	30	
F30	8	
F31	8	
F32	8	
F33	9	RM7
F34	9	
F35	9	
F36	10	
F37	9	
F38	10	
F39	8	
F4	18	
F40	9	
F41	10	
F42	8	
F43	9	
F44	12	
F45	8	
F46	7.5	
F47	9	
F48	10	
F49	10	
F5	34	
F50	8	
F51	9	
F52	14	
F53	12	East CB
F54	8	East Road
F55	8	
F56	8	
F57	8	
F58	7	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
F59	7	road
F6	12	
F60	10	
F61	8	
F62	8	
F63	7	
F64	8	
F65	8	
F66	8	
F67	8	
F68	8	
F69	7	
F7	32	
F70	7	
F71	8	rock pile
F72	9	
F73	8	
F74	7	
F75	7	
F76	6	
F77	7	
F78	7	
F79	8	
F8	13	
F80	7	
F81	6	
F82	5	
F83	6	
F84	10	
F85	6	
F86	7	
F87	6	
F88	7	
F89	7	
F9	14	
F90	6	
F91	6	SS
F92	6	
F93	10	
F94	7	
F95	7	
F96	6	
F97	6	
F98	6	SS
F99	6	above SS
G1	6	
G10	7	draw
G100	19	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
G101	20	
G102	11	
G103	9	
G104	10	
G105	19	edge of white depot
G106	18	
G107	24	
G108	25	
G109	16	
G11	8	draw
G110	16	
G111	17	
G112	15	
G113	18	
G12	8	draw
G13	7	draw
G14	8	split in draw
G15	8	draw
G16	8	draw
G17	8	draw
G18	8	draw
G19	8	draw
G2	6	
G20	9	draw
G21	9	draw
G22	10	upst. draw
G23	7	E. 1/16 33 draw
G24	8	draw
G25	8	draw
G26	8	draw
G27	7	draw
G28	7	draw
G29	7	edge draw SS
G3	7	
G30	8	draw
G31	7	draw
G32	7	draw SS
G33	7	road
G34	7	
G35	8	
G36	7	road
G37	7	road
G38	7	road
G39	7	
G4	8	
G40	7	road
G41	8	
G42	7	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
G43	7	road and draw
G44	7	
G45	8	road and draw
G46	8	road and draw
G47	9	draw
G48	9	RM8
G49	9	draw
G5	7	
G50	12	draw
G51	12	draw
G52	9	5' top SS
G53	10	draw
G54	16	draw
G55	23	draw
G56	12	draw
G57	10	5' above
G58	11	5' above
G59	18	draw
G6	7	Entrada
G60	36	draw
G61	12	1.5' head cut
G62	15	
G63	11	edge
G64	9	5' above
G65	8	10' above
G66	16	draw
G67	13	c. draw
G68	30	draw
G69	17	edge
G7	9	c. channel
G70	11	10' above
G71	16	edge
G72	13	edge
G73	14	draw
G74	19	
G75	12	
G76	10	top slope
G77	9	
G78	9	top slope
G79	12	bot. Slope
G8	8	edge SS
G80	11	
G81	8	top slope
G82	8	bot. slope
G83	7	bot. slope
G84	8	
G85	8	
G86	8	power switch

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
G87	8	top slope
G88	10	top point
G89	8	bot. slope
G9	7	edge SS
G90	8	bot. slope
G91	11	
G92	10	
G93	10	
G94	14	
G95	13	
G96	13	
G97	9	top slope
G98	14	
G99	18	
H1	18	
H10	9	
H100	42	0-3" sample
H101 (0-6")	31	0-6"
H101 (6-12")	22	6-12"
H102	24	1'-1.5' below rock
H11	7	
H12	8	5' above
H13	7	draw
H14	7	draw
H15	7	draw
H16	7	draw
H17	7	draw
H18	7	draw
H19	7	top slope
H2	15	end of pipe
H20	7	
H21	8	draw
H22	7	draw
H23	8	draw
H24	8	draw
H25	9	draw
H26	10	draw
H27	10	draw
H28	12	
H29	15	toe 4' pile
H3	15	
H30	18	toe 4' pile
H31	15	toe 4' pile
H32	16	toe 4' pile
H33	18	toe 4' pile
H34	22	toe 4' pile
H35	16	
H36	18	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
H37	18	
H38	12	top w sand cover
H39	15	
H4	15	
H40	10	
H41	10	toe 20' pile
H42	10	toe 20' pile
H43	8	toe 20' pile in SS
H44	7	top SS
H45	9	
H46	8	start toe dam w. bt.
H47	9	
H48	12	
H49	14	
H5	14	
H50 (1)	20	start of deposit 20 in.
H50 (2)	15	5' above a rock
H51	25	
H52 (1)	28	
H52 (2)	18	5' above sol. to 4'
H53	30	
H54	16	rock
H55	11	RM9
H56	22	rock edge
H57	23	
H58	19	last sign of acid
H59	12	
H6	13	
H60	9	
H61 (1)	8	edge of large and small rock
H61(2)	8	top edge f. rock
H62	8	top edge f. rock
H63	8	e. edge small rock
H64	8	
H65	8	
H66	8	
H67	8	rock sample
H68	8	rock sample
H69	8	rock sample
H7	13	5' pile
H70	7	
H71	8	PZ
H72	7	dust NE cor.
H73	8	dust
H74	7	dust
H75	8	P2
H76	9	upst. Removed H7
H77	8	upst. Removed H7

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
H78	8	PZ
H79	8	closest rock M1
H8	21	
H80	8	NW cor. dust
H81	8	SW cor. upst
H82	8	RM
H83	8	RM
H84	8	dust
H85	9	dust
H86	8	dust
H87	7	dust
H88	7	dust
H89	7	dust
H9	10	
H90	7	dust
H91	8	SE cor. Dust
H92	7	RM
H93	7	RM
H94	7	PZ
H95	9	sump
H96	7	PZ4
H97	7	draw
H98	7	draw
H99 (0-6")	12	0-6" sample
H99 (6-12")	17	6-12" sample
I1	12	S.W. Office
I10	12	
I11	16	
I12	11	
I13	24	
I14	8	
I15	8	
I16	8	
I17	12	center of road
I18	9	l. of road
I19	9	
I2	20	
I20	8	
I21	9	
I22	9	
I23	10	fence
I24	12	
I25	8	
I26	8	
I27	10	
I28	10	
I29	11	
I3	15	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
I30	12	
I31	10	
I32	12	
I33	11	
I34	9	weather stat.
I35	10	
I36	12	
I37	9	
I38	9	
I39	10	
I4	15	
I40	10	
I41	12	
I42	11	
I43	11	
I44	12	
I45	10	
I46	10	
I47	11	
I48	11	
I49	26	
I5	14	
I50	14	
I51	8	
I52	8	
I53	7	
I54	8	
I55	7	
I56	7	
I57	6	
I58	6	
I59	6	
I6	15	
I60	7	
I61	6	
I62	6	
I63	6	
I64	6	
I65	6	
I66	6	
I67	7	
I68	14	
I69	12	
I7	16	
I70	13	light pole
I8	13	
I9	15	
NC1 (1)	90	0-6" sample

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
NC1 (2)	90	6-12"
NC2	20	
NC3	20	
NC4	20	
NC5	20	
NC6	20	
OP2 (3.7-4.2')	280	
OP2 (4.2-4.6')	170	
OP2 (ore)	650	
OP3 (1.3-2.9')	600	0-1.3' red v.f. sand, 1.3-2.9' gray sand ore
OP3 (2.9-3.4')	250	tan fine sand, some rock
OP3 (3.4-3.9')	160	red v.f. sand

APPENDIX C

MATERIALS PROPERTIES

APPENDIX C

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TABLES

APPENDIX C

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FIGURES

ATTACHMENTS

C.1 Tailings and Ore Physical Properties

Samples were taken from the tailings and the ore piles and tests were run on these samples to determine the physical properties of these materials for use in the design of the tailings reclamation plan. Gradation results from tailings samples T3, T4 and T7 are presented in Tables C-1, C-2, and C-3, respectively. Tailings samples T3 and T4 are tailings sand samples and tailings sample T7 is a sample of the tailings slime. Tables C-4, C-5, and C-6 present the gradation results from ore samples OP31, OP32, and CV4, respectively. Ore samples OP31 and OP32 were taken directly from the ore piles. Ore sample CV4 was taken from the cross-valley berm at a depth of 0”-5”.

TABLE C-1. Gradation Results for Tailings Sample T3, 8' – 10'8"

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Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-007
Client Sample ID: T3 8-10'8"

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	5.1	%		0.1		USDA26	06/12/02 10:27 / vh
RADIONUCLIDES - TOTAL							
Radium 226	45.6	pCi/g-dry		0.1		E903.0	06/27/02 03:08 / rs
Radium 226 precision	1.6	±				E903.0	06/27/02 03:08 / rs
Thorium 230	12.4	pCi/g-dry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	0.5	±				E907.0	06/21/02 10:30 / ph
Uranium	100	pCi/g-dry		0.01		SW6020	06/23/02 02:47 / smd
SIEVES							
0.125 Inch Sieve, Passed	99.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	99.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	97.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	1.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	95.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	2.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	61.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	33.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	23.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	37.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	4.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	18.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

TABLE C-2. Gradation Results for Tailings Sample T4, 10' – 13'

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Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-008
Client Sample ID: T4 10'-13'

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	9.4	%		0.1		USDA26	06/12/02 10:27 / vh
RADIONUCLIDES - TOTAL							
Radium 226	51.8	pCi/g-dry		0.1		E903.0	06/27/02 03:17 / rs
Radium 226 precision	1.9	±				E903.0	06/27/02 03:17 / rs
Thorium 230	28.8	pCi/g-dry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	0.8	±				E907.0	06/21/02 10:30 / ph
Uranium	21.5	pCi/g-dry		0.01		SW6020	06/23/02 02:50 / smd
SIEVES							
0.125 Inch Sieve, Passed	98.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	1.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	96.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	96.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	92.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	3.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	90.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	2.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	76.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	13.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	26.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	49.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	6.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	20.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

TABLE C-3. Gradation Results for Tailings Slime T7

ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-009
Client Sample ID: T7

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	41.0	%		0.1		USDA26	06/12/02 10:27 / vh
RADIONUCLIDES - TOTAL							
Radium 226	139	pCi/g-dry		0.1		E903.0	06/27/02 03:21 / rs
Radium 226 precision	5.0	±				E903.0	06/27/02 03:21 / rs
Thorium 230	3800	pCi/g-dry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	25.0	±				E907.0	06/21/02 10:30 / ph
Uranium	3880	mg/kg-dry		0.02		SW6020	06/23/02 03:01 / smd
SIEVES							
0.125 Inch Sieve, Passed	93.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	6.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	80.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	13.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	60.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	20.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	40.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	19.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	22.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	18.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	16.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	6.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	10.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	5.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit
QCL - Quality control limit
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

TABLE C-4. Gradation Results for Ore Sample OP31

ENERGY LABORATORIES, INC. · 2393 Salt Creek Highway (82601) · P.O. Box 3258 · Casper, WY 82602
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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-001
Client Sample ID: OP1 (OP31)

Report Date: 07/08/02
Collection Date: 06/06/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	1.8	%		0.1		USDA26	06/12/02 10:27 / vh
SIEVES							
0.125 Inch Sieve, Passed	91.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	8.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	88.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	2.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	85.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	3.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	61.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	23.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	24.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	36.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	6.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	17.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

TABLE C-5. Gradation Results for Ore Sample OP32

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Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-002
Client Sample ID: OP2 (OP32)

Report Date: 07/08/02
Collection Date: 06/06/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	3.3	%		0.1		USDA26	06/12/02 10:27 / vh
SIEVES							
0.125 Inch Sieve, Passed	94.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	5.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	93.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	90.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	2.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	86.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	4.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	60.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	25.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	25.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	35.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	6.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	19.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit
QCL - Quality control limit
MCL - Maximum contaminant level
ND - Not detected at the reporting limit

TABLE C-6. Gradation Results for Ore Sample CV4 on Cross Valley Berm, 0" – 5"

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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-010
Client Sample ID: CV4 0-0.5

Report Date: 07/08/02
Collection Date: 06/04/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	ND	%		0.1		USDA26	06/12/02 10:27 / vh
RADIONUCLIDES - TOTAL							
Radium 226	45.8	pCi/g-dry		0.1		E903.0	06/27/02 03:31 / rs
Radium 226 precision	1.6	±				E903.0	06/27/02 03:31 / rs
Thorium 230	56.2	pCi/g-dry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	1.0	±				E907.0	06/21/02 10:30 / ph
Uranium	71.5	pCi/g-dry		0.01		SW6020	06/23/02 03:13 / smd
SIEVES							
0.125 Inch Sieve, Passed	91.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	8.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	90.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	1.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	88.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	1.8	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	85.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	3.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	61.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	24.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	23.4	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	38.0	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	5.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	17.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

C.2 Clay Barrier Physical Properties

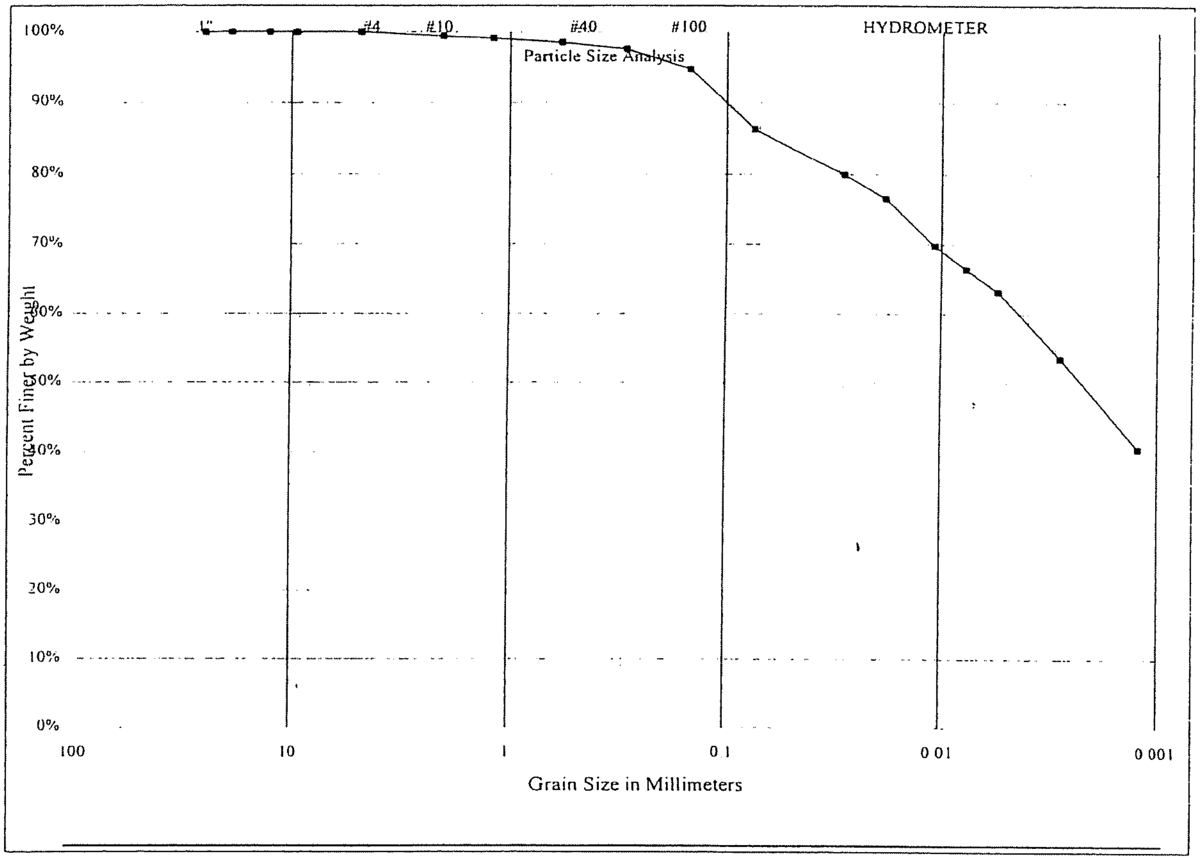
Clay samples were taken from various locations at the site to determine physical properties for the clay that is to be used for the radon/infiltration barrier in the tailings cell. Gradation results for clay samples NP11, NP10, NP6, WP4, NP4, C4, and DA1 are presented in Tables C-7, C-8, C-9, C-10, C-11, C-12, and C-13, respectively. Samples NP11, NP10, NP6, WP4, and NP4 were taken from backhoe pits around the existing tailings cell where the clay liner system was in place. Sample C4 was taken from the exposed clay east of the east dike. Sample DA1 was taken from a backhoe pit on the top of the Shootaring Canyon Dam. Table C-14 presents the liquid limits, plastic limits, plasticity indexes and lab permeability results for these same samples. Moisture density analyses were performed on the samples from NP11, NP10, NP6, C4, and Dam 1. Tables C-15 through C-19 present the results of these tests.

Double ring infiltrometer tests were performed on the clay at various locations to determine the in-situ permeability of the clay. Figures C-1, C-2, C-3, C-4, C-5, C-6, and C-7 present the results of these infiltrometer tests in locations WP1, WP2, NP2, NP3, NP5, NP7, and NP8, respectively. Figure C-8 presents evaporation test results that were performed at locations NP2 and NP5.

TABLE C-7. Gradation Results for Clay Sample NP11

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	NP-11	DATE RECEIVED	06/20/2002
CLIENT.	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-11		
SOIL DESCRIPTION.	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO 10	2.0000	99.4%
NO 16	1.1900	99.1%
NO 30	0.5900	98.5%
NO 50	0.2970	97.6%
NO. 100	0.1490	94.7%
NO. 200	0.0740	86.3%
Hydrometer Range	0.0283	79.9%
	0.0181	76.5%
	0.0108	69.8%
	0.0077	66.4%
	0.0055	63.1%
	0.0028	53.5%
	0.0012	40.5%

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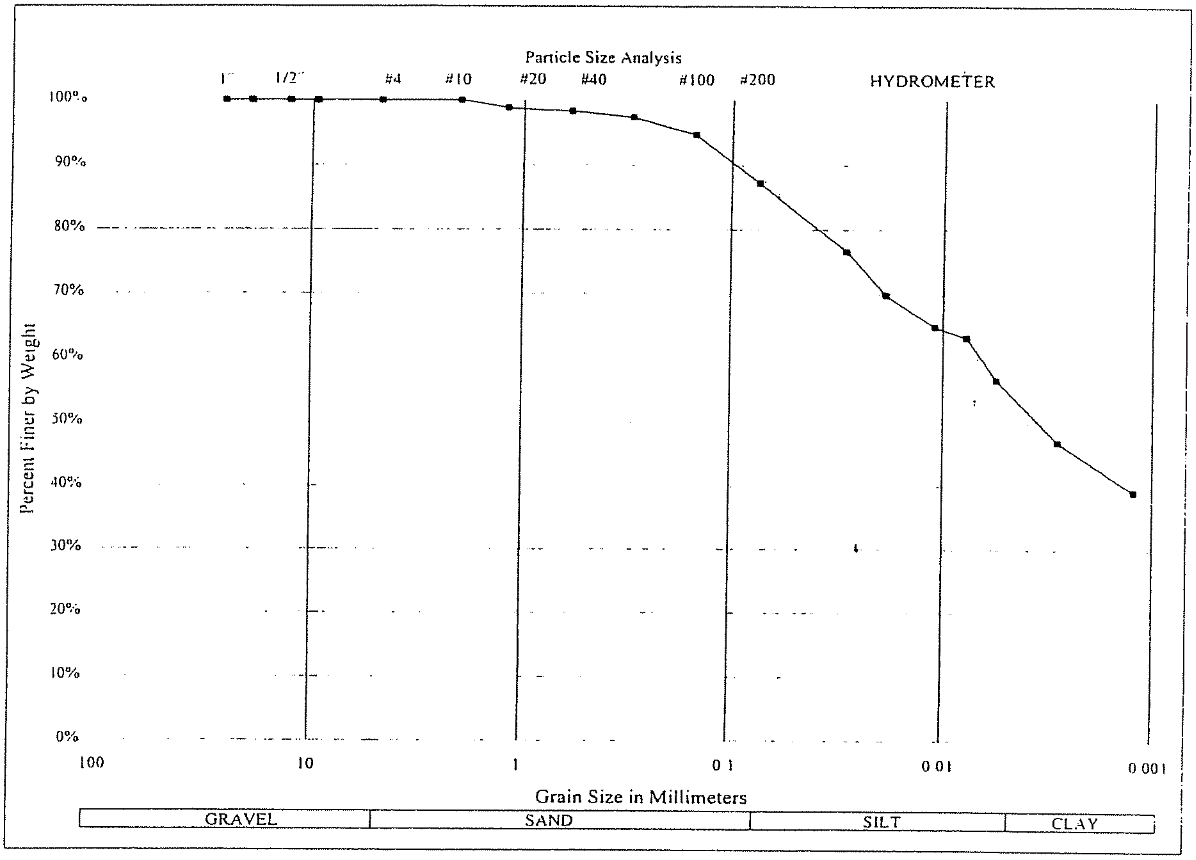
TABLE C-8. Gradation Results for Clay Sample NP10

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.	NP-10	DATE RECEIVED:	
CLIENT.	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-10		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	100.0%
NO. 16	1.1900	98.8%
NO. 30	0.5900	98.3%
NO. 50	0.2970	97.4%
NO. 100	0.1490	94.6%
NO. 200	0.0740	87.2%
Hydrometer Range	0.0287	76.5%
	0.0187	69.8%
	0.0110	64.9%
	0.0078	63.2%
	0.0056	56.7%
	0.0029	47.0%
	0.0012	39.2%

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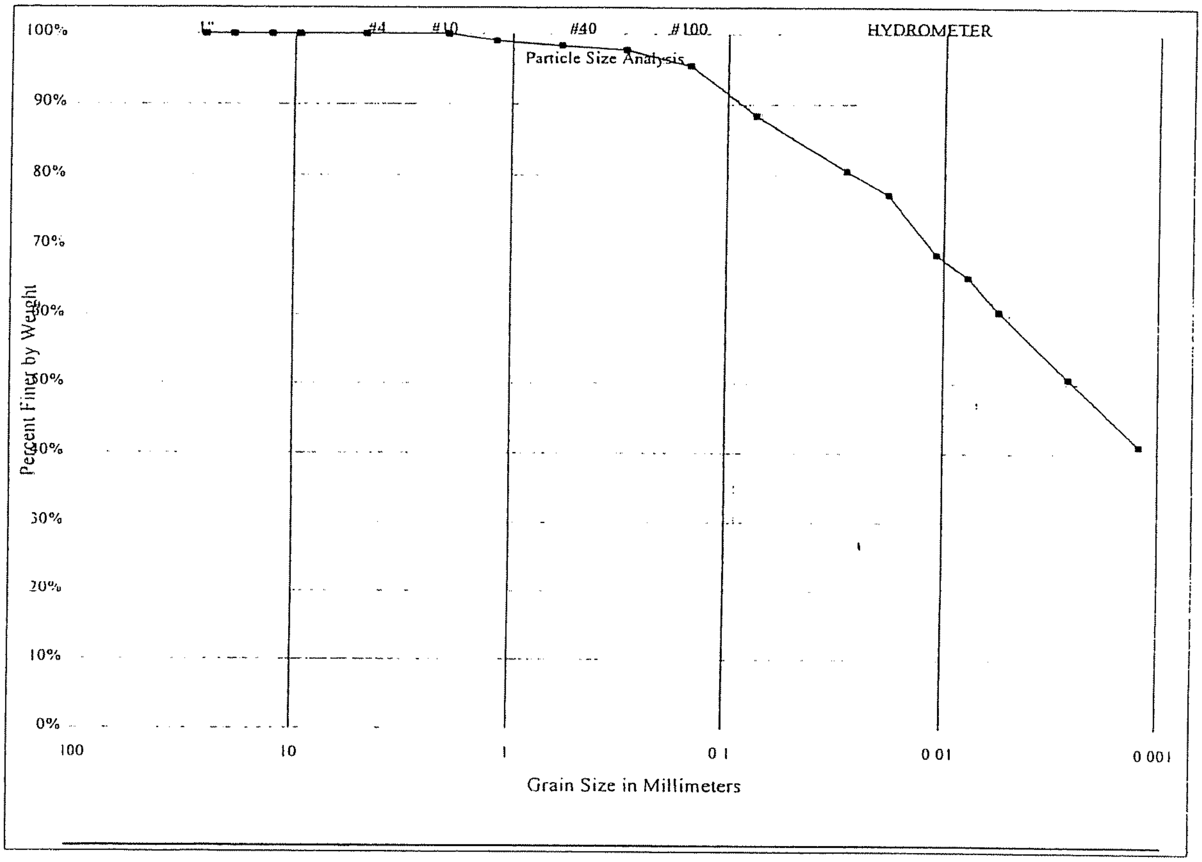
TABLE C-9. Gradation Results for Clay Sample NP6

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	NP-6	DATE RECEIVED	06/20/2002
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-6		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	100.0%
NO. 16	1.1900	99.0%
NO. 30	0.5900	98.3%
NO. 50	0.2970	97.7%
NO. 100	0.1490	95.4%
NO. 200	0.0740	88.4%
Hydrometer Range	0.0283	80.6%
	0.0181	77.2%
	0.0108	68.7%
	0.0078	65.4%
	0.0056	60.5%
	0.0026	50.6%
	0.0012	41.1%

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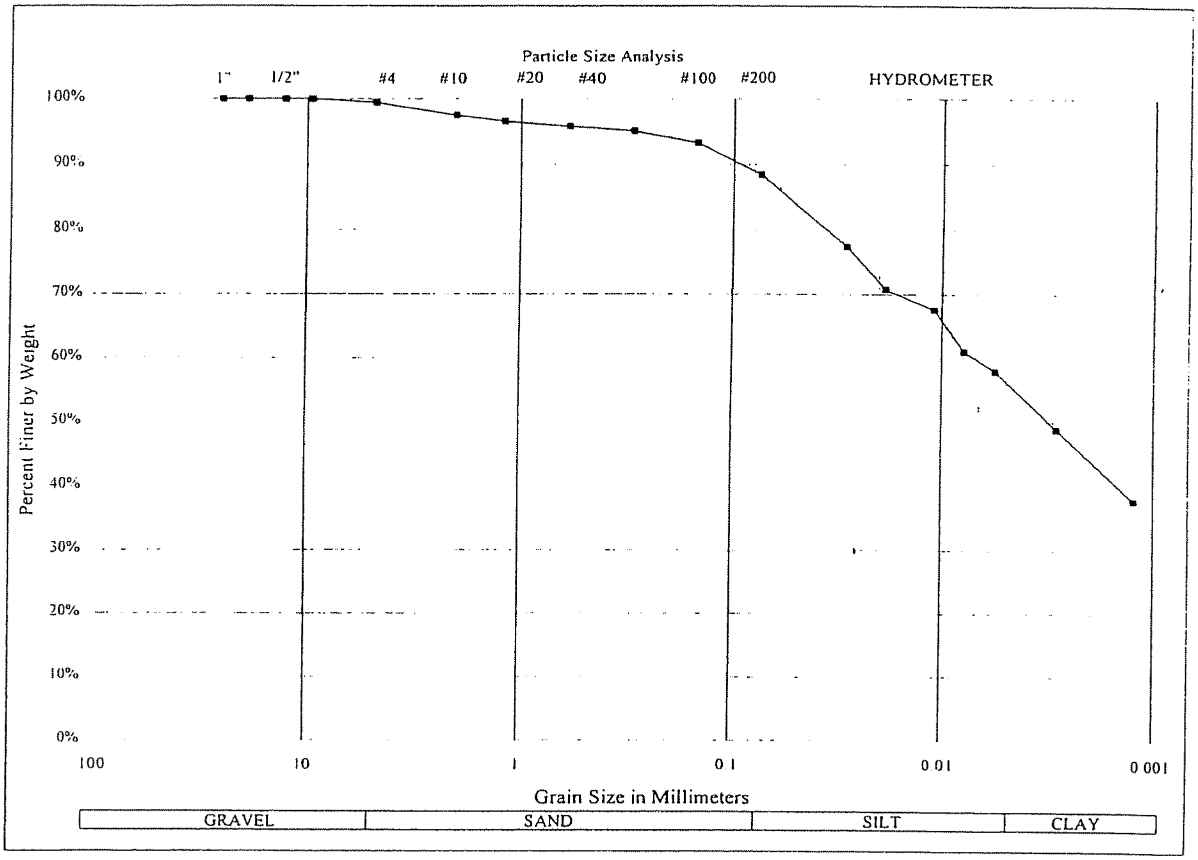
TABLE C-10. Gradation Results for Clay Sample WP4

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.	WP-4	DATE RECEIVED	06/20/2002
CLIENT.	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.	WP-4		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	99.4%
NO 10	2.0000	97.5%
NO 16	1.1900	96.5%
NO 30	0.5900	95.8%
NO. 50	0.2970	95.1%
NO. 100	0.1490	93.2%
NO. 200	0.0740	88.4%
Hydrometer Range	0.0286	77.4%
	0.0186	70.8%
	0.0109	67.6%
	0.0079	61.1%
	0.0056	57.9%
	0.0029	48.8%
	0.0012	37.8%

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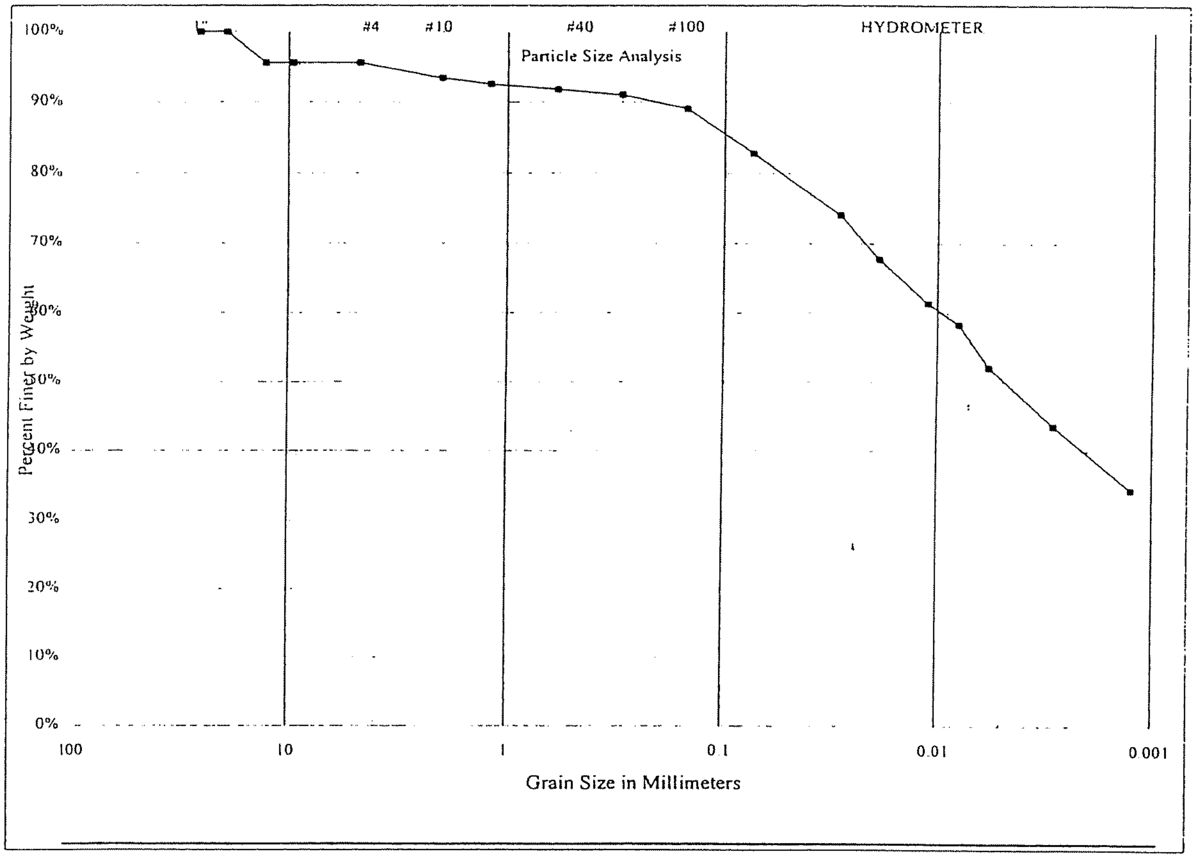
TABLE C-11. Gradation Results for Clay Sample NP4

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	NP-4	DATE RECEIVED	06/20/2002
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-4		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	95.6%
3/8"	9.5200	95.6%
NO. 4	4.7600	95.6%
NO. 10	2.0000	93.4%
NO. 16	1.1900	92.5%
NO. 30	0.5900	91.8%
NO. 50	0.2970	91.0%
NO. 100	0.1490	89.1%
NO. 200	0.0740	82.8%
Hydrometer Range	0.0287	74.0%
	0.0187	67.7%
	0.0111	61.3%
	0.0079	58.3%
	0.0057	52.0%
	0.0029	43.5%
	0.0012	34.4%

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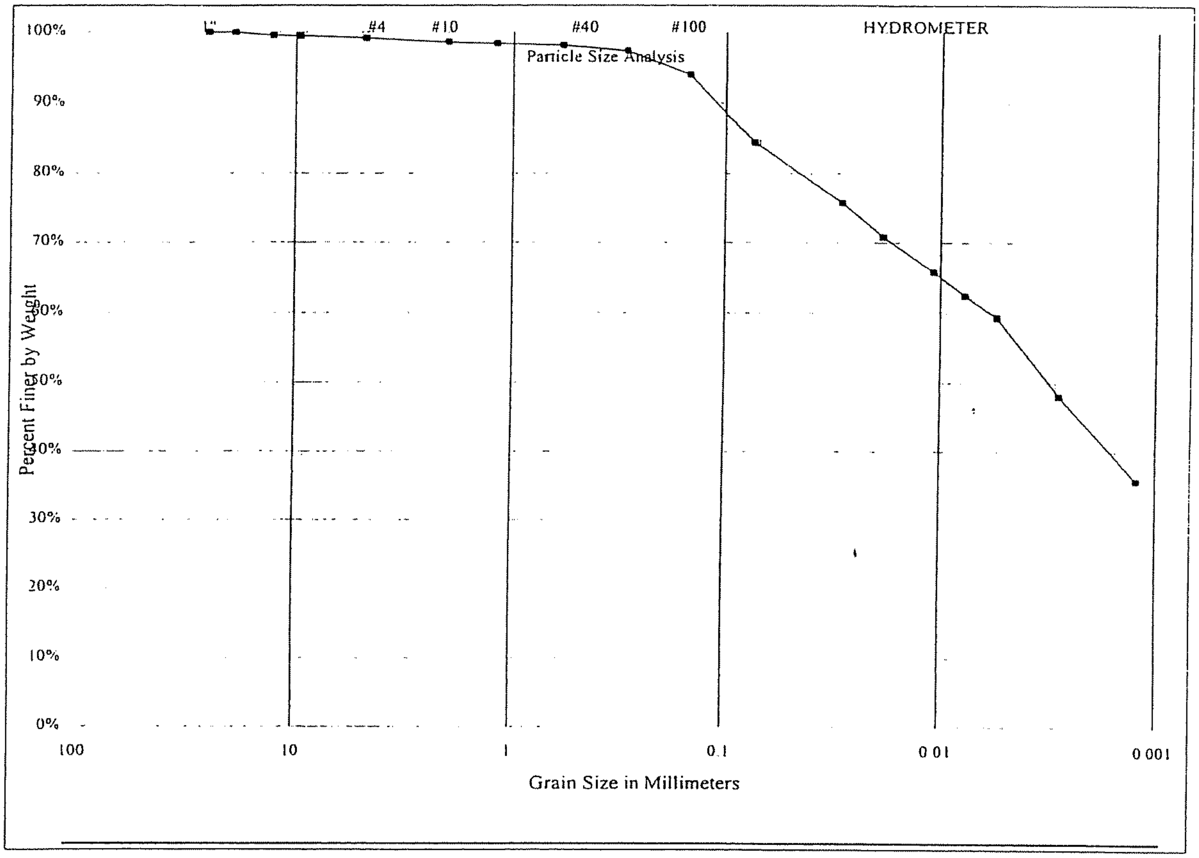
TABLE C-12. Gradation Results for Clay Sample C4

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	C-4	DATE RECEIVED	06/20/2002
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	C-4		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	99.5%
3/8"	9.5200	99.5%
NO. 4	4.7600	99.1%
NO.10	2.0000	98.6%
NO. 16	1.1900	98.4%
NO. 30	0.5900	98.1%
NO. 50	0.2970	97.4%
NO. 100	0.1490	94.0%
NO. 200	0.0740	84.4%
Hydrometer Range	0.0285	75.7%
	0.0184	70.8%
	0.0108	65.8%
	0.0078	62.4%
	0.0055	59.3%
	0.0029	48.1%
	0.0012	35.8%

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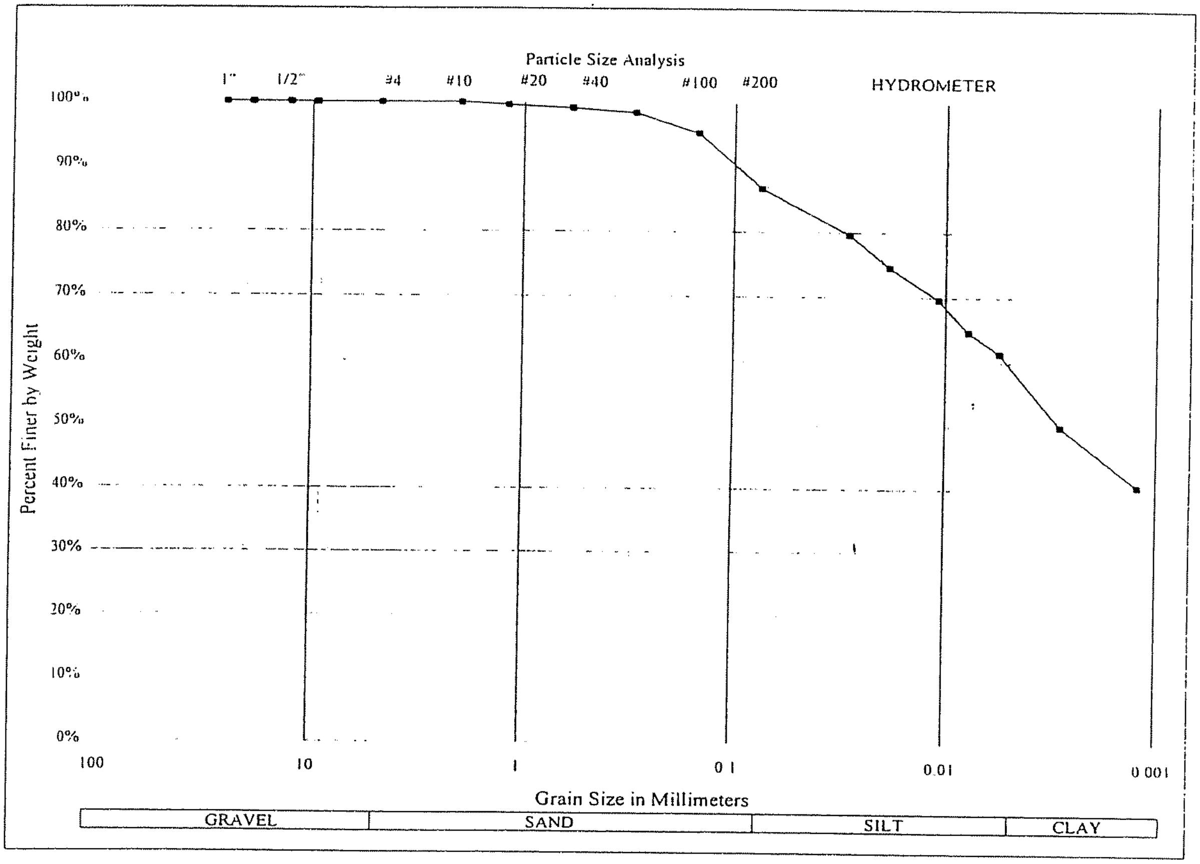
TABLE C-13. Gradation Results for Clay Sample DA1

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	Dam 1	DATE RECEIVED	06/20/2002
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	Dam 1		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	100.0%
NO. 16	1.1900	99.5%
NO. 30	0.5900	99.1%
NO. 50	0.2970	98.4%
NO. 100	0.1490	95.3%
NO. 200	0.0740	86.7%
Hydrometer Range	0.0285	79.6%
	0.0184	74.5%
	0.0108	69.6%
	0.0078	64.6%
	0.0056	61.3%
	0.0029	50.0%
	0.0012	40.5%

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TABLE C-14. SOIL PROPERTIES FOR CLAY SAMPLES DA1, NP4, NP6, NP10, NP11, WP4, AND C4

Sample	Liquid Limit	Plastic Limit	Plasticity Index	Permeability (cm/sec)
DA1	76	25	51	NA
NP4	73	21	52	NA
NP6	95	29	66	3.2×10^{-8}
NP11	79	31	48	6.5×10^{-8}
NP10	76	26	50	NA
WP4	90	30	60	NA
C4	73	29	44	4.4×10^{-7}

Note: Results from Inber-Miller letter dated September '

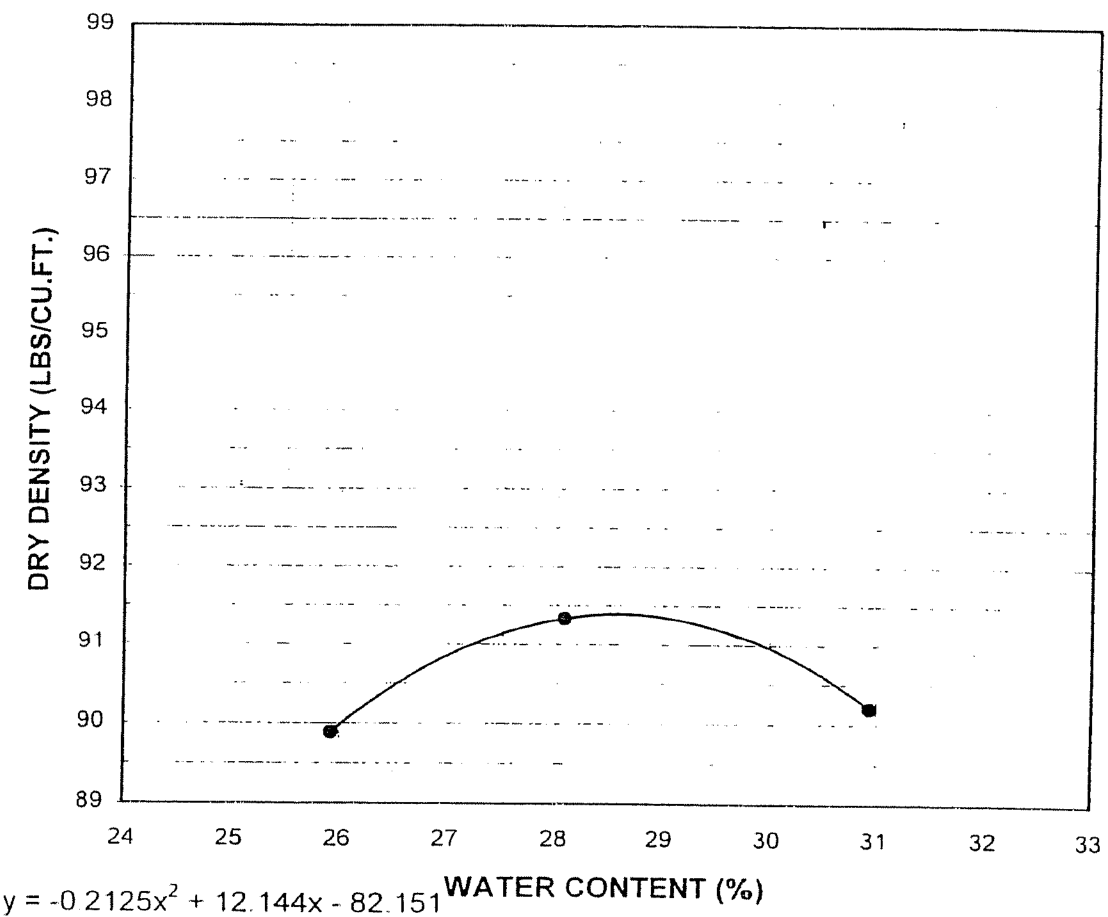
TABLE C-15. Moisture Density Analysis for NP11

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-8-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: NP-11
SAMPLED BY: Client
TESTED BY : JPM
TEST METHOD: ASTM D 698-method A



$y = -0.2125x^2 + 12.144x - 82.151$

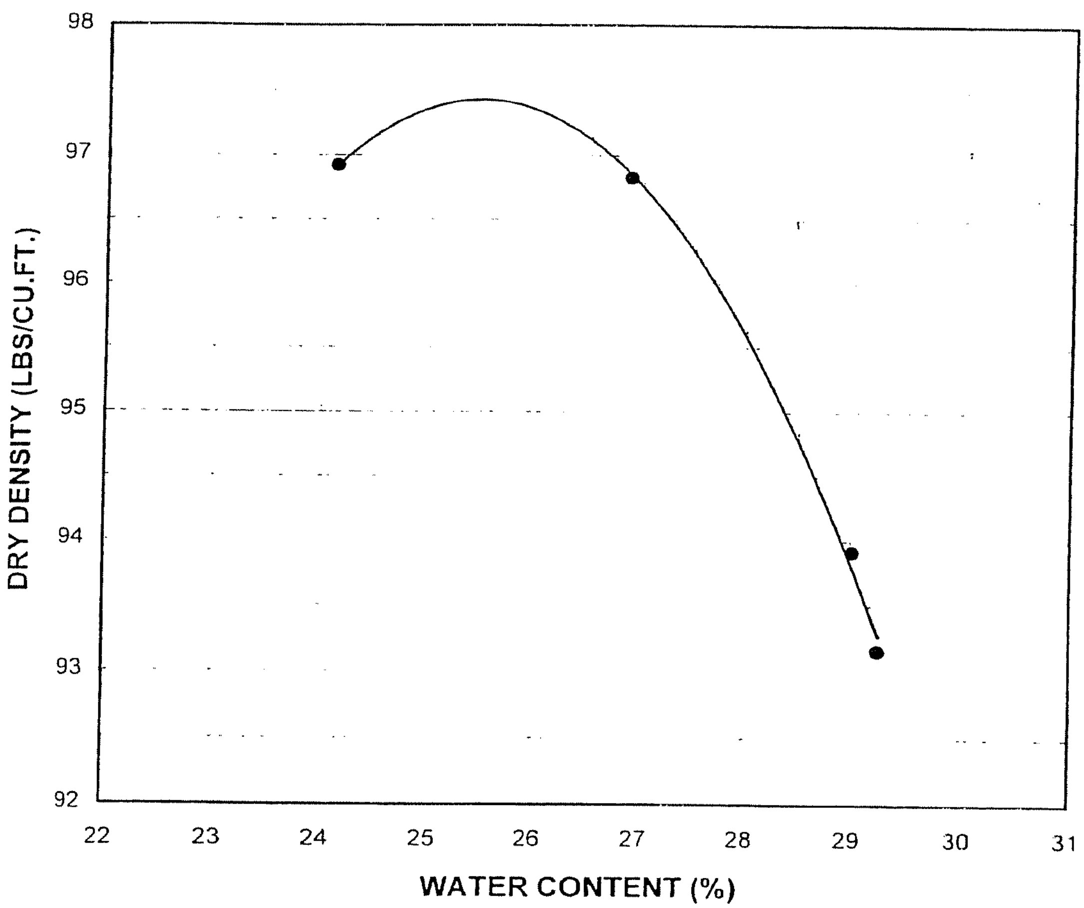
OPTIMUM WATER CONTENT (%): 28.6
MAXIMUM DRY DEN. (LBS/CU. FT): 91.4

TABLE C-16. Moisture Density Analysis for NP10

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT:	U.S. Energy	SAMPLE NO.:	NP-10
PROJECT:	Shootering Canyon	SAMPLED BY:	Client
JOB NO.	10223 RM	TESTED BY :	TGE
TEST DATE:	7-1-02	TEST METHOD:	ASTM D 698-method A
SOURCE:	On-site		
DESCRIPTION:	Weak red clay		



OPTIMUM WATER CONTENT (%):	25.4
MAXIMUM DRY DEN. (LBS/CU. FT):	97.4

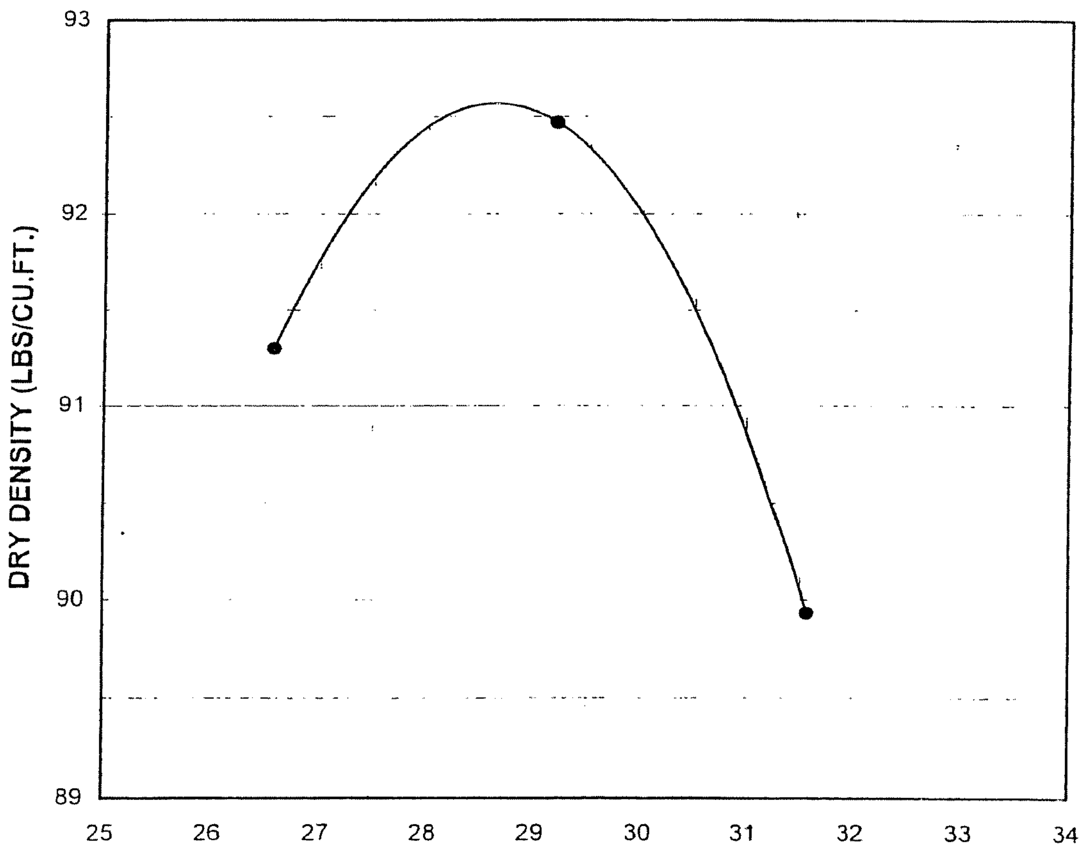
TABLE C-17. Moisture Density Analysis for NP6

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-3-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: NP-6
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



$y = -0.3036x^2 + 17.378x - 156.11$

OPTIMUM WATER CONTENT (%): 28.6
MAXIMUM DRY DEN. (LBS/CU. FT): 92.5

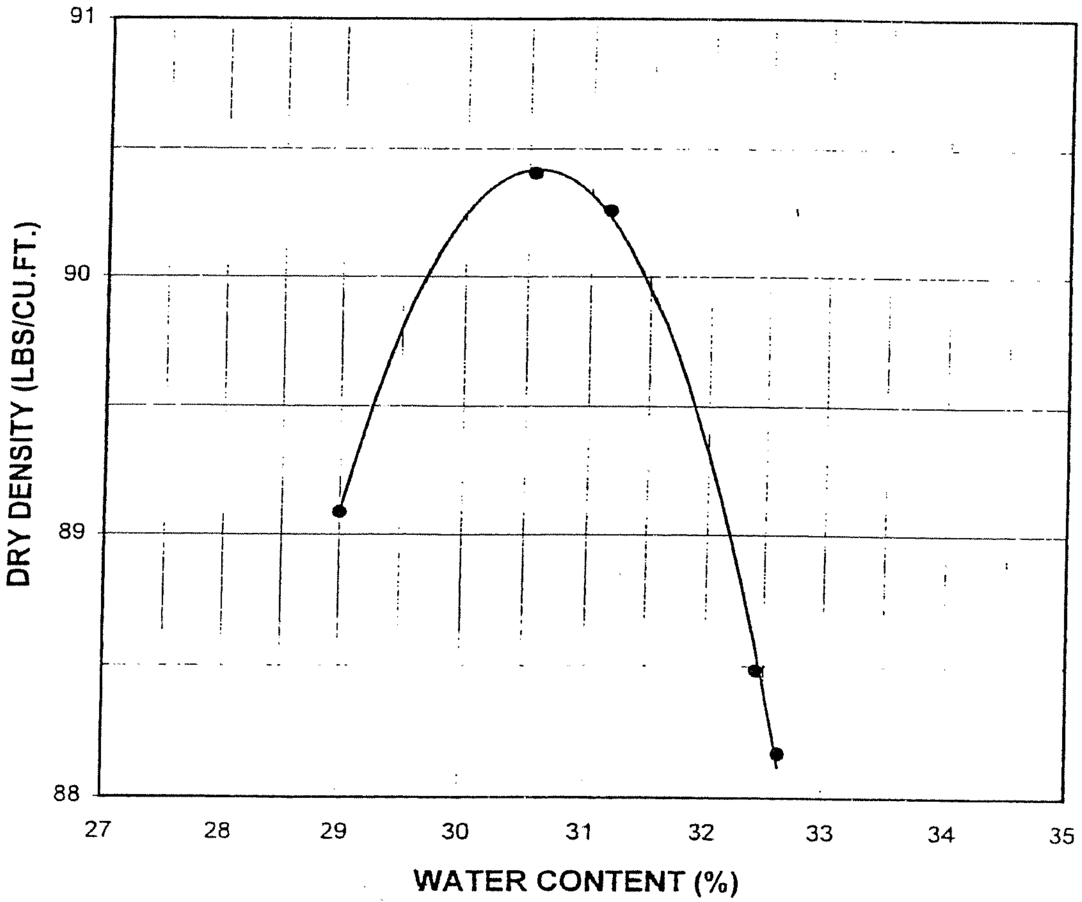
TABLE C-18. Moisture Density Analysis for C4

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 8-15-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: C-4
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



OPTIMUM WATER CONTENT (%): 30.8
MAXIMUM DRY DEN. (LBS/CU. FT): 90.4

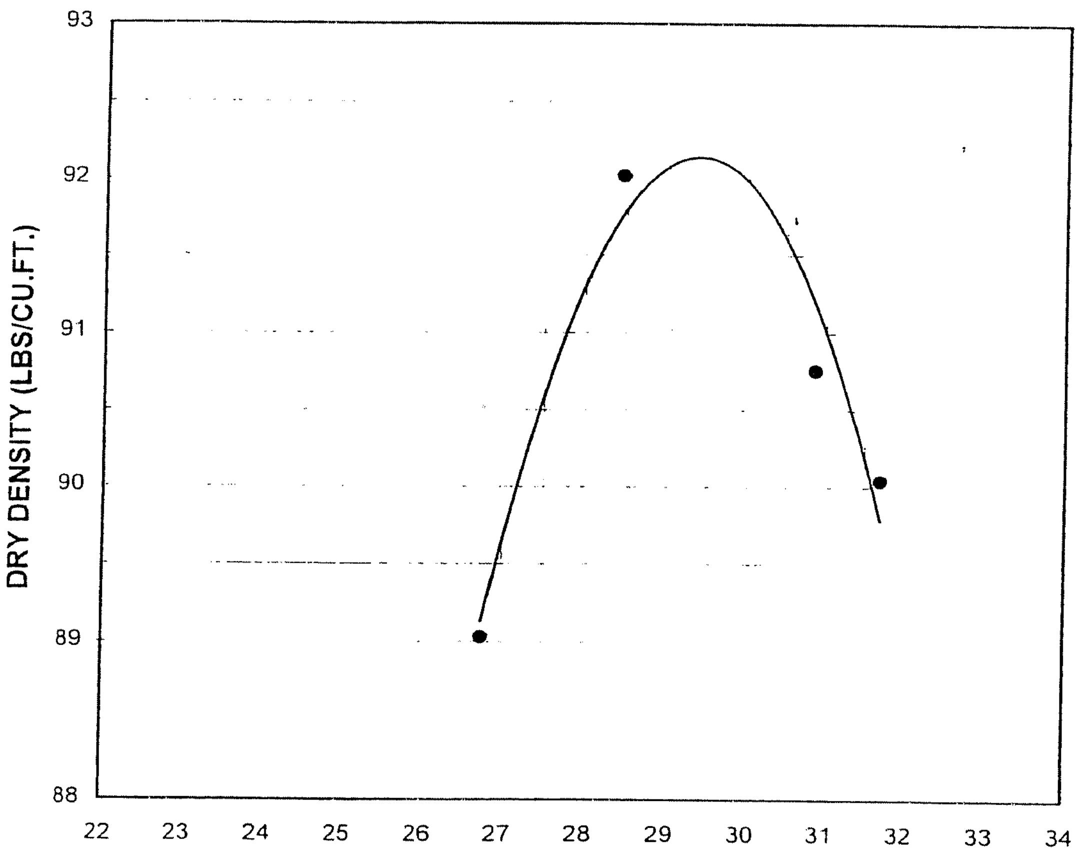
TABLE C-19. Moisture Density Analysis for DA1

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-3-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: Dam 1-Clay
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



$y = -0.4384x^2 + 25.76x - 286.3$

OPTIMUM WATER CONTENT (%):	29.4
MAXIMUM DRY DEN. (LBS/CU. FT):	92.1

C.3 Alternate Clay Source Physical Properties

Two samples were taken from the alternate clay source borrow area. These samples were designated A and C and were taken from the mining face in the borrow area. Attachment C.1 contains the transmittal letter and the testing results for these two samples. The transmittal letter discusses the general properties of the material and the results of the permeability testing. The additional pages in Attachment C.1 include the results of the Atterberg Limits tests, the results of the gradation analyses, and the results of the moisture-density analyses. Attachment C.2 contains a letter from the soil testing laboratory (Inberg-Miller Engineers) discussing the properties of the clay samples.

C.4 Soil Cover Physical Properties

Two gradations were performed on samples of the soil cover. Figures C-9 and C-10 present the results of the gradations performed on samples RSC1 and RSC2, respectively. Both RSC1 and RSC2 were taken from the soil cover placed in the north cell.

C.5 Rock Physical Properties

Gradations were performed on rock samples from the quarry area and the face of the Shootaring Canyon Dam. Rock durability analysis were also performed on the rock from the quarry, the dam face, as well as the rock soil cover material. Figures C-11, C-12, and C-13 present the results of the gradations of quarry samples QU1, QU2, and QU3, respectively. A gradation was also performed on the fines from sample QU3. The results of this test are presented on Table C-20. The results for the gradation on dam rock sample DS1 are presented in Figure C-14. The results for the gradation on dam rock sample DS2 are presented in Figure C-15.

Rock durability analyses were performed on a rock sample from each of the potential sources; the quarry, the dam face, and the rock soil cover. The results of these durability tests are presented in Table C-21. Table C-22 presents rock durability tests that were conducted in 1997 which yield similar results. Petrographic analysis results are presented in Table C-23.

TABLE C-20. Gradation Results for QU-3 Sand

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.:	10223RM
TEST DATE	6-18-02
TESTED BY	TGE
TEST METHOD	ASTM D422
SAMPLE NO.	QU-3 Sand
SAMPLED BY	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT.:	
GRADATION DESCRIPTION:	

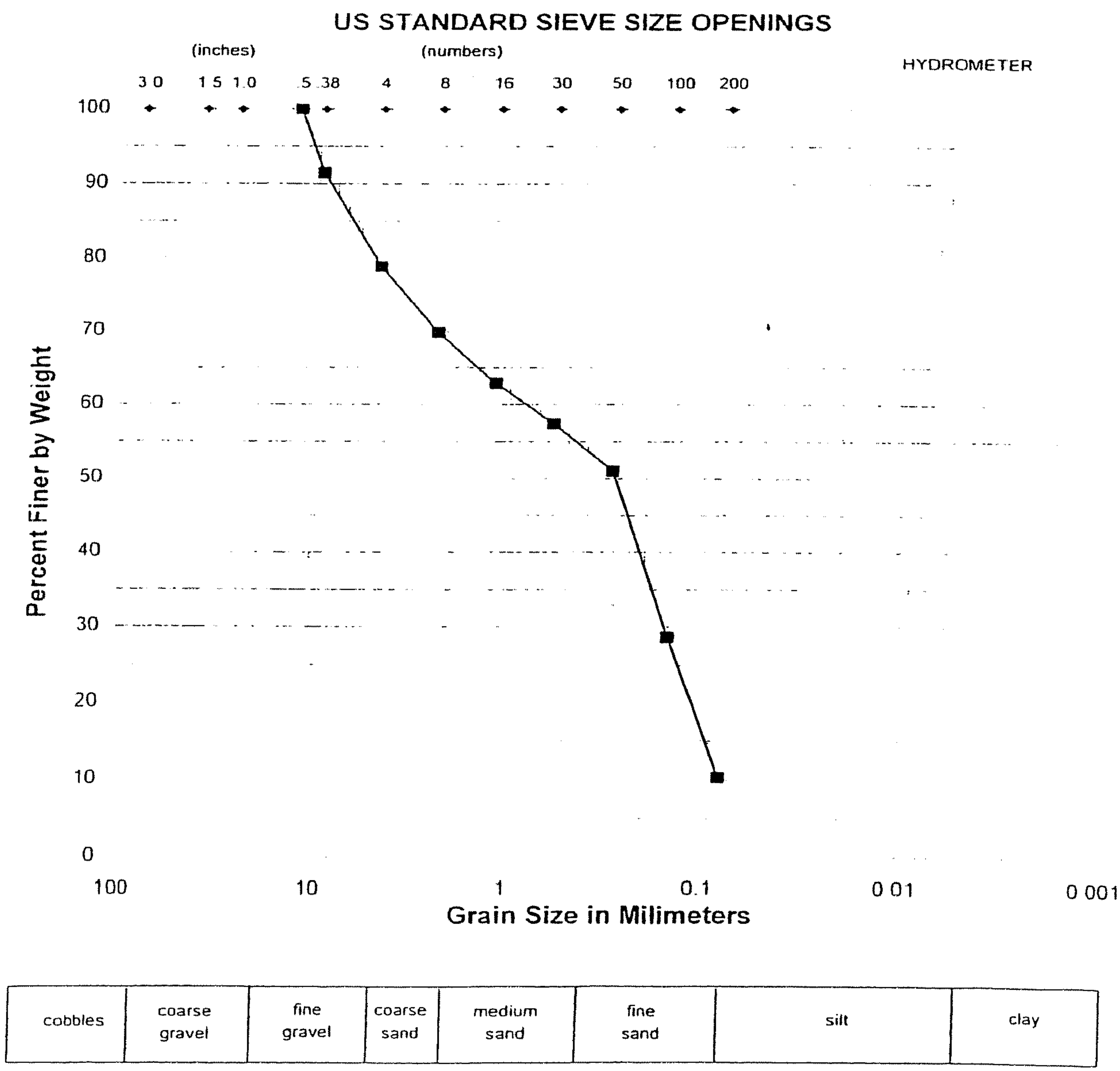
Sieve No.	Sieve Size (mm)	Wt. Retained (g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70	0.00	0.00	100.00		
0.375	9.53	41.75	8.54	91.46		
4	4.75	61.78	12.64	78.82		
8	2.36	44.07	9.02	69.81		
10	2.00					
16	1.18	34.09	6.97	62.83		
30	0.60	26.75	5.47	57.36		
40	0.43					
50	0.30	31.16	6.37	50.99		
100	0.15	109.45	22.39	28.60		
200	0.08	89.45	18.30	10.30		

TABLE C-20. Gradation Results for QU-3 Sand (continued)

PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT:	U.S. Energy	SAMPLE NO.:	QU-3 Sand
PROJECT:	Shootering Canyon	SAMPLED BY:	Client
JOB NO.:	10223RM	SOURCE:	On-site
TEST DATE:	6-18-02	SAMPLE DESCRIPTION:	Reddish silty fine sand with some gravel
TESTED BY:	TGE		
TEST METHOD:	ASTM C136	GRADATION DESCRIPTION:	



Unified Soil Classification System (ASTM D2487)

TABLE C-21. ROCK DURABILITY TEST RESULTS, JUNE 2002

Loss LA Abrasion, Specific Gravity and Absorption Results

Sample Identification	% Loss LA Abrasion	Apparent Sp. G.	Bulk Sp. G.	Bulk SSD Sp.G.	Absoption %	Composite Sodium Sulphate Soundness % Loss
QU - Igneous	3.7	2.638	2.532	2.572	1.6	1.90
QU - Sandstone	5.1	2.579	2.445	2.497	2.13	4.35
RSC - Igneous	5.5	2.615	2.475	2.528	2.16	8.45
RSC - Sandstone	9.9	2.542	2.356	2.429	3.1	13.50
DS - Igneous	3.9	2.637	2.529	2.57	1.63	4.20
DS - Sandstone	7.7	2.528	2.392	2.446	2.25	12.85

Sodium Sulfate Soundness Tests

Sample Identification	1-1/2" to 2" Percent Loss	2" to 2-1/2" Percent Loss
QU - Igneous	1.7	2.1
QU - Sandstone	3	5.7
RSC - Igneous	12	4.9
RSC - Sandstone	12.3	14.7
DS - Igneous	1.1	7.3
DS - Sandstone	12.3	13.4

Rock Proportions in Samples

Sample Identification	Percentage Igneous	Percentage Sandstone	Size Range
QU1	42	58	2"-5"
QU2	32	68	3"-5"
QU3	31	69	2"-8"
DS1	34	66	2"-6"
DS2	39	61	2"-5.5"
RSC1	41	59	2"-6.5"
RSC2	31	69	2"-5.5"

Note: Results from Inber-Miller letter dated September 17, 2002

TABLE C-22. Rock Durability Test Results April, 1997

ROCK DURABILITY TEST RESULTS
U. S. Energy
Shootering Canyon, Utah
IME Job No. 7664-RM
April 4, 1997

Test	Tan Sandstone	Igneous Rock
Los Angeles Abrasion - % Loss[1]	7.8	2.3
Apparent Bulk Specific Gravity	2.556	2.676
Bulk Specific Gravity	2.409	2.548
SSD Bulk Specific Gravity	2.467	2.596
Absorption (%)	2.39	1.88
$NaSO_4$ Soundness[2] % Loss 2½ to 2"	5.29	1.37
$NaSO_4$ Soundness[2] % Loss 2" to 1-1/2"	3.44	0.98
$NaSO_4$ Soundness[2] % Loss 1-1/2" to 1"	2.22	2.25
$NaSO_4$ Soundness[2] % Loss 1" to 3/4"	14.55	5.94
$NaSO_4$ Soundness[2] % Loss 3/4" to 1/2"	13.75	4.41
$NaSO_4$ Soundness[2] % Loss 1/2" to 3/8"	24.96	8.60
$NaSO_4$ Soundness[2] % Loss 3/8" to #4	16.74	9.39
Rebound No.	43	52

Notes:
1. Modified for 100 revolutions
2. Actual percent loss - not weighted for "original gradation." As requested, $NaSO_4$ Soundness samples were crushed to generate sufficient material of practical test size.

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks

THEODORE P. PASTER, Ph.D.
Consultant
11425 East Cimmarron Drive
Englewood, Colorado 80111
(303) 771-8219

August 19, 2002

Thomas G. Michel
Hydro-Engineering, LLC
4685 South Magnolia
Casper, WY 826042

RE: Petrographic Analyses of Andesite and Sandstone to be Used as Erosion Protection for a Reclaimed Uranium Tailings Facility.

SUMMARY

The petrographic analyses of the two rock types in the riprap source yields the following parameters:

ROCK NAME	NRC GROUP (Table 6.1)	EXPANDABLE SMECTITE CONTENT
Andesite porphyry & Porphyritic andesite	2	Nil
Fine-grained sandstone	? (parameters not in Table 6.1)	Nil

The minimum fracture spacing is estimated to be greater than 2" to 4" based on the particles sizes. The particles are equant and rounded with no weathering rinds.

Respectfully submitted:

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

INTRODUCTION

An aggregate source in Utah is petrographically analyzed for a source of erosion protection rock mulch or riprap to be used in a reclaimed uranium tailings facility.

The aggregate is characterized by two primary rock types:

1) An andesite porphyry and porphyritic andesite.
2) A fine-grained porous sandstone.

PETROGRAPHIC ANALYSES

Megascopic Description of Andesite

Six andesite samples were received. They are rounded particles measuring 2" to 3" in average diameter and contain no visible weathering rind when broken open. Samples 1a, 1b and 1c are andesite porphyry containing more than 50% phenocrysts of plagioclase (Pl) and hornblende (Hb). Samples 1d, 1e and 1f are porphyritic andesites containing less than 50% phenocrysts of Pl and Hb. Two particles of each type of andesite were sectioned for petrographic analysis and the measured percentages of the four samples are given in **TABLE 1**.

TABLE 1
MINERAL PERCENTAGES IN FOUR ANDESITE SAMPLES
UTAH RIPRAP

	Sample No.							
	QU-1a		QU-1c		QU-1d		QU-1e	
Phase	cts	%	cts	%	cts	%	cts	%
Groundmass	209	43.4 ±4.5	254	41.1 ±4.0	346	59.6 ±4.1	265	45.4 ±4.1
Plagioclase(Pl)	98	20.3 ±3.7	180	29.1 ±3.7	61	10.5 ±2.5	116	19.8 ±3.3
Carbonate inPl	22	4.6 ±1.9	11	1.8 ±1.1	5	0.9 ±0.8	47	8.0 ±2.2
" in HB	33	6.8 ±2.3	30	4.9 ±1.7	12	2.1 ±1.2	33	5.6 ±1.9
Goethite	0	0	0	0	49	8.4 ±2.3	0	0
Kaolinite	35	7.3 ±2.4	1	0.2 ±0.2	0	0	0	0
Chlorite	38	7.9 ±2.5	56	9.1 ±2.3	8	1.4 ±1.0	18	3.1 ±1.4
Magnetite	5	1.0 ±0.9	5	0.8 ±0.7	4	0.7 ±0.7	14	2.4 ±1.3
Vnlts/Fracs*	2	0.4 ±0.4	0	0	2	0.3 ±0.3	tr	tr
Ht/Lx**	12	2.5 ±1.4	10	1.6 ±1.0	11	1.9 ±1.1	7	1.2 ±0.9
Apatite	1	0.2 ±0.2	0	0	1	0.2 ±0.2	2	0.3 ±0.3
Illite	7	1.5 ±1.1	42	6.8 ±2.0	17	2.9 ±1.4	8	1.4 ±1.0
Pores in gdms	5	1.0 ±0.9	0	0	57	9.8 ±2.5	6	1.0 ±0.8
Voids,Fracs/Ves	11	2.3 ±1.4	7	1.1 ±0.8	4	0.7 ±0.7	5	0.9 ±0.8
Biotite	3	0.6 ±0.6	1	0.2 ±0.2	1	0.2 ±0.2	0	0
Sphene/Rutile	0	0	2	0.3 ±0.3	0	0	0	0
Quartz	1	0.2 ±0.2	6	1.0 ±0.8	0	0	5	0.9 ±0.8
Carb in gdms***	0	0	4	0.6 ±0.6	1	0.2 ±0.2	23	3.9 ±1.6
Carb in Ves****	0	0	9	1.4 ±0.9	1	0.2 ±0.2	2	0.3 ±0.3
Gdms, pore-free	0	0	0	0	0	0	30	5.1 ±1.8
Quartz Phenos	0	0	0	0	0	0	4	0.7 ±0.7
Totals	482	100.0	618	100.0	580	100.0	585	100.0

Legend:

Vnlts/Fracs* = Veinlets/Fractures

Carb in Ves**** = Carbonate in Vesicles

Ht/Lx** = Hematite/Leucoxene

Carb in gdms*** = Carbonate

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

The phenocrysts of Pl are up to 6 mm in size in the andesite porphyry and up to 14 mm in size in the porphyritic andesite samples.

Microscopic Description of Andesite

Due to deuteric or low grade metasomatism (Not weathering.) the phenocrysts are replaced by secondary minerals as shown in **TABLE 2.**

TABLE 2
SECONDARY MINERALOGY OF PLAGIOCLASE AND HORNBLENDE IN UTAH ANDESITE

	Constituent Minerals*			
Phenocryst / Sample:	1a	1c	1d	1e
Pl = Pl + Pl Carb + Kaol + Ill**	34.0	37.9	14.3	29.2
Hb = Hb Carb + Chl + Ht/Lx + Q**	15.6	15.6	13.8	10.8

Legend:

* = from Table 1.	Hb Carb = Carbonate in hornblende.
**: Pl = plagioclase	Chl = chlorite
Pl Carb = Carbonate in Pl.	Ht/Lx = hematite and leucoxene
Kaol = kaolinite	Q = quartz
Ill = illite	Hb = hornblende

Note that the Hb is totally altered leaving only relict outlines of the original phenos.

Andesite Rating

The group in Table 6.1 of Nelson et al.* into which the andesite would fit is 2.

Fractures in Andesite

The fractures trend in one direction in samples a and d and more than 1 direction in e. The density of fractures more than 4 mm long are listed in **TABLE 3.**

TABLE 3
FRACTURE DENSITY IN ANDESITE SECTIONS
(Fractures larger than 4 mm.)

Sample No.	Avg fracture spacing (in mm)
QU - 1a	3
QU - 1c	>22
QU - 1d	8
QU - 1e	17

Evidently the through-going fractures that determine particle size are spaced 2" to 3" as judged by the particle sizes.

* = 1986; Nelson, J.D. et al.; Methodology for Evaluating Long Term Stabilization Designs of Uranium Mill Tailings Impoundments; NUREG/CR-4620.

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

Clays in Andesite

The clay and clay-size minerals identified in the andesite are kaolinite, illite and chlorite as shown in **TABLE 1**.

X-ray diffraction on QU-1c confirmed the presence of kaolinite and chlorite and no detectable smectite. Based on the x-ray and sample parameters the detection limit is 0.3% of the sample.

Megascopic Description of Sandstone

Six sandstone samples were received. They measure 2" to 4" average diameter with no weathering rinds and are rounded to broken with sharp edges. They are briefly described below in three types:

Sample No.	Description
QU-s_1	Thinly laminated (1-4mm thick laminae) shown by reddish-brown Fe-staining, fine-grained sandstone* Grayish-orange**. Also contains 4-9mm thick cross-bedded layers.
QU-S_2, S_4	Fine-grained sandstone is a very pale orange color** with ≤ 1mm Fe-oxide stained blebs. Non-laminated.
QU-S_3, S_5, S_6	Fine-grained, very pale orange** sandstone with little or no iron staining and no laminae.

* = Average grain size is 0.1 to 0.2mm. Fine sand size is 0.06mm to 0.2mm.
**= Color on Geological Society of America Rock Color Chart, 1991.

Microscopic Description of Sandstone

The mineralogical components of the sandstone are given in **TABLE 4** and **APPENDIX I**.

TABLE 4
MINERAL PERCENTAGES IN THREE SANDSTONE SAMPLES
UTAH RIPRAP

	Sample No.					
	QU-1a		QU-1c		QU-1d	
Phase	cts	%	cts	%	cts	%
Clasts:						
Q + K-Spar*	440	69.7	491	75.3	444	76.0
Microcline	7	1.1	14	2.1	17	2.9
Other	1	0.1	0	0	3	0.5
Interstitial voids:	149	23.6	74	11.4	99	17.0
Cement:						
Carbonate	1	0.2	37	5.7	4	0.7
Clay	8	1.3	8	1.2	16	2.7
Goethite	25	4.0	27	4.1	1	0.2
Fracture:	0	0	1	0.2	0	0
Totals	631	100.0	651	100.0	584	100.0

Legend:
Q + K-Spar = Quartz + Orthoclase

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

The average clast percentage is approximately 76%, pore space is 17% and cement is 7%. The cement is composed of goethite, carbonate and clay.

Sandstone Rating
The references at hand and information supplied by Hydro-Engineering are not complete enough to rate the sandstone.

Fractures in Sandstone
No fractures were seen in thin section. Joints/fractures comprise some surfaces of the particles and these are estimated to be greater than 2" spacing.

Clay in Sandstone
The total clay content of the sandstone is estimated to be less than 2.&% and average 1.7%. No expandable smectite was found by x-ray diffraction. The limit is 0.2% of the sample.

August 19, 2002

APPENDIX I
PETROGRAPHIC DESCRIPTIONS

QU-1a; Andesite Porphyry

Phenos (52.6%):

34.0% Plagioclase (Pl, An_{16})	0.06-6.0mm	Oligoclase centers. Euhedra with oscillatory zoning. 8-90% replaced with carbonate, illite and kaolinite. Alteration is generally in layers corresponding to compositional zoning.
17.4% [Hornblende] (Hb)	<0.08-3.6mm	Relict euhedra. 100% replaced by chlorite >carbonate. Contains inclusions of hematite (Ht) + leucoxene (Lx). Occasionally partly replaced by quartz (Q).
1.0% Magnetite (Mt)	<0.04-0.3mm	Eu-anhedra. Partly replaced by Ht/Lx. Notably in relict Hb.
0.2% Apatite	0.05-0.15mm	Stubby prisms.

Groundmass (43.4%):

43.4% Feldspar(F)/Ferromagnesian(FM)	<0.01-0.01mm	Indistinctly bounded anhedral patches of incipient, sub-variolitic inter-growths of F and FM.

Fractures (0.4%):

0.4% Carbonate	0.04mm thick 0.04x<1.0mm	Anhedral blebs in groundmass that are probably relict FM.

Illite is approximately 1.5 % of rock

No weathering rinds.

Alteration is late stage metasomatism common in volcanic rocks. The metasomatism is propylitic/deuteric that has altered the Hb and partially altered the Pl and Mt.

QU-S; Medium-Grained, Quartz Sandstone with Little Cement.

Clastics (79.4%):

76.0% Quartz(Q)> Orthoclase(K-Spar)	0.05-0.3mm	Equant clastics. Rounded in voids and and straight edges where in contact due to load compression.
2.9% Microcline	0.12-0.35mm	Same description as Q and K-Spar.
0.5% Other	<0.01-0.06mm	Predominately eu-subhedral rutile and chert. Very rare volcanic (andesite?).

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

Interstices (20.6%):

17.0% Voids	<0.01-0.3mm	Irregular shapes interstitial to clastics.
2.&% Clay	<<0.01mm	In ragged clumps or dispersed in voids.
0.7% Carbonate	<0.01mm	Subhedral in aggregates.
0.2% Goethite	<0.01-0.12mm	Predominately anhedra to euhedra.

C.6 Entrada Sand Physical Properties

Gradations were performed on three samples of the Entrada Sandstone at the site. The gradation results for samples CV4, NP10, and NP6 are presented in Tables C-24, C-25, and C-26, respectively. Sample CV4 was taken from the cross valley berm at a depth of 1.5' to 2.5'. Samples NP10 and NP6 were taken from the red sand in backhoe pits in the north cell.

TABLE C-24. Gradation Results for Entrada Sand CV4, 1.5' – 2.5'

ENERGY LABORATORIES, INC. · 2393 Salt Creek Highway (82601) · P.O. Box 3258 · Casper, WY 82602
Toll Free 888.235.0515 · 307.235.0515 · Fax 307.234.1639 · casper@energylab.com · www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Plateau Resources Shootaring Canyon
Lab ID: C02060335-011
Client Sample ID: CV4 1 5-2.5

Report Date: 07/08/02
Collection Date: 06/04/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	1.8	%		0.1		USDA26	06/12/02 10:27 / vh
RADIONUCLIDES - TOTAL							
Radium 226	0.2	pCi/g-dry		0.1		E903.0	06/27/02 04:31 / rs
Radium 226 precision	0.1	±				E903.0	06/27/02 04:31 / rs
Thorium 230	0.3	pCi/g-dry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	0	±				E907.0	06/21/02 10:30 / ph
Uranium	2.75	mg/kg-dry		0.02		SW6020	06/23/02 03:16 / smd
SIEVES							
0.125 Inch Sieve, Passed	99.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.125 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Passed	99.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Passed	99.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 12 Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Passed	99.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Passed	79.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 60 Sieve, Retained	19.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	25.6	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Retained	54.3	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Passed	3.1	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 200 Sieve, Retained	22.5	%		1.0		ASA15-2	06/26/02 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level
ND - Not detected at the reporting limit.

TABLE C-25. Gradation Results for Entrada Sand NP10

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.:	10223RM
TEST DATE:	8-21-02
TESTED BY:	GLM
TEST METHOD:	ASTM D422
SAMPLE NO.:	NP-10 Sand
SAMPLED BY:	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT.:	
GRADATION DESCRIPTION:	

Sieve No.	Sieve Size (mm)	Wt. Retained (g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70					
0.375	9.53					
4	4.75	0.00	0.00	100.00		
8	2.36	0.73	0.25	99.75		
10	2.00					
16	1.18	0.26	0.09	99.66		
30	0.60	0.26	0.09	99.57		
40	0.43					
50	0.30	7.14	2.47	97.10		
100	0.15	157.43	54.51	42.59		
200	0.08	96.70	33.48	9.11		

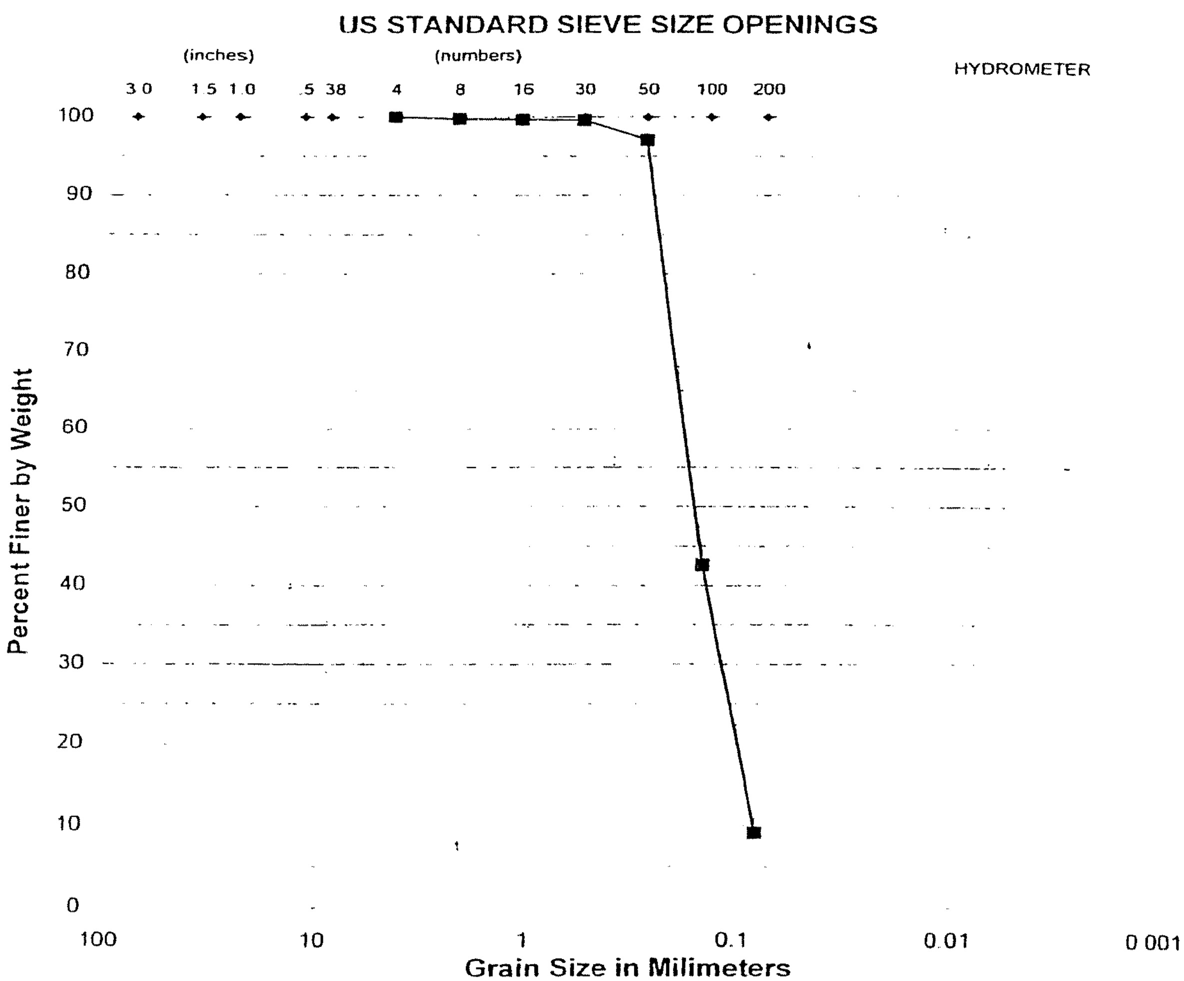
TABLE C-25. Gradation Results for Entrada Sand NP10 (continued)

PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO.: 10223RM
TEST DATE: 8-21-02
TESTED BY: GLM
TEST METHOD: ASTM C136

SAMPLE NO.: NP-10 Sand
SAMPLED BY: Client
SOURCE: On-site
SAMPLE DESCRIPTION: Reddish silty fine sand
GRADATION DESCRIPTION:



cobbles	coarse gravel	fine gravel	coarse sand	medium sand	fine sand	silt	clay

Unified Soil Classification System (ASTM D2487)

TABLE C-26. Gradation Results for Entrada Sand NP6

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.:	10223RM
TEST DATE:	8-21-02
TESTED BY:	GLM
TEST METHOD:	ASTM D422
SAMPLE NO.:	NP-6 Sand
SAMPLED BY:	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT.:	
GRADATION DESCRIPTION:	

Sieve No.	Sieve Size (mm)	Wt. Retained (g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70					
0.375	9.53					
4	4.75	0.00	0.00	100.00		
8	2.36	0.05	0.02	99.98		
10	2.00					
16	1.18	0.20	0.08	99.90		
30	0.60	4.28	1.65	98.26		
40	0.43					
50	0.30	4.40	1.69	96.57		
100	0.15	122.33	47.05	49.52		
200	0.08	95.26	36.64	12.88		

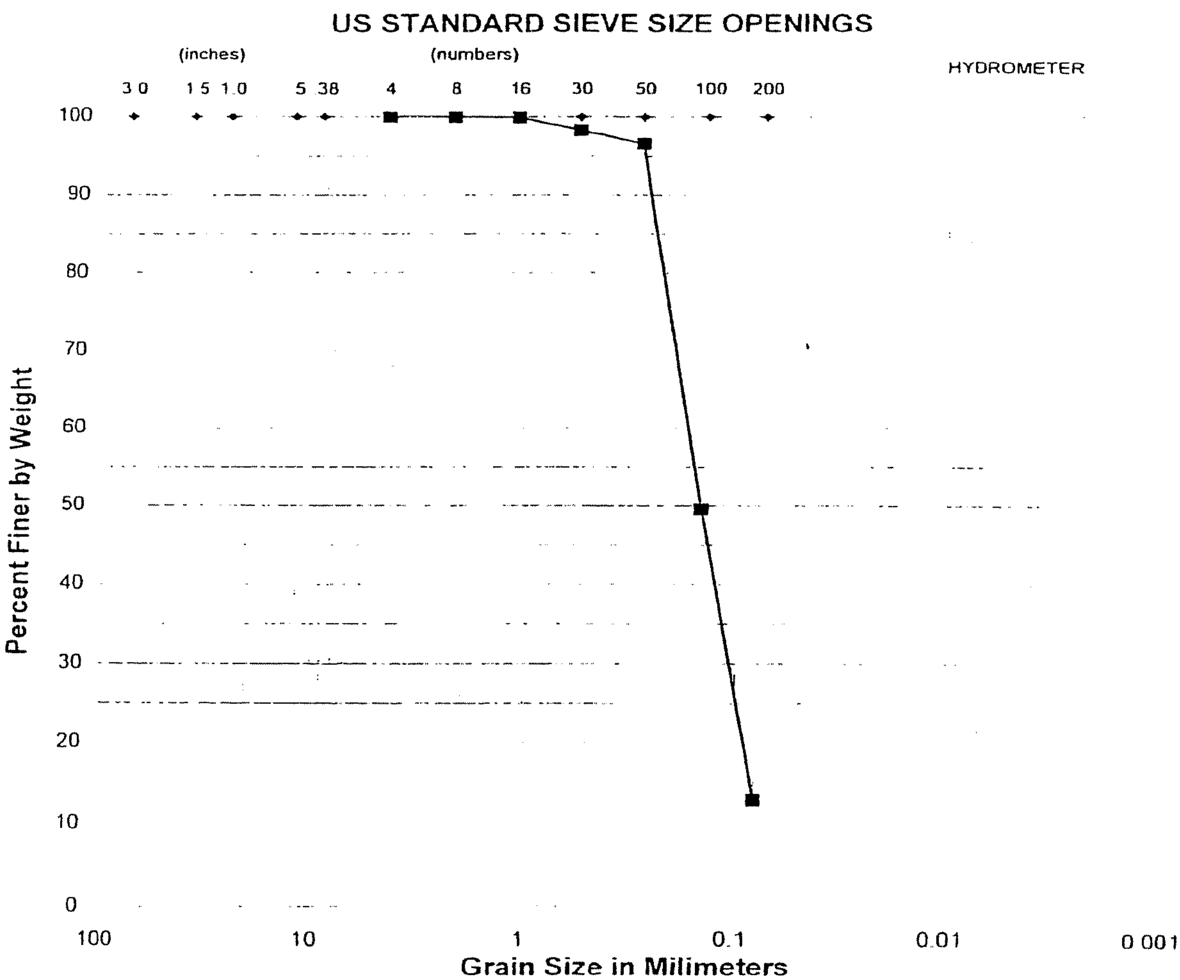
TABLE C-26. Gradation Results for Entrada Sand NP6 (continued)

PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO.: 10223RM
TEST DATE: 8-21-02
TESTED BY: GLM
TEST METHOD: ASTM C136

SAMPLE NO.: NP-6 Sand
SAMPLED BY: Client
SOURCE: On-site
SAMPLE DESCRIPTION: Reddish silty fine sand
GRADATION DESCRIPTION:



cobbles	coarse gravel	fine gravel	coarse sand	medium sand	fine sand	silt	clay

Unified Soil Classification System (ASTM D2487)

C.7 Shootaring Dam Large Rock Classification

Two 20 foot by 20 foot test areas were selected on the upstream face of the Shootaring Canyon Dam. Within each test area, the visible rocks were classified into three size categories (9 inch to 15 inch, 15 inch to 24 inch, and larger than 24 inch), and also classified by rock type. The number of smaller rocks (<9 inch) was also determined. The rock types included sandstone, andesite porphyry, and a third category currently designated as "other". An approximate weight was assumed for the average rock within each size category, and the proportion of each rock type by weight was estimated. The results of the rock classification are included in Table C-27.

TABLE C-27. Shootaring Dam Large Rock Classification

AREA 1

Rock Classification	< 9" Diameter Assume 25 pounds per rock				9" to 15" Diameter Assume 100 pounds per rock			
	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	-	-	-	-	69	48.6%	6900	15.3%
Porphyry	-	-	-	-	49	34.5%	4900	10.9%
Other	-	-	-	-	24	16.9%	2400	5.3%
Total	399	-	9975	22.2%	142	-	14200	31.6%

Rock Classification	15" to 24" Diameter Assume 400 pounds per rock				> 24" Diameter Assume 800 pounds per rock			
	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	19	47.5%	7600	16.9%	4	66.7%	3200	7.1%
Porphyry	15	37.5%	6000	13.3%	1	16.7%	800	1.8%
Other	6	15.0%	2400	5.3%	1	16.7%	100	0.2%
Total	40	-	16000	35.6%	6	-	4800	10.7%

AREA 2

Rock Classification	< 9" Diameter Assume 25 pounds per rock				9" to 15" Diameter Assume 100 pounds per rock			
	# of Rocks	% of each type in size bracket	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	-	-	-	-	28	27.2%	2800	7.4%
Porphyry	-	-	-	-	32	31.1%	3200	8.5%
Other	-	-	-	-	43	41.7%	4300	9.6%
Total	500	-	12500	33.2%	103	-	10300	27.4%

Rock Classification	15" to 24" Diameter Assume 400 pounds per rock				> 24" Diameter Assume 800 pounds per rock			
	# of Rocks	% of each type in size bracket	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	7	33.3%	2800	7.4%	3	37.5%	2400	6.4%
Porphyry	9	42.9%	3600	9.6%	2	25.0%	1600	4.3%
Other	5	23.8%	2000	4.4%	3	37.5%	300	0.7%
Total	21	-	8400	22.3%	8	-	6400	17.0%

COMBINATION OF AREAS 1 AND 2

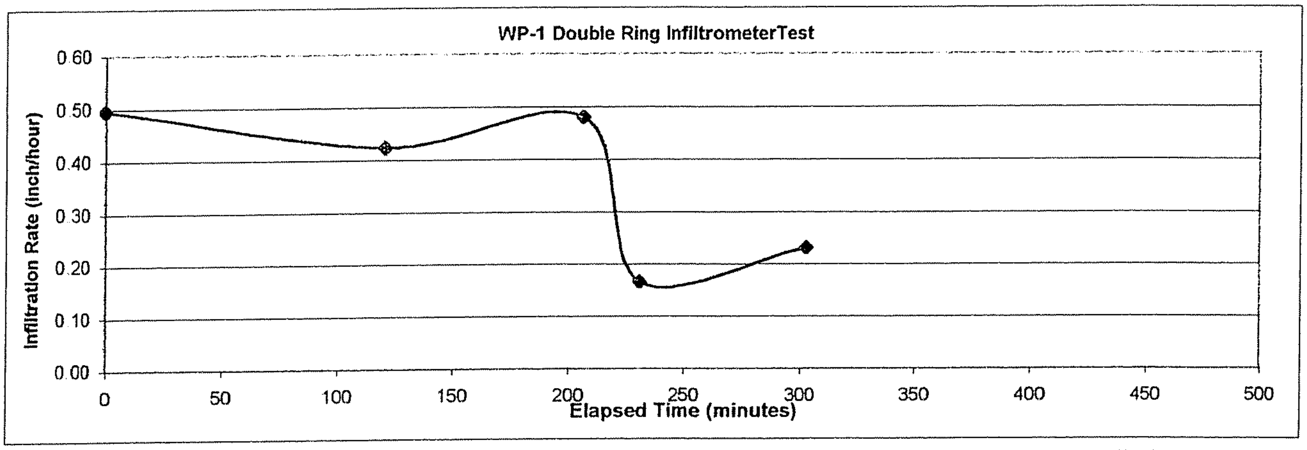
Rock Classification	< 9" Diameter Assume 25 pounds per rock				9" to 15" Diameter Assume 100 pounds per rock			
	# of Rocks	% of each type in size bracket	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	-	-	-	-	97	39.6%	9700	11.7%
Porphyry	-	-	-	-	81	33.1%	8100	9.8%
Other	-	-	-	-	67	27.3%	6700	14.9%
Total	899	-	22475	27.2%	245	-	24500	29.7%

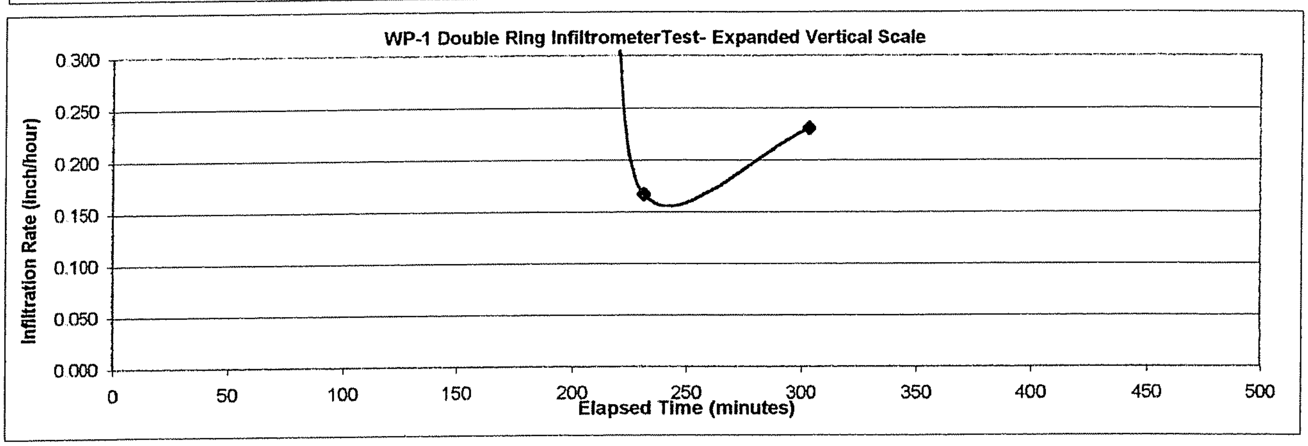
Rock Classification	15" to 24" Diameter Assume 400 pounds per rock				> 24" Diameter Assume 800 pounds per rock			
	# of Rocks	% of each type in size bracket	Total Weight of each type in size bracket	% of total sample by weight	# of Rocks	% of each type in size bracket by # of rocks	Total Weight of each type in size bracket	% of total sample by weight
Sandstone	26	42.6%	10400	12.6%	7	50.0%	5600	6.8%
Porphyry	24	39.3%	9600	11.6%	3	21.4%	2400	2.9%
Other	11	18.0%	4400	9.8%	4	28.6%	400	0.9%
Total	61	-	24400	29.5%	14	-	11200	13.6%

NOTE:

Percent Sandstone > 9" By Weight = 42.8%
Percent Porphyry > 9" By Weight = 33.4%
Percent Other > 9" By Weight = 23.8%

FIGURE C-1. INFILTROMETER TEST RESULTS FOR WP1



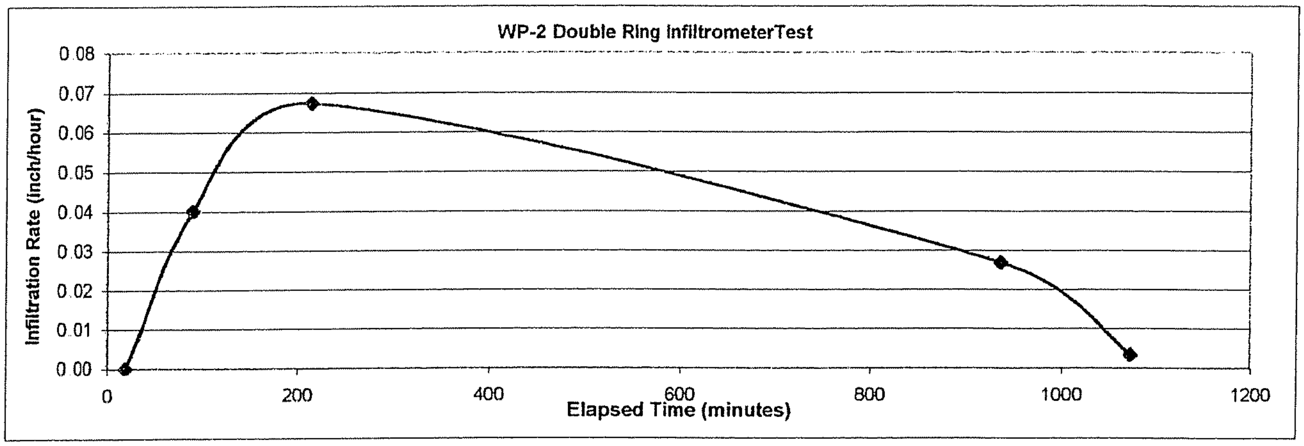


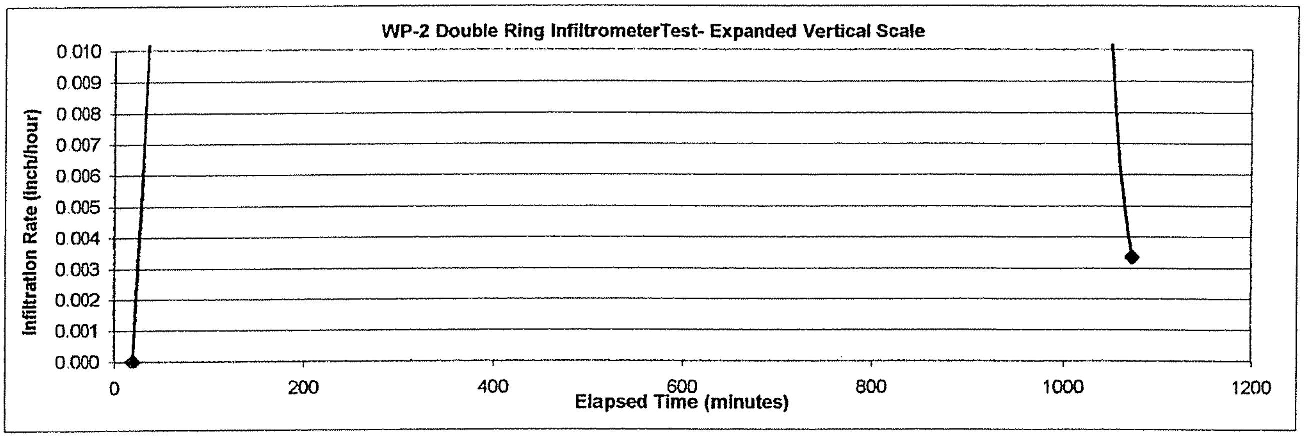
INFILTRATION TEST #1
ON CLAY IN BACKHOE PIT WP-1
INNER RING = 12-1/8" DIAMETER

DATE	TIME	VOLUME IN JUG (GAL.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INCREMENT VOLUME (GAL.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/3/02	11:21	FILLED OUTER RING						
	11:24	FIILLED INNER RING						
	11:45	HAVING PROBLEMS WITH GLUG JUG						
	11:48	2.75	0					
	13:49	2.25	121	121	0.5	**0.99191**	**0.49595**	3.50E-04
	15:14	1.95	206	85	0.3	**0.84721**	**0.42360**	2.99E-04
	15:36	1.85	231	25	0.1	**0.96017**	**0.48008**	3.39E-04
	16:51	1.75	303	72	0.1	**0.33339**	**0.16670**	1.18E-04
	19:01	1.5	433	130	0.25	**0.46162**	**0.23081**	1.63E-04
	19:10	REFILL INNER RING TO 2.3 GAL						
6/4/02	7:03	GLUG JUG FAILED OVER NIGHT 0.22' FROM TOP						
	9:29	0.22' FROM TOP						

*Note - The failure of the supply system rendered the test results unusable.
No average infiltration rate is calculated.

FIGURE C-2. INFILTROMETER TEST RESULTS FOR WP2



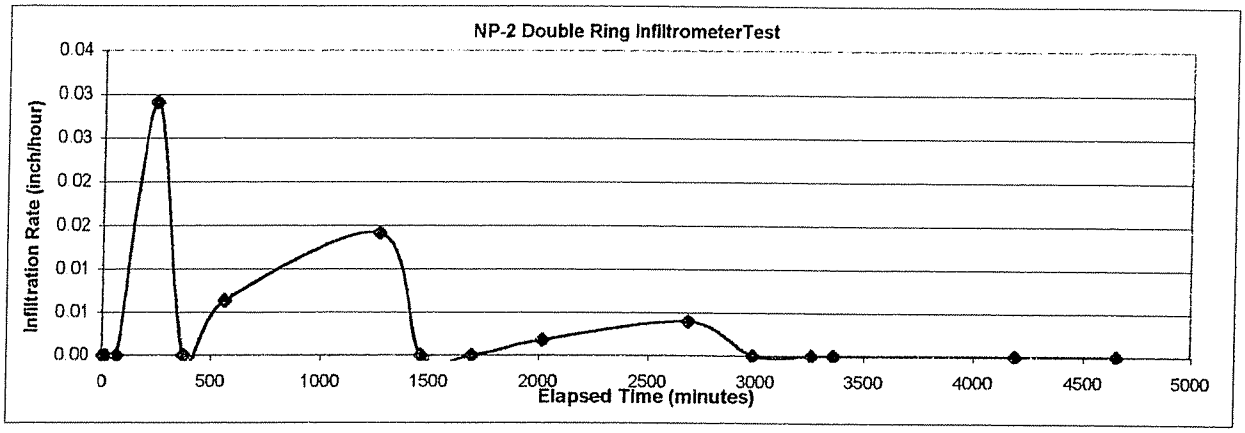


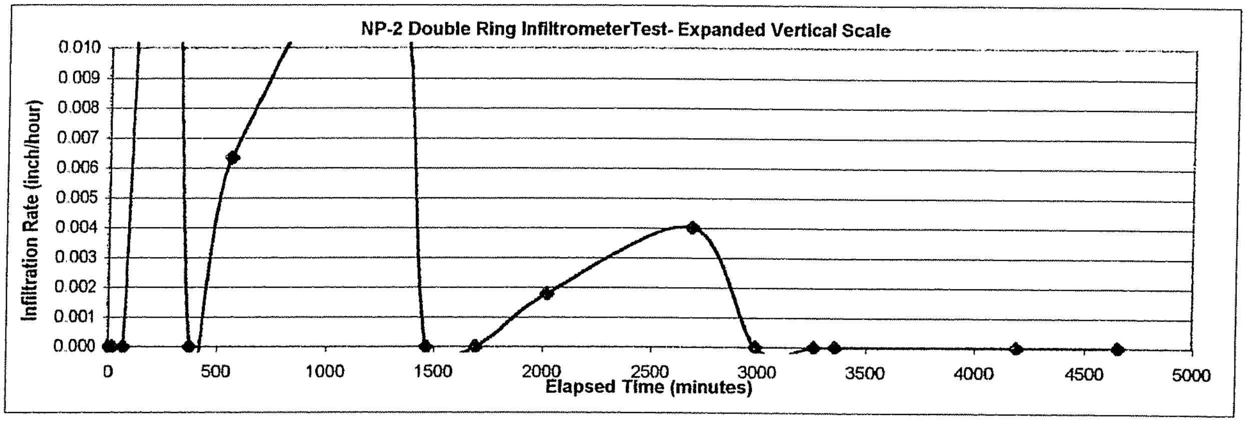
INFILTRATION TEST #2
ON CLAY IN BACKHOE PIT WP-2

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/3/02	14:27			FILLED OUTER RING				
	14:39			FILLED INNER RING				
	15:06			HAVING PROBLEMS WITH GLUG JUG				
	15:10			HAVING PROBLEMS WITH GLUG JUG				
	15:20			HAVING PROBLEMS WITH GLUG JUG				
	15:24	0.415	0	0				
	15:44	0.415	0	20	20	**0.00000**	**0.00000**	**0.00E+00**
	16:54	0.42	0.005	90	70	**0.08000**	**0.04000**	**2.82E-05**
	18:58	0.44	0.02	214	124	**0.13458**	**0.06729**	**4.75E-05**
6/4/02	7:01	0.475	0.035	937	723	**0.05379**	**0.02689**	**1.90E-05**
	9:17	0.48	0.005	1073	136	**0.00671**	**0.00336**	**2.37E-06**

Average Infiltration Rate after 1000 minutes	**0.00336**	**2.367E-06**

FIGURE C-3. INFILTROMETER TEST RESULTS FOR NP2

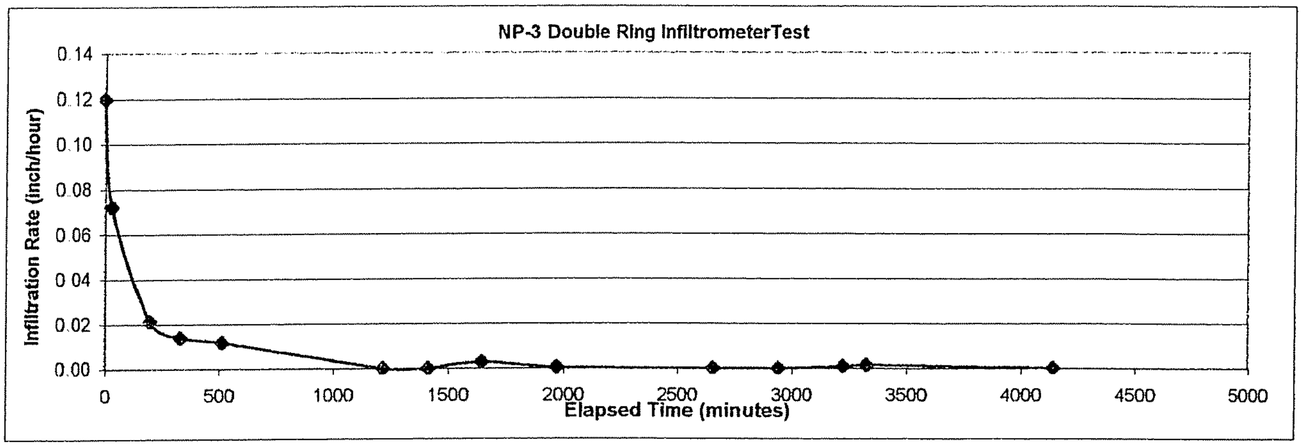


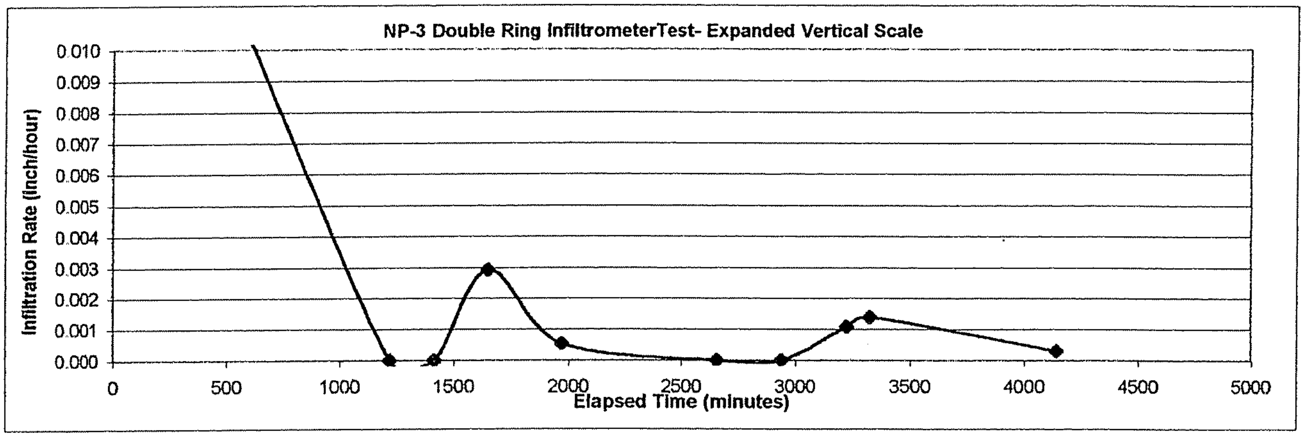


INFILTRATION TEST #3
ON CLAY IN BACKHOE PIT NP-2

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/4/02	9:43			SETTING RINGS				
	9:50			FILLED OUTER RING				
	9:54			FILLED INNER RING				
	9:56	0.59	0	0				
	10:00	0.59	0	4	4	**0.00000**	**0.00000**	0.00E+00
	10:17	0.59	0	21	17	**0.00000**	**0.00000**	0.00E+00
	11:09	0.59	0	73	52	**0.00000**	**0.00000**	0.00E+00
	14:03	0.6	0.01	247	174	**0.05830**	**0.02915**	2.06E-05
	16:16	0.6	0	380	133	**0.00000**	**0.00000**	0.00E+00
	19:22	0.605	0.005	566	186	**0.01272**	**0.00636**	4.49E-06
6/5/02	7:08	0.63	0.025	1272	706	**0.02830**	**0.01415**	9.98E-06
	10:23	0.63	0	1467	195	**0.00000**	**0.00000**	0.00E+00
	14:15	0.63	0	1699	232	**0.00000**	**0.00000**	0.00E+00
	19:37	0.635	0.005	2021	322	**0.00356**	**0.00178**	1.26E-06
6/6/02	6:50	0.65	0.015	2694	673	**0.00802**	**0.00401**	2.83E-06
	11:48	0.65	0	2992	298	**0.00000**	**0.00000**	0.00E+00
	16:20	0.65	0	3264	272	**0.00000**	**0.00000**	0.00E+00
	18:01	0.65	0	3365	101	**0.00000**	**0.00000**	0.00E+00
6/7/02	7:48	0.65	0	4192.2	827.2	**0.00000**	**0.00000**	0.00E+00
	15:36	0.65	0	4660	467.8	**0.00000**	**0.00000**	0.00E+00
				Average Infiltration Rate after 1500 minutes			0.00072	5.107E-07

FIGURE C-4. INFILTROMETER TEST RESULTS FOR NP3

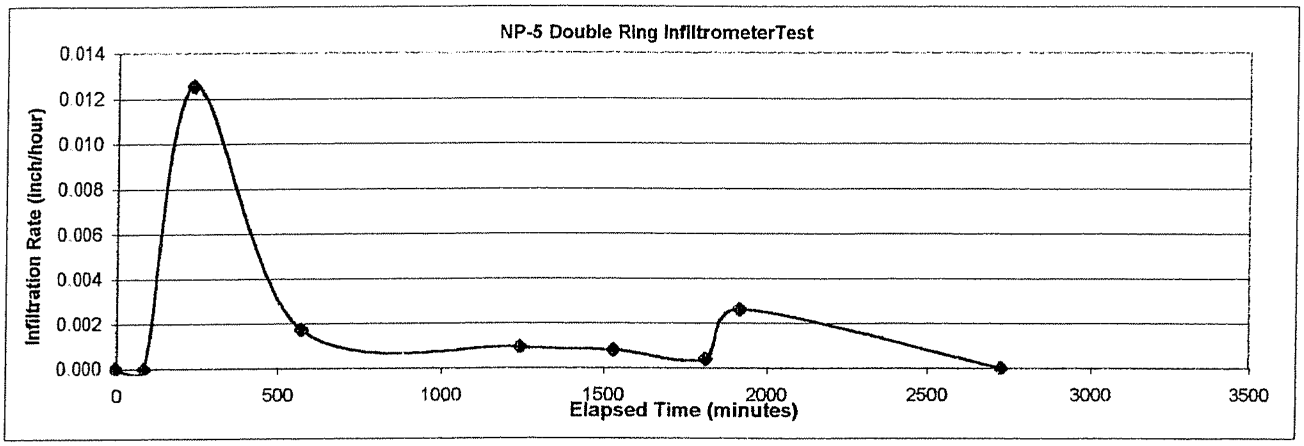


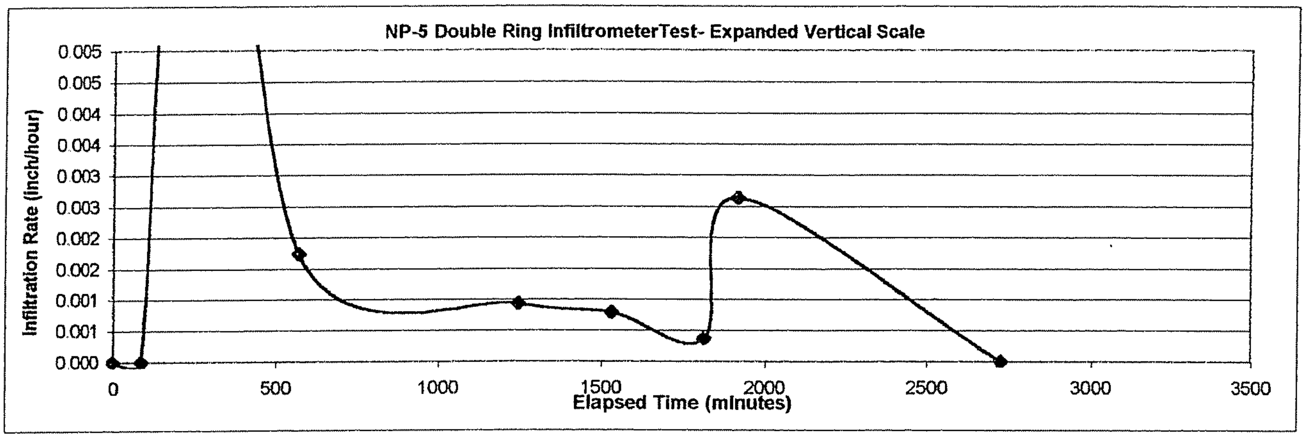


INFILTRATION TEST #4
ON CLAY IN BACKHOE PIT NP-3

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/4/02	10:24			SETTING RINGS				
	10:40			FILLED INNER RING				
	10:43	0.495	0	0				
	11:13	0.5	0.005	30	30	**0.24000**	**0.12000**	**8.47E-05**
	14:02	0.52	0.02	199	169	**0.14472**	**0.07236**	**5.11E-05**
	16:18	0.53	0.01	335	136	**0.04299**	**0.02149**	**1.52E-05**
	19:20	0.54	0.01	517	182	**0.02785**	**0.01393**	**9.83E-06**
6/5/02	7:04	0.56	0.02	1221	704	**0.02359**	**0.01179**	**8.32E-06**
	10:21	0.56	0	1418	197	**0.00000**	**0.00000**	**0.00E+00**
	14:12	0.56	0	1649	231	**0.00000**	**0.00000**	**0.00E+00**
	19:35	0.568	0.008	1972	323	**0.00584**	**0.00292**	**2.06E-06**
6/6/02	7:04	0.57	0.002	2661	689	**0.00108**	**0.00054**	**3.82E-07**
	11:47	0.57	0	2944	283	**0.00000**	**0.00000**	**0.00E+00**
	16:32	0.57	0	3229	285	**0.00000**	**0.00000**	**0.00E+00**
	18:12	0.575	0.005	3329	100	**0.00216**	**0.00108**	**7.63E-07**
6/7/02	7:46	0.583	0.008	4143	814	**0.00278**	**0.00139**	**9.81E-07**
	15:29	0.585	0.002	4606	463	**0.00063**	**0.00031**	**2.21E-07**
				Average Infiltration Rate after 1200 minutes			0.00069	**4.897E-07**

FIGURE C-5. INFILTROMETER TEST RESULTS FOR NP5



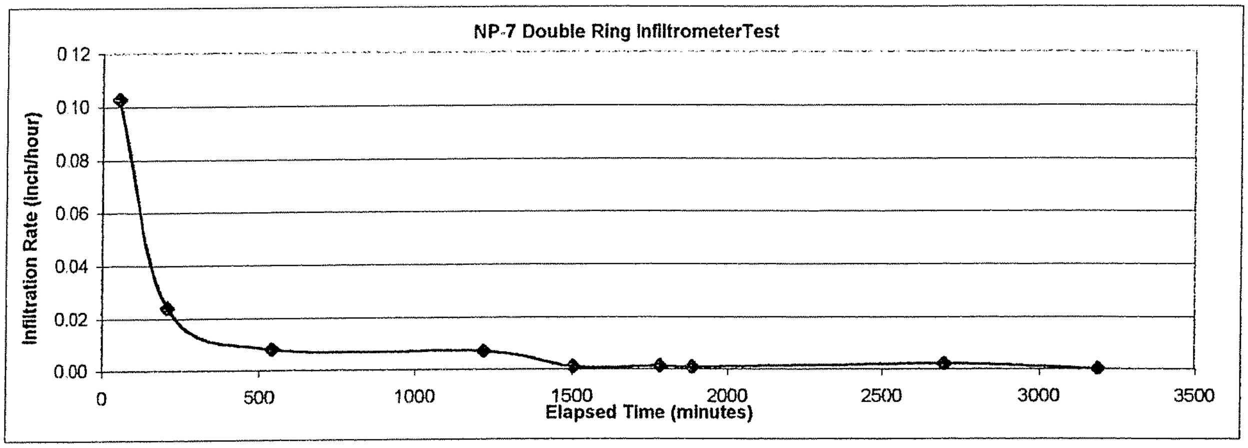


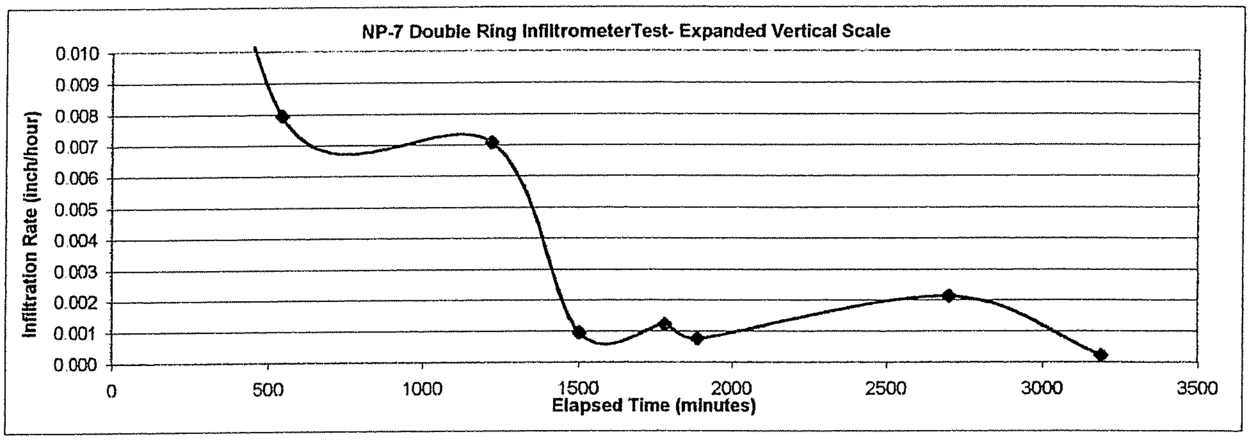
INFILTRATION TEST #5
ON CLAY IN BACKHOE PIT NP-5

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	9:55			SETTING RINGS				
	10:00			FILLED INNER RING				
	10:07	0.135	0	0				
	11:34	0.135	0	87	87	**0.00000**	**0.00000**	**0.00E+00**
	14:03	0.135	0	236	149	**0.00000**	**0.00000**	**0.00E+00**
	19:40	0.145	0.01	573	337	**0.02513**	**0.01257**	**8.87E-06**
6/6/02	6:55	0.148	0.003	1248	675	**0.00346**	**0.00173**	**1.22E-06**
	11:40	0.15	0.002	1533	285	**0.00188**	**0.00094**	**6.63E-07**
	16:24	0.152	0.002	1817	284	**0.00159**	**0.00079**	**5.59E-07**
	18:04	0.153	0.001	1917	100	**0.00075**	**0.00038**	**2.65E-07**
6/7/02	7:36	0.163	0.01	2729	812	**0.00528**	**0.00264**	**1.86E-06**
	15:45	0.163	0	3218	489	**0.00000**	**0.00000**	**0.00E+00**

Average Infiltration Rate after 1000 minutes **0.00108** **7.616E-07**

FIGURE C-6. INFILTROMETER TEST RESULTS FOR NP7



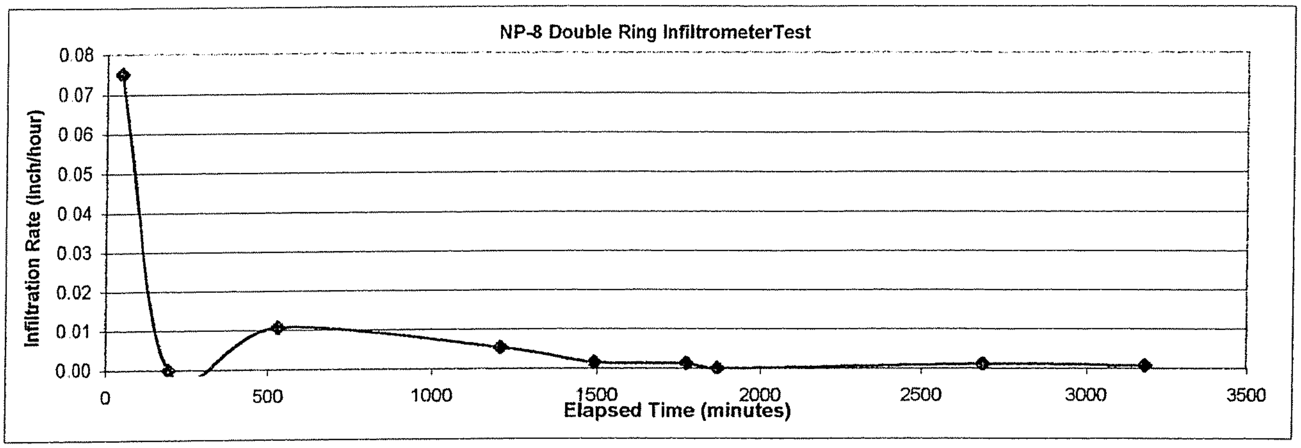


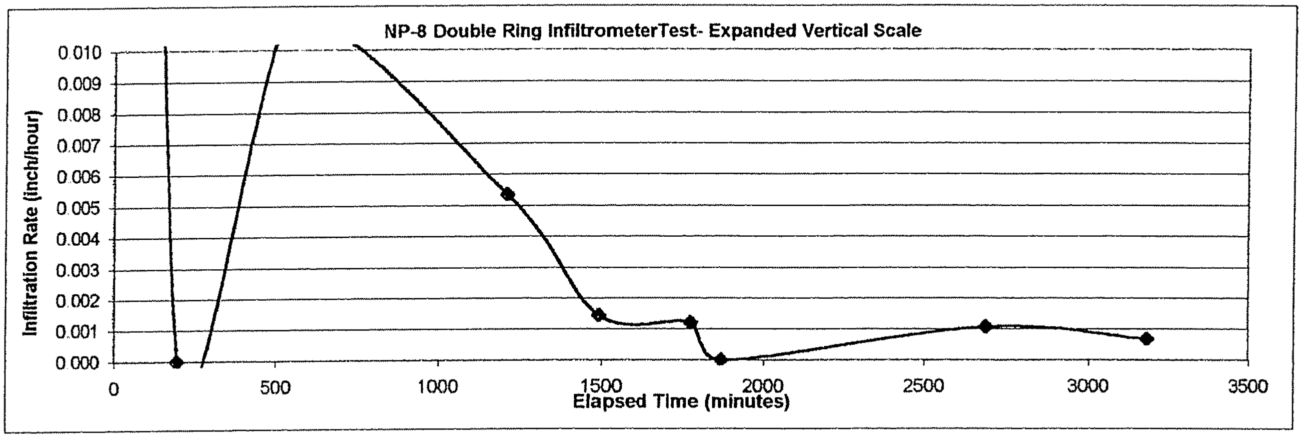
INFILTRATION TEST #6
ON CLAY IN BACKHOE PIT NP-7

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	10:35			SETTING RINGS				
	10:39			FILLED INNER RING				
	10:40	0.155	0	0				
	11:36	0.163	0.008	56	56	**0.20571**	**0.10286**	**7.26E-05**
	14:09	0.17	0.007	209	153	**0.04823**	**0.02411**	**1.70E-05**
	19:44	0.176	0.006	544	335	**0.01588**	**0.00794**	**5.60E-06**
6/6/02	7:02	0.188	0.012	1222	678	**0.01414**	**0.00707**	**4.99E-06**
	11:45	0.19	0.002	1505	283	**0.00191**	**0.00096**	**6.75E-07**
	16:25	0.193	0.003	1785	280	**0.00242**	**0.00121**	**8.54E-07**
	18:10	0.195	0.002	1890	105	**0.00152**	**0.00076**	**5.38E-07**
6/7/02	7:43	0.203	0.008	2703	813	**0.00426**	**0.00213**	**1.50E-06**
	15:50	0.204	0.001	3190	487	**0.00045**	**0.00023**	**1.59E-07**

Average Infiltration Rate after 1500 minutes 0.00106 7.458E-07

FIGURE C-7. INFILTROMETER TEST RESULTS FOR NP8



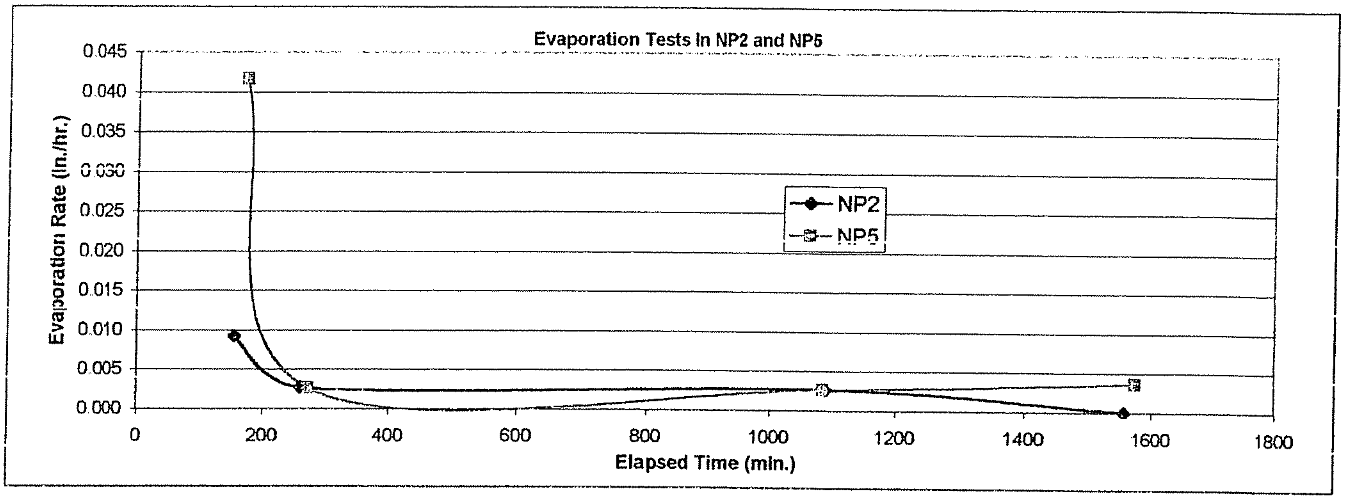


INFILTRATION TEST #7
ON CLAY IN BACKHOE PIT NP-8

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	10:40			SETTING RINGS				
	10:46			FILLED INNER RING				
	10:50	0.14	0	0				
	11:38	0.145	0.005	48	48	**0.15000**	**0.07500**	5.29E-05
	14:07	0.145	0	197	149	**0.00000**	**0.00000**	0.00E+00
	19:43	0.153	0.008	533	336	**0.02161**	**0.01081**	7.62E-06
6/6/02	7:00	0.162	0.009	1210	677	**0.01071**	**0.00536**	3.78E-06
	11:44	0.165	0.003	1494	284	**0.00289**	**0.00145**	1.02E-06
	16:27	0.168	0.003	1777	283	**0.00243**	**0.00122**	8.58E-07
	18:03	0.168	0	1873	96	**0.00000**	**0.00000**	0.00E+00
6/7/02	7:41	0.172	0.004	2691	818	**0.00214**	**0.00107**	7.55E-07
	15:55	0.175	0.003	3185	494	**0.00136**	**0.00068**	4.78E-07

Average Infiltration Rate after 1400 minutes 0.00088 6.223E-07

FIGURE C-8. EVAPORATION TEST RESULTS FOR NP2 AND NP5



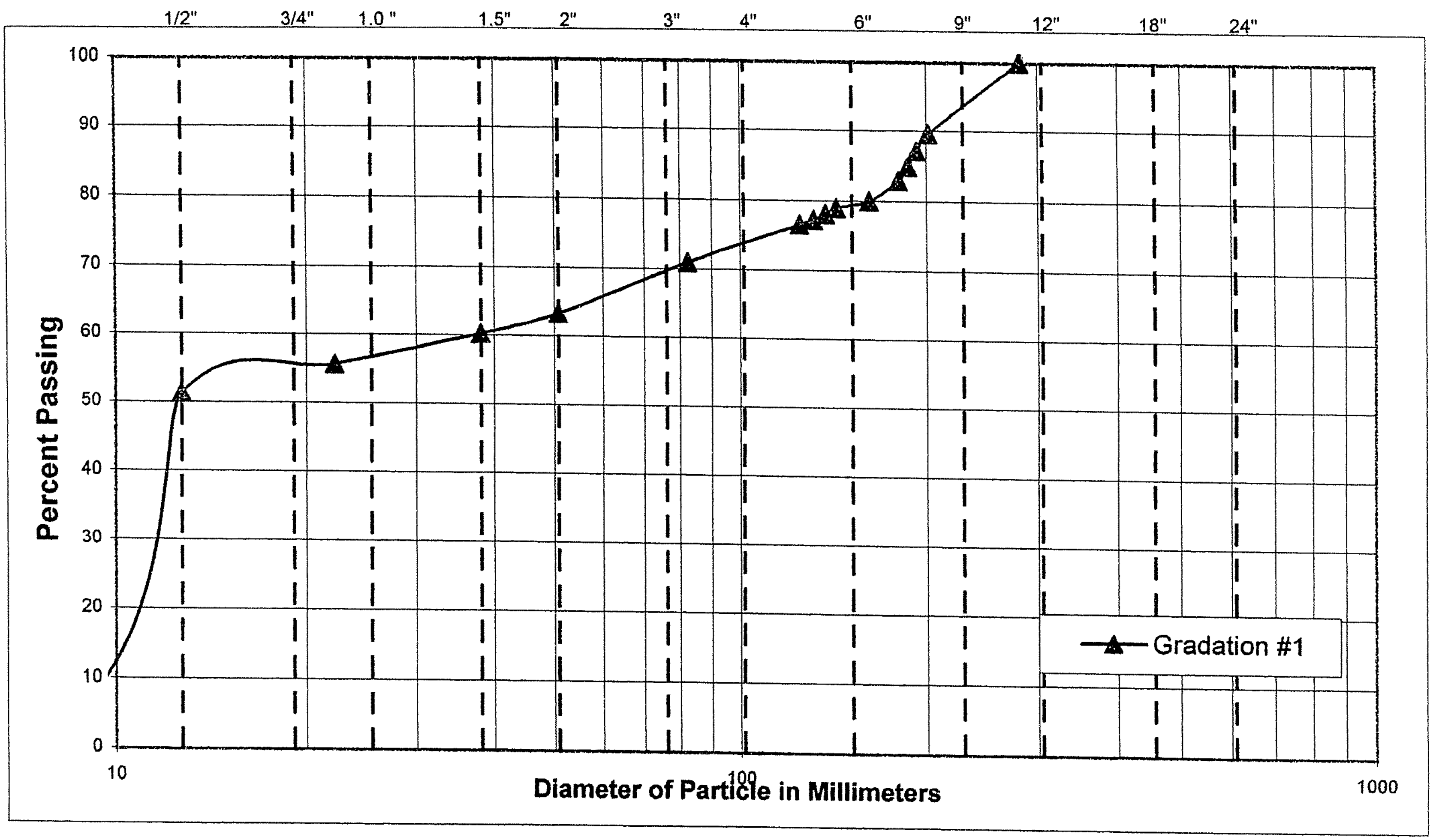
EVAPORATION TEST #1
IN BACKHOE PIT NP-2

DATE	TIME	DEPTH TO WATER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	EVAPORATION RATE (FT/DAY)	EVAPORATION RATE (IN/HR)	EVAPORATION RATE (CM/SEC)
6/6/02	13:38	0.145	0	0				
	16:14	0.147	0.002	156	156	**0.01846**	**0.00923**	**6.51E-06**
	18:00	0.148	0.001	262	106	**0.00550**	**0.00275**	**1.94E-06**
6/7/02	7:48	0.152	0.004	1090	828	**0.00528**	**0.00264**	**1.86E-06**
	15:35	0.152	0	1557	467	**0.00000**	**0.00000**	**0.00E+00**
					Average Evaporation Rate -		**0.00366**	**2.579E-06**

EVAPORATION TEST #2
IN BACKHOE PIT NP-5

DATE	TIME	DEPTH TO WATER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	EVAPORATION RATE (FT/DAY)	EVAPORATION RATE (IN/HR)	EVAPORATION RATE (CM/SEC)
6/6/02	13:30	0.152	0	0				
	16:23	0.162	0.01	173	173	**0.08324**	**0.04162**	**2.94E-05**
	18:03	0.163	0.001	273	100	**0.00527**	**0.00264**	**1.86E-06**
6/7/02	7:36	0.167	0.004	1086	813	**0.00530**	**0.00265**	**1.87E-06**
	15:44	0.175	0.008	1574	488	**0.00732**	**0.00366**	**2.58E-06**
					Average Evaporation Rate -		**0.01264**	**8.920E-06**

FIGURE C-9. GRADATION TEST RESULTS FOR SOIL COVER SAMPLE RSC1



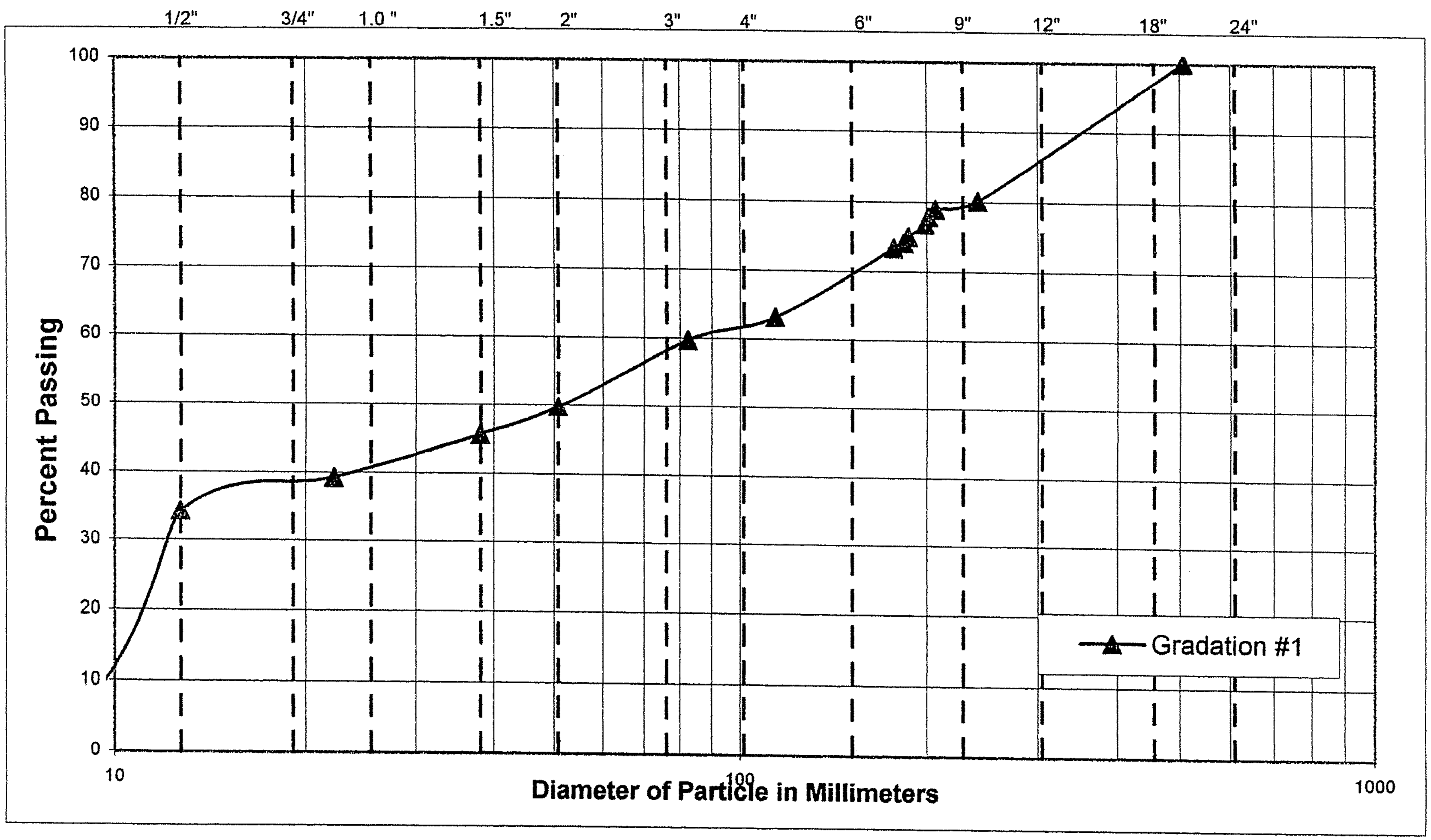
	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.323	0.37	0.49	4.45	11.08

Shape Factor 1.00 Assumed Sp. Wt. 165

Gradation D50- 0.493

Sample Weight 894

FIGURE C-10. GRADATION TEST RESULTS FOR SOIL COVER SAMPLE RSC2



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.359	0.43	2.04	7.37	20.00

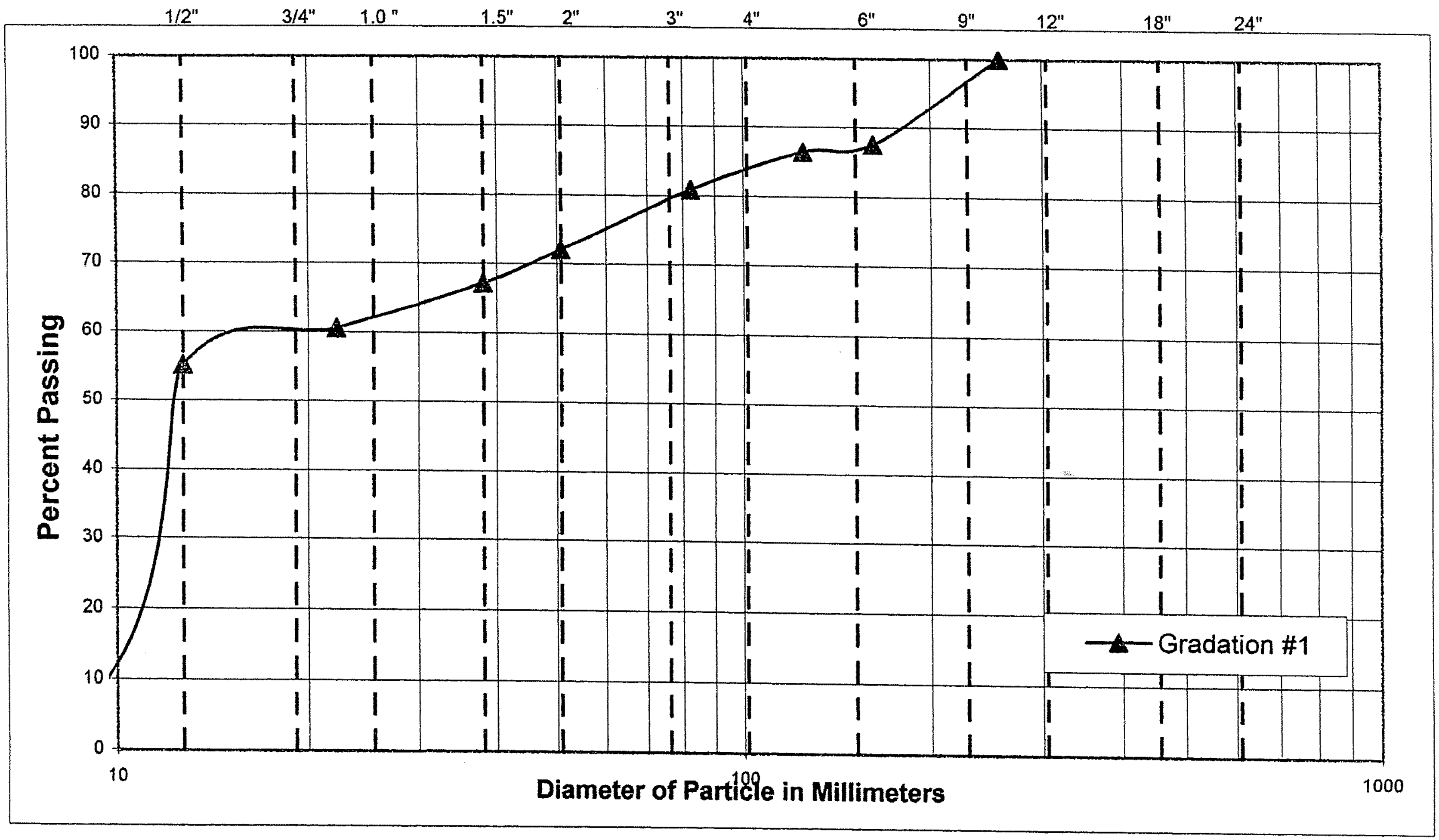
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 2.036

Sample Weight 2235

FIGURE C-11. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU1



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.318	0.36	0.48	2.41	10.13

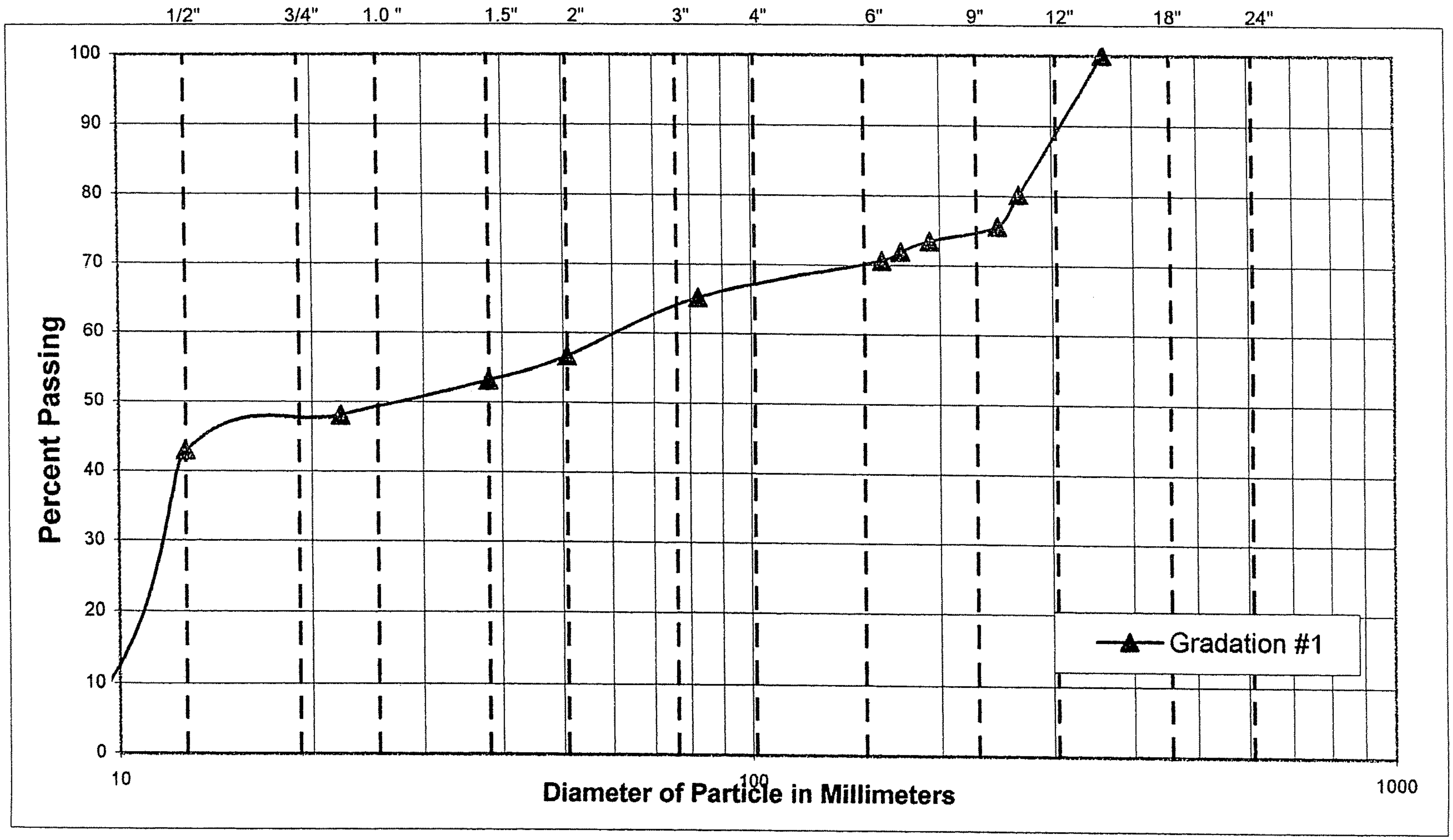
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 0.476

Sample Weight 523

FIGURE C-12. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU2



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.337	0.40	1.11	9.05	14.23

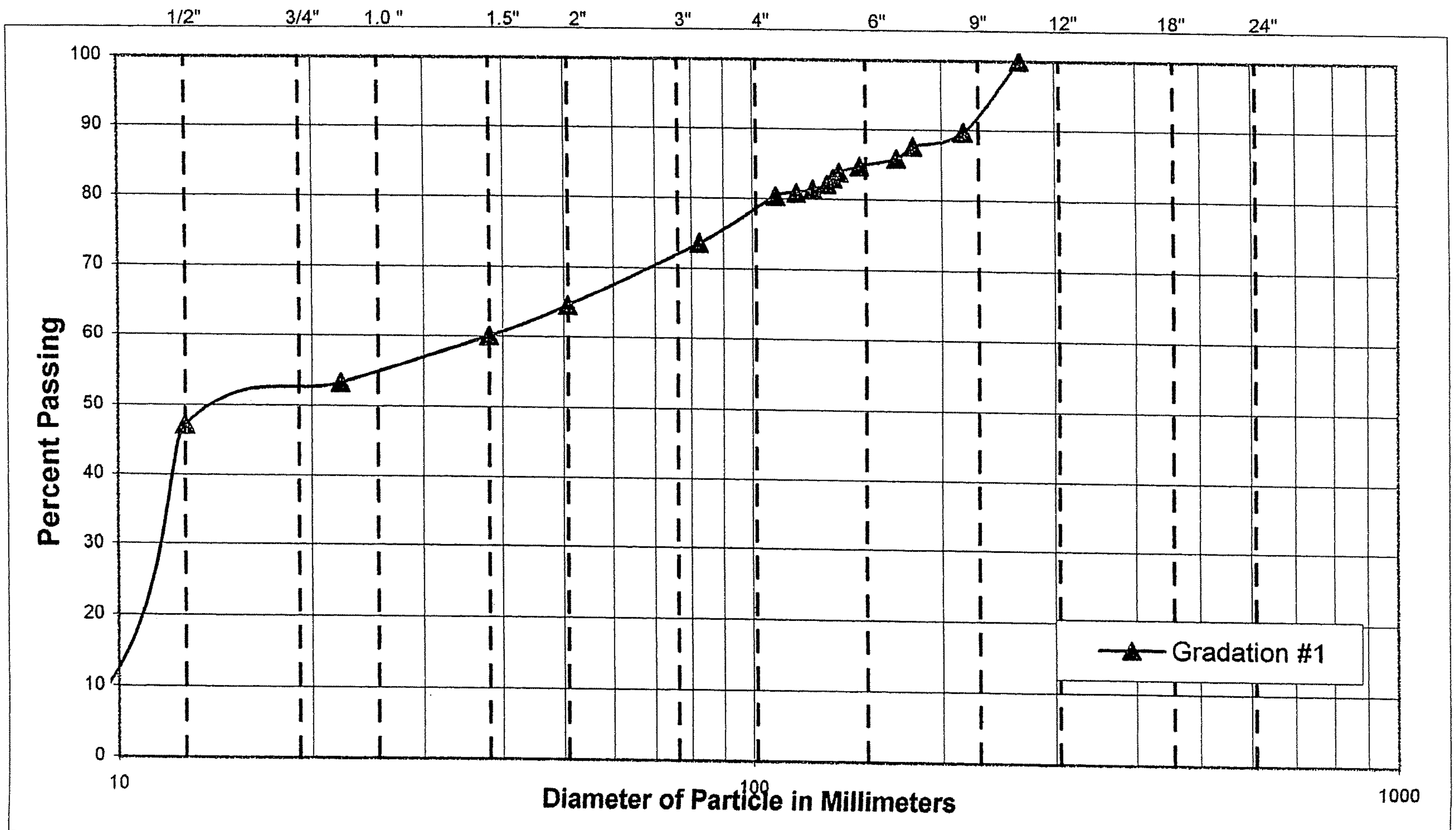
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 1.111

Sample Weight 1020

FIGURE C-13. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU3



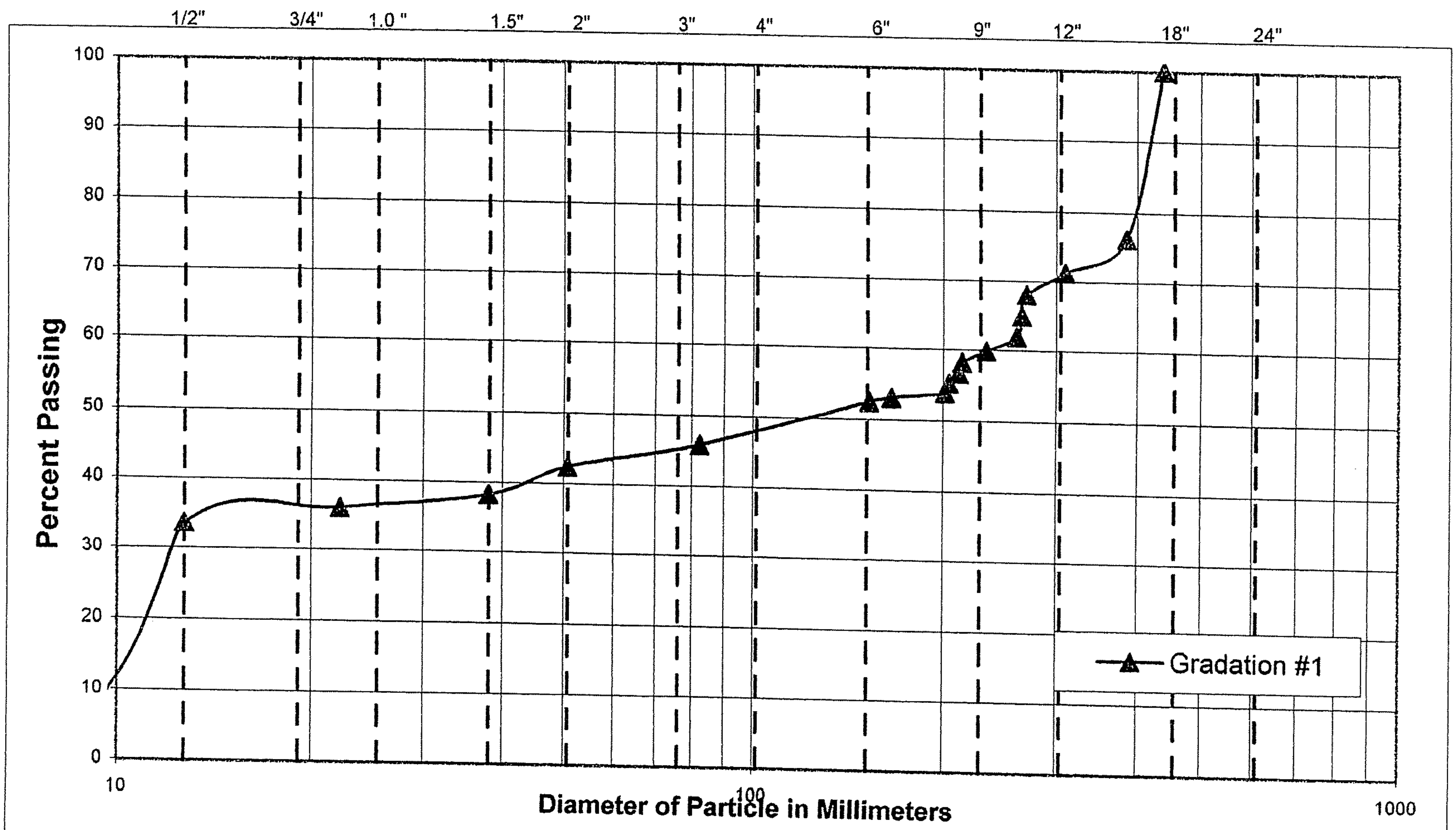
	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.330	0.38	0.68	3.47	10.45

Shape Factor 1.00 Assumed Sp. Wt. 165

Gradation D50- 0.675

Sample Weight 858.5

FIGURE C-14. GRADATION TEST RESULTS FOR TAILINGS DAM ROCK SAMPLE DS1



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.361	0.44	4.99	14.42	17.33

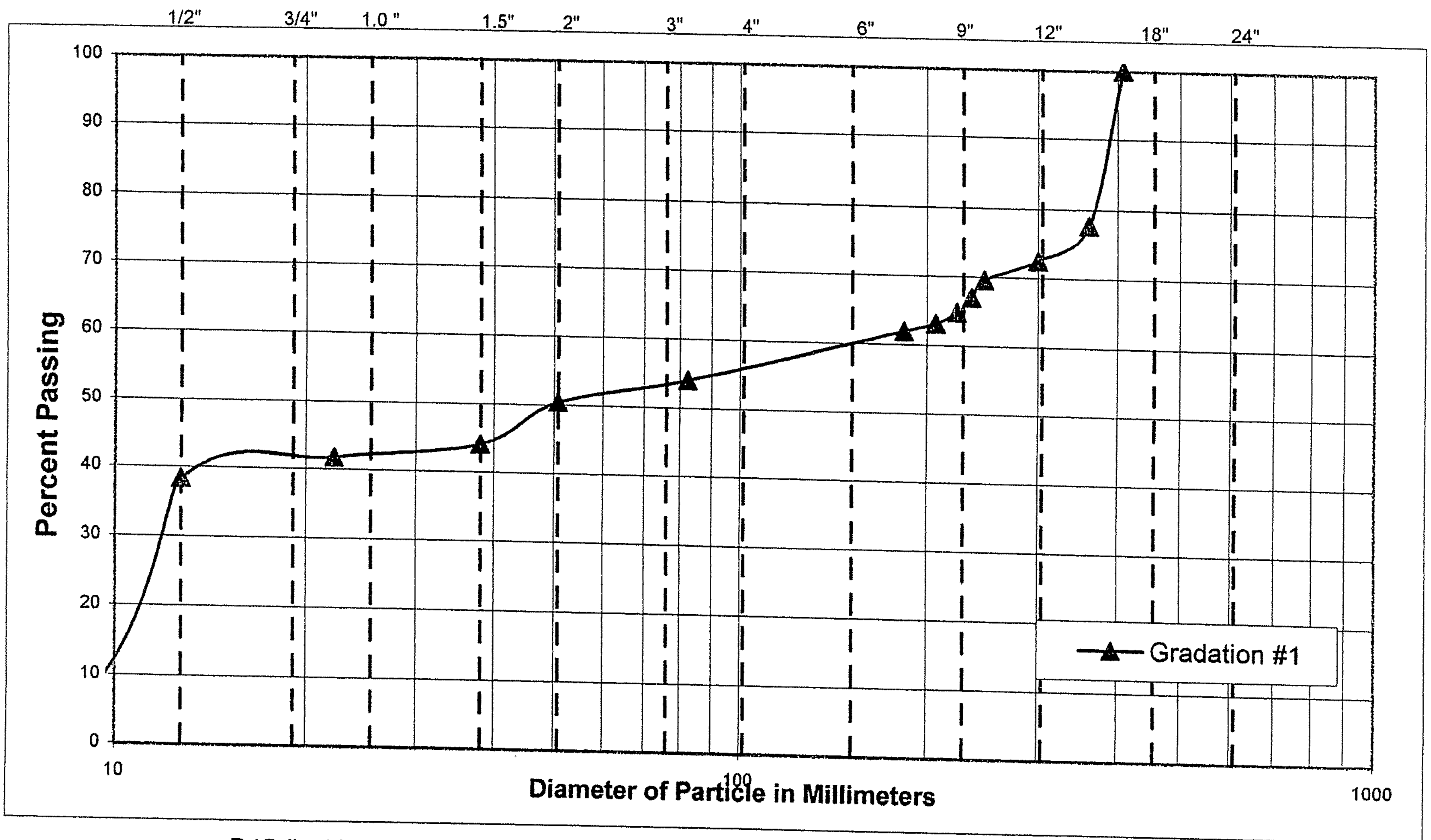
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 4.989

Sample Weight 1833

FIGURE C-15. GRADATION TEST RESULTS FOR TAILINGS DAM ROCK SAMPLE DS2



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.348	0.41	1.97	12.99	16.08

Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 1.965

Sample Weight 1580

ATTACHMENT C

ALTERNATE CLAY SOURCE PHYSICAL PROPERTIES

ATTACHMENT C

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C.1 Permeability, Atterbert Limits, Gradation and Moisture-Density for the Alternate Clay Source
by Inberg-Miller Engineers, September 20, 2005

RIVERTON . CASPER . CHEYENNE
POWELL . GREEN RIVER

INBERG-MILLER ENGINEERS

QUALITY SOLUTIONS THROUGH TEAMWORK

September 20, 2005

10223-RM

RECEIVED
SEP 21 2005

Mr. Fred Craft
U.S. Energy Corporation
877 North 8th West
Riverton, WY 82501

RE: SOIL TEST RESULTS
SHOOTERING CANYON MILL PROJECT

Dear Fred:

This letter transmits the results of laboratory testing that we performed on a sample of claystone that you submitted to our Riverton, Wyoming laboratory.

Specifically, you requested that we perform classification tests consisting of Moisture-Density Relationship (Standard Proctor), Atterberg-Limits, and Particle Size Analysis on 2 sub-samples of the claystone that you submitted. Further, you requested permeability testing on 3 specimens re-molded from the claystone.

The claystone as submitted was hard, dry, and shale-like. The claystone rapidly softened when submerged in water. The tests were performed on the claystone after it was softened to a soil-like consistency.

Refer to the attached test results. Note that the progress of permeability testing was slow due to the low permeability of the remolded claystone (which had been remolded to 95 percent of the ASTM D698 maximum dry density). The permeability tests were terminated when the volume of water measured passing through the sample was determined to represent permeability on the order of 10^{-8} centimeters/second or less.

Please call if you have any questions or require further information.

Sincerely,

INBERG-MILLER ENGINEERS

Glen M. Bobnick, P.E.
Geotechnical Engineer
Riverton Office

Enclosures as stated

124 East Main Street
Riverton, WY 82501
307-856-8136
307-856-3851 (fax)
riverton@inberg-miller.com

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Casper, WY 82601
307-577-0806
307-472-4402 (fax)
casper@inberg-miller.com

350 Parsley Boulevard
Cheyenne, WY 82007
307-635-6827
307-635-2713 (fax)
cheyenne@inberg-miller.com

428 Alan Road
Powell, WY 82435
307-754-7170
307-754-7088 (fax)
powell@inberg-miller.com

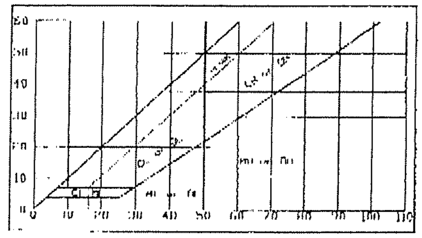
520 Wilkes Drive, Suite 13
Green River, WY 82935
307-875-4394
307-875-4395 (fax)
greenriver@inberg-miller.com

ATTERBERG LIMITS TEST

INBERG-MILLER ENGINEERS

ASTM D4318

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon Mill
JOB NO.:	10223 RM
TEST DATE:	6-3-05
TESTED BY:	DAL
SAMPLE NOS:	Sec. 16, A & C
SAMPLED BY:	Client
SOURCE:	Site Soil



SAMPLE NO. A	Plastic (Y/N)?	Y			
PLASTIC LIMIT INFORMATION			**LIQUID LIMIT INFORMATION**		
TRIAL NO.:	1	2	1	2	3
Tare (Pan) No.:	2P		3L		
Tare (Pan) Wt.:	13.83		23.58		
Tare + Wet Soil Wt.:	17.81		45.5		
Tare + Dry Soil Wt.:	16.92		35.14		
No. of Blows:			25		
PERCENT MOISTURE:	28.80%		89.62%		
AVERAGE MOISTURE:	28.80%		89.62%		

TEST RESULTS	
LIQUID LIMIT:	90
PLASTIC LIMIT:	29
PLASTIC INDEX:	61
USCS CLASSIFICATION:	CH
ERROR MESSAGES	

SAMPLE NO. C	Plastic (Y/N)?	Y			
PLASTIC LIMIT INFORMATION			**LIQUID LIMIT INFORMATION**		
TRIAL NO.:	1	2	1	2	3
Tare (Pan) No.:	6		6L		
Tare (Pan) Wt.:	14.35		23.76		
Tare + Wet Soil Wt.:	17.51		48.1		
Tare + Dry Soil Wt.:	16.82		36.64		
No. of Blows:			28		
PERCENT MOISTURE:	27.94%		90.20%		
AVERAGE MOISTURE:	27.94%		90.20%		

TEST RESULTS	
LIQUID LIMIT:	90
PLASTIC LIMIT:	28
PLASTIC INDEX:	62
USCS CLASSIFICATION:	CH
ERROR MESSAGES	

SAMPLE NO.	Plastic (Y/N)?				
PLASTIC LIMIT INFORMATION			**LIQUID LIMIT INFORMATION**		
TRIAL NO.:	1	2	1	2	3
Tare (Pan) No.:					
Tare (Pan) Wt.:					
Tare + Wet Soil Wt.:					
Tare + Dry Soil Wt.:					
No. of Blows:					
PERCENT MOISTURE:					
AVERAGE MOISTURE:					

TEST RESULTS	
LIQUID LIMIT:	
PLASTIC LIMIT:	
PLASTIC INDEX:	
USCS CLASSIFICATION:	
ERROR MESSAGES	

SAMPLE NO.	Plastic (Y/N)?				
PLASTIC LIMIT INFORMATION			**LIQUID LIMIT INFORMATION**		
TRIAL NO.:	1	2	1	2	3
Tare (Pan) No.:					
Tare (Pan) Wt.:					
Tare + Wet Soil Wt.:					
Tare + Dry Soil Wt.:					
No. of Blows:					
PERCENT MOISTURE:					
AVERAGE MOISTURE:					

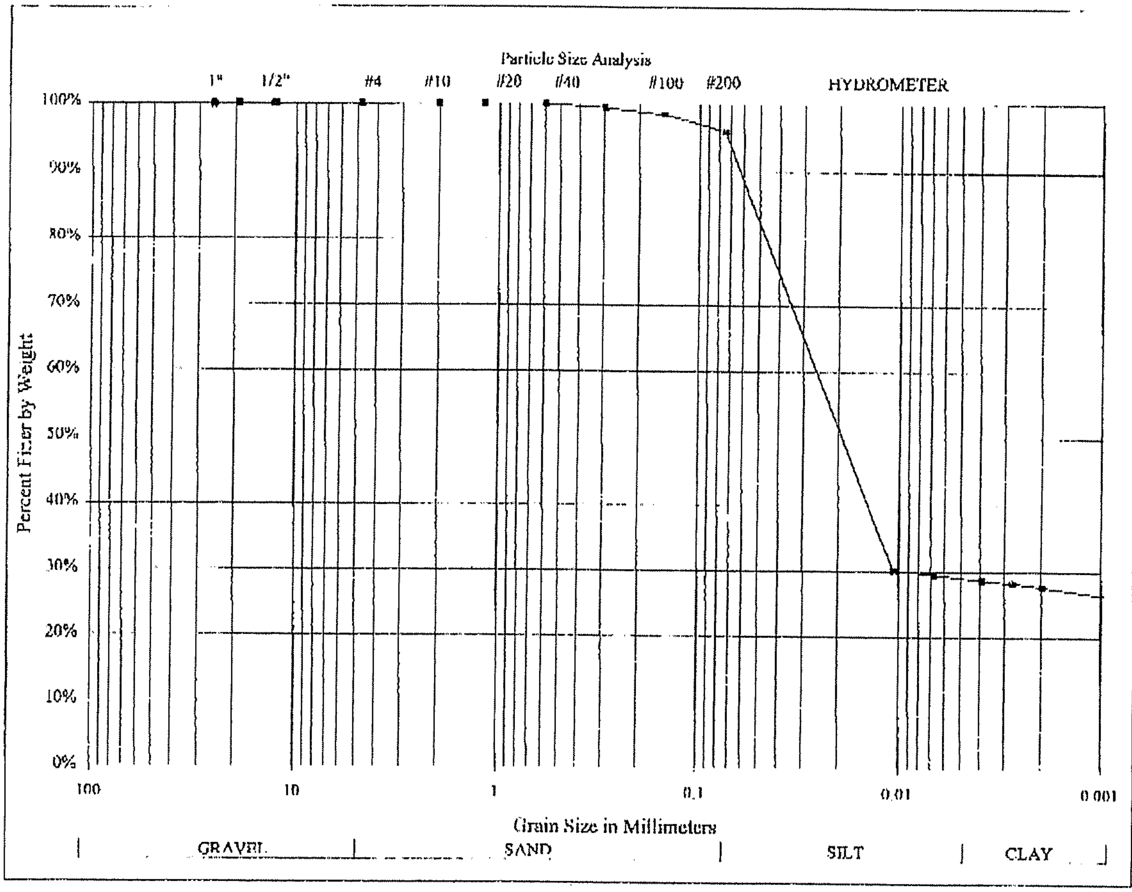
TEST RESULTS	
LIQUID LIMIT:	
PLASTIC LIMIT:	
PLASTIC INDEX:	
USCS CLASSIFICATION:	
ERROR MESSAGES	

SAMPLE NO.	Plastic (Y/N)?				
PLASTIC LIMIT INFORMATION			**LIQUID LIMIT INFORMATION**		
TRIAL NO.:	1	2	1	2	3
Tare (Pan) No.:					
Tare (Pan) Wt.:					
Tare + Wet Soil Wt.:					
Tare + Dry Soil Wt.:					
No. of Blows:					
PERCENT MOISTURE:					
AVERAGE MOISTURE:					

TEST RESULTS	
LIQUID LIMIT:	
PLASTIC LIMIT:	
PLASTIC INDEX:	
USCS CLASSIFICATION:	
ERROR MESSAGES	

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO :	C	DATE RECEIVED:	5/6/1998
CLIENT:	U.S. Energy	TYPE OF SAMPLE	Bulk
CLIENT SAMPLE NO.:	Sec. 16 Site Soil		
SOIL DESCRIPTION:	Shale/Clay		

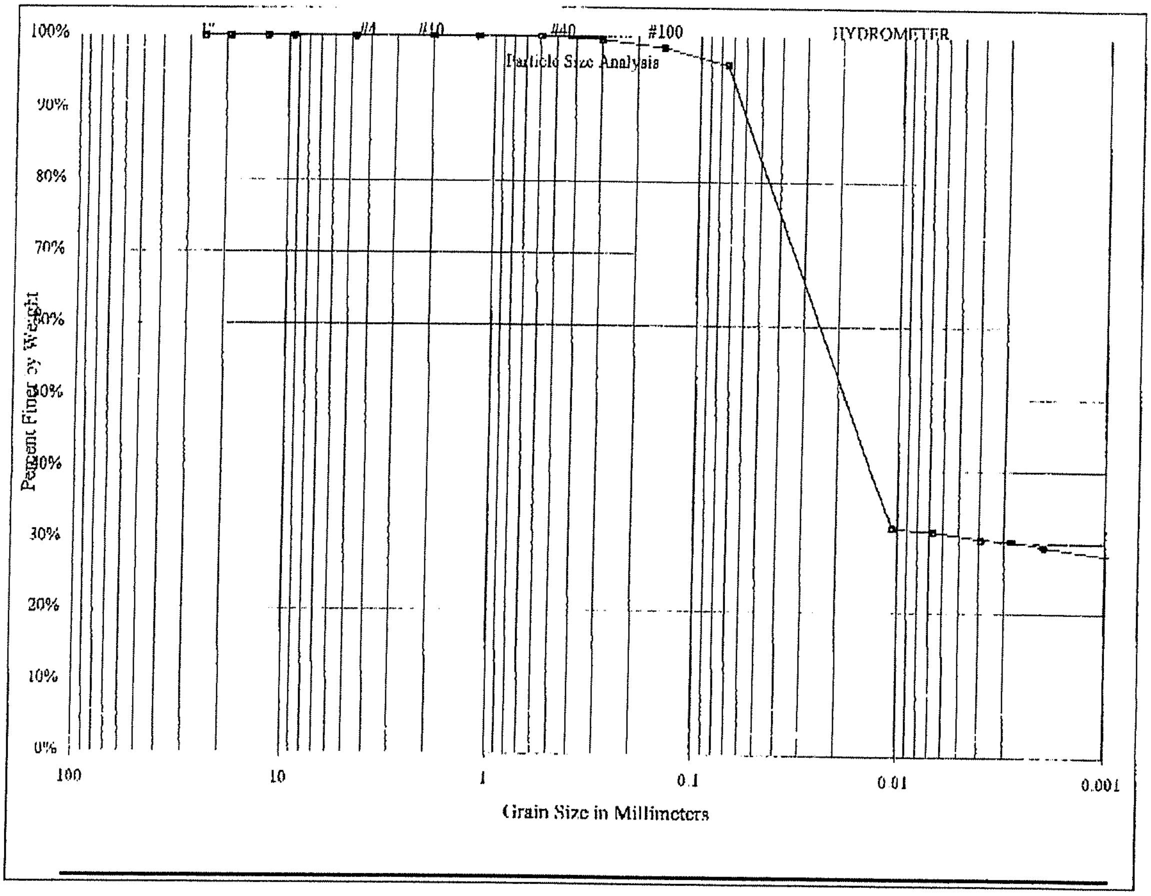


Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	100.0%
NO. 16	1.1900	100.0%
NO. 30	0.5900	100.0%
NO. 50	0.2970	99.4%
NO. 100	0.1490	98.4%
NO. 200	0.0740	95.9%
Hydrometer Range	0.0106	30.2%
	0.0067	29.5%
	0.0039	28.7%
	0.0028	28.3%
	0.0020	27.7%
	0.0010	26.4%
	0.0004	26.0%

Inberg-Miller Engineers
270 North American Road
Cheyenne, WY 82007

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	A	DATE RECEIVED:	5/6/1998
CLIENT:	U.S. Energy	TYPE OF SAMPLE	Bulk
CLIENT SAMPLE NO :	Sec. 16 Site Soil		
SOIL DESCRIPTION:	Shale/Clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO.10	2.0000	100.0%
NO. 16	1.1900	100.0%
NO. 30	0.5900	100.0%
NO. 50	0.2970	99.6%
NO. 100	0.1490	98.5%
NO. 200	0.0740	96.0%
Hydrometer Range	0.0106	31.8%
	0.0067	31.5%
	0.0039	30.5%
	0.0028	30.3%
	0.0020	29.4%
	0.0010	28.1%
	0.0004	27.5%

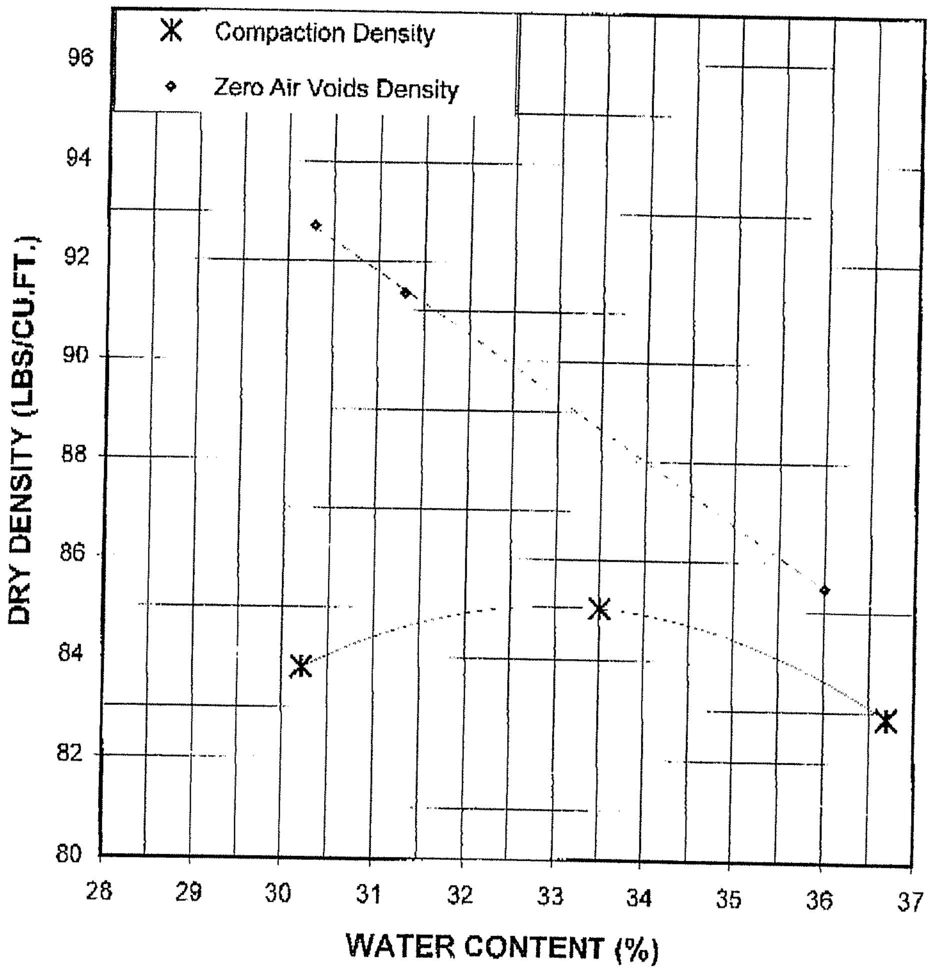
Inberg Miller Engineers
270 North American Road
Cheyenne, WY 82007

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon Mill
JOB NO. 10223 RM
TEST DATE: 6-3-05
SOURCE: Site Soil
DESCRIPTION: Shale/Clay

SAMPLE NO.: Sec. 16, #C
SAMPLED BY: Client
TESTED BY : BJC
TEST METHOD: D 698-A



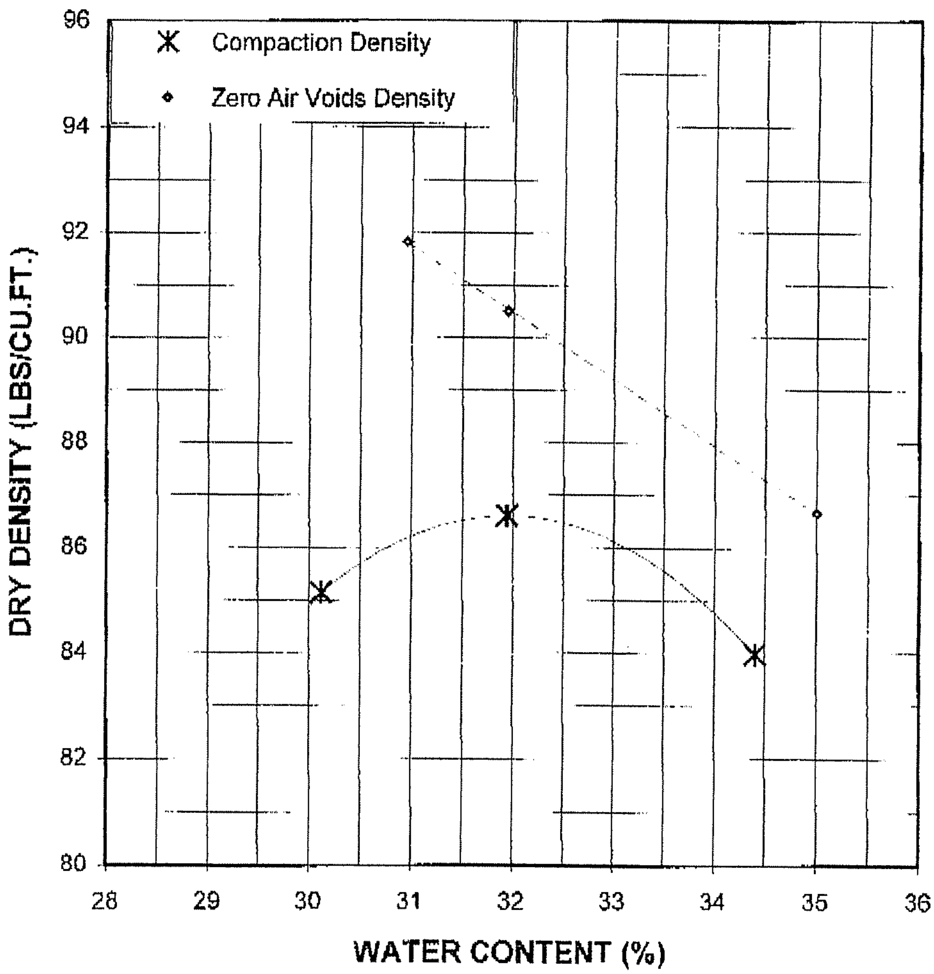
OPTIMUM WATER CONTENT (%): 31.3
MAXIMUM DRY DEN. (LBS/CU. FT): 85.7

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon Mill
JOB NO. 10223 RM
TEST DATE: 6-3-05
SOURCE: Site Soil
DESCRIPTION: Shale/Clay

SAMPLE NO.: Sec. 16, #A
SAMPLED BY: Client
TESTED BY : BJC
TEST METHOD: D 698-A



OPTIMUM WATER CONTENT (%): 32.0
MAXIMUM DRY DEN. (LBS/CU. FT): 86.6

C.2 Discussion of Alternate Source Clay Properties
by Inberg-Miller Engineers, December 7, 2005

RIVERTON . CASPER . CHEYENNE
POWELL . GREEN RIVER

INBERG-MILLER ENGINEERS

December 7, 2005

10223-RM

Mr. Fred Craft
U.S. Energy
877 North 8th West
Riverton, WY 82501

RECEIVED
DEC - 8 2005

RE: SEPTEMBER 19, 2005 SOIL TESTING
SHOOTERING CANYON MILL PROJECT

Dear Fred:

This letter summarizes our observations of the claystone soil sample you submitted for laboratory testing, the results of which were reported on September 19, 2005.

As mentioned in our test report, the sample (as originally submitted) appeared shale-like, but softened rapidly upon inundation with water. Subsequently, moisture-density relationship, particle size analysis including hydrometer analysis, Atterberg Limits and permeability tests were performed. You and your consultant, Hydro Engineers, noted that the particle size analysis test indicated the fine fraction (minus 200 sieve) appeared to be substantially silt-size particles, and that the particle size analysis does not corroborate the relatively low permeability for the sample which was more representative of clay.

There are two observations that we make with regard to your note as presented above:

1. As stated, the sample was processed from hard shale-rock fragments to an apparent relatively soft soil through the addition of water. While the majority of the sample was soil when tested, the disintegration from silt to clay was likely incomplete based on visual and manual observations of variable texture.

2. Hydraulic permeability is controlled by pore size and pore volume of the soil mass through which water flows. Although a substantial portion of a certain soil may include silt through gravel-sized particles, if the soil particles are well graded and there is sufficient clay-sized particles to close the pore space of the larger soil particle fraction (soil matrix), soil pore size and pore volume may be reduced to that of the clay and render clay-like permeability test results.

Based on the above observations, it is our opinion the hydrometer analysis is not a good indicator of hydraulic permeability for the subject sample.

Please feel free to call if you have questions or require further information.

Sincerely,

INBERG-MILLER ENGINEERS

Glen M. Bobnick, P.E.
Geotechnical Engineer
Riverton Office

GMB:bjh:10223/10223 test observ. Ltr 12-07-05

124 East Main Street, Riverton, WY 82501, 307-856-8136, 307-856-3851 (fax), riverton@inberg-miller.com
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APPENDIX D

INFILTRATION MODELING

APPENDIX D

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APPENDIX D

Infiltration Modeling

D.0 Introduction

The HYDRUS-2D partially-saturated flow and transport model and the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et. al, 1994) were considered in predicting the infiltration through the radon/infiltration barrier at the Shootaring Canyon Uranium Processing Facility. The planned layer sequence for the tailings disposal cell cover system at this site includes (listing from top to bottom): a rock mulch erosion protection layer, a rocky soil freeze/thaw protection layer, a sand layer, a clay radon/infiltration barrier, and a generally sandy grading/interim cover layer. The primary concern is the percolation of water through the barrier into the dewatered uranium tailings, and subsequent accumulation within the synthetic-lined cells. While it is not possible to completely preclude infiltration through the barrier in the long-term, proper selection of barrier materials and construction techniques can reduce the infiltration to minimal levels.

The climate at the Shootaring Canyon facility is arid with relatively high temperatures. The surface of the tailings pile will be shaped to eliminate ponding on the surface and to induce runoff for more severe events. A limited precipitation depth and high evaporative demand combine to limit the quantity of water available for infiltration. The layer sequence for the tailings includes a freeze/thaw barrier that will prevent degradation of the underlying clay barrier material.

D.1 Model Descriptions

The HYDRUS-2D water flow model is based on a numerical solution to the Richards equation which describes transient variably-saturated flow in soil. HYDRUS-2D also includes contains components for plant growth and a variety of chemistry and transport methodologies, but only the water flow portion was considered in predicting infiltration. HYDRUS-2D was developed at the U.S. Salinity Laboratory, and is commercially distributed by the International Ground Water Modeling Center at the Colorado School of Mines. For this application, the geometry used in the modeling basically reduced the problem to a one-dimension (vertical) flow regime. Although the HYDRUS-2D model is computationally intensive, it is considered to be a much better representation of saturated/unsaturated water flow than simplified "water balance" models. Unfortunately, the HYDRUS-2D model does not allow usable runoff calculations or lateral drainage for sloping conditions.

The HELP model is a comprehensive water balance type model intended for use on lined or capped systems. This model is attractive for situations where barrier material is overlain by topsoil, but the water flow component is limiting for the evaporative conditions present on the covered tailings cells. The basic unsaturated water flow model component for the HELP model is a simplistic Darcy equation with unsaturated hydraulic conductivity estimated using a method developed by Rawls et al. (1982). Unfortunately, this approach does not adequately simulate the upward flux of infiltrate and subsequent evaporation at the surface. The HELP model incorporates several widely-accepted components for stochastic weather generation, evapotranspiration calculations, runoff calculations, and soil hydraulic parameter estimation. Because the HELP model does not reliably predict infiltration for the tailings cover configuration, it is used primarily in this analysis to provide precipitation input records for the HYDRUS-2D model.

D.1.1 HYDRUS-2D Model Description

HYDRUS-2D has facilities for developing elaborate two-dimensional finite-element meshes and allows a variety of boundary conditions. Units of centimeters and days were used in the modeling. The model geometry for this analysis was a simple vertical column with a width of 1 cm and column length of 230 cm (7.54 feet). Three materials were considered in the column including: a moderately permeable loamy sand, a moderately permeable sand, and a low permeability clay. The rock mulch was included in the upper rocky soil cover material because it will likely exhibit similar properties after much of the void space is filled with windblown sediment. The upper boundary was modeled as an atmospheric boundary allowing precipitation inputs and evaporation extraction. The lower boundary was modeled as a free drainage boundary.

The HYDRUS-2D model allows input of precipitation on a daily or even more frequent basis. Evaporation is also input at the same frequency in the model. A single year of precipitation and evaporation data inputs was replicated to produce a 27 year record to allow the modeled infiltration to reach a pseudo-equilibrium condition. The HYDRUS-2D model does not have any provisions for predicting runoff for nonspecific storms or an increase in head due to ponding of water. While the latter condition is not likely to be a problem on the tailings impoundment, the runoff or lateral drainage from the impoundment through the rock protection will undoubtedly be important to the prevention of infiltration. The methods for incorporating runoff and lateral drainage into the HYDRUS-2D modeling are discussed in a later section. HYDRUS-2D also allows evapotranspiration under a variety of vegetative conditions. This feature was not used in these simulations.

D.2 Model Inputs

The inputs to the model were taken from field-measured values when available, and model defaults when actual data were not available. The HELP model defaults include local weather generation coefficients for locations in Utah, and where applicable, the HELP model input data was used in the HYDRUS-2D model.

D.2.1 Cover Material Properties

The upper rock mulch layer (4 inch thickness) and the 24 inches of rocky soil freeze/thaw layer were modeled as moderately permeably loamy sand. The 6-inch thick sand layer between the rocky soil and the clay layer was modeled as moderately permeable fine sand. The 18-inch thick clay layer was modeled as a low permeability clay. The remainder of the profile was modeled as the moderately permeable fine sand. The properties of these materials are listed in the Table D-1. HYDRUS-2D has several options for the soil hydraulic model for the various soil types. The option selected was the van Genuchten-Mualem model with hysteresis in the water retention curve.

TABLE D-1. MODELED SOIL PROPERTIES

Layer	General Soil Type	Thickness (cm)	Thickness (inch)	Hydraulic Conductivity (cm/day)	Hydraulic Conductivity (cm/s)	Residual Volumetric Moisture Content	Saturated Volumetric Moisture Content
Upper Rocky Soil and Rock Mulch	Loamy Sand	71	28	80	9.26E-04	0.065	0.41
Fine Sand	Fine Sand	15	6	100	1.16E-03	0.057	0.41
Clay Radon/Infiltration Barrier	Clay	46	18	0.00864	1.00E-07	0.068	0.38
Interim/Grading Cover	Fine Sand	98	38.5	100	1.16E-03	0.057	0.41

D.2.2 Tailings Properties

Because the modeled cover layer thickness is approximately 7.5 feet, the modeled column does not extend into the tailings. However, the lower boundary is far enough from the surface and the base of the clay to minimize boundary effects. Therefore, the tailings properties are not critical to the infiltration modeling. The model is not particularly sensitive to the properties of the material underlying the clay barrier unless the permeability of the underlying material approaches that of the barrier, or the infiltration is so small that numerical accuracy becomes an issue. Once the infiltrate reaches a certain depth in the barrier, it is unlikely that it will move upward to supply evaporative demand. Because the barrier is less permeable than any of the modeled underlying tailings or interim cover materials, the model is not particularly sensitive to the physical properties of these materials.

D.2.3 Precipitation and Weather Conditions

The precipitation values were taken from estimates in the Decommissioning and Reclamation Plan. The estimate for annual precipitation was 7 inches. Climates of the States (1978), lists the annual precipitation for Hanksville, Utah as 5.21 inches. This is the nearest location with similar climate. An annual precipitation of 7.0 inches was used in both the HELP and HYDRUS-2D modeling as a measure of conservatism. The HELP model was able to use a stochastically varied precipitation record while an average annual precipitation record generated by the HELP model was repeated to produce a longer record for use in HYDRUS-2D to bring the model to steady state.

The planned general land slope on the tailings area is typically 15% to 20% and the covered tailings cells are configured to produce a radially outward flow pattern. The combination of land slopes and drainage configuration should induce runoff for moderate to severe events, subsequently reducing the water available for infiltration. An abstraction was taken from moderate to severe precipitation events in the record to reflect this runoff. The method for taking the abstraction was to remove 70% of the precipitation depth over 0.9 cm (0.35 inch) depth for those events that exceeded 0.9 cm. This reduced the precipitation depth for four of the events and resulted in an “effective” annual precipitation depth of 15.75 cm. (6.2 inches). This is a modest reduction to reflect runoff and is still larger than the annual precipitation depth for Hanksville. The precipitation record used in the model is presented in Figure D-1.

Weekly pan evaporation for the model was estimated from a variety of sources. A 1979 NCF study lists gross pan evaporation for the site as 110 inches. A general estimate from a large-scale map in the Handbook of Applied Meteorology lists lake evaporation as roughly 51 inches. These two sources tend to bracket the anticipated annual pan evaporation between 70 inches and 110 inches. Values of 90 inches/year and 70 inches/year were used in the HYDRUS-2D modeling with the distribution as shown in Figure D-1.

D.3 HYDRUS-2D Model Results

Multiple runs were conducted with the HYDRUS-2D model to evaluate the time to stabilization of the rate of infiltration through the cover system. The model produces a screen graph of the rate of drainage at the bottom boundary that was used to evaluate stability. The rate represented the quantity of water that had passed through the cover system to a depth where it would ultimately report to the base of the tailings cells. It was found that a 27 year run was sufficient to achieve stability.

The long-term stable drainage rate was considered the flux through the cover system and was recorded for two simulation scenarios. The first scenario included an annual precipitation depth of 15.75 cm (6.2 inches) and an annual potential evaporation depth of 228 cm (90 inches). The resulting long-term steady flux through the cover was 0.00013 cm/day (5.1E-05 in/day) which equates to 0.475 mm/year. This equates to a rate of recharge of 9.7E-04 gpm/acre.

The second modeled scenario also included an annual precipitation depth of 15.75 cm (6.2 inches), but the annual potential evaporation depth was reduced to 177.5 cm (70 inches). The resulting long-term steady flux through the cover was 0.000192 cm/day (7.6E-05 in/day) which equates to 0.701 mm/year. This equates to a rate of recharge of 1.4E-03 gpm/acre.

D.4 Discussion

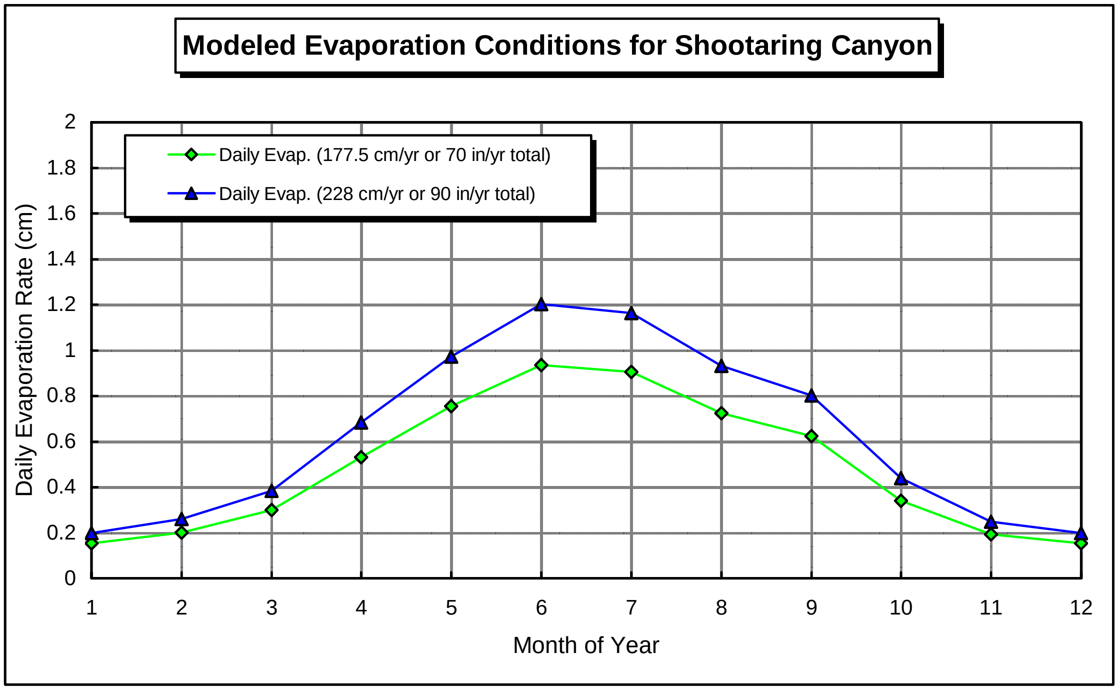
HYDRUS-2D appeared to provide reasonable predictions of the infiltration through the cover system. Both simulation scenarios indicate that significantly less than one millimeter of water is expected to penetrate the cover system each year. Given the conservative assumptions included in the modeling, an estimate of 0.5 mm/year of infiltrate is likely very conservative. The general conclusion of this analysis is that the infiltration through the cover is extremely small and is expected to be less than 0.07 gpm for the maximum tailings cell and EPPC area of approximately 68 acres.

D.5 References

Gale Research Company. (1978), “Climates of the States, Volume 1-2”, Book Tower, Detroit, MI.

Rawls, W.J., and Brakensiek, D.L., (1982), "Estimating soil water retention from soil properties," Journal of the Irrigation and Drainage Division 108(IR2), 166-171.

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/9-94/168a, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.



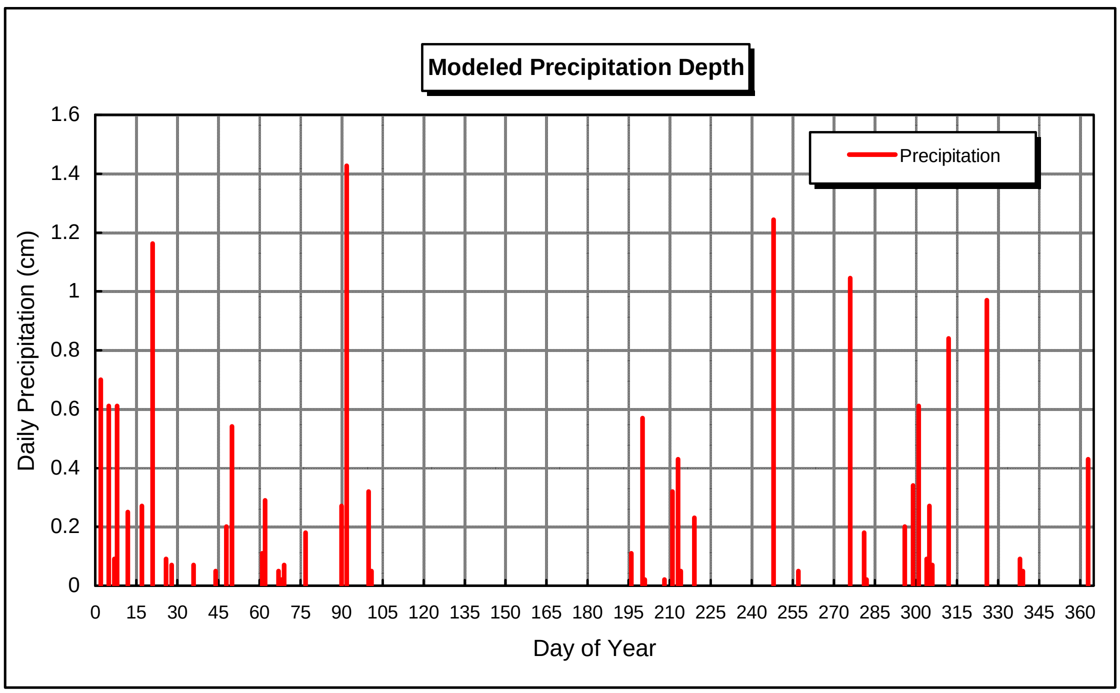


Figure D-1. Model Evaporation Rates and Precipitation Depth

APPENDIX E

DERIVATION OF SOIL CLEANUP CRITERIA

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Appendix E

Derivation of Soil Cleanup Criteria

E.0 Objective of Analysis

The NRC amended 10 CFR Part 40 on April 12, 1999 (FR/Vol. 64, No. 69, pp17506-17509) to require uranium recovery licensees to consider radionuclides other than Ra-226 in soil cleanup criteria. The existing soil Ra-226 criterion in 10 CFR Part 40, Appendix A, is used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct material radionuclides, including Ra-226. The radionuclide-specific criteria are adjusted so that the total dose resulting from the mixture of residual radionuclides will not exceed the Benchmark Dose. The dose from radon is excluded from the benchmark calculation. Other recommended guidance documents include NUREG-1620 and NUREG-1549.

For areas contaminated with uranium tailings, the cleanup limit for Ra-226 is 5 pCi/g above background levels. Section 3 in the main text shows that there are no known areas of windblown uranium tailings at the site nor are there evaporation pond areas where Th-230 may be of concern. Areas contiguous to the tailings pile will be cleaned to the Ra-226 criterion of 5 pCi/g above background, where necessary. In the mill area, small process material contaminated areas have been identified, where process materials have a radionuclide mix similar to uranium ore. The only area where significant quantities of contaminants exist is the ore storage area, where ore is presently stored but will be removed and placed in the tailings pile. Therefore, soil cleanup criteria for a radionuclide mix similar to uranium ore has been developed using the Benchmark Approach. It has been assumed that all radionuclides in the U-238 and U-235 decay series are in secular equilibrium.

E.1 Exposure Assessment

The exposure assessment is an evaluation of who may be exposed to constituents at the site, how they would be exposed, and how much exposure could occur. The first step for accomplishing this is to identify critical groups who may be potentially exposed. The second step is to develop a conceptual model and associated exposure pathways. The conceptual model includes the source term, mechanism for release, transport medium, and an exposure route. The Benchmark exposure assessment is done for the site where it is assumed that Ra-226 exists in the top 15-cm layer of soil at a concentration of 5 pCi/g above background.

E.1.1 Potential Receptors

The Bureau of Land Management owns the land contiguous to the site. After mill decommissioning and transfer of the small tailing and rubble disposal cell to the U. S. government, the decontaminated structures will be sold for industrial and/or commercial use. The only parcel of land that a "resident farmer" might purchase is the parcel now called the ore storage area. The ore affected portion of the area is estimated to be approximately 4.5 acres. This receptor scenario is, however, unlikely since most people would choose to live near Ticaboo (3.5 miles away) where electricity is available.

E.1.2 Potential Exposure Pathways

The summers are hot with highs above 100 degrees Fahrenheit. The winters are harsh, with temperatures reaching near zero degrees Fahrenheit. The growing season is quite variable and normally short. The annual precipitation is approximately 17 cm (7 inches).

There is no electrical supply and probably will not be in the near future. There is adequate potable water in the aquifer, approximately 55 meters below surface, for drinking and irrigation water. Vegetation in the area is exclusively native, uncultivated, and generally sparse. The soils are weathered sandstone and would require extensive soil amendments prior to gardening. The extremely hot summers and the poor soil conditions make the growing of grain crops nearly impossible. Vegetable gardening is done in the spring and fall seasons. However, this is normally limited to a few plants suitable for short growing seasons. Fruit-tree blossoms are subject to frequent frost damage and are considered an unreliable crop, possibly bearing fruit only one year out of ten.

All poultry and beef feed would have to be imported at a very high cost, making it very expensive to have chickens and dairy and beef cattle.
There are no streams or surface water impoundments that would provide an exposure pathway to waterfowl or other aquatic life. Beef animals may graze on the natural grasses. However, an insignificantly small percentage of the annual diet would come from the sparsely vegetated contaminated area. Therefore radiation exposure to animals and aquatic life or indirect exposure to man via radionuclide uptake in beef or other animals is not considered in this analysis.

In summary, exposure pathways for potential future residents include external radiation, incidental soil ingestion, direct soil ingestion, dust inhalation, and ingestion of contaminated fruit, vegetables, and drinking water. The radon exposure pathway is excluded from the Benchmark Dose modeling approach per guidance from the NRC.

E.1.3 RESRAD Modeling

Exposure was quantified using the RESRAD program, version 6.2 (ANL, 2001). RESRAD is a computer code developed at Argonne National Laboratory for the U. S. Department of Energy and the U. S. Nuclear Regulatory Commission to calculate compliance with soil cleanup dose guidelines. For this application, the soil guideline for site constituents is the dose limit corresponding to the dose that a member of the critical group (user of the site) would receive if contamination levels were at the 10 CFR Part 40, Appendix A limit for Ra-226 in soil. This Benchmark Dose approach requires that this be calculated for Ra-226 over the time interval of 1000 years. Radon is to be excluded from the calculations. Using the same exposure pathway assumptions, the doses from other constituents at the site are then calculated and compared to the Benchmark Dose. The concentrations of each constituent are adjusted to correspond to the Benchmark

Dose. The cleanup criteria for each 100-m^2 area of the site will be determined by limiting the sum of the doses from all constituents to the Benchmark Dose. The NRC provides additional guidance for situations where the Benchmark Dose exceeds 100 mrem/y. The NRC also expects that the licensee reduce the concentrations to as low as reasonably achievable (ALARA) levels.

Part 40 of Title 10 of the Code of Federal Regulations, Appendix A, limits the Ra-226 to soil layers deeper than 15 cm to 15 pCi/g. This limit normally applies when backfill is applied. Pathway exposure modeling is difficult for these site specific situations and, therefore, modeling was not done. Consistent with 10 CFR 40, Appendix A it is assumed that the dose is expected to be a factor of three higher from the surface contaminated layer than from buried contaminated soil layers. With this assumption, it will be conservative to scale the Benchmark Dose for Ra-226 and the other constituents by a factor of three and derive cleanup criteria for buried contamination.

As is demonstrated in the main text of this report, the only radionuclides of concern are natural uranium (with daughters). For modeling purposes, we have assumed that the top 15-cm layer is uniformly contaminated and that there is no residual contamination beneath this layer. In our experience at other sites, this is a good assumption for undisturbed surface soils.

RESRAD runs were made for Ra-226 and natural uranium ore. They are attached at the end of this section. Parameters used in the calculations are given along with RESRAD default parameters. The default parameters tend to overestimate the dose but are used when site data are not available. Discussions supporting the use of some of the more important parameters follow. Tables E-1 and E-2 present the parameter values along with the rationale.

Table E-1 RESRAD Site Parameters

Parameter	Units	Value	Rationale
Contaminated Zone Parameters			
Area of Contaminated Zone	m²	18,000	Approximate size of current contaminated area (305 m x 58 m).
Thickness of Contaminated Zone	m	0.15	Approximate thickness of contaminated soil that will remain after remediation.
Length of Contaminated Zone Parallel to Aquifer Flow	m	305	Length of major side of rectangular area of contamination .
Cover and Contaminated Zone Hydrological Data			
Cover Depth	m	0	No cover is planned as part of this removal action.
Soil Density	g/cm^3	1.84	Site Specific Parameter
Erosion Rate	m/y	0.001	Default value for RESRAD model.
Total Porosity	dimensionless	0.40	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Evaportranspiration Coefficient	dimensionless	0.5	RESRAD default value
Wind Speed	m/s	2.6	NUREG-0583, 7/77-1/78, site specific
Precipitation	m/y	0.18	Site Specific Parameter
Runoff Coefficient	dimensionless	0.2	RESRAD default value
Watershed Area for Nearby Stream or Pond	m²	0.1	Stream/pond nearly impossible.
Uncontaminated Unsaturated Zone Parameters			
Unsaturated Zone Thickness	m	55	Site Specific Parameter
Soil Density	g/cm³	1.84	Site Specific Parameter
Total Soil Porosity	dimensionless	0.4	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Saturated Zone Parameters			
Soil Density	g/cm³	1.84	Site Specific Parameter
Total Soil Porosity	dimensionless	0.27	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Hydraulic Gradient	dimensionless	0.02	RESRAD default value
Water Table Drop Rate	m/y	0.001	RESRAD default value
Well Pump Intake Depth	m	65	Site Specific Parameter
Well Pumping Rate	m^3/year	250	RESRAD default value
Occupancy, Inhalation, and External Gamma Data			
Indoor Dust Filtration Factor	dimensionless	0.4	RESRAD default value
Shielding Factor, External Gamma	dimensionless	0.5	Estimate of the shielding factor for a frame house built on a 3.5-inch thick slab (NRC, 1999).
Shape of Contaminated Zone	rectangle	305 m by 58 m	Approximate shape of contaminated zone-rectangular.
Mass Loading for Foliar Deposition	g/m^3	0.001	desert environment (NRC,1999 Table 6.47)
Depth of Soil Mixing Layer	m	0.15	RESRAD default value
Depth of Roots	m	0.9	RESRAD default value
Irrigation Fraction from Groundwater	dimensionless	1	Worst-case assumption.
Storage Times of Contaminated Foodstuffs			
Fruits and Non-Leafy Vegetables	days	14	RESRAD default value
Leafy Vegetables	days	1	RESRAD default value
Well Water	days	1	RESRAD default value
Additional Plant and Fodder Factors			
Wet Weight Crop Yield for Non-Leafy Vegetables	kg/m	0.7	RESRAD default value
Wet Weight Crop Yield for Leafy Vegetables	kg/m	1.5	RESRAD default value
Growing Season for Non-Leafy Vegetables	years	0.17	RESRAD default value
Growing Season for Leafy Vegetables	years	0.25	RESRAD default value
Translocation Factor for Non-Leafy Vegetables	dimensionless	0.1	RESRAD default value
Translocation Factor for Leafy Vegetables	dimensionless	1	RESRAD default value
Dry Foliar Interception Fraction for Non-Leafy Vegetables	dimensionless	0.25	RESRAD default value
Dry Foliar Interception Fraction for Leafy Vegetables	dimensionless	0.25	RESRAD default value
Wet Foliar Interception Fraction for Non-Leafy Vegetables	dimensionless	0.25	RESRAD default value
Wet Foliar Interception Fraction for Leafy Vegetables	dimensionless	0.25	RESRAD default value
Weathering Removal Constant for Vegetation	days	20	RESRAD default value
Radon Data			
Building Foundation Thickness	m	0.15	Typical foundation thickness for buildings (6 inches).
Building Foundation Bulk Density	g/cm³	2.4	RESRAD default value
Building Foundation Total Porosity	dimensionless	0.1	RESRAD default value
Building Foundation Volumetric Water Content	dimensionless	0.03	RESRAD default value
Building Foundation Radon Diffusion Coefficient	m²/s	$3x10^{-7}$	RESRAD default value
Contaminated Zone Radon Diffusion Coefficient	m²/s	$2x10^{-6}$	RESRAD default value
Radon Vertical Dimension of Mixing	m	2	RESRAD default value
Building Air Exchange Rate	1/hour	0.5	RESRAD default value
Building Room Height	m	2.5	RESRAD default value
Building Indoor Area Factor	dimensionless	0	RESRAD default value
Foundation Depth Below Ground Surface	m	-0.15	Assumes slab-on-grade construction with a six-inch thick slab.
Rn-222 Emanation Coefficient	dimensionless	0.25	RESRAD default value
Rn-220 Emanation Coefficient	dimensionless	0.15	RESRAD default value

Table E-2 RESRAD Receptor Parameters

Parameter	Units	On-Site Resident	Rationale
Cover and Contaminated Zone Hydrological Data			
Irrigation Rate	m/y	0.9	(NRC, 1999) Table 6.18
Irrigation Mode	-	overhead	
Occupancy, Inhalation, and External Gamma Data			
Inhalation rate	m^3/y	8,400	RESRAD default value
Mass Loading for Inhalation	g/m^3	0.001	NRC, 1999 Table 6.47
Exposure Duration	y	30	RESRAD default value
Indoor Time Fraction	dimensionless	0.5	RESRAD default value
Outdoor Time Fraction	dimensionless	0.25	RESRAD default value
Ingestion Pathway, Dietary Data			
Fruit, Vegetable, and Grain Consumption	kg/y	160	RESRAD default value
Leafy Vegetable Consumption	kg/y	14	RESRAD default value
Soil Ingestion	g/y	36.5	RESRAD default value
Drinking Water Intake	l/y	510	RESRAD default value
Contaminated Fraction of Drinking Water	dimensionless	1	Worst case
Contaminated Fraction of Irrigation Water	dimensionless	1	Worst case
Contaminated Fraction of Plant Food	dimensionless	0.25	Site Specific Parameter
Mass Loading for Floiar Deposition	g/m^3	0.001	NRC, 1999 Table 6.47

Residency Time

Permanent residents have been chosen as the critical population group. It is assumed that the maximum exposed individual spends 30 years living at the site, spending fifty percent of the time indoors, 25 percent outdoors, and 25 percent elsewhere. It is unlikely that families with children would live in the area since the nearest school is in Hanksville, approximately 60 miles from the site. Therefore, a 30-year exposure time is reasonable.

Food and Water: It is assumed that a well is placed at the down gradient of the site in the center of the contaminated area and that the resident obtains all drinking water from that source. The well is used for irrigation where the resident grows 25 percent of their vegetables and fruit on site. RESRAD default values for food intake were used. We have assumed no intake of contaminated food through milk, meat, or via aquatic pathway.

Area of contaminated zone: The largest contaminated area is the ore storage area which has an affected area of approximately 17,690 m^2 (4.4 acres). This is also the only contaminated area suitable for a resident farmer. The contaminated area is approximated by a 305-m by 58-m rectangular area. The receptor was located at the geometrical center of this area for the RESRAD calculations.

Length parallel to aquifer flow: The code assumes that the well is placed in the middle of the contaminated zone. We have conservatively assumed the area is rectangular (305 m by 58 m), with the aquifer flow parallel to the 305-m dimension.

Average Annual Wind Speed: Prevailing wind directions and monthly mean wind velocities were measured at the site from August 1977 through July 1978 as reported in NUREG-0583. The average wind speed from these data was calculated to be 2.6 m/s.

Average precipitation: The average annual precipitation rate for the area is 18 cm (7.3 inches), based on one year of site data (NUREG, 0583).

Irrigation: It is conservatively estimated that for a short growing season in this climate, approximately 90 cm (35.5 inches) of water will be required (NUREG/CR-5512, Vol. 3).

E.1.4 Results

A RESRAD run was made for the site assuming that the Ra-226 concentration in the contaminated layer was 5 pCi/g. Pb-210, the only long-lived progeny, was also assumed to be present at 3.5 pCi/g. This is consistent with a radon emanating fraction of 0.3. The output shows that the maximum annual dose within the next 1,000 years occurs at t = 0 years and is projected to be 34 mrem. A second run was made with the contaminated layer changed to 100 pCi/g U-nat (48.9 pCi/g for U-238 and U-234 and 2.2 pCi/g for U-235). The progeny concentrations were assumed to be in equilibrium with the exception of those below Rn-222, where the activity of Pb-210 was reduced by 30 percent to allow for the diffusion of radon. No loss of Rn-219 was assumed for the U-235 decay chain because of the very short half life of Rn-219. The computer outputs for both runs are included at the end of this Appendix. The maximum annual dose from the 100 pCi/g U-nat plus progeny run is 374 mrem/y. Using the Benchmark Approach, the cleanup limit for U-nat is (100pCi/g) x (34/374) = 9.1 pCi/g or 13.4 mg/kg above natural background concentrations.

E.2 Uncertainty

Calculations (see RESRAD output at the end of this section) show that approximately ninety percent of the total effective dose equivalent (TEDE) results from direct radiation while the majority of the remaining 10 percent comes from the food pathway. Changing to less conservative parameters for the transport of contaminants does not result in the contamination of the aquifer and therefore the water pathway is not of concern. The TEDE primarily depends on the exposure time and the amount of home garden produce consumed. The occupancy time of 50 percent indoors and 25 percent outdoors is the RESRAD default value for the resident farmer and is considered conservative. Similarly, the assumption that 25 percent of the fruit and vegetables come from the contaminated parcel is also very conservative, considering the location. Therefore the results of the calculations are considered very conservative. The maximum calculated TEDE would result from spending an additional 25 percent of the time at the site and eating all fruit and vegetables from the site. This would result in an increase of no more than 60 percent in the calculated TEDE. Therefore the uncertainty in the calculated TEDE is relatively small.

E.3 References

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NUREG-1549. (draft) Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination. July 1998. Division of Regulatory Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555.

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NRC, 1999. NUREG/CR-5512, Vol. 3. Residual Radioactive Contamination From Decommissioning. Parameter Analysis. Draft Report for Comment. October 1999. U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Washington, DC 20555-0001

ATTACHMENT E-1

RESRAD Benchmark Dose Run

Radium-226 without Radon

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary

File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(1)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(2)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(1)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(2)
D-34	Food transfer factors:			
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(1,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(1,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(1,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(2,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(1,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(2,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(2,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.800E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	3.050E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+02	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	2.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+01	1.000E+00	---	T(2)
R011	Times for calculations (yr)	1.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	not used	3.000E+01	---	T(5)
R011	Times for calculations (yr)	not used	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used,	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Pb-210	3.500E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	5.000E+00	0.000E+00	---	S1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(2)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.000E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.600E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.800E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	9.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E-01	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.700E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.000E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.500E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.840E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	1.000E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.889E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.698E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-03	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	-1.000E+00	1.000E+00	-1 shows non-circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	1.308E+01	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	2.617E+01	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	3.925E+01	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	5.233E+01	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	6.542E+01	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	7.850E+01	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	9.158E+01	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	1.047E+02	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	1.178E+02	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	1.308E+02	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	1.439E+02	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	1.570E+02	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	1.000E+00	1.000E+00	---	FRACA(1)
R017	Ring 2	1.000E+00	2.732E-01	---	FRACA(2)
R017	Ring 3	8.000E-01	0.000E+00	---	FRACA(3)
R017	Ring 4	4.300E-01	0.000E+00	---	FRACA(4)
R017	Ring 5	3.300E-01	0.000E+00	---	FRACA(5)
R017	Ring 6	2.600E-01	0.000E+00	---	FRACA(6)
R017	Ring 7	2.200E-01	0.000E+00	---	FRACA(7)
R017	Ring 8	1.900E-01	0.000E+00	---	FRACA(8)
R017	Ring 9	1.700E-01	0.000E+00	---	FRACA(9)
R017	Ring 10	1.500E-01	0.000E+00	---	FRACA(10)
R017	Ring 11	1.300E-01	0.000E+00	---	FRACA(11)
R017	Ring 12	9.300E-02	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-03	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used,	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	18000.00 square meters	Pb-210	3.500E+00
Thickness:	0.15 meters	Ra-226	5.000E+00
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 1.000E+02 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+01	1.000E+02	1.000E+03
TDOSE(t):	3.386E+01	2.546E+01	1.315E+00	0.000E+00
M(t):	3.386E-01	2.546E-01	1.315E-02	0.000E+00

Maximum TDOSE(t): 3.386E+01 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.209E-02	0.0004	5.126E-02	0.0015	0.000E+00	0.0000	1.808E+00	0.0534	0.000E+00	0.0000	0.000E+00	0.0000	6.772E-01	0.0200
Ra-226	2.914E+01	0.8606	2.859E-02	0.0008	0.000E+00	0.0000	1.949E+00	0.0576	0.000E+00	0.0000	0.000E+00	0.0000	1.940E-01	0.0057
Total	2.915E+01	0.8610	7.985E-02	0.0024	0.000E+00	0.0000	3.757E+00	0.1110	0.000E+00	0.0000	0.000E+00	0.0000	8.712E-01	0.0257

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.549E+00	0.0753
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.131E+01	0.9247
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.386E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	7.321E-03	0.0003	2.902E-02	0.0011	0.000E+00	0.0000	1.024E+00	0.0402	0.000E+00	0.0000	0.000E+00	0.0000	3.834E-01	0.0151
Ra-226	2.176E+01	0.8547	3.473E-02	0.0014	0.000E+00	0.0000	1.894E+00	0.0744	0.000E+00	0.0000	0.000E+00	0.0000	3.286E-01	0.0129
Total	2.177E+01	0.8550	6.375E-02	0.0025	0.000E+00	0.0000	2.917E+00	0.1146	0.000E+00	0.0000	0.000E+00	0.0000	7.119E-01	0.0280

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.443E+00	0.0567
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.402E+01	0.9433
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.546E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	7.021E-05	0.0001	1.146E-04	0.0001	0.000E+00	0.0000	4.046E-03	0.0031	0.000E+00	0.0000	0.000E+00	0.0000	1.514E-03	0.0012
Ra-226	1.167E+00	0.8877	2.539E-03	0.0019	0.000E+00	0.0000	1.097E-01	0.0834	0.000E+00	0.0000	0.000E+00	0.0000	2.962E-02	0.0225
Total	1.167E+00	0.8878	2.654E-03	0.0020	0.000E+00	0.0000	1.138E-01	0.0865	0.000E+00	0.0000	0.000E+00	0.0000	3.113E-02	0.0237

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.745E-03	0.0044
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.309E+00	0.9956
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.315E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	7.282E-01	4.124E-01	1.641E-03	0.000E+00
Ra-226	Ra-226	1.000E+00	6.249E+00	4.651E+00	2.422E-01	0.000E+00
Ra-226	Pb-210	1.000E+00	1.276E-02	1.530E-01	1.961E-02	0.000E+00
Ra-226	∑DSR(j)		6.262E+00	4.804E+00	2.618E-01	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	1.373E+02	2.425E+02	6.092E+04	*7.631E+13
Ra-226	1.597E+01	2.082E+01	3.819E+02	*9.882E+11

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pb-210	3.500E+00	0.000E+00	7.282E-01	1.373E+02	7.282E-01	1.373E+02
Ra-226	5.000E+00	0.000E+00	6.262E+00	1.597E+01	6.262E+00	1.597E+01

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	2.549E+00	1.443E+00	5.745E-03	0.000E+00
Pb-210	Ra-226	1.000E+00	6.378E-02	7.651E-01	9.805E-02	0.000E+00
Pb-210	∑DOSE(j)		2.612E+00	2.209E+00	1.038E-01	0.000E+00
Ra-226	Ra-226	1.000E+00	3.125E+01	2.326E+01	1.211E+00	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	3.500E+00	2.123E+00	2.364E-02	6.912E-22
Pb-210	Ra-226	1.000E+00	0.000E+00	1.058E+00	3.977E-01	8.572E-12
Pb-210	∑S(j):		3.500E+00	3.181E+00	4.213E-01	8.572E-12
Ra-226	Ra-226	1.000E+00	5.000E+00	3.801E+00	3.225E-01	6.223E-12

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 5.33 seconds

ATTACHMENT E-2

RESRAD Soil Contamination Run

Natural Uranium

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(8)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(7)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(8)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.800E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	3.050E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+02	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	2.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+01	1.000E+00	---	T(2)
R011	Times for calculations (yr)	1.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	not used	3.000E+01	---	T(5)
R011	Times for calculations (yr)	not used	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used,	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	2.200E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	2.200E+00	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	3.420E+01	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	4.890E+01	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Th-230	4.890E+01	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): U-234	4.890E+01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	2.200E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	4.890E+01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.000E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.600E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.800E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	9.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E-01	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Density of saturated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.700E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.000E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.500E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.840E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	1.000E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.408E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.889E-02	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.698E-02	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.152E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-03	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	-1.000E+00	1.000E+00	-1 shows non-circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	1.308E+01	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	2.617E+01	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	3.925E+01	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	5.233E+01	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	6.542E+01	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	7.850E+01	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	9.158E+01	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	1.047E+02	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	1.178E+02	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	1.308E+02	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	1.439E+02	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	1.570E+02	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	1.000E+00	1.000E+00	---	FRACA(1)
R017	Ring 2	1.000E+00	2.732E-01	---	FRACA(2)
R017	Ring 3	8.000E-01	0.000E+00	---	FRACA(3)
R017	Ring 4	4.300E-01	0.000E+00	---	FRACA(4)
R017	Ring 5	3.300E-01	0.000E+00	---	FRACA(5)
R017	Ring 6	2.600E-01	0.000E+00	---	FRACA(6)
R017	Ring 7	2.200E-01	0.000E+00	---	FRACA(7)
R017	Ring 8	1.900E-01	0.000E+00	---	FRACA(8)
R017	Ring 9	1.700E-01	0.000E+00	---	FRACA(9)
R017	Ring 10	1.500E-01	0.000E+00	---	FRACA(10)
R017	Ring 11	1.300E-01	0.000E+00	---	FRACA(11)
R017	Ring 12	9.300E-02	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-03	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used,	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions	
Area:	18000.00 square meters
Thickness:	0.15 meters
Cover Depth:	0.00 meters

Initial Soil Concentrations, pCi/g	
Ac-227	2.200E+00
Pa-231	2.200E+00
Pb-210	3.420E+01
Ra-226	4.890E+01
Th-230	4.890E+01
U-234	4.890E+01
U-235	2.200E+00
U-238	4.890E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 1.000E+02 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+01	1.000E+02	1.000E+03
TDOSE(t):	3.738E+02	2.780E+02	1.968E+01	3.601E-12
M(t):	3.738E+00	2.780E+00	1.968E-01	3.601E-14

Maximum TDOSE(t): 3.738E+02 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.333E+00	0.0062	8.991E+00	0.0241	0.000E+00	0.0000	5.706E-01	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	8.348E-01	0.0022
Pa-231	2.689E-01	0.0007	1.933E+00	0.0052	0.000E+00	0.0000	1.679E+00	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	6.378E-01	0.0017
Pb-210	1.181E-01	0.0003	5.009E-01	0.0013	0.000E+00	0.0000	1.767E+01	0.0473	0.000E+00	0.0000	0.000E+00	0.0000	6.617E+00	0.0177
Ra-226	2.850E+02	0.7624	2.796E-01	0.0007	0.000E+00	0.0000	1.906E+01	0.0510	0.000E+00	0.0000	0.000E+00	0.0000	1.897E+00	0.0051
Th-230	9.620E-02	0.0003	1.032E+01	0.0276	0.000E+00	0.0000	2.118E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	7.315E-01	0.0020
U-234	1.112E-02	0.0000	4.100E+00	0.0110	0.000E+00	0.0000	2.529E-01	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	3.705E-01	0.0010
U-235	9.331E-01	0.0025	1.719E-01	0.0005	0.000E+00	0.0000	1.075E-02	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.573E-02	0.0000
U-238	3.957E+00	0.0106	3.665E+00	0.0098	0.000E+00	0.0000	2.404E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	3.522E-01	0.0009
Total	2.927E+02	0.7830	2.996E+01	0.0801	0.000E+00	0.0000	3.969E+01	0.1062	0.000E+00	0.0000	0.000E+00	0.0000	1.146E+01	0.0306

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.273E+01	0.0341
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.518E+00	0.0121
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.490E+01	0.0666
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.062E+02	0.8192
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.136E+01	0.0304
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.734E+00	0.0127
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.132E+00	0.0030
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.214E+00	0.0220
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.738E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	6.565E-01	0.0024	2.382E+00	0.0086	0.000E+00	0.0000	1.512E-01	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	2.211E-01	0.0008
Pa-231	5.180E-01	0.0019	2.453E+00	0.0088	0.000E+00	0.0000	1.152E+00	0.0041	0.000E+00	0.0000	0.000E+00	0.0000	5.209E-01	0.0019
Pb-210	7.154E-02	0.0003	2.835E-01	0.0010	0.000E+00	0.0000	1.000E+01	0.0360	0.000E+00	0.0000	0.000E+00	0.0000	3.746E+00	0.0135
Ra-226	2.129E+02	0.7656	3.397E-01	0.0012	0.000E+00	0.0000	1.852E+01	0.0666	0.000E+00	0.0000	0.000E+00	0.0000	3.213E+00	0.0116
Th-230	1.156E+00	0.0042	9.624E+00	0.0346	0.000E+00	0.0000	2.772E-01	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	6.936E-01	0.0025
U-234	7.676E-03	0.0000	2.623E+00	0.0094	0.000E+00	0.0000	1.618E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	2.371E-01	0.0009
U-235	6.362E-01	0.0023	1.104E-01	0.0004	0.000E+00	0.0000	7.116E-03	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.017E-02	0.0000
U-238	2.676E+00	0.0096	2.345E+00	0.0084	0.000E+00	0.0000	1.538E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	2.253E-01	0.0008
Total	2.186E+02	0.7862	2.016E+01	0.0725	0.000E+00	0.0000	3.042E+01	0.1094	0.000E+00	0.0000	0.000E+00	0.0000	8.868E+00	0.0319

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.410E+00	0.0123
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.643E+00	0.0167
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.410E+01	0.0507
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.349E+02	0.8450
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.175E+01	0.0423
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.030E+00	0.0109
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.638E-01	0.0027
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.399E+00	0.0194
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.780E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	5.631E-06	0.0000	1.012E-05	0.0000	0.000E+00	0.0000	6.432E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.400E-07	0.0000
Pa-231	1.803E-02	0.0009	3.926E-02	0.0020	0.000E+00	0.0000	1.430E-02	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	7.119E-03	0.0004
Pb-210	6.861E-04	0.0000	1.120E-03	0.0001	0.000E+00	0.0000	3.953E-02	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	1.480E-02	0.0008
Ra-226	1.142E+01	0.5801	2.483E-02	0.0013	0.000E+00	0.0000	1.073E+00	0.0545	0.000E+00	0.0000	0.000E+00	0.0000	2.897E-01	0.0147
Th-230	2.676E+00	0.1360	3.405E+00	0.1730	0.000E+00	0.0000	2.340E-01	0.0119	0.000E+00	0.0000	0.000E+00	0.0000	2.771E-01	0.0141
U-234	7.938E-04	0.0000	3.193E-02	0.0016	0.000E+00	0.0000	1.971E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	2.877E-03	0.0001
U-235	1.619E-02	0.0008	1.383E-03	0.0001	0.000E+00	0.0000	1.116E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.341E-04	0.0000
U-238	6.120E-02	0.0031	2.785E-02	0.0014	0.000E+00	0.0000	1.828E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	2.676E-03	0.0001
Total	1.419E+01	0.7210	3.532E+00	0.1795	0.000E+00	0.0000	1.365E+00	0.0694	0.000E+00	0.0000	0.000E+00	0.0000	5.944E-01	0.0302

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.734E-05	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.871E-02	0.0040
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.614E-02	0.0029
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.280E+01	0.6506
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.592E+00	0.3350
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.757E-02	0.0019
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.781E-02	0.0009
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.355E-02	0.0048
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.968E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ac-227	2.600E-12	0.7220	0.000E+00	0.0000	0.000E+00	0.0000	4.498E-13	0.1249	0.000E+00	0.0000	0.000E+00	0.0000	3.050E-12	0.8469
Pa-231	4.700E-13	0.1305	0.000E+00	0.0000	0.000E+00	0.0000	8.112E-14	0.0225	0.000E+00	0.0000	0.000E+00	0.0000	5.512E-13	0.1531
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	1.485E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.559E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.741E-16	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.070E-12	0.8526	0.000E+00	0.0000	0.000E+00	0.0000	5.309E-13	0.1474	0.000E+00	0.0000	0.000E+00	0.0000	3.601E-12	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	5.786E+00	1.550E+00	7.881E-06	1.386E-12
Pa-231	Pa-231	1.000E+00	1.960E+00	1.258E+00	1.576E-02	0.000E+00
Pa-231	Ac-227	1.000E+00	9.352E-02	8.525E-01	2.001E-02	2.505E-13
Pa-231	∑DSR(j)		2.054E+00	2.110E+00	3.578E-02	2.505E-13
Pb-210	Pb-210	1.000E+00	7.282E-01	4.124E-01	1.641E-03	0.000E+00
Ra-226	Ra-226	1.000E+00	6.249E+00	4.651E+00	2.422E-01	0.000E+00
Ra-226	Pb-210	1.000E+00	1.276E-02	1.530E-01	1.961E-02	0.000E+00
Ra-226	∑DSR(j)		6.262E+00	4.804E+00	2.618E-01	0.000E+00
Th-230	Th-230	1.000E+00	2.309E-01	2.154E-01	7.650E-02	0.000E+00
Th-230	Ra-226	1.000E+00	1.354E-03	2.450E-02	5.618E-02	0.000E+00
Th-230	Pb-210	1.000E+00	1.978E-06	4.033E-04	2.127E-03	0.000E+00
Th-230	∑DSR(j)		2.322E-01	2.403E-01	1.348E-01	0.000E+00
U-234	U-234	1.000E+00	9.681E-02	6.194E-02	7.382E-04	0.000E+00
U-234	Th-230	1.000E+00	1.027E-06	1.681E-05	1.785E-05	0.000E+00
U-234	Ra-226	1.000E+00	4.025E-09	1.065E-06	1.185E-05	0.000E+00
U-234	Pb-210	1.000E+00	4.650E-12	1.239E-08	4.126E-07	0.000E+00
U-234	∑DSR(j)		9.681E-02	6.196E-02	7.683E-04	0.000E+00
U-235	U-235	1.000E+00	5.143E-01	3.468E-01	8.026E-03	0.000E+00
U-235	Pa-231	1.000E+00	2.023E-05	2.791E-04	3.355E-05	0.000E+00
U-235	Ac-227	1.000E+00	6.651E-07	1.092E-04	3.780E-05	7.914E-17
U-235	∑DSR(j)		5.143E-01	3.472E-01	8.098E-03	7.914E-17
U-238	U-238	1.000E+00	1.680E-01	1.104E-01	1.913E-03	0.000E+00
U-238	U-234	1.000E+00	1.362E-07	1.843E-06	2.103E-07	0.000E+00
U-238	Th-230	1.000E+00	9.646E-13	2.339E-10	1.224E-09	0.000E+00
U-238	Ra-226	1.000E+00	2.835E-15	1.013E-11	7.055E-10	0.000E+00
U-238	Pb-210	1.000E+00	2.738E-18	9.112E-14	2.221E-11	0.000E+00
U-238	∑DSR(j)		1.680E-01	1.104E-01	1.913E-03	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	1.728E+01	6.451E+01	1.269E+07	7.214E+13
Pa-231	4.869E+01	4.738E+01	2.795E+03	*4.722E+10
Pb-210	1.373E+02	2.425E+02	6.092E+04	*7.631E+13
Ra-226	1.597E+01	2.082E+01	3.819E+02	*9.882E+11
Th-230	4.306E+02	4.162E+02	7.418E+02	*2.018E+10
U-234	1.033E+03	1.614E+03	1.302E+05	*6.245E+09
U-235	1.944E+02	2.880E+02	1.235E+04	*2.160E+06
U-238	5.953E+02	9.057E+02	5.227E+04	*3.360E+05

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	2.200E+00	0.000E+00	5.786E+00	1.728E+01	5.786E+00	1.728E+01
Pa-231	2.200E+00	4.711 ± 0.009	2.247E+00	4.451E+01	2.054E+00	4.869E+01
Pb-210	3.420E+01	0.000E+00	7.282E-01	1.373E+02	7.282E-01	1.373E+02
Ra-226	4.890E+01	0.000E+00	6.262E+00	1.597E+01	6.262E+00	1.597E+01
Th-230	4.890E+01	18.27 ± 0.04	2.422E-01	4.129E+02	2.322E-01	4.306E+02
U-234	4.890E+01	0.000E+00	9.681E-02	1.033E+03	9.681E-02	1.033E+03
U-235	2.200E+00	0.000E+00	5.143E-01	1.944E+02	5.143E-01	1.944E+02
U-238	4.890E+01	0.000E+00	1.680E-01	5.953E+02	1.680E-01	5.953E+02

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	1.273E+01	3.410E+00	1.734E-05	3.050E-12
Ac-227	Pa-231	1.000E+00	2.057E-01	1.875E+00	4.403E-02	5.512E-13
Ac-227	U-235	1.000E+00	1.463E-06	2.402E-04	8.315E-05	1.741E-16
Ac-227	∑DOSE(j)		1.294E+01	5.286E+00	4.413E-02	3.601E-12
Pa-231	Pa-231	1.000E+00	4.312E+00	2.768E+00	3.468E-02	0.000E+00
Pa-231	U-235	1.000E+00	4.450E-05	6.141E-04	7.381E-05	0.000E+00
Pa-231	∑DOSE(j)		4.312E+00	2.768E+00	3.475E-02	0.000E+00
Pb-210	Pb-210	1.000E+00	2.490E+01	1.410E+01	5.614E-02	0.000E+00
Pb-210	Ra-226	1.000E+00	6.238E-01	7.483E+00	9.589E-01	0.000E+00
Pb-210	Th-230	1.000E+00	9.673E-05	1.972E-02	1.040E-01	0.000E+00
Pb-210	U-234	1.000E+00	2.274E-10	6.056E-07	2.018E-05	0.000E+00
Pb-210	U-238	1.000E+00	1.339E-16	4.456E-12	1.086E-09	0.000E+00
Pb-210	∑DOSE(j)		2.553E+01	2.161E+01	1.119E+00	0.000E+00
Ra-226	Ra-226	1.000E+00	3.056E+02	2.274E+02	1.185E+01	0.000E+00
Ra-226	Th-230	1.000E+00	6.623E-02	1.198E+00	2.747E+00	0.000E+00
Ra-226	U-234	1.000E+00	1.968E-07	5.208E-05	5.793E-04	0.000E+00
Ra-226	U-238	1.000E+00	1.386E-13	4.956E-10	3.450E-08	0.000E+00
Ra-226	∑DOSE(j)		3.057E+02	2.286E+02	1.459E+01	0.000E+00
Th-230	Th-230	1.000E+00	1.129E+01	1.053E+01	3.741E+00	0.000E+00
Th-230	U-234	1.000E+00	5.020E-05	8.220E-04	8.728E-04	0.000E+00
Th-230	U-238	1.000E+00	4.717E-11	1.144E-08	5.987E-08	0.000E+00
Th-230	∑DOSE(j)		1.129E+01	1.053E+01	3.742E+00	0.000E+00
U-234	U-234	1.000E+00	4.734E+00	3.029E+00	3.610E-02	0.000E+00
U-234	U-238	1.000E+00	6.661E-06	9.013E-05	1.029E-05	0.000E+00
U-234	∑DOSE(j)		4.734E+00	3.029E+00	3.611E-02	0.000E+00
U-235	U-235	1.000E+00	1.131E+00	7.630E-01	1.766E-02	0.000E+00
U-238	U-238	1.000E+00	8.214E+00	5.399E+00	9.354E-02	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	2.200E+00	6.246E-01	7.481E-06	0.000E+00
Ac-227	Pa-231	1.000E+00	0.000E+00	3.191E-01	1.819E-02	3.141E-17
Ac-227	U-235	1.000E+00	0.000E+00	3.865E-05	3.415E-05	6.639E-19
Ac-227	∑S(j):		2.200E+00	9.436E-01	1.823E-02	3.207E-17
Pa-231	Pa-231	1.000E+00	2.200E+00	1.508E+00	5.036E-02	8.696E-17
Pa-231	U-235	1.000E+00	0.000E+00	3.191E-04	1.067E-04	1.859E-18
Pa-231	∑S(j):		2.200E+00	1.508E+00	5.047E-02	8.882E-17
Pb-210	Pb-210	1.000E+00	3.420E+01	2.075E+01	2.310E-01	6.754E-21
Pb-210	Ra-226	1.000E+00	0.000E+00	1.034E+01	3.889E+00	8.384E-11
Pb-210	Th-230	1.000E+00	0.000E+00	2.557E-02	4.150E-01	4.626E-01
Pb-210	U-234	1.000E+00	0.000E+00	7.433E-07	8.028E-05	1.104E-04
Pb-210	U-238	1.000E+00	0.000E+00	5.169E-12	4.305E-09	8.302E-09
Pb-210	∑S(j):		3.420E+01	3.112E+01	4.535E+00	4.627E-01
Ra-226	Ra-226	1.000E+00	4.890E+01	3.718E+01	3.154E+00	6.086E-11
Ra-226	Th-230	1.000E+00	0.000E+00	1.852E-01	7.209E-01	7.432E-01
Ra-226	U-234	1.000E+00	0.000E+00	7.697E-06	1.518E-04	1.774E-04
Ra-226	U-238	1.000E+00	0.000E+00	6.983E-11	9.016E-09	1.334E-08
Ra-226	∑S(j):		4.890E+01	3.736E+01	3.875E+00	7.434E-01
Th-230	Th-230	1.000E+00	4.890E+01	4.888E+01	4.870E+01	4.696E+01
Th-230	U-234	1.000E+00	0.000E+00	3.666E-03	1.136E-02	1.121E-02
Th-230	U-238	1.000E+00	0.000E+00	4.870E-08	7.780E-07	8.427E-07
Th-230	∑S(j):		4.890E+01	4.888E+01	4.871E+01	4.697E+01
U-234	U-234	1.000E+00	4.890E+01	3.352E+01	1.121E+00	1.969E-15
U-234	U-238	1.000E+00	0.000E+00	9.504E-04	3.180E-04	5.589E-18
U-234	∑S(j):		4.890E+01	3.353E+01	1.122E+00	1.974E-15
U-235	U-235	1.000E+00	2.200E+00	1.508E+00	5.047E-02	8.882E-17
U-238	U-238	1.000E+00	4.890E+01	3.353E+01	1.122E+00	1.974E-15

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 24.17 seconds

APPENDIX F

NATURAL BACKGROUND CONCENTRATIONS
OF RADIONUCLIDES IN SOIL

APPENDIX F

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Natural Background Concentrations of Radionuclides in Soil

F.0 Introduction

The natural background data are taken from the draft report, Preoperational Radiological Environmental Monitoring Program – Interim Results 1979-1980, prepared by Woodward-Clyde Consultants (PRL, 1980). A total of 62 samples were taken in and around the mill site in May and August of 1979 (see Table F-1). The samples were taken in a radial grid extending out from the center of the site. A background sample location was defined as a 100-m^2 area where ten 0.5 kg samples were taken to a depth of 5 cm. These ten samples were then composited into one single sample for that location, split, with one half of the sample sent off to the lab for analysis and the other half stored for possible future reference. Results for natural uranium (U-nat), Th-230, and Ra-226 are used in this analysis.

Table F-1 Preoperational Background Sample Data

	U-nat		Th-230		Ra-226	
Location	Conc. (pCi/g)	Error. (pCi/g)	Conc. (pCi/g)	Error. (pCi/g)	Conc. (pCi/g)	Error. (pCi/g)
1	0.32	0.12	0.45	0.21	0.18	0.05
2					0.31	0.03
3					0.18	0.03
4	0.36	0.10	0.66	0.41	0.23	0.07
5					0.26	0.03
6					0.21	0.02
7					0.60	0.04
8					0.35	0.03
9					0.16	0.02
10	0.37	0.15	0.47	0.21	0.18	0.05
11					0.23	0.03
12					0.10	0.02
13					0.15	0.04
14					0.23	0.04
15					0.18	0.03
16					0.15	0.02
17					0.16	0.02
18					0.23	0.03
19					0.25	0.03
20					0.69	0.04
21					0.40	0.04
22					0.43	0.04
23					0.30	0.03
24					0.18	0.03
25	0.74	0.54	0.94	0.79	0.00	0.02
26	0.24	0.15	0.15	0.08	0.07	0.02
27					0.48	0.04
28					0.19	0.02
29					0.18	0.02
30	0.48	0.34	0.29	0.17	0.33	0.10
31					0.10	0.03
32					1.23	0.05
33					0.16	0.03
34					0.17	0.03
35					0.57	0.04
36					0.99	0.06
37					0.36	0.04
38					1.37	0.72
39					0.51	0.04
40					0.40	0.04
41					0.22	0.03
42					0.20	0.03
43					0.16	0.02
44	0.59	0.11	0.48	0.20	0.31	0.09
45					0.48	0.04
46					0.36	0.04
47					0.21	0.03
48					0.54	0.04
49					0.46	0.04
50					0.38	0.03
51					0.26	0.03
52	0.56	0.19	1.30	0.80	0.27	0.08
53					0.27	0.04
54					1.46	0.39
55					0.21	0.02
56					0.13	0.02
AP-1	1.56	0.20	1.20	0.40	0.62	0.19
AP-2	0.41	0.14	0.28	0.14	0.22	0.07
AP-3	0.37	0.13	0.46	0.20	0.19	0.06
AP-4	0.35	0.09	0.37	0.18	0.19	0.06
C-1	0.31	0.09	0.30	0.15	0.19	0.06
C-2	0.42	0.15	0.25	0.15	0.20	0.06

F.1 Natural Background Sample Statistics

Both the descriptive statistics and ordinal statistics of the 62 background samples are presented in Table F-2. Of the 62 samples, only 14 were analyzed for U-nat or Th-230. The descriptive statistics show the number of samples in each data set, mean, and standard deviation as well as variance and skewness. The ordinal statistics present the range, maximum and minimum value, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles and the interquartile range for the three data sets.

Table F-2 Descriptive and Ordinal Statistics

	U-nat	**Th-230**	**Ra-226**
Count (n)	14	14	62
Mean	0.51	0.54	0.34
Geometric Mean	0.45	0.45	0.25
95^{th} Percentile C.I.	0.17	0.19	0.07
Standard Deviation	0.33	0.36	0.29
Variance	0.11	0.13	0.08
Skewness	2.83	1.26	2.46
Kurtosis	8.97	0.53	6.49
Mean + Std. Dev.	0.84	0.90	0.63
Minimum	0.24	0.15	0.00
Maximum	1.56	1.3	1.46
Range	1.32	1.15	1.46
10^{th} Percentile	0.31	0.26	0.15
25^{th} Percentile	0.35	0.29	0.18
50^{th} Percentile (Median)	0.39	0.46	0.23
75^{th} Percentile	0.54	0.62	0.40
90^{th} Percentile	0.70	1.12	0.60
95^{st} Percentile	1.07	1.24	0.97
Interquartile Range (IOR)	0.19	0.32	0.22

F.2 Analysis of Distribution

The distribution of measured values has been analyzed following the EPA recommended procedure and, where appropriate, use of the EPA software, Data Quality Evaluation Statistical Toolbox (DataQUEST) (EPA QA/G-9D). An *a priori* screening of the data was performed to assure that no outliers were included in the analysis (see Table F-3).

Any observation that is 4 or 5 times as large as the rest of the data is considered suspect (EPA 1989). Conservatively for this test, outliers are defined as maximum values greater than three times the next highest value. If a datum value fails the *a priori* test then it must be removed from the data set and explained. No data values were found to be outliers.

Table F-3 A *Priori* Screening

Parameter	Maximum Value	Next Maximum Value	Multiplicative Factor	Results
U-Nat	1.56	0.74	2.1	Pass
Th-230	1.30	1.2	1.1	Pass
Ra-226	1.46	1.37	1.1	Pass

A Determination of Percent Non-detects Analysis was performed on the data. If the percentage of non-detects was less than 15 percent, the non-detect was replaced by the detection limit divided by two. If the percentage of non-detects was found to be greater than 15 percent then the distribution was considered non-parametric and a distribution was not performed (EPA 1989, 1992). As shown in Table F-4 there was not a determination of non-parametric distribution.

Table F-4 Percentage of Non-Detects

Parameter	Number of Records	Number of Non-Detects	Percentage of Non-Detects	Results
U-Nat	14	0	0.00	Pass
Th-230	14	0	0.00	Pass
Ra-226	62	1	0.02	Pass

Histograms were then prepared for the U-nat, Th-230, and Ra-226 data sets as shown in Figures F-1, F-2, and F-3 and Figures F-4, F-5, and F-6 for the natural log (ln)–transformed data. While the data are skewed to the high concentration end of the distribution, it is not apparent from the histograms that the data are log-normally distributed.

A series of tests was then conducted to ascertain whether the data follow a parametric distribution. For these data sets, the parametric tests were restricted to testing for normality using the log transformed and non-transformed raw data. Normally-distributed data usually have a coefficient of variation of less than 1.0. The results, as shown in Table F-5, indicate that normality cannot be ruled out for all constituents, using the raw data and log-transformed data sets. The Coefficient of Variation was calculated using the DataQUEST software.

Table F-5 Coefficient of Variation Analysis

Parameter	Standard Deviation	Mean	Coefficient of Variation	Results
U-Nat (raw data)	0.33	0.51	0.65	Pass
U-Nat (log transformed data)	0.46	-0.80	-0.57	Pass
Th-230 (raw data)	0.36	0.54	0.66	Pass
Th-230 (log transformed data)	0.62	-0.79	-0.78	Pass
Ra-226 (raw data)	0.29	0.34	0.85	Pass
Ra-226 (log transformed data)	0.75	-1.34	-0.56	Pass

Almost 100% for the area within a normal curve lies within +/- five standard deviations from the mean. The Studentized Range Test for Normality was developed using this fact. This test compares the range of the sample divided by the standard deviation (s) to a critical value range. If the value is outside the range, the test fails. The results of this test are given in Table F-6 where all data sets passed with the exception of the log-transformed Ra-226 data set. Therefore the Ra-226 log transformed data may not be described as lognormal. The other results indicate there is not enough evidence to reject the assumption of normality with a 5 % significance level. The Studentized Range Test was performed using the DataQUEST software.

Table F-6 Studentized Range Test Analysis

Parameter	Critical Values		W/S	Results
	Maximum	Minimum		
U-Nat (raw data)	2.92	4.09	3.99	Pass
U-Nat (log transformed data)	2.92	4.09	4.05	Pass
Th-230 (raw data)	2.92	4.09	3.22	Pass
Th-230 (log transformed data)	2.92	4.09	3.50	Pass
Ra-226 (raw data)	3.98	5.53	5.09	Pass
Ra-226 (log transformed data)	3.98	5.53	6.30	Fail

It has been shown that a small degree of skewness (between –1 and +1) is not likely to affect the results of statistical tests based on an assumption of normality. However, if the coefficient of skewness is larger than 1 (in absolute value) and the sample size is small (e.g. < 25), statistical research has shown that standard normal theory-based tests are much less powerful than when the skewness is less than 1 (Gayen, 1949). Therefore, it is considered a failure of the test for normality if the coefficient of skewness exceeds 1. The results of the Coefficient of Skewness Test are shown in Table F-7. All tests failed at a significance level of 5 percent with the exception of the log-transformed Th-230 and Ra-226 data sets. Therefore the log-transformed Th-230 and Ra-226 data sets may be described as lognormal.

Table F-7 Coefficient of Skewness Test

Parameter	Coefficient of Skewness	Results
U-Nat (raw data)	2.5	Fail
U-Nat (log transformed data)	1.4	Fail
Th-230 (raw data)	1.1	Fail
Th-230 (log transformed data)	0.2	Pass
Ra-226 (raw data)	2.4	Fail
Ra-226 (log transformed data)	-0.8	Pass

The Shapiro-Wilk Test of Normality is based on the premise that, if a data set is normally distributed, the ordered values should be highly correlative with the corresponding quantiles taken from a normal distribution (Shapiro-Wilk, 1965). In particular, the Shapiro-Wilk Test of Normality gives substantial weight to the evidence of non-normality in the tails of a distribution, where the robustness of statistical tests based on the normality assumption is the most severely affected (EPA, 1992). It is applied to data sets with fewer than 50 data points.

The Shapiro-Wilk test statistic will tend to be large (close to 1) when the data is normally distributed. Only when the plotted data shows significant bends or curves will the test statistic be small. The Shapiro-Wilk Test of Normality is considered to be one of the best available tests of normality (Miller, 1986; Madansky, 1988). The results shown in Table F-8 reject the assumption of normality at the 5% significance level for the raw and log-transformed data sets for U-nat and the raw data set for Th-230. The Shapiro-Wilk Test of Normality was performed using the DataQUEST software.

Table F-8 Shapiro-Wilk Test of Normality (n < 50)

Parameter	Shapiro-Wilk Test Statistic	Table Value	Results
U-Nat (raw data)	0.649	0.874	Non-normality detected at 5.0 % significance level
U-Nat (log transformed data)	0.872	0.874	Non-lognormality detected at 5.0 % significance level
Th-230 (raw data)	0.834	0.874	Non-normality detected at 5.0 % significance level
Th-230 (log transformed data)	0.956	0.874	Not enough evidence to reject the assumption of lognormailty with a 5.0% significance level

Geary's normality test is another commonly used test for data sets having a minimum of 50 data points. The Ra-226 raw and log-transformed data sets showed non-normality at the 5% confidence limit as shown in Table F-9. The Geary's Test was performed using the DataQUEST software.

Table F-9 Geary's Test (n > 50)

Parameter	Geary's Test Statistic	Table Value	Results
Ra-226 (raw data)	-4.722	1.645	Non-normality detected at 5.0 % significance level
Ra-226 (log transformed data)	-3.315	1.645	Non-lognormality detected at 5.0 % significance level

The Filliben's Statistic is also considered a powerful tool for detecting non-normality. When applied to the data sets, all but the log-transformed Th-230 data showed non-normality at the 5% significance level as shown in Table F-10. The test could not reject the assumption of normality for the log-transformed data at the 5% confidence level. The Filliben's Statistic was performed using the DataQUEST software.

Table F-10 Filliben's Statistic

Parameter	Filliben's Test Statistic	Table Value	Results
U-Nat (raw data)	0.786	0.934	Non-normality detected at 5.0 % significance level
U-Nat (log transformed data)	0.922	0.934	Non-lognormality detected at 5.0 % significance level
Th-230 (raw data)	0.916	0.934	Non-normality detected at 5.0 % significance level
Th-230 (log transformed data)	0.979	0.934	Not enough evidence to reject the assumption of lognormailty with a 5.0% significance level
Ra-226 (raw data)	0.838	0.981	Non-normality detected at 5.0 % significance level
Ra-226 (log transformed data)	0.938	0.981	Non-lognormality detected at 5.0 % significance level

F.3 Summary and Recommendation

The analyses of distributions in Section F.2 indicate that the data are probably not normally or log-normally distributed. Therefore the distribution is non-parametric. As such, one cannot use a formula to develop a background value that corresponds to a specified Type I and Type II error rate.

The raw data and statistical parameters have been given in Table F-2, along with the calculated percentiles. The mean concentrations are on the low end of the range of natural background concentrations found in the United States. The standard deviations of the data are also very small in absolute value. In fact, the standard deviations of the raw data in the U-nat, Th-230, and Ra-226 data sets suggest that the analytical counting errors are a significant fraction of the standard deviation. This presents a practical problem in that the Type I error rate (false positives) may be unacceptably high due to laboratory uncertainty if the cleanup limit is low.

Site background concentrations of 0.51, 0.54 and 0.34 pCi/g, respectively, are proposed for U-nat, Th-230, and Ra-226. This roughly corresponds to the mean for each data set and is consistent with the mean background concentrations within the United States.

F.4 References

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Shapiro-Wilk, 1965. An Analysis of Variance Test for Normality (Complete Samples). Biometrika, 52: 591-611.

Figure F-1 U-Nat Histogram

n=14

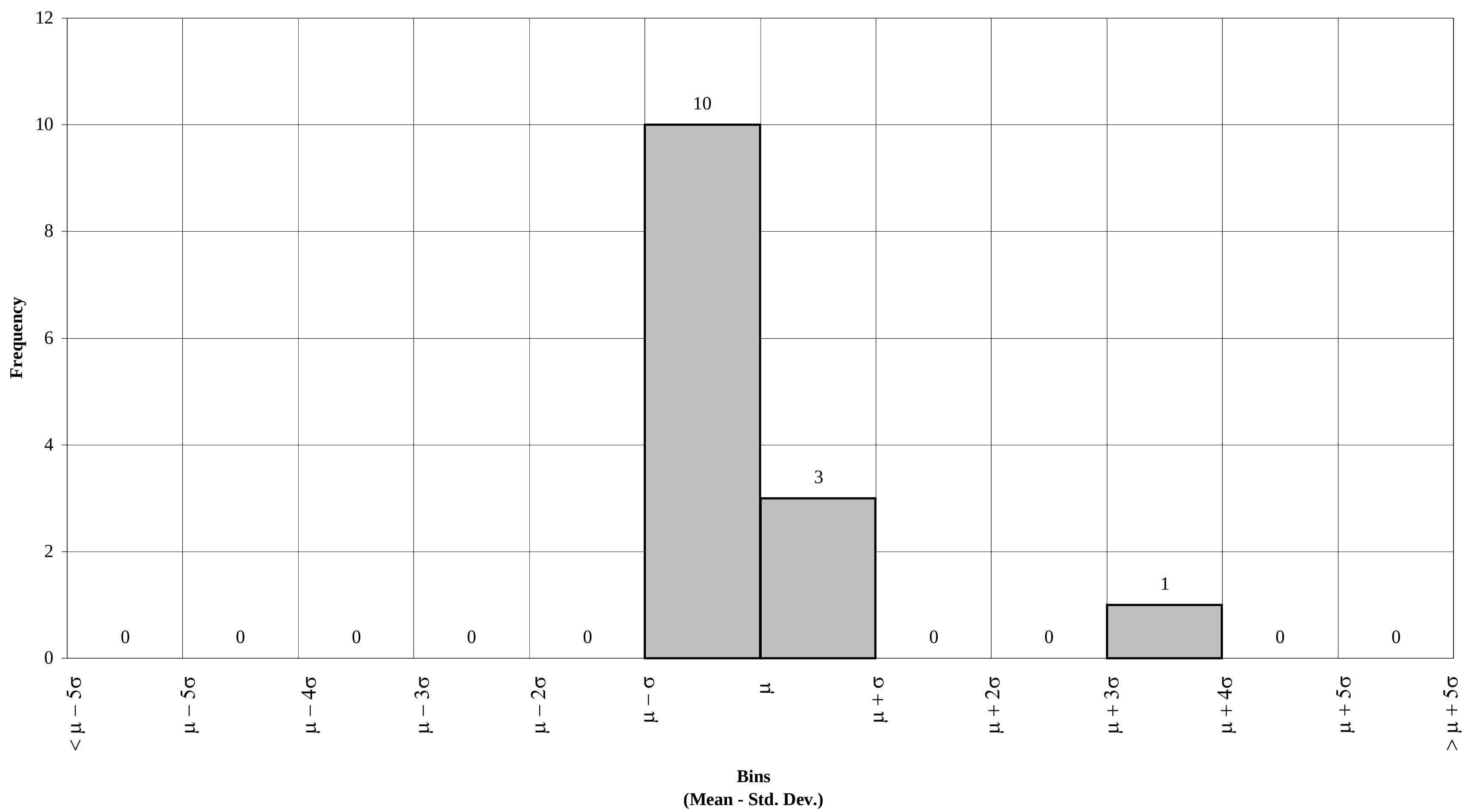


Figure F-2 Th-230 Histogram

n=14

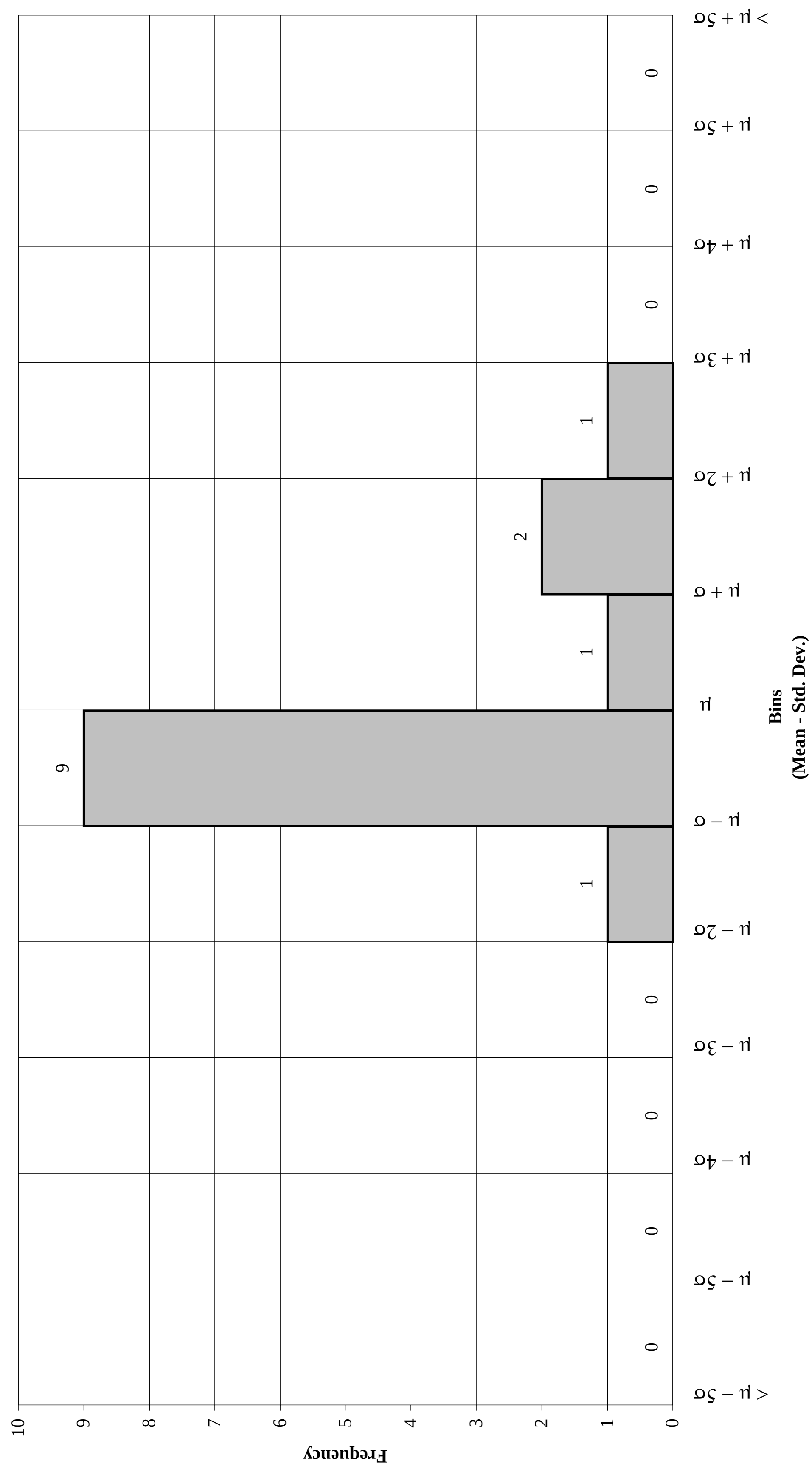


Figure F-3 Ra-226 Histogram
n=62

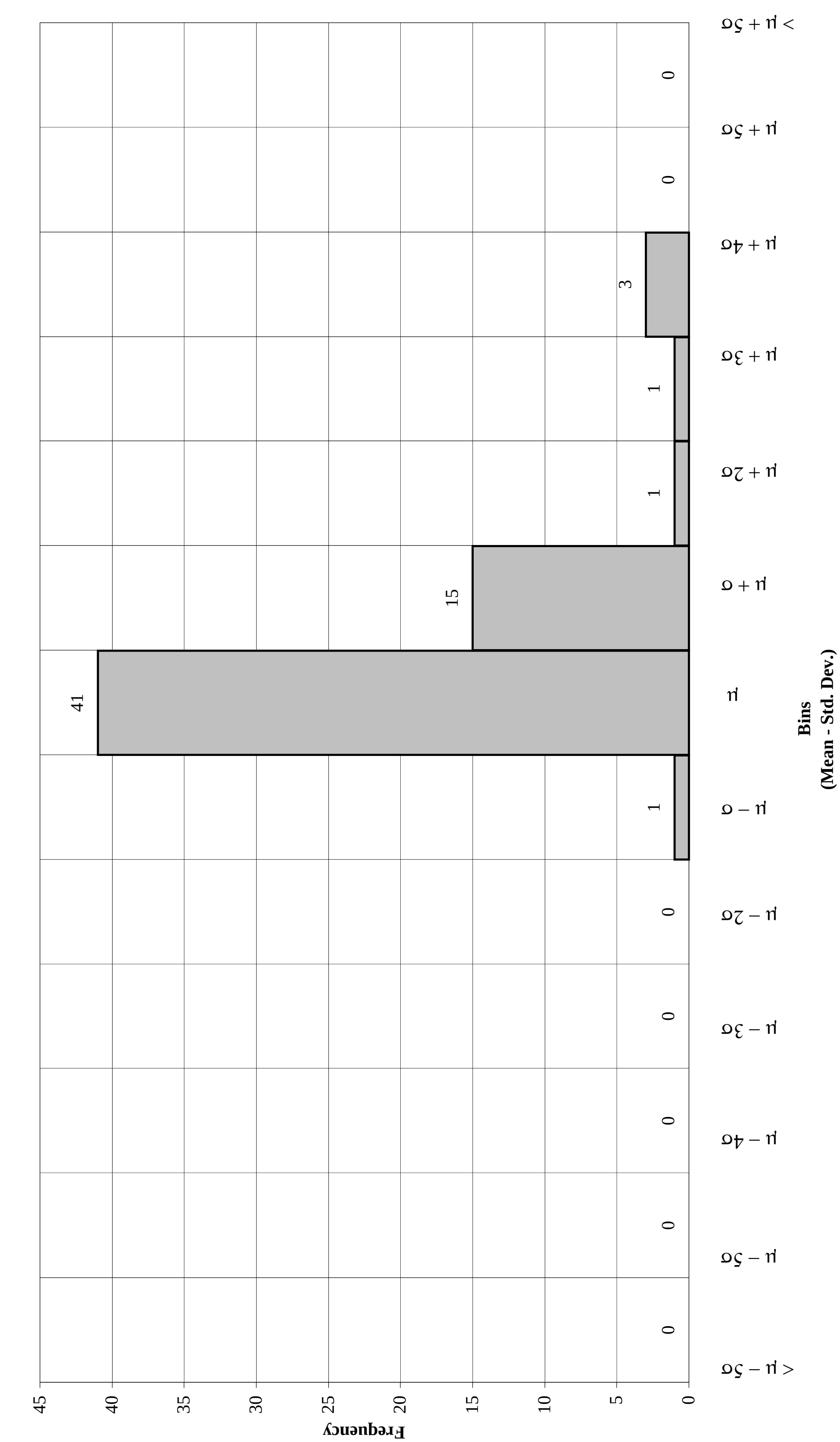


Figure F-4 Log Transformed U-Nat Data Histogram
n=14

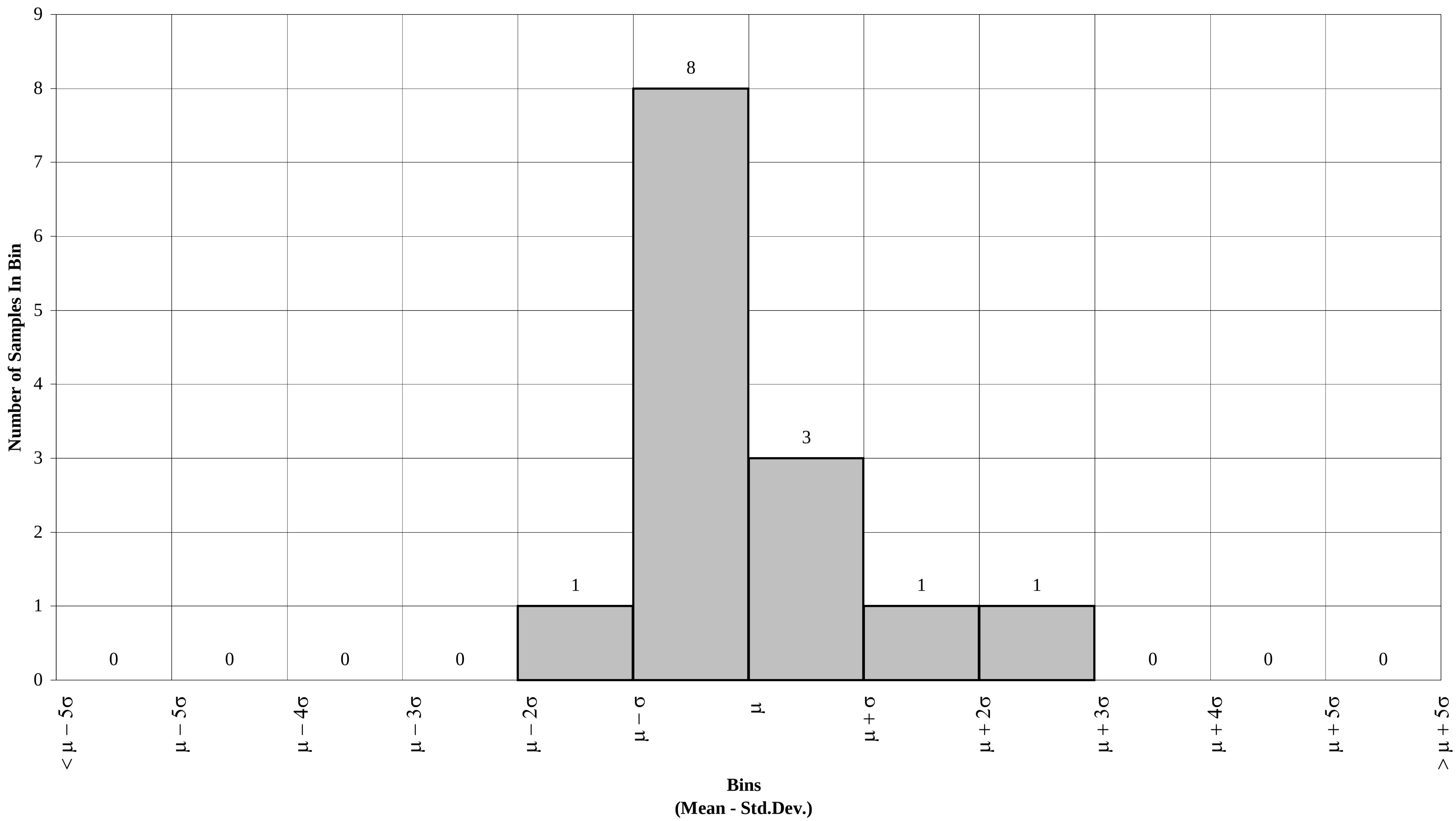


Figure F-5 Log Transformed Th-230 Data Histogram
n=14

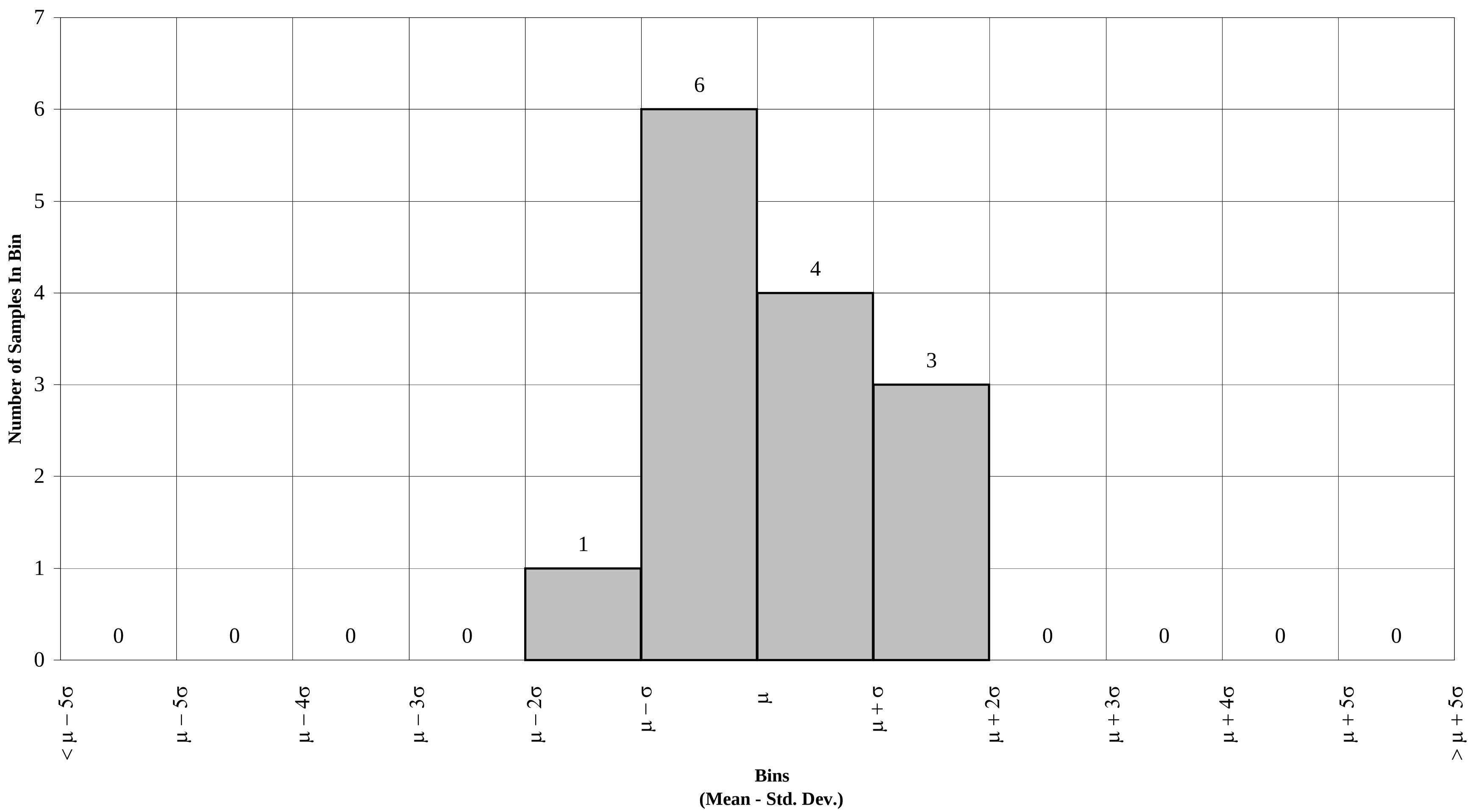
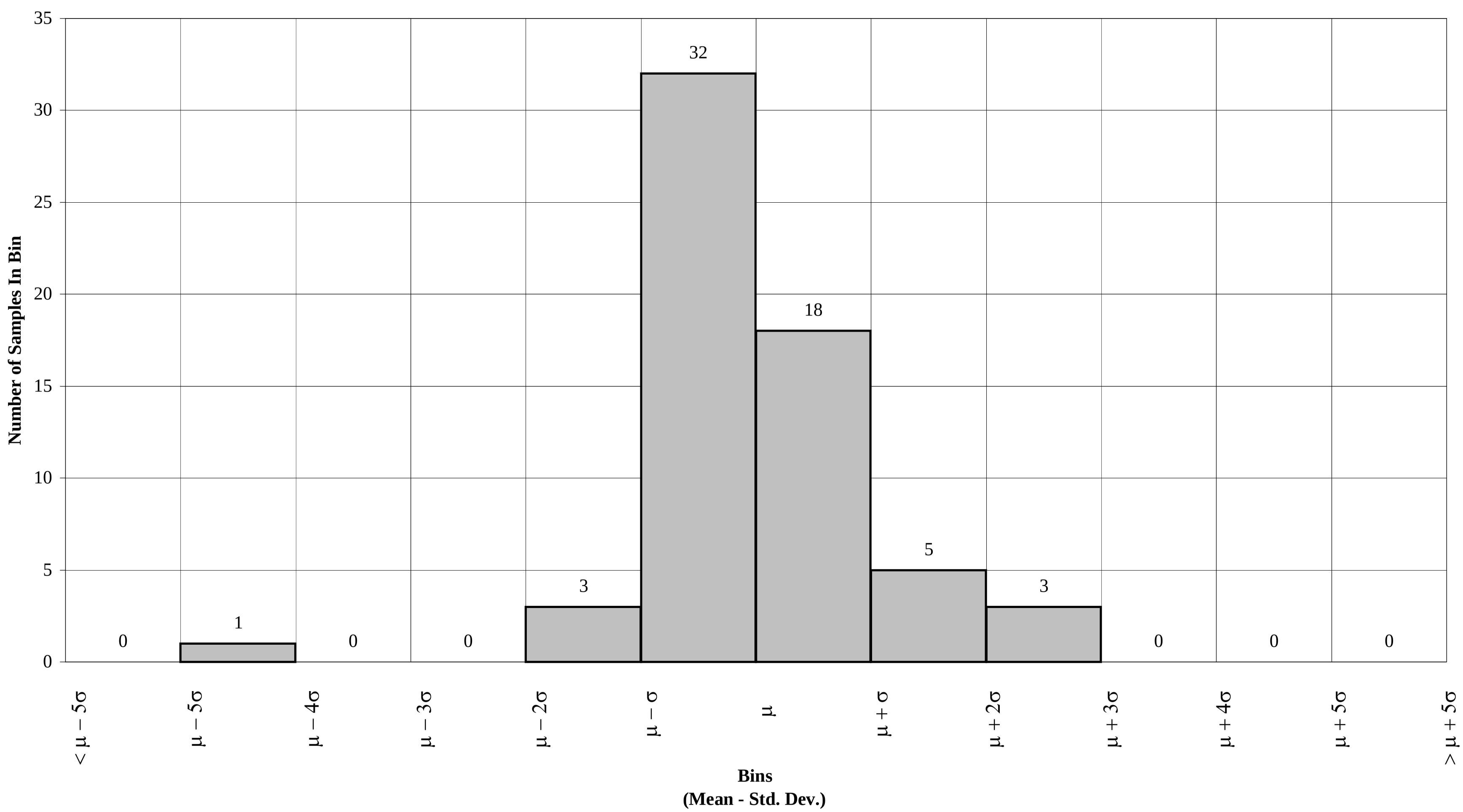


Figure F-6 Log Transformed Ra-226 Data Histogram
n=62



APPENDIX G

DERIVATION OF SURFACE CONTAMINATION LIMITS

APPENDIX G

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Appendix G
Derivation of Surface Contamination Limits

G.0 Introduction

RESRAD-Build 3.0 (ANL, 1994; NRC, 2000) was used to evaluate the dose to industrial workers occupying the buildings on the site currently within the radiologically restricted area. The future use for these buildings will likely be associated with the recreational needs of the local area. Possibilities include boat maintenance, refurbishing, and storage. The existing electrical power facilities could provide power to these buildings as well as to the local community.

The most restrictive exposure scenario related to these buildings is for workers, such as mechanics, hired to do boat service or repair. It is assumed the current offices within the buildings will remain to serve as administrative and support facilities for the workers.

The principal constituents in the surface contamination should reflect the process stream. The milling operations consist of the Ore Hopper and Conveyor Feed, SAG Mill, and Solvent Extraction Areas, where the radionuclide mix should be similar to ore. The radionuclide mix in the yellowcake drying and packaging area should consist of natural uranium that has been purified within the last 30 years.

The approach used was to calculate the radiological dose to industrial workers, assuming that the surface contamination was made up exclusively of one constituent. As will be seen, the worst-case model assumed all of the contamination to be uranium. The total gross surface contamination limit was then based on the presence of radionuclides that would result in a maximum dose to the workers of 25 mrem/y. This value is conservative compared to the Benchmark Approach and is consistent with 10 CFR Part 20, §20.1402.

G.1 Current Contamination

Low levels of surface contamination are known to exist generally throughout the buildings. The levels are considered low and less extensive when compared to those of uranium mills that were operated for long periods of time. Measured total gross alpha levels up to 796 dpm/100 cm^2 have been measured recently in the processing areas of the plant. Prior surface contamination data show that individual removable fractions of contamination are limited to approximately 8 percent of the total. Once the process equipment is removed from the buildings, a thorough cleaning of the contaminated building surface areas will be performed, rendering the surface cleanliness and contamination levels comparable to and possibly below current levels.

G.2 Parameter Justification

The exposure pathways considered in the industrial occupancy scenario are external exposure due to the source, inhalation of airborne radioactive material, and inadvertent ingestion of radioactive material. The parameter analysis is based on guidance provided in NUREG-5512 Volumes 1 and 3 (NRC, 1992, NRC, 1999) and NRC 2000. The selected parameter values, along with default parameter values, are provided in Table G-1. The bases for selecting parameter values are discussed below.

The default condition assumes that the maximum dose is received during the first year of occupancy by assuming the removable fraction is linearly removed within 365 days. We believe that this is reasonable but conservative for this situation since the levels of removable contamination will decrease over time in some areas. A build-up of dirt, grease, oil, paint, or other coverings may also occur which will reduce airborne concentration levels. The occupancy time was assumed to be 250 days per year, 8 hours per day over the 365-day exposure period. The fraction of the exposure period that a worker spends indoors is then (250 * 8)/(365 * 24) = 0.228. The workers were assumed to spend the entire work day in the contaminated area. A breathing rate of 18 m^3/day was used since it is representative of active workers.

Several room sizes and ceiling heights were evaluated. The calculated dose, however, is not highly sensitive to the room size but is highly dependent on ceiling height. An exchange rate of slightly less than 1 change per hour is normal for homes in the U.S. Reported studies of homes show maximum air exchange rates for homes average slightly less than one per hour and are typically less than 3 air exchanges per hour. (NRC, 2000). Since the buildings are not built to have low air exchange rates, and it is probable that the large doors would remain open during occupancy in reasonably warm weather, an air exchange rate of 2 air exchanges per hour was used in the model.

The model provides for a plane source or volume source. The source selected for the model was assumed to be a uniformly contaminated floor of size equal to the room size. It is unlikely that the contaminated area is larger than the floor area. Should this not be the case, the characterization surveys will reveal it and the calculated average limits will be reduced by an appropriate area factor. The results will show that the airborne activity is the predominant dose pathway to the occupants. It is probable that the resuspended particulate will arise from the contaminated floor rather than the walls or ceiling. For these reasons, it is believed that considering only the floor to be contaminated is a reasonable approach for modeling the dose using RESRAD-Build. The receptor was placed in the center of the floor and the total effective dose equivalent (TEDE) calculated at a height of one meter above the floor.

The deposition velocity for indoor air has been shown to vary considerably. RESRAD-Build assumes a loguniform probability distribution with a range from 2.7E-6 m/s to 2.7E-3 m/s. A sensitivity analysis shows that the TEDE varied less than three percent with changes in this parameter. Therefore a conservative value of 0.01 m/s was selected. Similarly, the results were influenced by less than three percent with changes in the resuspension rate. RESRAD-Build assumes a loguniform probability distribution ranging from 2.8E-10 s^{-1} to 1.4E-5 s^{-1}. A value of 5E-7 s^{-1} was selected for this parameter.

Preliminary site characterization data indicate removable fractions of less than 8 percent. Since an extensive survey and cleaning effort will occur prior to the release of the sites, we believe that 20 percent is conservative for these buildings.

Table G-1 Parameter for the Industrial Use Scenario

RESRAD Building Parameter	Selected Value
External dose rate factor from surfaces (mrem/h per dpm/100 cm^2	FG Report No. 12
Inhalation CEDE factor (mrem/pCi inhaled)	FG Report No. 11
Ingestion CEDE factor (mrem/pCi ingested)	FG Report No. 11
Exposure period (days)	365
Fraction of time that exposure occurs during the exposure period (called indoor fraction in RESRAD-Build)	0.228
Time fraction of receptor	1
Deposition velocity (m/s)	0.01
Resuspension rate (1/s)	5.0E-07
Volumetric breathing rate (m^3/day)	18
Effective transfer rate for ingestion of removable contamination from surfaces to hands, from hands to mouth (m^2/h)	1.0E-04
Fraction of Removable Contamination	20%
Size of Room (m * m * m)	10 * 10 * 10
Loose Fraction Removal Time (days)	365
Air Exchange Rate (1/h)	2
Source Geometry (m * m * m)	10 * 10 * 0
Radon Release Fraction	0.3
Fraction of time at work subject to exposure	1
Direct Ingestion Rate	0

The radon release fraction is based on the emanating fraction for radon in mill tailings, which typically ranges from 0.1-0.3. Since the contamination layer is very thin, we believe that a larger fraction of the Rn-222 will be released. The radon release rate for Rn-219 is probably closer to zero since the half life is less than 1 minute. However, the low abundance of the U-235 decay chain makes the TEDE from the U-235 decay chain negligible. We have therefore used 0.3 as the emanation fraction for radon.

G.3 Radionuclide Source Term

RESRAD-Build considers only the long-lived radionuclides (half lives longer than 0.5 years). For short-lived progeny, the code automatically includes the in-growth and corresponding dose contributions with the parent. The two source terms of interest for the buildings are yellowcake and ore (or process material). For ore (or process material) the secular equilibrium was assumed down to radon. It was assumed that 30 percent of the Rn-222 escaped from the solid matrix for ore. No release of the Rn-219 in the U-235 series was assumed since gaseous diffusion out of the matrix is unlikely because the half life of Rn-219 is less than one second.

The natural activity abundance of natural uranium is 2.2 percent U-235, and 48.9 percent each of U-238 and U-234. It is desirable to measure surface contamination for these facilities as gross alpha/100 cm^2. We therefore have derived surface activity limits by first calculating, using RESRAD-Build, a TEDE corresponding to 1,000 dpm gross alpha/100 cm^2. For the yellowcake-contaminated areas the in-growth of alpha-emitting progeny can be shown to be negligible, thus a gross alpha contamination level of 1,000 dpm/100 cm^2 would result in contributions of 489 dpm/100 cm^2, 489 dpm/100 cm^2, and 22 dpm/100 cm^2 from U-238, U-234, and U-235 respectively. These activities were used as input into RESRAD-Build for yellowcake contamination.

The determination of the activities for the long-lived radionuclides in uranium ore is more difficult as shown below. The alpha emitting radionuclides from uranium ore are given in Table G-2 below. Only the radionuclides with half lives longer than 0.5 year are considered. The alpha decays of each radionuclide and short-lived progeny are listed in the second column of Table G-2. The value for Ra-226 was obtained by assuming that 70 percent of the Rn-222 remained in the solid matrix. Thus only 70 percent of the alpha emissions from the Rn-222 and progeny (Po-218 and Po-214) will be observed. Similarly, only 70 percent of the alpha particles from the Pb-210 progeny, Po-210, will be observed.

Table G-2 Alpha Emissions from the Parent Decay of Long-Lived Radionuclides in Uranium Ore

Decay Chain	Radionuclide	Alpha emissions per parent decay
D_{238}	U-238	1
	U-234	1
	Th-230	1
	Ra-226	3.1
	Pb-210	0.7
D_{235}	U-235	1
	Pa-231	1
	Ac-227	5

In order to calculate the activity concentrations of the radionuclides for input into the RESRAD-Build code, we have used the following relationship:

$$D_{235} + D_{238} = 1000 \text{ dpm/100 cm}^2$$

Where: D_{235} and D_{238} are the emission rate of alphas from the U-235 and U-238 decay chains per 100 cm^2, respectively. Using data from Table G-2 and the natural activity abundance ratio for U-235/U-238 (0.022/0.0489), the equation can be rewritten using the following steps as:

(1) $(D'_{235} * 7) + (D'_{238} * 6.8) = 1000$
(2) $D'_{235} = (0.022/0.489) * D'_{238}$
(3) $[(0.022/0.489) * 7 * D'_{238}] + (6.8 * D'_{238}) = 1000 \text{ dpm/100 cm}^2$

Where: D'_{235} is the disintegration rate of U-235 per 100 cm^2 and D'_{238} is the disintegration rate of U-238 per 100 cm^2. Solving for D_{238} and using the natural abundance ratios, D'_{238} = 140 dpm/100 cm^2 and D'_{235} = 6.3 dpm/100 cm^2.

The source term input for uranium ore is provided in Table G-3, using the calculated activities for the parents of the decay chain, U-238 and U-235, and the assumed radon release rates as discussed above.

Table G-3 Surface Parent Activities of Long-Lived Radionuclides of Uranium Ore that Result in a Gross Alpha Activity of 1,000 dpm/100 cm^2

Radionuclide	Activity (dpm/100 cm^2)
U-238	140
U-234	140
Th-230	140
Ra-226	140
Pb-210	98
U-235	6.3
Pa-231	6.3
Ac-227	6.3

G.4 Results

RESRAD-Build was run for rooms of various sizes where the contaminants were either yellowcake or residue having a radionuclide mix corresponding to uranium ore. In all cases, only the floor was assumed to be contaminated at 1,000 dpm/100 cm^2 (4.5E+4 pCi/m^2). For uranium, the natural abundance ratio was assumed where the total activity for uranium was divided into 48.9 percent each for U-238 and U-234 and 2.2 percent for U-235. The results of the calculations are included in the RESRAD-Build reports included at the end of this section as Attachment G-1 through G-8 and summarized in Table G-4.

Table G-4 TEDE from Industrial Worker Exposure to Surface Contamination at a Level of 1,000 dpm/100 cm^2

Contaminant	Room Size L x W x H (m x m x m)	Total Effective Dose Equivalent (TEDE) (mrem)
Yellowcake	3 * 3 * 3	32.1
Yellowcake	3 * 3 * 15	6.43
Yellowcake	10 * 10 * 5	19.3
Yellowcake	100 * 100 * 15	6.44
Uranium Ore	3 * 3 * 3	35.3
Uranium Ore	3 * 3 * 15	7.11
Uranium Ore	10 * 10 * 5	21.3
Uranium Ore	100 * 100 * 15	7.3

The results show that the TEDE decreases as the volume of the room increases which is to be expected since the room air exchange rate was held constant at 2 air exchanges per hour. Currently, the mill building has very large rooms and a few small offices or rooms, all having a height of approximately 15 m. Table G-4 shows that the TEDE for workers in the large rooms (approximately 100 m * 100 m * 15 m) is almost identical to that for workers in small rooms (3 m * 3 m * 15 m) as long as the ceiling height remains the same. It is likely that work areas will be 10 m * 10 m in size or larger and the desirable ceiling height of 15 m would be retained. If a false ceiling were added to allow for more efficient air conditioning, a minimum ceiling height of 5 m would be expected. One or more of the smaller rooms might be used as an office where occupancy is a consideration. While the current height is approximately 15 m, the ceiling might be lowered to as low as 3 m. A floor covering would probably be added thus limiting the airborne radioactive particulate. This suggests that the most conservative room model would be a room with dimensions of 10 m * 10 m * 5 m high for industrial workers and 3 m * 3 m * 3 m for clerical or management personnel. The results shown in Table G-4 show that the TEDE remains constant as the area of room shrinks to the size of a small office (3 m * 3 m) and depends primarily on the ceiling height. It also shows that the most limiting model (3 m * 3 m * 3 m) results in a TEDE of approximately 35 mrem/y for a contamination level of 1,000 dpm/100 cm^2, for either yellowcake contamination or uranium ore. Thus, an average gross alpha surface contamination level of 1,000 dpm would expect to result in a maximum TEDE of 35 mrem/y.

The RESRAD-Build output shows that more than 99 percent of the TEDE arises from the inhalation pathway. Therefore the TEDE is proportional to the average contamination on the floor. Multiplying the contamination level of 1,000 dpm/100 cm^2 by 25 mrem/35 mrem, an average gross alpha surface contamination of 700 dpm/100 cm^2 should limit the TEDE to 25 mrem/y. The RESRAD-Build modeling assumed a removable fraction of

0.2, resulting in a removable limit of 140 dpm/100 cm^2. Using the Benchmark Dose of 34 mrem/y, the limits could be significantly higher. However because of ALARA considerations, it is proposed to use 700 and 140 dpm/100 cm^2 for the total and removable gross alpha limits, respectively.

G.5 Conservatism and ALARA

RESRAD-Build uses conservative dose conversation factors taken from Federal Guidance Report No. 11 (EPA, 1998). There is no user option for changing these factors. For uranium, the chemical form for inhalation is assumed by RESRAD-Build to be very insoluble (Class Y) rather than the more soluble form (Class W) or the highly soluble (Class D) chemical form. While no data are available for this site, it is probable that a large percentage of the uranium is Class W and Class D, which would reduce the TEDE significantly. Other parameters chosen conservatively include ceiling height, loose fraction removal time, and building air exchange rate.

G.6 References

ANL, 1994. RESRAD-Build: A Computer Model for Analyzing the Radiological Doses Resulting from the Remediation and Occupancy of Buildings Contaminated with Radioactive Material. ANL/EAD/LD-3. Environmental Assessment Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439.

EPA, 1988. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Federal Guidance Report No. 11. 1988. Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460

NRC, 1992. Residual Radioactive Contamination from Decommissioning. NUREG/CR-5512 Vol. 1. 1992. U. S. Nuclear Regulatory Commission, Washington, D.C. 20555.

NRC, 1999. Residual Radioactive Contamination from Decommissioning. Parameter Analysis. Draft Report for Comment. October 1999. U. S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

NRC, 2000. Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes. November 2000. Prepared by Argonne National Laboratory for U. S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

ATTACHMENT G-1

Yellowcake RESRAD-Build Run

Room Size 3m x 3m x 3m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]          Air Exchanges [m3/hr]
 Area [m2]
                   ******************************
                   *                            *
                   *                            *
                   *                            <=Q01: 5.40E+01
 H1:    3.000      *          Room  1           *       Q10 :  5.40E+01
                   *   LAMBDA: 2.00E+00         *
 Area   9.000      *                            *
                   *                            *
                   ******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

```
Source:  1
       Location::  Room :  1   x:    1.50 y:    1.50   z:    0.00[m]
       Geometry::  Type: Area        Area:9.00E+00 [m2]  Direction: z
       Pathway ::
            Direct Ingestion Rate:     0.000E+00 [1/hr]
            Fraction released to air: 1.000E+00
            Removable fraction:        2.000E-01
            Time to Remove:            3.650E+02 [day]

            Radon Release Fraction:    3.000E-01
```

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.775E-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.667E-03	3.027E+00	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	3.21E+01	3.21E+01
Total	3.21E+01	3.21E+01

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.76E-03	2.33E-04	3.84E-06	3.19E+01	1.84E-11	1.88E-01
Total	2.76E-03	2.33E-04	3.84E-06	3.19E+01	1.84E-11	1.88E-01

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	1.48E+01	1.48E+01
U-234	2.26E-05	2.26E-05
TH-230	1.70E-10	1.70E-10
RA-226	6.55E-16	6.55E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	6.98E-01	6.98E-01
PA-231	7.77E-05	7.77E-05
AC-227	4.16E-06	4.16E-06
U-234		
U-234	1.66E+01	1.66E+01
TH-230	1.84E-04	1.84E-04
RA-226	1.07E-09	1.07E-09
PB-210	2.61E-11	2.61E-11

ATTACHMENT G-2

Yellowcake RESRAD-Build Run

Room Size 3m x 3m x 15m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

```
             ═══════  Building Information  ═══════

      Building Air Exchange Rate: 2.00E+00 1/hr

   Height[m]          Air Exchanges [m3/hr]
   Area [m2]
                     *******************************
                     *                             *
                     *                             *
                     *                             *<=Q01: 2.70E+02
   H1:  15.000       *         Room  1             *      Q10 :  2.70E+02
                     *   LAMBDA: 2.00E+00          *
  Area    9.000      *                             *
                     *                             *
                     *******************************

     Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]
```

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00[m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.775E-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.667E-03	3.027E+00	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

```
Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time:     0.000000     years

    ==      Assessment for Time:  1        ==
    ==           Time =0.00E+00 yr         ==

    ======= Source Information =======

Source:  1
       Location::  Room :  1   x:    1.50 y:    1.50   z:    0.00 [m]
       Geometry::  Type: Area       Area:9.00E+00 [m2]  Direction: z
       Pathway ::
            Direct Ingestion Rate:     0.000E+00 [1/hr]
            Fraction released to air: 1.000E+00
            Removable fraction:        2.000E-01
            Time to Remove:            3.650E+02 [day]
```

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	6.43E+00	6.43E+00
Total	6.43E+00	6.43E+00

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.76E-03	4.66E-05	7.68E-07	6.39E+00	8.23E-12	3.76E-02
Total	2.76E-03	4.66E-05	7.68E-07	6.39E+00	8.23E-12	3.76E-02

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.97E+00	2.97E+00
U-234	4.53E-06	4.53E-06
TH-230	3.40E-11	3.40E-11
RA-226	1.67E-16	1.67E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	1.40E-01	1.40E-01
PA-231	1.55E-05	1.55E-05
AC-227	8.41E-07	8.41E-07
U-234		
U-234	3.32E+00	3.32E+00
TH-230	3.67E-05	3.67E-05
RA-226	2.74E-10	2.74E-10
PB-210	5.28E-12	5.28E-12

ATTACHMENT G-3

Yellowcake RESRAD-Build Run

Room Size 10m x 10m x 5m

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	5.000	5.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

```
                ========  Building Information  ========

     Building Air Exchange Rate: 2.00E+00 1/hr

  Height[m]        Air Exchanges [m3/hr]
  Area [m2]
                  ******************************
                  *                            *
                  *                            *
                  *                            <=Q01: 1.00E+03
  H1:    5.000    *         Room  1            *      Q10 :  1.00E+03
                  *   LAMBDA: 2.00E+00         *
 Area 100.000     *                            *
                  *                            *
                  ******************************

    Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]
```

Source Information

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00[m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors: Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/(pCi/m3)]
U-238	2.200E+04	2.690E-04	1.180E-01	1.600E-04
U-235	9.910E+02	2.670E-04	1.230E-01	9.030E-04
U-234	2.200E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	0.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-230	0.000E+00	5.480E-04	3.260E-01	2.040E-06
AC-227	0.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-226	0.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

```
Source:  1
        Location::  Room :  1  x:   5.00 y:   5.00  z:   0.00 [m]
        Geometry::  Type: Area      Area:1.00E+02 [m2]  Direction: z
        Pathway ::
             Direct Ingestion Rate:    0.000E+00 [1/hr]
             Fraction released to air: 1.000E+00
             Removable fraction:       2.000E-01
             Time to Remove:           3.650E+02 [day]
```

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	2.200E+04
U-235	9.910E+02
U-234	2.200E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	1.93E+01	1.93E+01
Total	1.93E+01	1.93E+01

Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	6.98E-03	3.53E-04	2.30E-06	1.92E+01	1.48E-11	1.13E-01
Total	6.98E-03	3.53E-04	2.30E-06	1.92E+01	1.48E-11	1.13E-01

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.91E+00	8.91E+00
U-234	1.36E-05	1.36E-05
TH-230	1.02E-10	1.02E-10
RA-226	4.82E-16	4.82E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	4.20E-01	4.20E-01
PA-231	4.66E-05	4.66E-05
AC-227	2.51E-06	2.51E-06
U-234		
U-234	9.96E+00	9.96E+00
TH-230	1.10E-04	1.10E-04
RA-226	7.90E-10	7.90E-10
PB-210	1.58E-11	1.58E-11

ATTACHMENT G-4

Yellowcake RESRAD-Build Run

Room Size 100m x 100m x 15m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	50.000	50.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]          Air Exchanges [m3/hr]
 Area [m2]
                   ******************************
                   *                            *
                   *                            *
                   *                           <=Q01: 3.00E+05
 H1:  15.000       *          Room  1           *      Q10 :  3.00E+05
                   *   LAMBDA: 2.00E+00         *
Area********       *                            *
                   *                            *
                   ******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1
Location:: Room : 1 x: 50.00 y: 50.00 z: 0.00[m]
Geometry:: Type: Area Area:1.00E+04 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
		Ingestion	Inhalation	Submersion
	[dpm/m2]	[mrem/dpm]	[mrem/dpm]	[mrem/yr/ (dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.775E-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.667E-03	3.027E+00	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

```
=== Assessment for Time: 1 ===
===      Time =0.00E+00 yr   ===
```

Source Information

```
Source:  1
      Location::  Room :  1  x:  50.00 y:  50.00  z:   0.00 [m]
      Geometry::  Type: Area       Area:1.00E+04 [m2]  Direction: z
      Pathway ::
           Direct Ingestion Rate:     0.000E+00 [1/hr]
           Fraction released to air: 1.000E+00
           Removable fraction:        2.000E-01
           Time to Remove:            3.650E+02 [day]
```

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	6.44E+00	6.44E+00
Total	6.44E+00	6.44E+00

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.61E-02	2.72E-04	7.68E-07	6.39E+00	8.23E-12	3.76E-02
Total	1.61E-02	2.72E-04	7.68E-07	6.39E+00	8.23E-12	3.76E-02

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.98E+00	2.98E+00
U-234	4.53E-06	4.53E-06
TH-230	3.40E-11	3.40E-11
RA-226	3.77E-16	3.77E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	1.43E-01	1.43E-01
PA-231	1.56E-05	1.56E-05
AC-227	8.42E-07	8.42E-07
U-234		
U-234	3.32E+00	3.32E+00
TH-230	3.67E-05	3.67E-05
RA-226	6.17E-10	6.17E-10
PB-210	5.28E-12	5.28E-12

ATTACHMENT G-5

Uranium Ore RESRAD-Build Run

Room Size 3m x 3m x 3m

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Building Information

```
   Building Air Exchange Rate: 2.00E+00 1/hr

 Height[m]          Air Exchanges [m3/hr]
 Area [m2]
                   ******************************
                   *                            *
                   *                            *
                   *                            <=Q01: 5.40E+01
 H1:    3.000      *         Room  1            *      Q10 :  5.40E+01
                   *   LAMBDA: 2.00E+00         *
 Area   9.000      *                            *
                   *                            *
                   ******************************

  Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]
```

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00[m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
		Ingestion	Inhalation	Submersion
	[dpm/m2]	[mrem/dpm]	[mrem/dpm]	[mrem/yr/ (dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	3.53E+01	3.53E+01
Total	3.53E+01	3.53E+01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.34E-02	2.81E-03	5.84E-05	3.44E+01	8.62E-03	8.23E-01
Total	3.34E-02	2.81E-03	5.84E-05	3.44E+01	8.62E-03	8.23E-01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	4.25E+00	4.25E+00
U-234	6.48E-06	6.48E-06
TH-230	4.70E-11	4.70E-11
RA-226	1.76E-16	1.76E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	1.99E-01	1.99E-01
PA-231	2.14E-05	2.14E-05
AC-227	1.13E-06	1.13E-06
U-234		
U-234	4.75E+00	4.75E+00
TH-230	5.07E-05	5.07E-05
RA-226	2.93E-10	2.93E-10
PB-210	7.03E-12	7.03E-12
PA-231		
PA-231	2.11E+00	2.11E+00
AC-227	1.63E-01	1.63E-01
TH-230		
TH-230	1.17E+01	1.17E+01
RA-226	9.96E-05	9.96E-05
PB-210	3.16E-06	3.16E-06
AC-227		
AC-227	1.06E+01	1.06E+01
RA-226		
RA-226	4.78E-01	4.78E-01
PB-210	2.23E-02	2.23E-02
PB-210		
PB-210	1.04E+00	1.04E+00

ATTACHMENT G-6

Uranium Ore RESRAD-Build Run

Room Size 3m x 3m x 15m

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

═══════ Building Information ═══════

```
     Building Air Exchange Rate: 2.00E+00 1/hr

  Height[m]          Air Exchanges [m3/hr]
  Area [m2]
                   ******************************
                   *                            *
                   *                            *
                   *                            <=Q01: 2.70E+02
  H1:  15.000      *          Room  1           *      Q10 :  2.70E+02
                   *   LAMBDA: 2.00E+00         *
 Area   9.000      *                            *
                   *                            *
                   ******************************

    Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]
```

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00[m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
		Ingestion	Inhalation	Submersion
	[dpm/m2]	[mrem/dpm]	[mrem/dpm]	[mrem/yr/ (dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	7.11E+00	7.11E+00
Total	7.11E+00	7.11E+00

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.34E-02	5.62E-04	1.17E-05	6.91E+00	3.85E-03	1.66E-01
Total	3.34E-02	5.62E-04	1.17E-05	6.91E+00	3.85E-03	1.66E-01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.50E-01	8.50E-01
U-234	1.30E-06	1.30E-06
TH-230	9.39E-12	9.39E-12
RA-226	4.56E-17	4.56E-17
PB-210	0.00E+00	0.00E+00
U-235		
U-235	4.00E-02	4.00E-02
PA-231	4.29E-06	4.29E-06
AC-227	2.28E-07	2.28E-07
U-234		
U-234	9.49E-01	9.49E-01
TH-230	1.01E-05	1.01E-05
RA-226	7.56E-11	7.56E-11
PB-210	1.42E-12	1.42E-12
PA-231		
PA-231	4.21E-01	4.21E-01
AC-227	3.29E-02	3.29E-02
TH-230		
TH-230	2.34E+00	2.34E+00
RA-226	2.57E-05	2.57E-05
PB-210	6.38E-07	6.38E-07
AC-227		
AC-227	2.14E+00	2.14E+00
RA-226		
RA-226	1.23E-01	1.23E-01
PB-210	4.50E-03	4.50E-03
PB-210		
PB-210	2.09E-01	2.09E-01

ATTACHMENT G-7

Uranium Ore RESRAD-Build Run

Room Size 10m x 10m x 5m

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	5.000	5.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld

Building Information

```
     Building Air Exchange Rate: 2.00E+00 1/hr

  Height[m]          Air Exchanges [m3/hr]
  Area [m2]
                    ******************************
                    *                            *
                    *                            *
                    *                           <=Q01: 1.00E+03
  H1:    5.000      *         Room  1            *      Q10 :  1.00E+03
                    *   LAMBDA: 2.00E+00         *
 Area 100.000       *                            *
                    *                            *
                    ******************************

    Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]
```

Source Information

```
Source:  1
       Location::  Room :  1  x:    5.00 y:    5.00  z:    0.00[m]
       Geometry::  Type: Area        Area:1.00E+02 [m2]  Direction: z
       Pathway ::
           Direct Ingestion Rate:     0.000E+00 [1/hr]
           Fraction released to air: 1.000E+00
           Removable fraction:        2.000E-01
           Time to Remove:            3.650E+02 [day]

           Radon Release Fraction:    3.000E-01
```

Contamination::

Nuclide	Concentration [dpm/m2]	Dose Conversion Factors: Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	2.13E+01	2.13E+01
Total	2.13E+01	2.13E+01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	8.61E-02	4.34E-03	3.50E-05	2.07E+01	6.92E-03	4.95E-01
Total	8.61E-02	4.34E-03	3.50E-05	2.07E+01	6.92E-03	4.95E-01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.55E+00	2.55E+00
U-234	3.89E-06	3.89E-06
TH-230	2.82E-11	2.82E-11
RA-226	1.31E-16	1.31E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	1.20E-01	1.20E-01
PA-231	1.29E-05	1.29E-05
AC-227	6.81E-07	6.81E-07
U-234		
U-234	2.85E+00	2.85E+00
TH-230	3.04E-05	3.04E-05
RA-226	2.17E-10	2.17E-10
PB-210	4.24E-12	4.24E-12
PA-231		
PA-231	1.26E+00	1.26E+00
AC-227	9.82E-02	9.82E-02
TH-230		
TH-230	7.03E+00	7.03E+00
RA-226	7.39E-05	7.39E-05
PB-210	1.90E-06	1.90E-06
AC-227		
AC-227	6.38E+00	6.38E+00
RA-226		
RA-226	3.54E-01	3.54E-01
PB-210	1.34E-02	1.34E-02
PB-210		
PB-210	6.25E-01	6.25E-01

ATTACHMENT G-8

Uranium Ore RESRAD-Build Run

Room Size 100m x 100m x 15m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	50.000	50.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]          Air Exchanges [m3/hr]
 Area [m2]
                   ******************************
                   *                            *
                   *                            *
                   *                          <=Q01: 3.00E+05
 H1:  15.000       *          Room  1           *      Q10 :  3.00E+05
                   *   LAMBDA: 2.00E+00         *
Area********       *                            *
                   *                            *
                   ******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1
Location:: Room : 1 x: 50.00 y: 50.00 z: 0.00[m]
Geometry:: Type: Area Area:1.00E+04 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 50.00 y: 50.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+04 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	7.28E+00	7.28E+00
Total	7.28E+00	7.28E+00

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.97E-01	3.32E-03	1.17E-05	6.91E+00	3.85E-03	1.66E-01
Total	1.97E-01	3.32E-03	1.17E-05	6.91E+00	3.85E-03	1.66E-01

Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.53E-01	8.53E-01
U-234	1.30E-06	1.30E-06
TH-230	9.39E-12	9.39E-12
RA-226	1.05E-16	1.05E-16
PB-210	0.00E+00	0.00E+00
U-235		
U-235	4.08E-02	4.08E-02
PA-231	4.29E-06	4.29E-06
AC-227	2.28E-07	2.28E-07
U-234		
U-234	9.50E-01	9.50E-01
TH-230	1.01E-05	1.01E-05
RA-226	1.74E-10	1.74E-10
PB-210	1.42E-12	1.42E-12
PA-231		
PA-231	4.21E-01	4.21E-01
AC-227	3.29E-02	3.29E-02
TH-230		
TH-230	2.34E+00	2.34E+00
RA-226	5.91E-05	5.91E-05
PB-210	6.39E-07	6.39E-07
AC-227		
AC-227	2.14E+00	2.14E+00
RA-226		
RA-226	2.84E-01	2.84E-01
PB-210	4.50E-03	4.50E-03
PB-210		
PB-210	2.10E-01	2.10E-01

APPENDIX H

BUILDING CONTAMINATION SURVEY AND SAMPLING PLAN

APPENDIX H

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Building Contamination Survey and Sampling Plan

H.0 Introduction

The procedures for conducting gross alpha surface contamination surveys follow guidance prepared by the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (NUREG-1575). The instrumentation performance calculations assume that all contamination is yellowcake. This is a conservative assumption since the average energy of the alpha particles from yellowcake is less than for uranium ore. This will be conservative since it will underestimate the efficiency of the detectors when ore is present, thus increasing the estimated MDA, reducing the allowable scanning speed, and overestimating the uranium ore contamination level.

At this time, it is believed that once the process equipment has been removed from the buildings and the structure has been washed, the walls and ceilings will be uncontaminated. At this time, PRL is not permitted to discharge water to the tailings area and thus cannot wash the surfaces. The data in Section 3.3 indicate relatively low levels of contamination in the mill building (excluding the yellowcake processing area) which is consistent with a facility that has had limited use as a uranium mill.

The gross alpha contamination limit for the floors of structures was calculated to be 700 dpm/100 cm^2. The walls and ceilings of the rooms were assumed to be uncontaminated. If significant contamination is found on the walls and ceiling, the contamination limits may have to be adjusted. The limit was found to be independent of the room. Since the exposure pathway was almost exclusively due to inhalation (See Appendix G), there is no maximum limit and thus no area factor.

It will be shown that as a part of ALARA, the scanning technique will have a high probability of identifying all areas of contamination at, or above the DGCL. These areas will be further decontaminated resulting in an average surface contamination for each survey area that is significantly less than the DGCL. In MARSSIM terminology, the 700 dpm/100 cm^2 gross alpha limit is the derived concentration guideline level (DCGL).

H.1 Area Classification and Survey Unit Sizes

For most of the structures within the radiological restricted area, the floors and walls up to a height of 3 feet are made of concrete and classified as Class 1 or 2. The walls above three feet high and ceiling are metal and normally classified as Class 2 or 3, depending on site knowledge. Table H-1 provides a complete listing of the affected structures and the classification.

Table H-1. Survey Classification of Areas

Area/Location	Classification	Source
Office floor	Class 3	
Guard station floor	Class 3	
Scales	Class 2	Ore
Scale house floor	Class 2	Ore
Walls/ceiling	Class 3	
Sample preparation building floor/walls up 3'	Class 2	Ore
Ore hopper/grizzly	Class 2	Ore
Conveyor feeder	Class 2	Ore
Conveyor belt line only belt	Class 1	Ore
Structure	Class 2	Ore
Temporary generators area	Class 3	
Pump/fire house floor	Class 3	
Main fresh water tanks	Class 3	
Acid tank	Class 3	
Diesel fuel tank	Class 3	
Power house control room floor	Class 3	
Power house gensets floor	Class 3	
Air compressors floor	Class 3	
Dry floor/ walls up 3'	Class 2	Ore/Yellowcake
Switch gear room floor	Class 3	
SAG mill floor	Class 1	Ore/Yellowcake
Walls up 3'	Class 1	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake Process
Leach floor	Class 1	Yellowcake
Walls up 3'	Class 1	Yellowcake
Wall/ceiling	Class 2	Yellowcake
Control room floor	Class 1	Ore/Yellowcake
Walls up 3'	Class 1	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake
Water tank outside near leach walls up 3'	Class 2	Yellowcake
Mill offices floors	Class 2	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake
Reagent room floor	Class 2	Yellowcake
Wall/ceiling	Class 2	Yellowcake Process
Solvent extraction floor	Class 1	Mill process
Wall up 3'	Class 1	Mill process
Wall/ceiling	Class 2	Mill process
Yellowcake precip/drying area floor	Class 1	Yellowcake
Walls up 10'	Class 1	Yellowcake
Lab floor	Class 2	Ore/Yellowcake
Walls up 3 '	Class 2	Ore/Yellowcake
Wall/ceilings	Class 3	Ore/Yellowcake
Maintenance shop floor	Class 2	Ore/Yellowcake
Wall/ceilings	Class 3	Ore/Yellowcake
Warehouse floor	Class 2	Ore/Yellowcake
Wall/ceilings	Class 3	Ore/Yellowcake

Definitions:
Ore - Natural uranium ore mined from the ground with no enrichment and in natural equilibrium. For this table, it includes
Yellowcake - Uranium oxide or yellow cake is a liquid or solid in which the uranium has been concentrated and decay products
Class 1 - Direct contact with 11e(2) material, possibly above DCGL.
Class 2 - Indirect contact defined as possible transport of 11e(2) material to item in question and possibly some low level of
Class 3 - No contact with 11e(2) material and activity below DCGL or no activity.

The size of the Class 1 area is limited to the area of the floor plus lower wall of each room. MARSSIM suggests that Class 1 areas for structures be limited to 100 m^2 unless justified. For many of the buildings, the area associated with a classification will be small and thus survey units will be on the order of 100 m^2. This includes the Office, Guard Station, Scale house, Sample Preparation Building, and Control Room. The Mill Building, however, has rooms up to 10,000 m^2 in size. Future use of this building is expected to be by an industry desiring high ceilings (15 m) and large room sizes. Therefore it is unlikely that partitions will be placed in the rooms and thus the TEDE to occupants will be a function of average contamination on the floor and the ceiling height (See Appendix G). It will be demonstrated that the proposed scanning method will be able to identify very small areas contaminated at or above the DCGL. For Class 1 areas, a 100 percent scan will be performed and areas approaching the DCGL will be further decontaminated. This will assure that contamination within the entire Class 1 area is uniformly low. We propose that the survey unit size within the mill building be limited to 2,500 m^2. We anticipate that this will still result in more than 100 sampling points for the Class 1 areas in each of the large rooms within the mill building. For the Class 2 areas, approximately 10 percent of the area will be scanned using a biased sampling approach. If contamination above the DCGL is found, the area will be reclassified as Class 1. A sampling strategy similar to the Class 1 strategy will be used for the Class 2 areas in the buildings. This will result in additional samples taken in each room. Therefore, the total number of sampling points will be excess of one hundred for each of the large rooms.

H.2 Equipment

The gross alpha scanning surveys will be conducted on floor surfaces using a Ludlum Model 239-1F Floor Monitor (or equivalent). The floor monitor has a Ludlum Model 43-37 gas proportional detector with an active area of 582 cm^2. The detector window active area is 43.8-cm wide and 13.3-cm long. The alpha background for this detector is typically less than 5 cpm. For difficult to access areas, smaller gas proportional counters or alpha ZnS detectors will be used. The scanning speeds will be determined by detector size, the measured background count rate, and the detector efficiency. MARSSIM methods for calculating scanning speeds have been used.

Static measurements (measurements at a single point) will also be made using the floor monitor or other gas proportional or ZnS detectors. The counting time will be adjusted to assure a minimum detectable activity (MDA) of less than 25 percent of the DCGL of 700 dpm/cm^2.

Detector efficiency measurements were made for the Model 43-90 and Model 43-37 detectors using an NIST-traceable depleted uranium source. While it is true that the efficiency will be slightly higher for a natural uranium source due to the higher average alpha energy, the use of the efficiency from depleted uranium is conservative and thus should overestimate the level of contamination when surveying ore areas. The Model 43-90 had an alpha efficiency of 13 percent when the detector was in contact with the surface while only 5.5 percent when the detector was placed at 11 mm from the surface. The Model 43-37 had an alpha efficiency of 9 percent at a height of 11 mm from the surface. The Models 43-20 and 43-68 should have similar efficiencies as the Model 43-37. The background count rates for the detectors were measured but may have to be adjusted for specific site conditions. Estimates of the gross-alpha MDA for a one-minute static count are provided in Table H-2 using Equation 6-7 from MARSSIM.

Table H-2. MDA for Measurement of Uranium Surface Contamination Using a One-Minute Count

Manufacturer	Model	Background (cpm)	Active Area (cm^2)	Alpha Efficiency	MDA (dpm/100 cm^2)
Ludlum	43-37	4	582	0.09	26
Ludlum	43-20	2	181	0.09	59
Ludlum	43-68	1	126	0.09	67
Ludlum	43-90	1	126	0.055	111

The MDAs will be evaluated at the site and may be changed slightly when actual background count rates for the facility are used. The counting times will be changed to obtain an MDC of less than 25 percent of the DCGL (175 dpm/100 cm^2) for gross alpha measurements, based on the background count rate in the facility.

The critical level, L_c, is defined as the net response level, in counts, at which the detector output can be considered above background. For this project, a 5 percent error rate has been assumed for both the Type 1 and Type 2 errors where Equation 6-6 is used to calculate both the critical levels and detection limit. For static one-minute counts, the floor monitor has an L_c = 5 counts, the Ludlum 43-20 has an L_c = 3 counts, and the Ludlum 43-90 and Ludlum 43-68 have an L_c = 2 counts. Therefore, any area where the net counts (after subtracting background counts) exceed these levels is considered above background. Again, this may change as the background changes at the facility.

H.3 Scanning Surveys and Decontamination

H.3.1 Class 1 Areas

A scanning survey will be conducted on all surfaces using a floor monitor. The detector may be removed from the floor monitor and manually placed on wall surfaces. With a low background count rate, the technician will consider stopping upon hearing a count to determine whether the count was from contamination or a spurious background count. The maximum scanning speed for an instrument was calculated using Equation 6-12 in MARSSIM and the detector parameters noted above. The result shows that in order to have a probability of at least 95 percent of observing at least one count while passing over an area the size of the detector contaminated at 700 dpm/100 cm^2, the scanning speed has to be 27 cm/sec or less. This is a very fast scanning speed and shows that the instrumentation is adequate for the task. Application of equation 6-13 shows that if one stops for a minimum of 0.4 seconds after hearing a count, there is a 90 percent probability that an additional count will be observed within the 0.4 seconds, providing the area is contaminated at the DCGL level of 700 dpm/100 cm^2 level or higher. These and other calculations using the formulae referenced above are shown in Attachment H-1.

A more practical approach is for the technician to stop after hearing 2 counts in 1 second. Applying equation 6-14 shows that there is a 98.5 percent probability that 2 or more counts will be registered in 1 second while traversing an area contaminated at the limit of 700 dpm/100 cm^2. If the technician stops when he/she hears 2 counts within a 1 second period and investigates further, the calculations indicate that areas greater than 0.18 m^2 contaminated at or above the limit will be investigated. In order to arrive at that number, since the detector is 43.8-cm wide and 13.3-cm long, the area covered in the 1 second at the rate of 27 cm/sec will be equal to:

$$\text{Area covered} = (w * l) + (w * v * \text{t})$$

Where: detector width = w = 43.8 cm, detector length = l = 13.3 cm, scanning speed = v = 27 cm/sec, and time = t = 1 seconds.

$$\text{Area covered} = (43.8 * 13.3) + (43.8 * 27 * 1) = 1765\ \text{cm}^2\text{, or approximately } 0.18\ \text{m}^2.$$

Areas identified as exceeding the 700 dpm/100 cm^2 action level will be delineated and investigated further by static-point measurements. Further attempts at decontamination will be made to assure compliance with the ALARA goal of reducing the levels as low as reasonably achievable.

The dose assessment (see Appendix G) was based on a floor area of 100 m^2 with uniform contamination. The dose calculations show that the principal dose pathway is via inhalation of resuspended contaminated dust. The direct gamma exposure pathway was not significant and therefore no “hot spot” criteria are proposed for these buildings. However, the proposed scanning method should specifically identify all but a very insignificant percentage of the 0.18-m^2 areas having contamination above the criterion. Larger areas contaminated at the DCGL will, with almost certainty, be detected and decontaminated to ALARA levels. The ALARA efforts at reducing the contamination levels in these special areas should result in an average contamination level that is considerably less than the DCGL.

H.3.2 Class 2 Areas

A minimum of twenty-five percent of the Class 2 area will be scanned using the Ludlum Model 43-37 detector (or equivalent) taken from the floor monitor at a speed of not more than 27 cm/s. This includes 100 percent of floor areas. The performance criteria and method of scanning will be the same as calculated for the Class 1 area presented above.

Smaller detectors, coupled to a ratemeter/scaler may be used in small or difficult to access areas. Applying Equations 6-12 and 6-13 to the Model 43-90 detector shows that in order to have a 95 percent probability of detecting at least one count while passing over an area the size of the detector contaminated at the 700 dpm/100 cm^2 level, a maximum scanning speed of 2 cm/sec should be used. If one stops for 3 seconds, there is a 90 percent probability of at least one other count if the contamination limit of 700 dpm/100 cm^2 is exceeded (from Equation 6-13).

Another option for scanning walls or hard to access areas is to use a smaller detector, such as the Ludlum 43-20. This gas proportional detector is approximately 10.2-cm wide and 17.8-cm long with an active area of 181 cm^2. It is expected to have the same efficiency (9 percent) for uranium alpha particles as the Ludlum 43-37 detector on the floor monitor. The background would be expected to be 2 cpm. Applying Equations 6-12, 6-13, and 6-14 from MARSSIM to the Model 43-20 detector shows that in order to have a 95 percent probability of detecting at least one count while passing over an area the size of the detector contaminated at the 700 dpm/100 cm^2 level, a maximum scanning speed of 6 cm/sec should be used. If one stops for 1.2 seconds, there is a 90 percent probability of at least one other count. The calculations show that two or more counts should be recorded within a time period of 2.5 seconds more than 95 percent of the time while scanning an area at the DCGL of 700 dpm/100^2. At a scanning speed of 6 cm/sec, the corresponding area traversed, using the same equation used in Section H.3.1, in 2.5 seconds is (10.2 * 17.8) + (17.8 * 2.5 * 6) = 448 cm^2. This would imply that smaller spots contaminated at the DCGL would not be identified if the 2 counts/2.5 second criteria were applied while scanning. The 2-count criterion using this detector is considered acceptable since missing isolated “hot spots” will not result in a significant TEDE to future occupants.

Should areas of contamination be found in Class 2 areas that exceed 700 dpm/100 cm^2, the area will be reclassified as Class 1 and Class 1 survey and verification procedures will be followed.

H.3.3 Class 3 Areas

The floors of rooms or buildings classified as Class 3 will be scanned using the same scanning technique as for Class 1 and Class 2. Biased static surface-contamination measurements will be made near floor drains, horizontal ledges, and HVAC systems using one of the detectors described in previous sections. Counting times will typically be one minute but adjusted, if necessary, to assure an MDA of less than 25 percent of the DCGL of 700 dpm/100 cm^2. Biased static-point measurements will be made at a minimum of 30 locations within each building. One or more measurements will be made in all areas where site specific knowledge indicates a potential for contamination. Potential sampling points include horizontal ledges, surfaces, and beams where dust may have collected as well as in and around HVAC and other ducts.

Measurements results from Class 3 areas that exceed 25 percent of the limit of 700 dpm/100 cm^2 will indicate a need to reclassify at least a portion of the Class 3 area as Class 2. A scan of at least 25 percent of this Class 2 area will be done according to Class 2 procedures.

H.4 Final Verification (Status) Survey

The MARSSIM guidance for developing a final status survey is based on the existing data and professional judgment. The method recognizes that small changes may be required as additional data are gathered.

H.4.1 Class 1 Areas

In order to determine that the Class 1 areas meet the DCGL, the areas will be divided into survey units of 2500 m^2 or less, using a grid system appropriate for each structure. The purpose of the Final Verification Survey is to demonstrate that each survey unit meets the cleanup criteria. In this case, the result of the dose modeling effort showed that a surface contamination limit of 700 dpm/100 cm^2, averaged over the entire area, would not result in a TEDE of more than 25 mrem/y to the occupant.

Historical surface contamination data show that the background contamination levels are a very small fraction of the DCGL value of 700 dpm/100 cm^2 and thus the background level may be ignored (assumed to be zero).

The null hypothesis, H_o, is that the survey unit exceeds the release criterion. Therefore it will be necessary to demonstrate that the null hypothesis can be rejected prior to release of the survey unit. A Type 1 decision error (α) would release the unit containing activity that exceeds the limit. A Type 2 decision error (β) is to incorrectly accept the null hypothesis, resulting in unnecessary work. For this project, we will accept 5 percent for both α and β decision errors.

The next task is to calculate the relative shift parameter as defined in MARSSIM by the equation:

$$(DCGL-LBGR)/\sigma$$

Where: DCGL is 700 dpm/100 cm^2, the Lower Bound of the Gray Region (LBGR) is to be defined, and σ is the standard deviation of the measurements.

In Section H.3, it was shown that the scanning capability of the proposed instrumentation is very good and that significantly large hot spots will be identified and investigated further. Where practical, these areas will be further cleaned to ALARA levels. Since all Class 1 surfaces will be scanned, this reduces the probability that a significant fraction of the survey unit will exceed the cleanup criterion. In addition, further cleaning will result in reducing the levels and thus result in reducing the standard deviation of the measurements in the final verification survey. It is reasonable to expect a standard deviation of 300dpm/100 cm^2 for the verification data for each Class 1 survey unit. Assuming a LBGR of 350dpm/100 cm^2, the relative shift is 1.2. Substituting into the equation 5-2 of MARSSIM, the number of fixed point measurements in each survey area, N, is calculated to be

$$N = (Z_{1-\alpha} + Z_{1-\beta})^2 / 4(\text{Sign P} - 0.5)^2$$
$$= 18$$

Where: $Z_{1-\alpha} = Z_{1-\beta} = 1.645$ from Table 5.2 and Sign P = 0.885 from Table 5.4

Using the equations in MARSSIM, the number of data points to demonstrate compliance is calculated to be 18. Increasing this by 20 percent, as recommended, brings the total measurements per survey area to 22.

H.4.2 Class 2 and Class 3 Areas

Class 2 and Class 3 areas are not anticipated to be contaminated and therefore the contaminant distribution should be near background levels. We have assumed that the background levels are insignificant and that the one-sample Sign test applies. It is estimated that the standard deviation of the areas will be approximately 100 dpm/100 cm^2 Assuming a LBER of 350 dpm/100 cm^2 would still result in a relative shift of 3.5, where the Sign P is equal to 1. Type 1 errors are not as significant in Class 2 and Class 3 areas since the potential for exposure is much less from the lower walls and ceiling than for the floor (The floors will be scanned). Therefore we have chosen $\alpha = 0.2$. We have limited Type 2 errors to 0.1 since this type of error would necessarily involve further unnecessary remediation or further sampling. Type 2 errors set $\beta = 0.1$.

It is reasonable to expect a standard deviation of 100dpm/100 cm^2 for these areas. Assuming a LBGR of 350dpm/100 cm^2, the relative shift is 3.5. Substituting into the equation 5-2 of MARSSIM, the number of fixed point measurements in each survey area, N, is calculated to be

$$N = (Z_{1-\alpha} + Z_{1-\beta})^2 / 4(\text{Sign P} – 0.5)^2$$
$$= 4.5$$

Where: $Z_{1-\alpha} = 0.842$ and $Z_{1-\beta} = 1.282$ from Table 5.2 and Sign P = 1 from Table 5.4

Using the equations in MARSSIM, the number of data points to demonstrate compliance is calculated to be 5. Increasing this by 20 percent, as recommended, brings the total measurements per survey area to 6.

H.5 Measurement and Grid Construction

A grid will be established across all survey units according to guidance in MARSSIM. Twenty-two static point measurements will be made in Class 1 survey units and 6 measurements will be made in Class 2 and Class 3 survey units. Data normally will be collected for one minute using standard operating procedures. A drawing of the grid and sampling points will be prepared and documented.

H.6 Data Evaluation

With the assumption that the background can be ignored, the data are evaluated using the MARSSIM guidance. If all values within a survey unit are below the criterion, the survey unit passes. If individual values exceed the criterion, the Sign Test will be applied to the data and the result used to determine whether the unit passes or fails.

H.7 References

NUREG-1575. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Published jointly by the U.S. Nuclear Regulatory Commission, U. S. Environmental Protection Agency, U. S. Department of Energy, and the U. S. Department of Defense. August, 2000.

ATTACHMENT H-1

DETECTION PROBABILITIES

Attachment H-1. Detection Probabilities

Ludlum Model 43-37

Probability of Detecting One Count at Scanning Speed v				
P_1	**G**	**E**	**d**	**v**
1.000	4074	0.09	13.3	10
0.983	4074	0.09	13.3	20
0.951	4074	0.09	13.3	27
0.934	4074	0.09	13.3	30
0.870	4074	0.09	13.3	40
0.804	4074	0.09	13.3	50
Probability of Two Counts Detected in Time t				
P_2	**G**	**E**	**t**	**B**
0.985	4074	0.09	1	4
0.975	4074	0.09	0.9	4
0.958	4074	0.09	0.8	4
0.929	4074	0.09	0.7	4
0.884	4074	0.09	0.6	4
0.814	4074	0.09	0.5	4

LudlumModel 43-90

Probability of Detecting One Count at Scanning Speed v				
P_1	**G**	**E**	**d**	**v**
0.998	882	0.055	7.5	1
0.952	882	0.055	7.5	2
0.868	882	0.055	7.5	3
0.780	882	0.055	7.5	4
0.703	882	0.055	7.5	5
Probability of Two Counts Detected in Time t				
P_2	**G**	**E**	**t**	**B**
0.990	882	0.055	8	1
0.979	882	0.055	7	1
0.958	882	0.055	6	1
0.917	882	0.055	5	1
0.841	882	0.055	4	1

Ludlum Model 43-20

Probability of Detecting One Count at Scanning Speed v				
P_1	**G**	**E**	**d**	**v**
0.998	1267	0.09	10.2	3
0.979	1267	0.09	10.2	5
0.960	1267	0.09	10.2	6
0.937	1267	0.09	10.2	7
0.911	1267	0.09	10.2	8
Probability of Two Counts Detected in Time t				
P_2	**G**	**E**	**t**	**B**
0.979	1267	0.09	3	2
0.954	1267	0.09	2.5	2
0.898	1267	0.09	2	2
0.786	1267	0.09	1.5	2

Parameter	
P_1	Probability of observing a single count in time interval t. MARSSIM Eq. 6-12
P_2	Probability of observing two or more counts in time interval t. MARSSIM Eq. 6-14
G	Contamination activity(dpm)
E	Detector efficiency (4π)
d	Width of detector in direction of scan (cm)
v	Scan speed (cm/s)
t	Time (sec)
B	Instrument background counts (cpm)

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HEC-1 Runoff Modeling

J.0 Runoff Modeling

The U.S. Army Corps of Engineers (ACOE) HEC-1 flood hydrograph model was used to predict runoff from the Shootaring Canyon area drainage basins. The HEC-1 model was used to predict runoff at key locations for the reclamation plan with only Cell 1 utilized, and for the reclamation plan that included both Cell 1 and Cell 2. The suffixes of Cell-1 and Cell-2 on the table number indicate the reclamation plan for which the table was developed. This distinction in the numbering format is not necessary for the figures. The area was divided into subbasins for the purpose of estimating peak runoff at critical locations under Probable Maximum Flood (PMF) conditions. The HEC-1 model takes input data for precipitation and drainage basin characteristics (Tables J-1-Cell-1 and J-1-Cell-2) and produces output including a flow schematic (Table J-2-Cell-1 and J-2-Cell-2) and hydrograph data (see Figures J-1 thru J-10).

Table J-1-Cell-1. HEC-1 Input File for Cell 1 Reclamation

```
ID SHOOTARING, TAILINGS AREA DRAINAGE
ID BASED UPON PMF RAINFALL OF 8.25 IN. 1.0 MINUTE INCREMENTS
ID DATE=11/01/05
*FREE
*DIAGRAM
IT 1.0,,,300,,
IO 5,1
IN 1,,
PG HMR49
PC .0000,.0293,.0601,.0924,.1261,.1613,.1980,.2362,.2779,.3197,
PC .3617,.4041,.4476,.4933,.5426,.5970,.6588,.7303,.8143,.9139,
PC 1.0325,1.1739,1.3422,1.5420,1.7781,2.0556,2.3800,2.7574,3.1937,3.8905,
PC 4.7050,5.2388,5.6449,5.9950,6.2953,6.5514,6.7687,6.9522,7.1065,7.2360,
PC 7.3446,7.4360,7.5134,7.5797,7.6376,7.6892,7.7364,7.7809,7.8238,7.8659,
PC 7.9078,7.9496,7.9911,8.0285,8.0645,8.0989,8.1319,8.1635,8.1935,8.2221,
PC 8.2500,
KK NORTHEAST
KO 0,,,,21,1,300
BA .027
PR HMR49
LS 0,88
UD .1437
KK NORTHWEST
KO 0,,,,21,1,300
BA .055
PR HMR49
LS 0,88
UD .0850
KK DIVERSION
KO 0,,,,21,1,300
HC 2
KK NORTH-MILL
KO 0,,,,21,1,300
BA .028
PR HMR49
LS 0,86
UD .1268
KK CENTRAL-MILL
KO 0,,,,21,1,300
BA .0120
PR HMR49
LS 0,82
UD .1000
KK CENTRAL_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.236 0.376 0.459 0.534
SQ 0 43 143 295
SE 0 1 2 3
KK HC-2
KO 0,,,,21,1,300
HC 2
KK WEST-CELL-1-TAILINGS
KO 0,,,,21,1,300
BA .028
PR HMR49
LS 0,81
UD .1776
KK CENT-CELL1-TAILINGS
KO 0,,,,21,1,300
```

Table J-1-Cell-1. HEC-1 Input File for Cell 1 Reclamation (continued)

```
BA .024
PR HMR49
LS 0,77
UD .2038
KK NCELL1+MILL
KO 0,,,,21,1,300
HC 3
KK CELL1_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.0 0.209 0.504 1.001 1.377 1.885 2.557 3.525 4.283 5.017
SQ 0 4 15 30 40 55 88 203 381 627
SE 0 1 2 3 3.5 4 5 6 7 8
KK EAST-CELL-1-TAILINGS
KO 0,,,,21,1,300
BA .013
PR HMR49
LS 0,70
UD .1403
KK CELL1+MILL
KO 0,,,,21,1,300
HC 2
KK ECELL1_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.0 0.074 0.300 0.374 0.450 0.531 0.658
SQ 0 12 80 202 381 622 932
SE 0 0.5 1.5 2.5 3.5 4.5 5.5
KK SOUTH-MILL
KO 0,,,,21,1,300
BA .020
PR HMR49
LS 0,86
UD .2060
KK CELL1-TOTAL
KO 0,,,,21,1,300
HC 2
KK SOUTH
KO 0,,,,21,1,300
BA .139
PR HMR49
LS 0,85
UD .1289
KK TOTAL
KO 0,,,,21,1,300
HC 2
ZZ
```

Table J-1-Cell-2. HEC-1 Input File for Cell 1 and Cell 2 Reclamation

```
ID SHOOTARING, TAILINGS AREA DRAINAGE
ID BASED UPON PMF RAINFALL OF 8.25 IN. 1.0 MINUTE INCREMENTS
ID DATE=11/01/05
*FREE
*DIAGRAM
IT 1.0,,,300,,
IO 5,1
IN 1,,
PG HMR49
PC .0000,.0293,.0601,.0924,.1261,.1613,.1980,.2362,.2779,.3197,
PC .3617,.4041,.4476,.4933,.5426,.5970,.6588,.7303,.8143,.9139,
PC 1.0325,1.1739,1.3422,1.5420,1.7781,2.0556,2.3800,2.7574,3.1937,3.8905,
PC 4.7050,5.2388,5.6449,5.9950,6.2953,6.5514,6.7687,6.9522,7.1065,7.2360,
PC 7.3446,7.4360,7.5134,7.5797,7.6376,7.6892,7.7364,7.7809,7.8238,7.8659,
PC 7.9078,7.9496,7.9911,8.0285,8.0645,8.0989,8.1319,8.1635,8.1935,8.2221,
PC 8.2500,
KK NORTHEAST
KO 0,,,,21,1,300
BA .027
PR HMR49
LS 0,88
UD .1437
KK NORTHWEST
KO 0,,,,21,1,300
BA .055
PR HMR49
LS 0,88
UD .0850
KK DIVERSION
KO 0,,,,21,1,300
HC 2
KK NORTH-MILL
KO 0,,,,21,1,300
BA .028
PR HMR49
LS 0,86
UD .1268
KK CENTRAL-MILL
KO 0,,,,21,1,300
BA .0120
PR HMR49
LS 0,82
UD .1000
KK CENTRAL_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.236 0.376 0.459 0.534
SQ 0 43 143 295
SE 0 1 2 3
KK HC-2
KO 0,,,,21,1,300
HC 2
KK WEST-CELL-1-TAILINGS
KO 0,,,,21,1,300
BA .028
PR HMR49
LS 0,81
UD .1776
KK CENT-CELL1-TAILINGS
KO 0,,,,21,1,300
```

Table J-1-Cell-2. HEC-1 Input File for Cell 1 and Cell 2 Reclamation (continued)

```
BA .024
PR HMR49
LS 0,77
UD .2038
KK NCELL1+MILL
KO 0,,,,21,1,300
HC 3
KK CELL1_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.0 0.209 0.504 1.001 1.377 1.885 2.557 3.525 4.283 5.017
SQ 0 4 15 30 40 55 88 203 381 627
SE 0 1 2 3 3.5 4 5 6 7 8
KK EAST-CELL-1-TAILINGS
KO 0,,,,21,1,300
BA .013
PR HMR49
LS 0,70
UD .1403
KK CELL1+MILL
KO 0,,,,21,1,300
HC 2
KK ECELL1_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0.0 0.074 0.300 0.374 0.450 0.531 0.658
SQ 0 12 80 202 381 622 932
SE 0 0.5 1.5 2.5 3.5 4.5 5.5
KK SOUTH-MILL
KO 0,,,,21,1,300
BA .020
PR HMR49
LS 0,86
UD .2060
KK CELL1-TOTAL
KO 0,,,,21,1,300
HC 2
KK CELL-2-SWALE
KO 0,,,,21,1,300
BA .028
PR HMR49
LS 0,71
UD .2252
KK EAST-UPPER
KO 0,,,,21,1,300
HC 2
KK EAST-CELL-2
KO 0,,,,21,1,300
BA .039
PR HMR49
LS 0,74
UD .1263
KK WEST-CELL-2
KO 0,,,,21,1,300
BA .070
PR HMR49
LS 0,81
UD .2678
KK CELL2_SURGE
KO 0,,,,21,1,300
```

Table J-1-Cell-2. HEC-1 Input File for Cell 1 and Cell 2 Reclamation (continued)

```
RS 1,STOR,0,0
SA 0.41 0.59 0.77 0.99 1.52 2.14 2.52 2.79 2.98
SQ 0 0 0 0 0 0 67 224 463
SE 0 2 4 6 7 8 9 10 11
KK EAST-LOWER
KO 0,,,,21,1,300
HC 3
ZZ
```

Table J-2-Cell-1. HEC-1 Flow Schematic for Cell 1 Reclamation

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK

           (V) ROUTING         (--->) DIVERSION OR PUMP FLOW
           (.) CONNECTOR       (<---) RETURN OF DIVERTED OR PUMPED FLOW

    NORTHEAST
           .
           .
           .    NORTHWEST
           .           .
           .           .
    DIVERSION...........
           .
           .
           .    NORTH-MILL
           .           .
           .           .
           .           .    CENTRAL-MILL
           .           .           V
           .           .           V
           .           .    CENTRAL_SURGE
           .           .           .
           .           .           .
           .        HC-2............
           .           .
           .           .
           .           .    WEST-CELL-1-TAILINGS
           .           .           .
           .           .           .
           .           .           .    CENT-CELL1-TAILINGS
           .           .           .           .
           .           .           .           .
           .    NCELL1+MILL.....................
           .           V
           .           V
           .    CELL1_SURGE
           .           .
           .           .
           .           .    EAST-CELL-1-TAILINGS
           .           .           .
           .           .           .
           .    CELL1+MILL..........
           .           V
           .           V
           .    ECELL1_SURGE
           .           .
           .           .
           .           .    SOUTH-MILL
           .           .         .
           .           .         .
           .    CELL1-TOTAL.......
           .           .
           .           .
           .           .       SOUTH
           .           .           .
           .           .           .
           .       TOTAL............

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

Table J-2-Cell-2. HEC-1 Flow Schematic for Cell 1 and Cell 2 Reclamation

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK

           (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
           (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    NORTHEAST
           .
           .    NORTHWEST
           .          .
    DIVERSION..........
           .
           .
           .    NORTH-MILL
           .          .
           .          .    CENTRAL-MILL
           .          .          V
           .          .          V
           .          .    CENTRAL_SURGE
           .          .          .
           .          .          .
           .        HC-2...........
           .          .
           .          .
           .          .    WEST-CELL-1-TAILINGS
           .          .          .
           .          .          .
           .          .          .    CENT-CELL1-TAILINGS
           .          .          .          .
           .          .          .          .
           .    NCELL1+MILL....................
           .          V
           .          V
           .    CELL1_SURGE
           .          .
           .          .    EAST-CELL-1-TAILINGS
           .          .          .
           .          .          .
           .    CELL1+MILL.........
           .          V
           .          V
           .    ECELL1_SURGE
           .          .
           .          .
           .          .    SOUTH-MILL
           .          .        .
           .          .        .
           .    CELL1-TOTAL.......
           .          .
           .          .
           .          .    CELL-2-SURGE
           .          .          .
           .          .          .
           .    EAST-UPPER.........
           .          .
           .          .
           .          .    EAST-CELL-2
           .          .          .
           .          .          .
           .          .          .    WEST-CELL-2
           .          .          .          V
           .          .          .          V
           .          .          .    CELL2_SURGE
           .          .          .          .
           .          .          .          .
           .    EAST-LOWER.....................

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

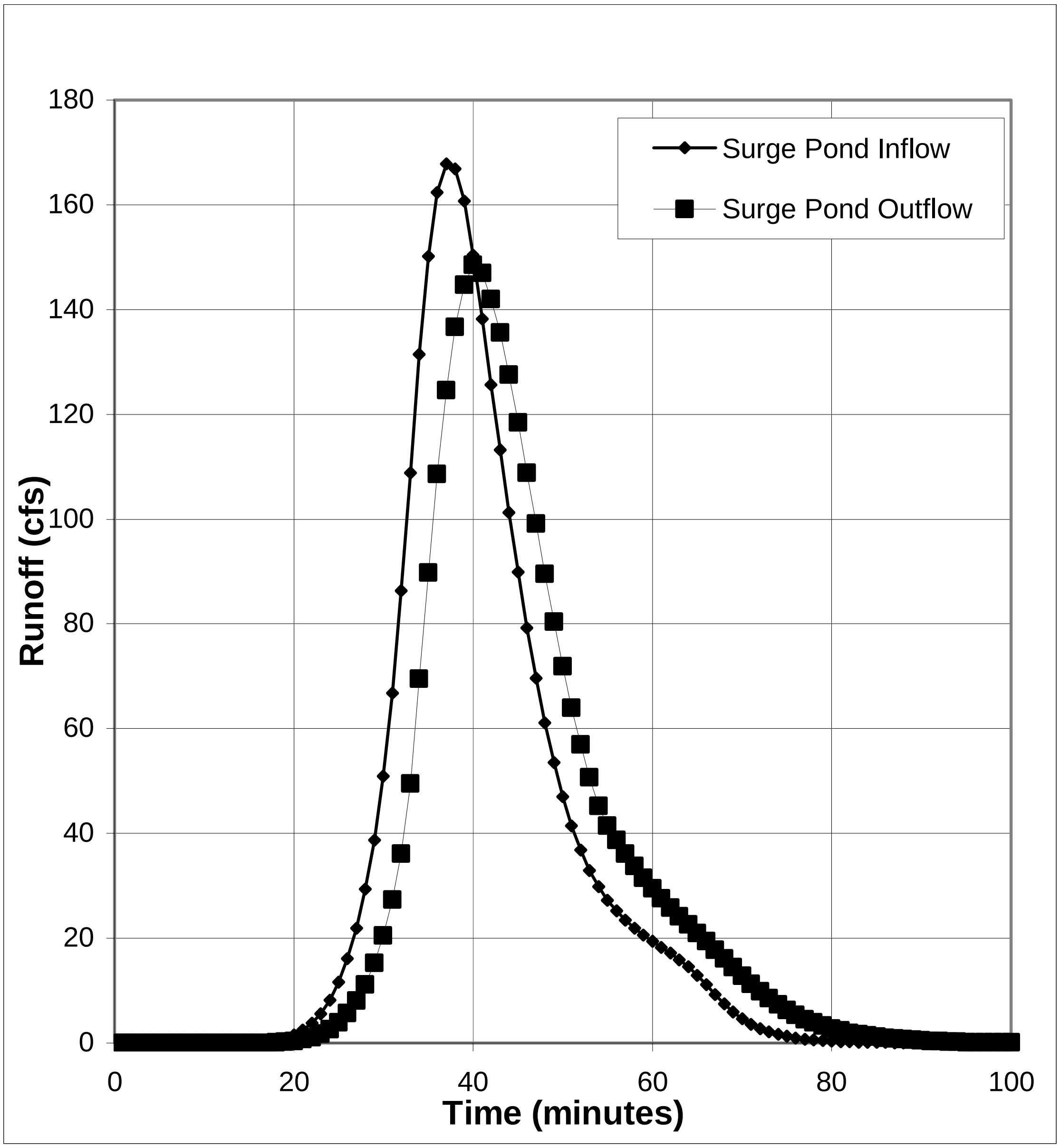


Figure J-1. Hydrograph for Tailings Area Cross Section HC-1

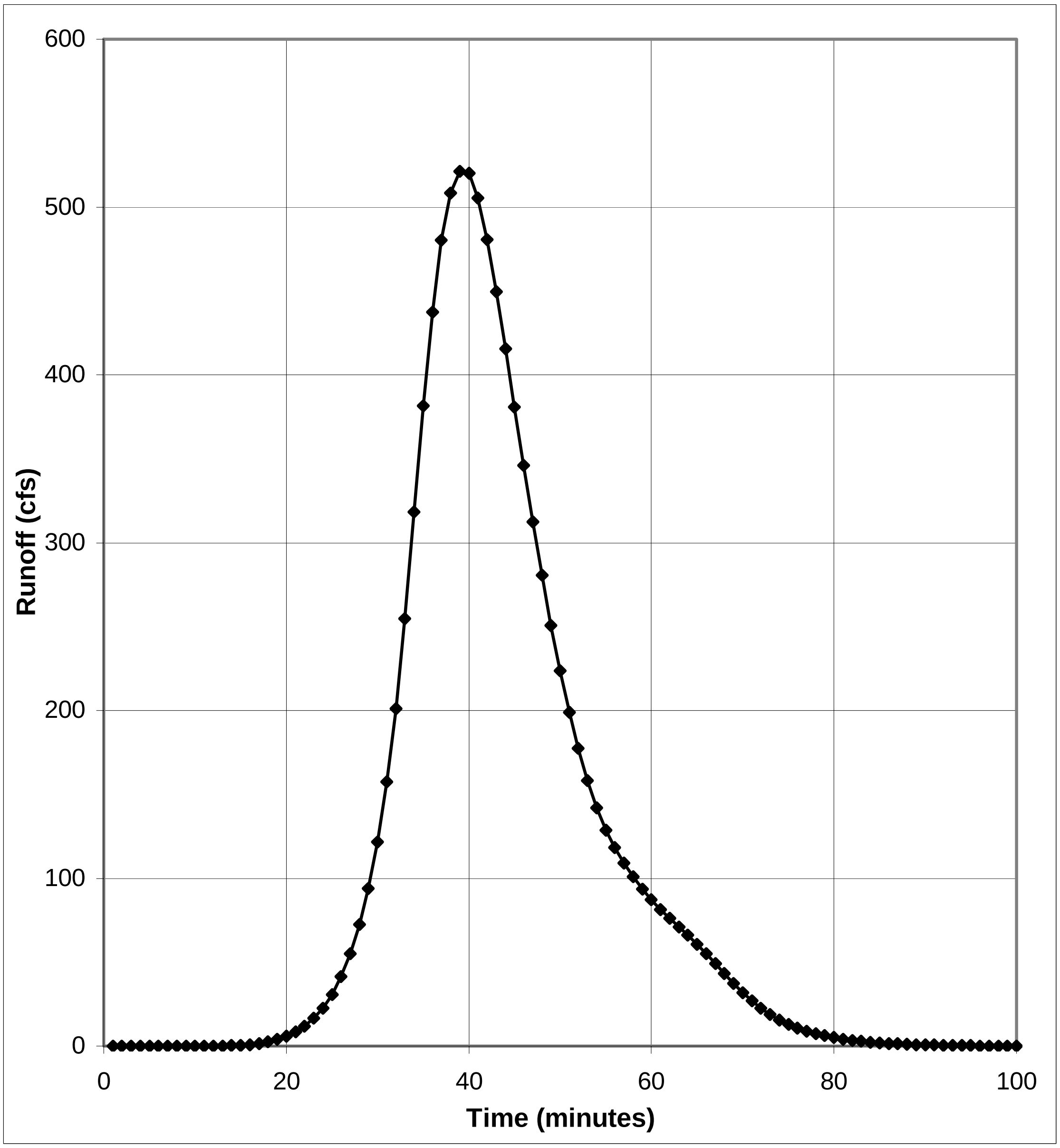


Figure J-2. Hydrograph for Tailings Area Cross Section HC-2

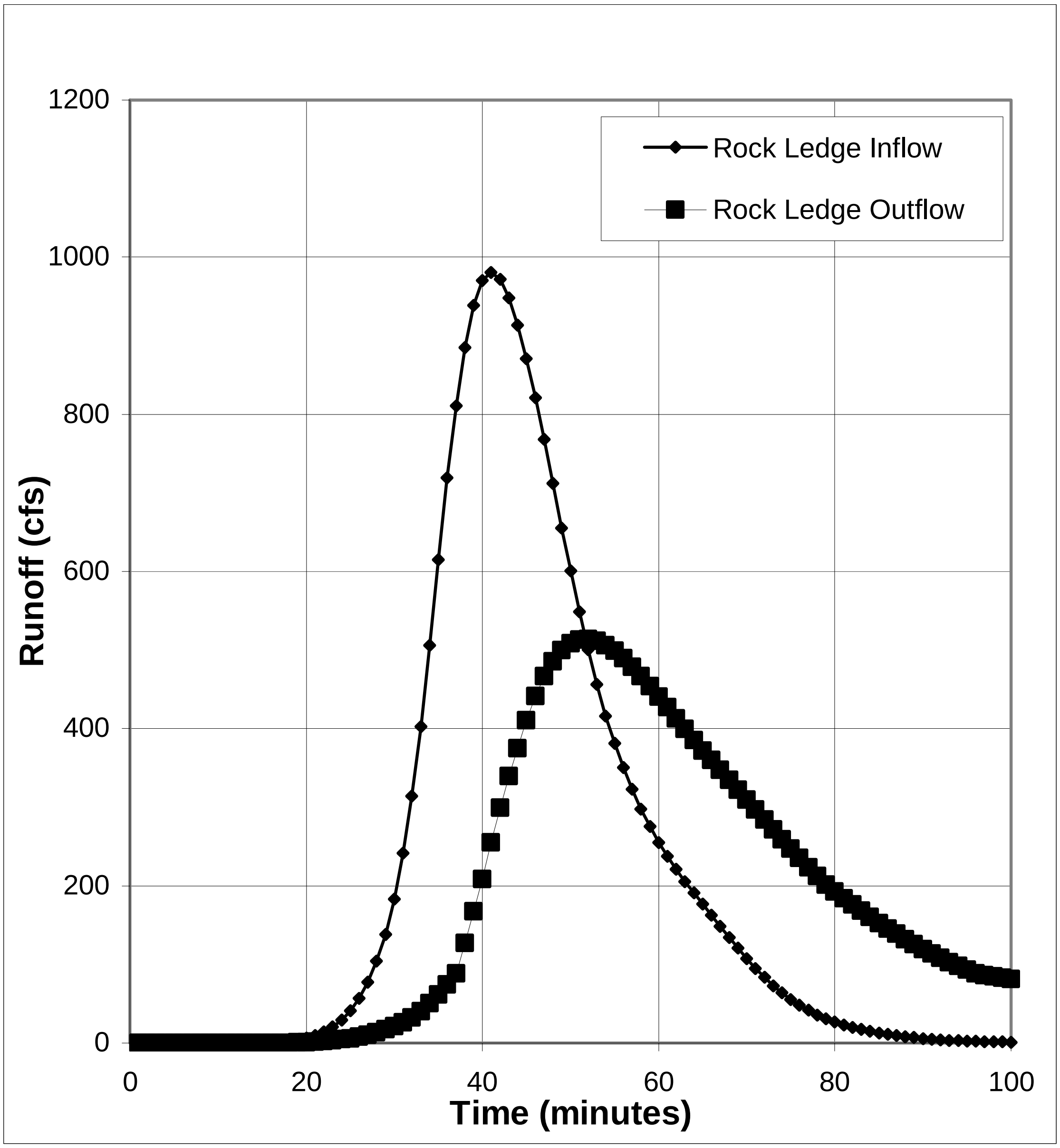


Figure J-3. Hydrographs for the Rock Ledge Inflow and Outflow

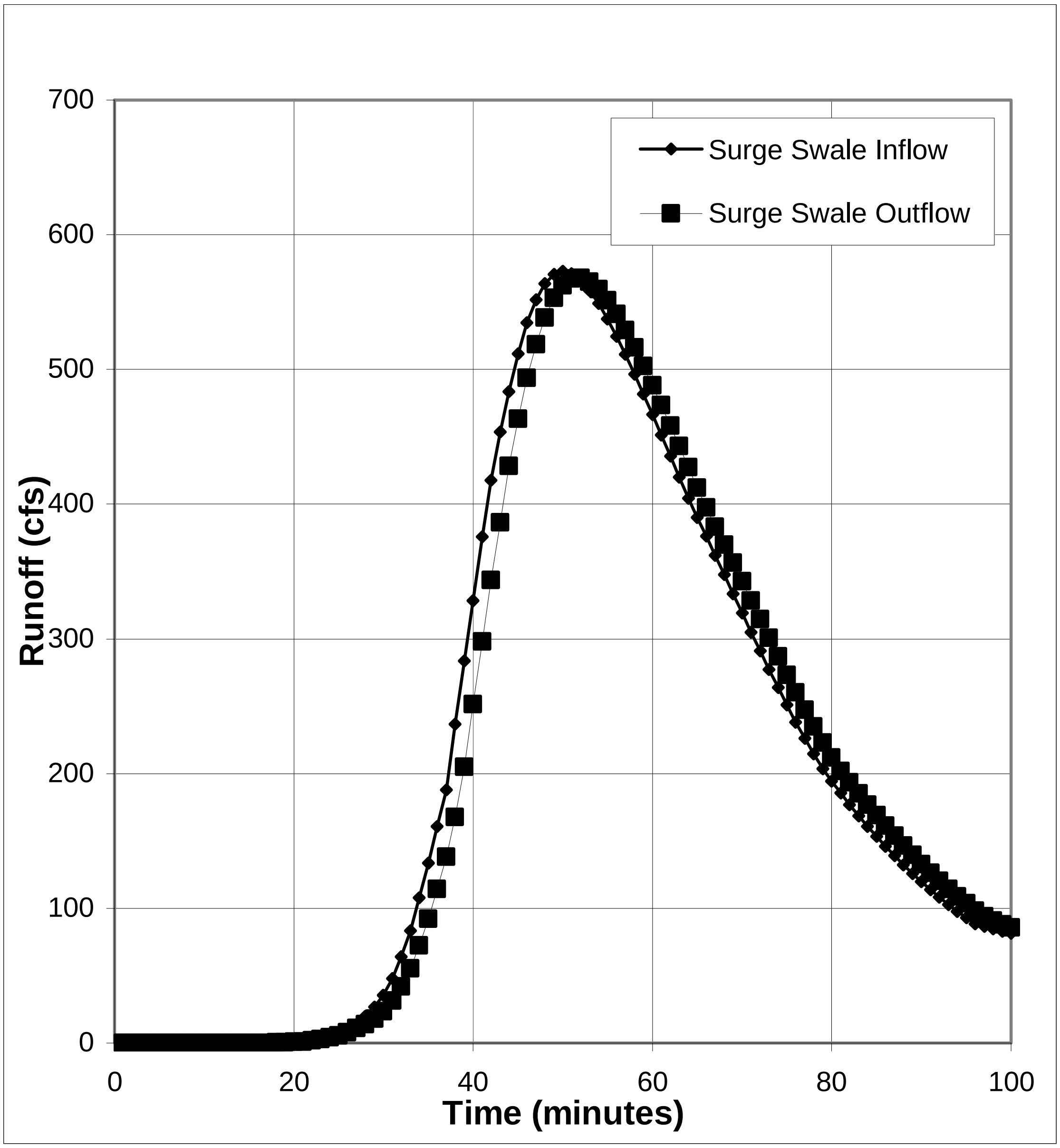


Figure J-4. Hydrograph for Tailings Area Cross Section HC-4

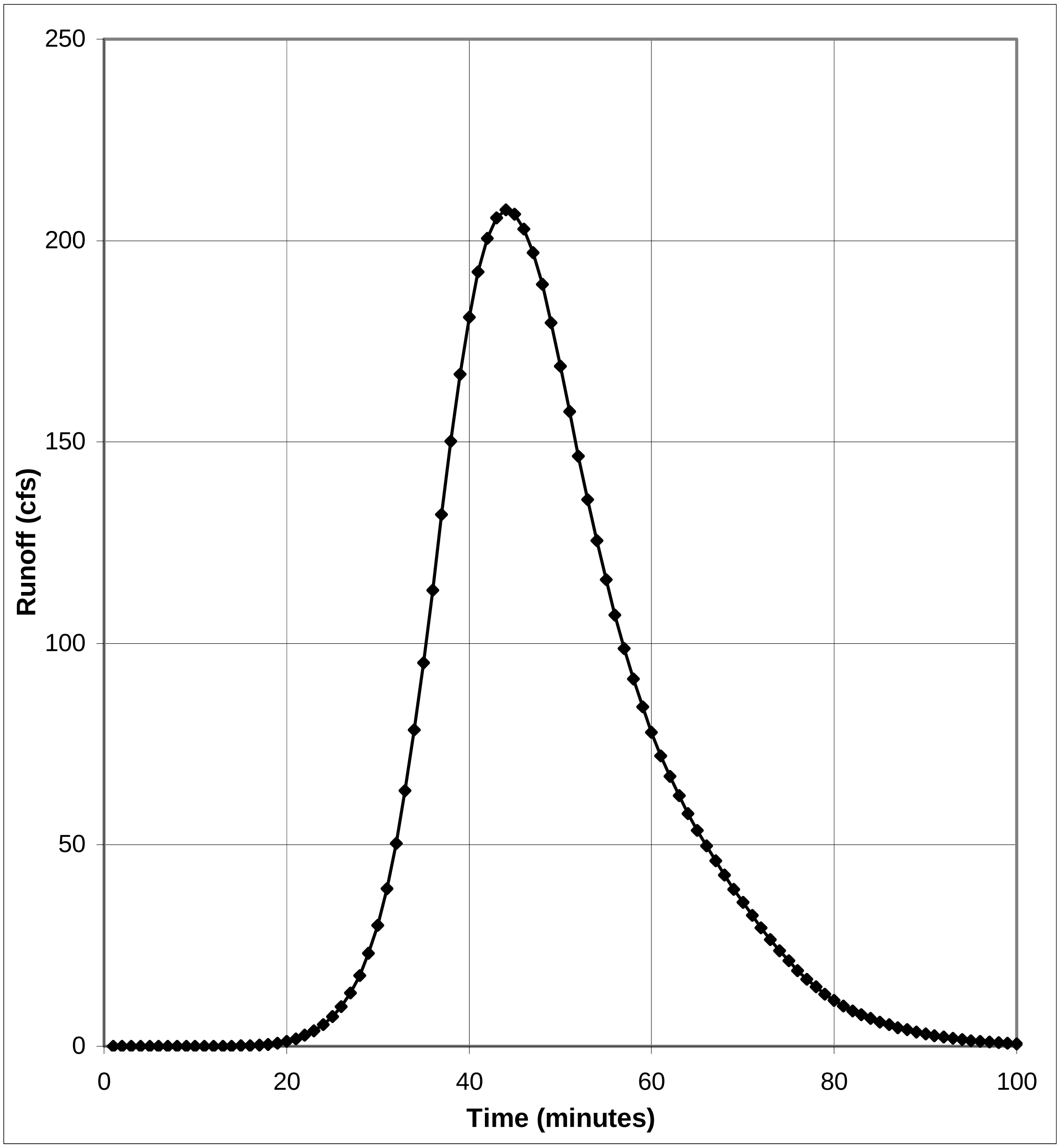


Figure J-5. Hydrograph for Tailings Area Cross Section HC-5

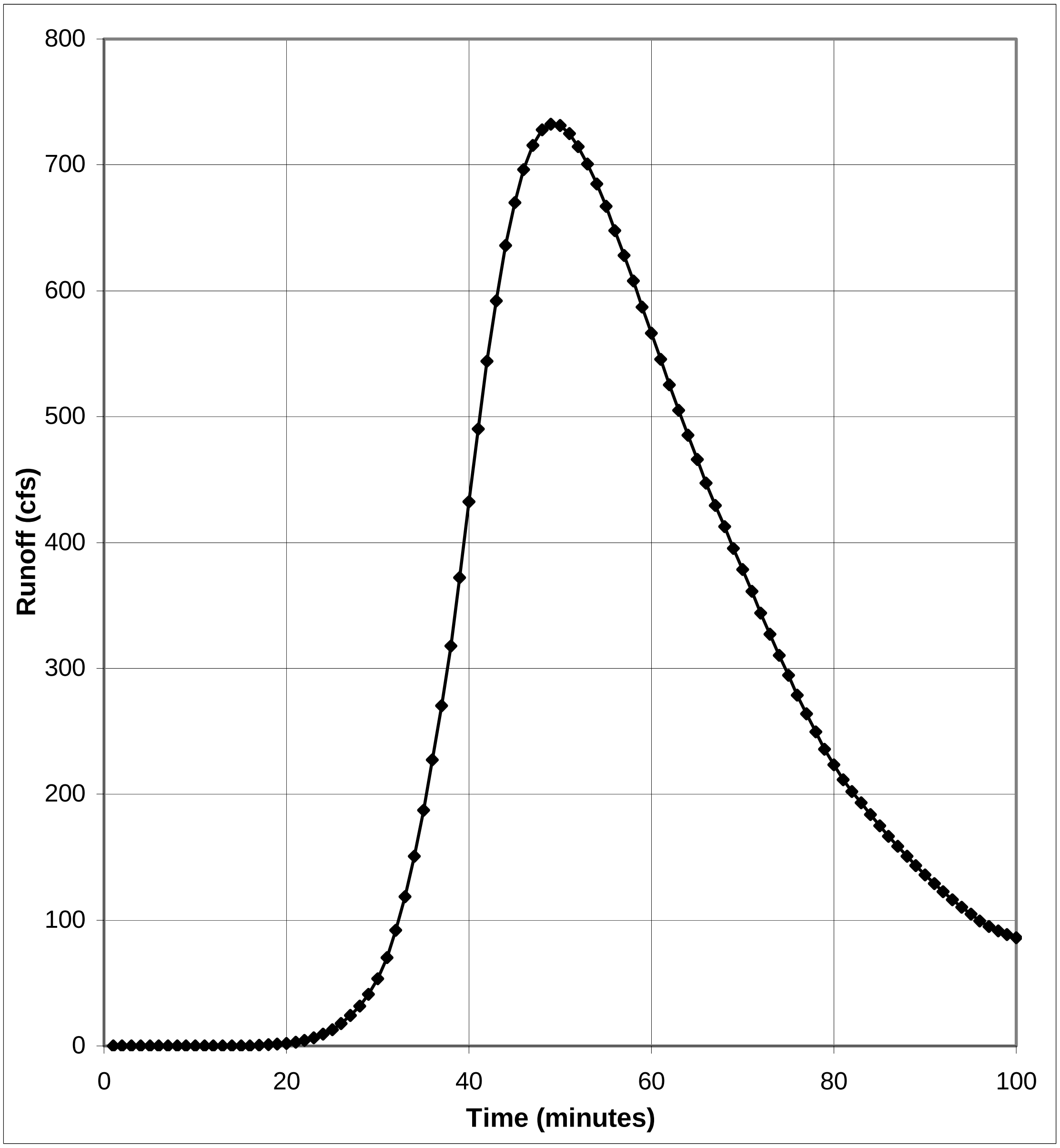


Figure J-6. Hydrograph for Tailings Area Cross Section HC-6

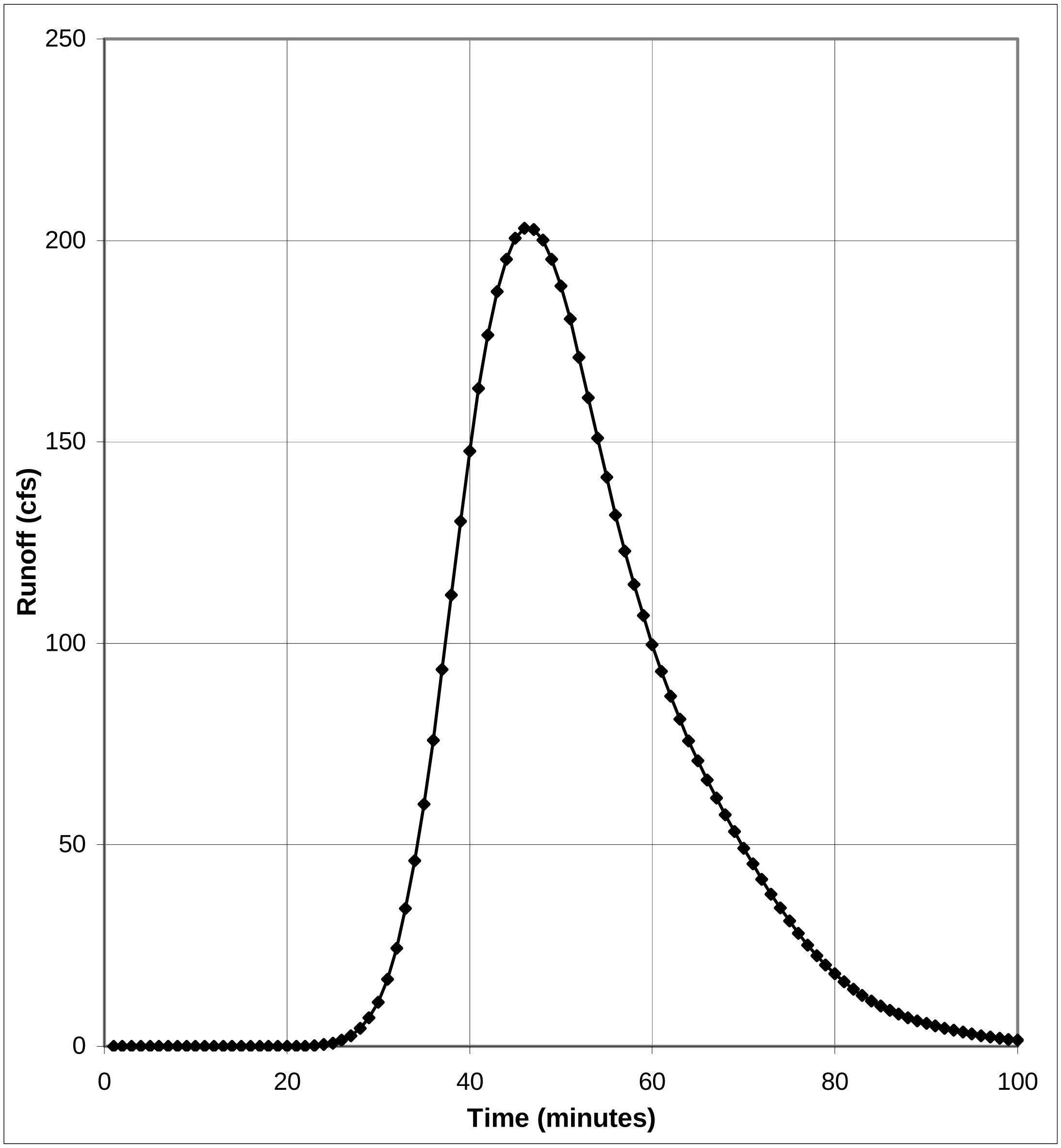


Figure J-7. Hydrograph for Tailings Area Cross Section HC-7

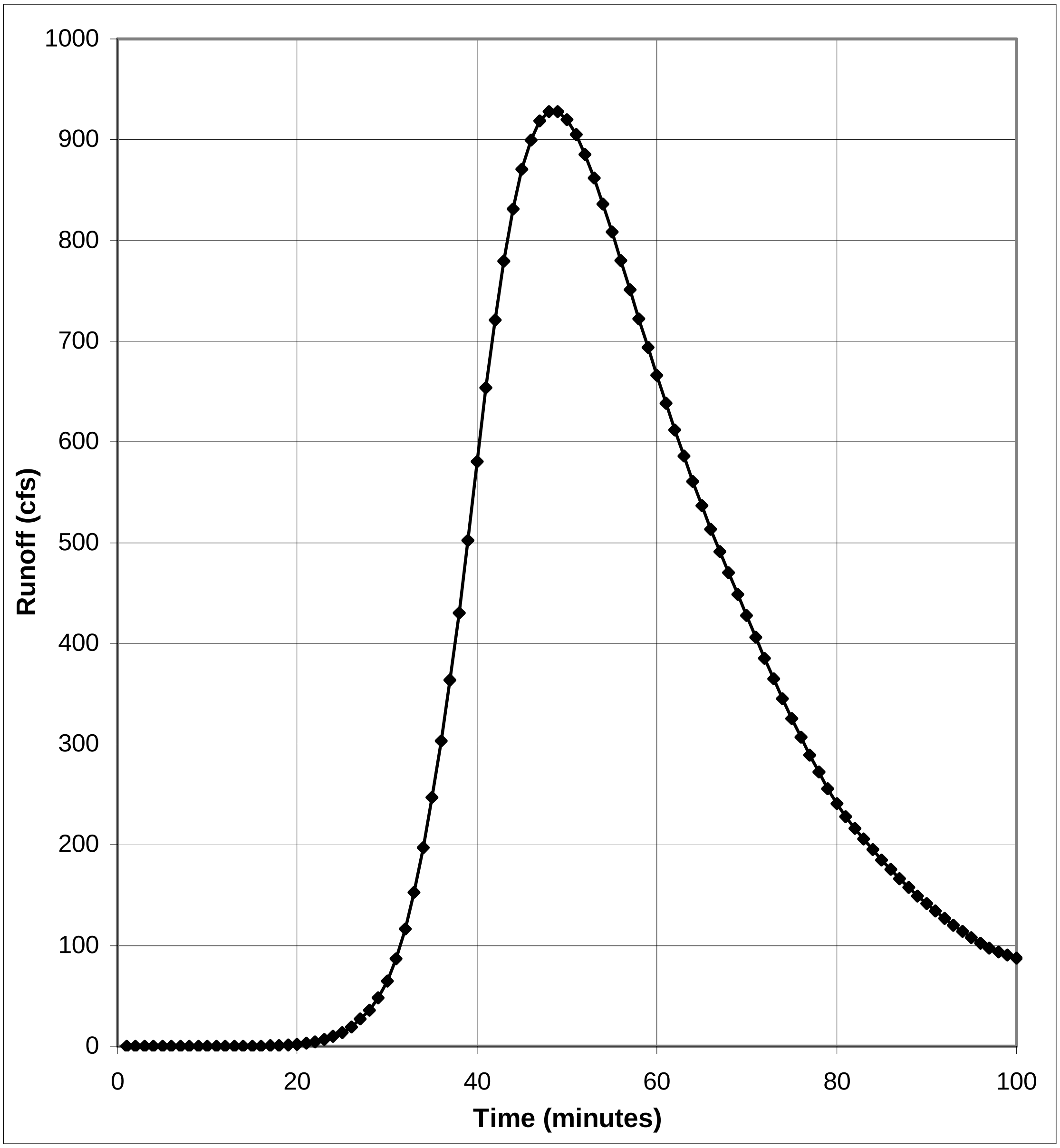


Figure J-8. Hydrograph for Tailings Area Cross Section HC-8

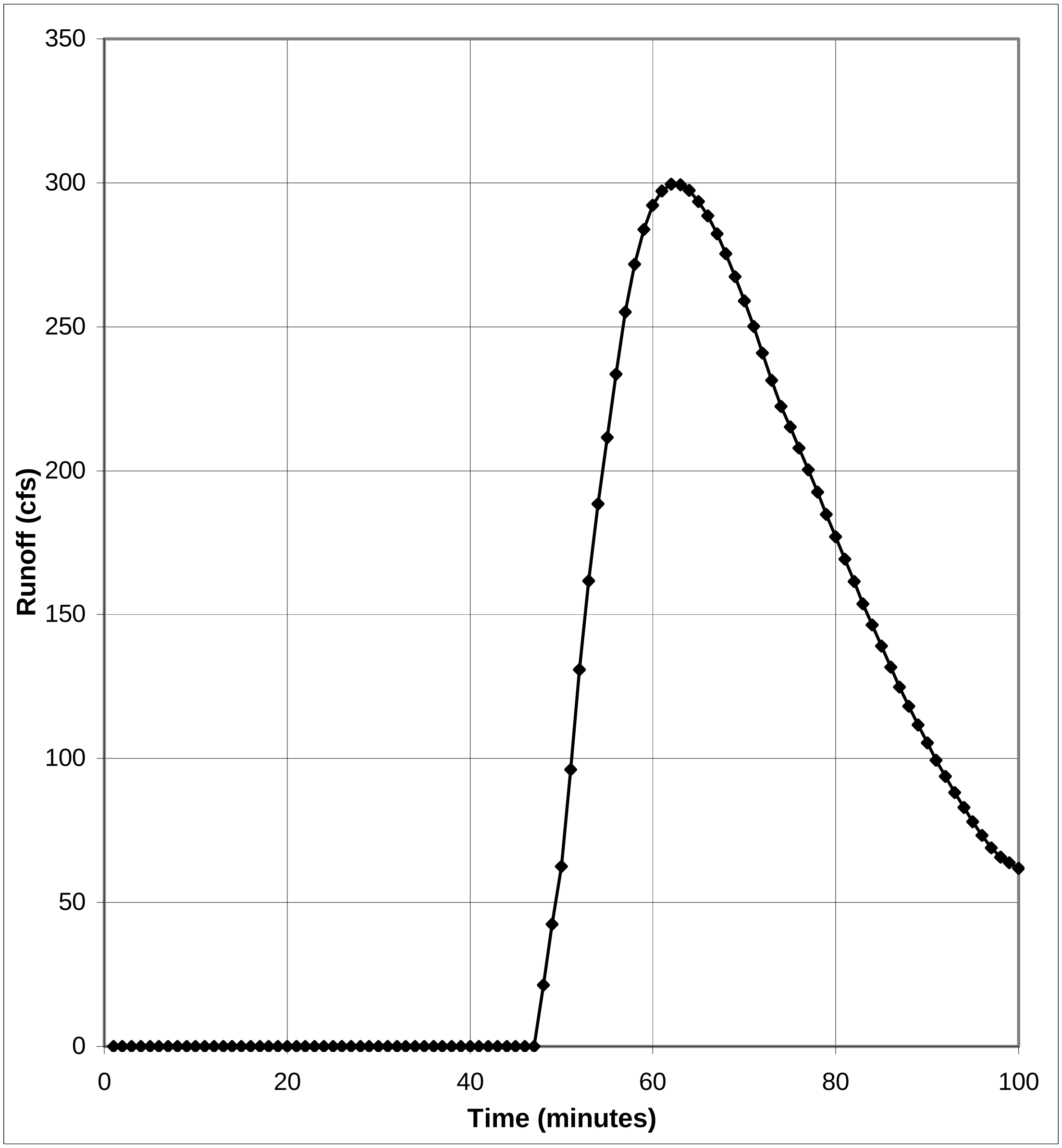


Figure J-9. Hydrograph for Tailings Area Cross Section HC-9

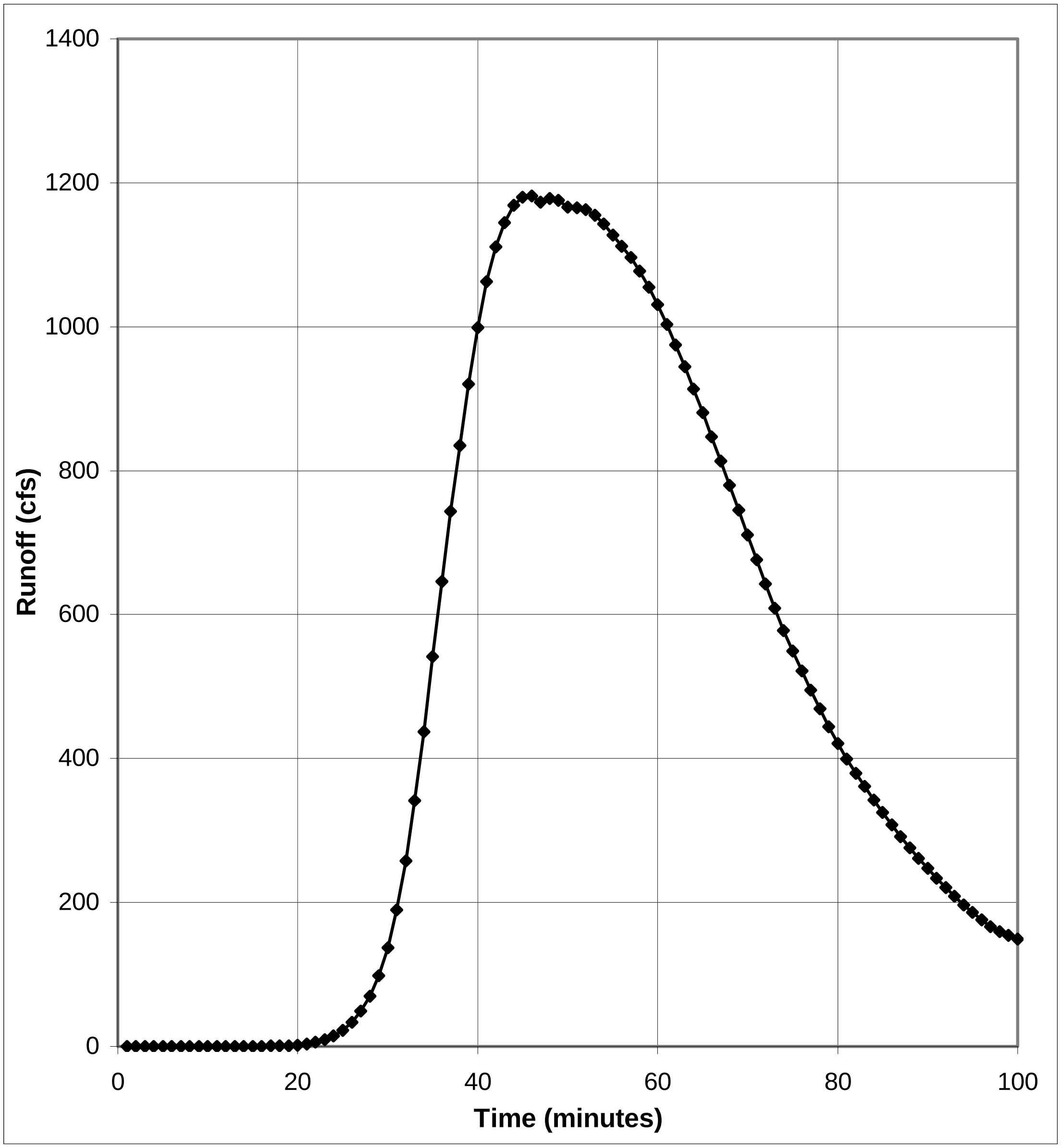


Figure J-10. Hydrograph for Tailings Area Cross Section HC-10

APPENDIX K

HYDRAULIC ANALYSIS METHODS AND DETAILS

APPENDIX K

TABLE OF CONTENTS

Page Number

FIGURES

APPENDIX K

Hydraulic Analysis Methods and Details

K.0 Introduction

As a supplement to hydraulic analysis presented in Section 6, the methods of hydraulic analysis and some relevant design details are included in the following sections.

K.1 Runoff Modeling

The runoff modeling was conducted with HEC-1 model using the basin characteristics presented in Tables 6-1-Cell-1 and 6-1-Cell-2 and the basins shown in Figures 6-1-Cell-1 and 6-1-Cell-2. The toe protection for the channel is the effective terminus of the erosion protection system for the encapsulated tailings for both reclamation configurations. The toe protection is excavated to a depth of four feet in the base of the surrounding swale, and should contact the sandstone bedrock over much of the width of the swale. In the Cell 1 reclamation configuration, the Shootaring Canyon Dam is located approximately 550 feet downstream of the channel toe protection for the primary channel and is not considered an integral part of the erosion protection system. The dam is breached in the Cell 1 reclamation configuration to reestablish the natural drainage in Shootaring Canyon and to prevent permanent ponding of significant quantities of water within the basin.

The runoff analysis described in Section 6.3 used the SCS curve number method to describe watershed conditions along with the PMP to produce a PMF analysis. The general curve number used for this analysis was a very conservative value of 88 for native areas and a conservative value of 70 for the areas covered with riprap or rock mulch. These numbers incorporated antecedent moisture condition III, which resulted in large volumes of runoff and large peak flow for the erosion protection features in the immediate tailings area. The hydrographs were extracted from the HEC-1 output and the peak flows were used in channel rock sizing. Hydrographs for key channel locations are presented in Appendix J in Figures J-1 through J-10.

K.1.1 Runoff Through the Shootaring Canyon Dam Breach

With the Cell 1 reclamation configuration, the Shootaring Canyon Dam will be breached to facilitate drainage. The configuration of the dam breach allows discharge at an elevation of 4374 feet above MSL. This elevation is approximately 16 feet lower than the elevation of toe of the reclaimed cross valley berm outslope, so it is not plausible that backwater from the breach would encroach on the tailings. The configuration of the dam breach includes a very flat trapezoidal channel section with a base width of 20 feet and 2H:1V side slopes. The downstream section of the breach includes a trapezoidal riprap channel section at a slope of 20%. The riprap will be taken from the dam face and is expected to have a D50 of greater than 12 inches. There are no specifications for this rock because this structure is not a part of the tailings erosion protection system. However, this configuration restricts the flow through the breach and exploits the basin upstream of the dam as a large temporary surge pond, thereby greatly enhancing the erosional stability of this area. A brief hydrologic analysis was conducted for the breach by determining an approximate temporary surge pond volume for the basin upstream of the breach. The volume upstream of the Shootaring Canyon Dam was estimated at approximately 84 acre-feet up to an elevation of 4384 feet above MSL, which is slightly above the elevation of the end of the channel. An additional HEC-1 analysis was conducted using a SCS curve number of 68 for the entire basin and the PMP storm as presented in Figure 6-3. This curve number represents a well drained soil with a poor range condition at antecedent moisture condition II, and this is a reasonably conservative curve number for this site given the arid environment. The estimated peak discharge through the breach for this PMP event was 212 cfs. The required rock D50 for the riprap according to the methodology described in Section 6.4.2 is 9.5 inches. Thus, the anticipated rock D50 of greater than 12 inches is adequate for this very conservative analysis.

K.2 Water Surface Profiles

The water surface profile for the major channel is presented in Figures K-1-CELL-1 and K-1-CELL-2 for the two respective reclamation configurations. There is a 10:1 vertical exaggeration in the scales for the profiles. The water surface profiles were developed for the PMF with the PMP distribution shown in Figure 6-3. The HEC-1 model was used with level pool flood routing for the area above the porous rock ledge. The large size rock (D50 = 24 inches) in the porous rock ledge will allow complete drainage of runoff from the tailings area.

K.3 Rock Sizing

The rock sizing for both channel rock and rock mulch was done with the Abt/Johnson method as presented in NUREG 1623. The average unit discharge was used in both applications to determine the required rock size. A minimum oversizing of 50% was then applied to insure the adequacy of the rock size in nonuniform flow conditions. The oversizing also included oversizing for rock quality concerns and the specific gravity of the rock.

K.3.1 Rock Mulch Sizing

The overland flow paths shown on Figures 6-2-CELL-1 and 6-2-CELL-2 were used in determining the unit discharge for rock sizing by the Abt/Johnson method as presented in NUREG 1623. The following discussion provides a sample calculation for flow path O1-2 which is divided into two sections of relatively uniform slope labeled O1-2A and O1-2B. These calculations for all overland flow paths are summarized in Table 6-2.

Segment O1-2A: length = 290 feet, relief = 36 feet, slope = 0.124 ft./ft.

Time of Concentration by Kirpich's Method expressed as:

$$t_c = 60*(11.9 * (\text{length}/5280)^3 / \text{relief})^{0.385}$$

$t_c = 60*(11.9 * (290/5280)^3 / 36)^{0.385} = 1.37$ minute

Since tc is less than 2.5 minutes, the maximum intensity is 32.75 inch/hour (see Page 6-4).

The segment is on rock mulch so the runoff coefficient (C) is 0.8.

The Rational equation is used to calculate the segment discharge on a unit width basis as:

$q = C * I * A$

where: A = (length * 1 feet width) / (43560 ft^2/acre)

$q = 0.8 * 32.75 * 290 / 43560 = 0.174$ cfs/ft.

The rock D50 is calculated by the Abt/Johnson method expressed as:

$D50 = 5.23 * q^{0.56} * slope^{0.43}$

$D50 = 5.23 * (0.174)^{0.56} * (0.124)^{0.43} = 0.80$ inch

The target minimum D50 for the rock mulch is 1.5 inches, so the rock mulch over sizing for this segment is:

Oversize = (1.50 – 0.80) / 0.80 * 100 = 88%

Segment O1-2B: length = 160 feet, relief = 21 feet, slope = 0.131 ft./ft.

Progressive Time of Concentration by Kirpich's Method expressed as:

$t_c = 60*(11.9 * (length/5280)^3 / relief)^{0.385}$

$t_c = 60*(11.9 * ((290+160)/5280)^3 / (36+21))^{0.385} = 1.91$ minute

Since tc is less than 2.5 minutes, the maximum intensity is 32.75 inch/hour (see Page 6-4).

The segment is on rock mulch so the runoff coefficient (C) is 0.8.

The Rational equation is used to calculate the segment discharge on a unit width basis as:

$q = C * I * A$

where: A = (length * 1 feet width) / (43560 ft^2/acre)

$q = 0.8 * 32.75 * (290+160) / 43560 = 0.271$ cfs/ft.

The rock D50 is calculated by the Abt/Johnson method expressed as:

$$D50 = 5.23 * q^{0.56} * slope^{0.43}$$

$$D50 = 5.23 * (0.271)^{0.56} * (0.131)^{0.43} = 1.05 \text{ inch}$$

The target minimum D50 for the rock mulch is 2.25 inches, so the rock mulch oversizing for this segment is:

$$Oversize = (2.25 – 1.05) / 1.05 * 100 = 114\%$$

The Manning's n was calculated by the Abt method and using in determining normal depth according to Manning's equation. These calculations are not used in the rock sizing for the rock mulch.

K.3.2 Channel Rock Sizing

The channel rock was sized at key locations using the Abt/Johnson method, the peak flows from the HEC-1 runoff modeling for the PMF, and the average unit discharge. A comparison rock size calculation was also done with the Stephenson method to insure the adequacy of the channel riprap. A constant Manning's n of 0.035 was used. Following rock sizing, a minimum oversizing of 46% based on the Abt/Johnson method was applied to all channel rock. This oversizing was well in excess of that required by rock quality scoring and compensates for minor deviation from the shear stress realized under a normal flow regime. These calculations are summarized in Table 6-3 for the channel hydrologic sections shown in Figure 6-6. Representative channel cross-sections are presented in Figures K-3 through K-5 for the locations presented on Figure K-2. A sample calculation is presented below.

Section HC-6: PMF Discharge = 733 cfs.

Trapezoidal Channel – Base width = 30 feet
Right Side Slope (looking downstream) is 3H:1V
Left Side Slope (looking downstream) is 3H:1V

Manning's Equation is used to calculate the normal flow characteristics according to:

$$Q = (1.49 / n) * A * R^{2/3} * S^{1/2}$$

Since the area of flow (A) and the hydraulic radius (R) are both functions of normal flow depth (y) and channel geometry, an iterative procedure is implemented in a spreadsheet to calculate y, A, R, the wetted perimeter (P), the top width (T), the average velocity (V), and the maximum velocity (V_m). The average unit discharge is calculated as:

$$q = V * y = 13.78 * 1.537 = 21.18 \text{ cfs/ft}$$

The rock D50 is calculated by the Abt/Johnson method expressed as:

$$D50 = 5.23 * q^{0.56} * slope^{0.43}$$

$$D50 = 5.23 * (21.18)^{0.56} * (0.071)^{0.43} = 9.27 \text{ inch} = 0.77 \text{ feet}$$

The target minimum D50 for the rock is 14 inches (1.17 feet), so the channel rock oversizing for this section is:

Oversize = (1.17 – 0.77) / 0.77 * 100 = 52%

The Froude number (F) is calculated as:

$$F = ((Q^2 * T) / (32.2 * A^3))^{1/2}$$

$$F = ((733^2 * 39.22) / (32.2 * 53.2^3))^{1/2} = 2.08$$

Flow is supercritical.

The Stephenson method, which was used for comparison rock sizing in channels, is expressed as:

$$D_{50} = \left[\frac{q(\tan\theta)^{7/6} n_p^{1/6}}{C\, g^{1/2} [(1 - n_p)(G_s - 1)\cos\theta(\tan\phi - \tan\theta)]^{5/3}} \right]^{2/3}$$

where:

D_{50}= required rock diameter in feet, (50% of the rock must be larger than this),
q = flow rate per unit width,
θ = angle of channel bottom from horizontal,
ρ = angle of friction for the rock,
n_p = rockfill porosity,
G_s = specific gravity of the rock,
g = the acceleration of gravity, and
C = empirical factor which varies from 0.22 for gravel to 0.27 for crushed granite.

The assumption of uniform flow is implicit in the use of θ, the channel bottom angle. Since sin(θ) and tan(θ) are approximately equal to channel bottom slope expressed in rise/run, the channel bottom slope is often substituted for sin(θ) and tan(θ). A rockfill porosity of 0.325%, angle of repose of 42.2 degrees for the rock, C value of 0.27, and specific gravity of 2.5 were used in this calculation. The unit discharge of 21.18 cfs/ft and channel slope of 0.071 feet/feet were used in calculating the rock size as:

$$D_{50} = [\frac{21.18(\tan 4.061)^{7/6}\, 0.325^{1/6}}{0.27\,(32.2)^{1/2}\,[(1 - 0.325)(2.5 - 1)\cos 4.061(\tan 42.2 - \tan 4.061)]^{5/3}}]^{2/3}$$

D_{50} = 0.78 feet

The rock size based on the Abt/Johnson method is similar to that produced by the Stephenson method.

K.3.2.1 Channel Rock Sizing in Bend

There are two gradual channel bend in the major channel between stations 2+00 and 9+00 on Figure K-1-CELL-1. The bends are similar in radius, so only the bend between stations 6+00 to 9+00 will be analyzed. There is an increase in shear stress and required rock size in channel bends. This increased shear stress can be estimated using a method presented by USACOE, (1970). This method is based on Plate 34 of USACOE (1970), which is a figure relating the ratio of increased shear in bends to the ratio of channel bend radius divided by water surface width. The equation for this ratio of shear stress for smooth channels is given as:

$$\frac{\tau_b}{\tau_o} = 2.65\,(\frac{r}{w})^{0.5}$$

where:

τ_b = maximum boundary shear in bend,
τ_o = average boundary shear,
r = center-line radius of channel bend, and
w = upstream water surface width of bend.

Unfortunately, this equation does not produce results that correspond with the figure in Plate 34 of USACOE (1970) and the correct form of the equation should be:

$$\frac{\tau_b}{\tau_o} = 2.65\,(\frac{w}{r})^{0.5}$$

For rough channels, the plotted data indicates that the constant 3.1 should be substituted for the constant 2.65 in the preceding equation. However, there are only two data points for a very small r/w ratio (less than 1.6 for the incorrect form of the equation) to support the rough channel constant, and these values were determined from a two foot wide flume. Very little confidence can be placed in the increased constant (3.1) and the former version of the equation is considered more applicable. The Abt/Johnson method does not use shear stress directly in the calculation of rock size, but increasing the unit discharge is analogous to the increase in shear stress. The width of flow upstream of the bend is approximately 39 feet. The radius of the bend is approximately 275 feet, giving the ratio of shear stress as:

$$\frac{\tau_b}{\tau_o} = 2.65\left(\frac{w}{r}\right)^{0.5} = 2.65(39/275)^{0.5} = 0.998$$

Because the radius of the bend is relatively long, there is no indicated increase in shear stress through the bend.

K.4 Sedimentation

The reclamation surface for the tailings area includes slopes of 8% to approximately 20%. There is virtually no off-tailings area contributing runoff to the actual covered tailings surface, but there is a significant off-tailings area contributing to the perimeter swale and drainage channels. With the moderate slopes on the tailings, the potential for a significant depth of sediment accumulation above the rock mulch is very limited. It is likely that much of the pore space in the rock will eventually be filled with windblown sediment. However, once the rock mulch is covered, there will no longer be a stabilizing matrix to allow continued aggradation. The sediment above the rock will be highly erodible by both wind and runoff.

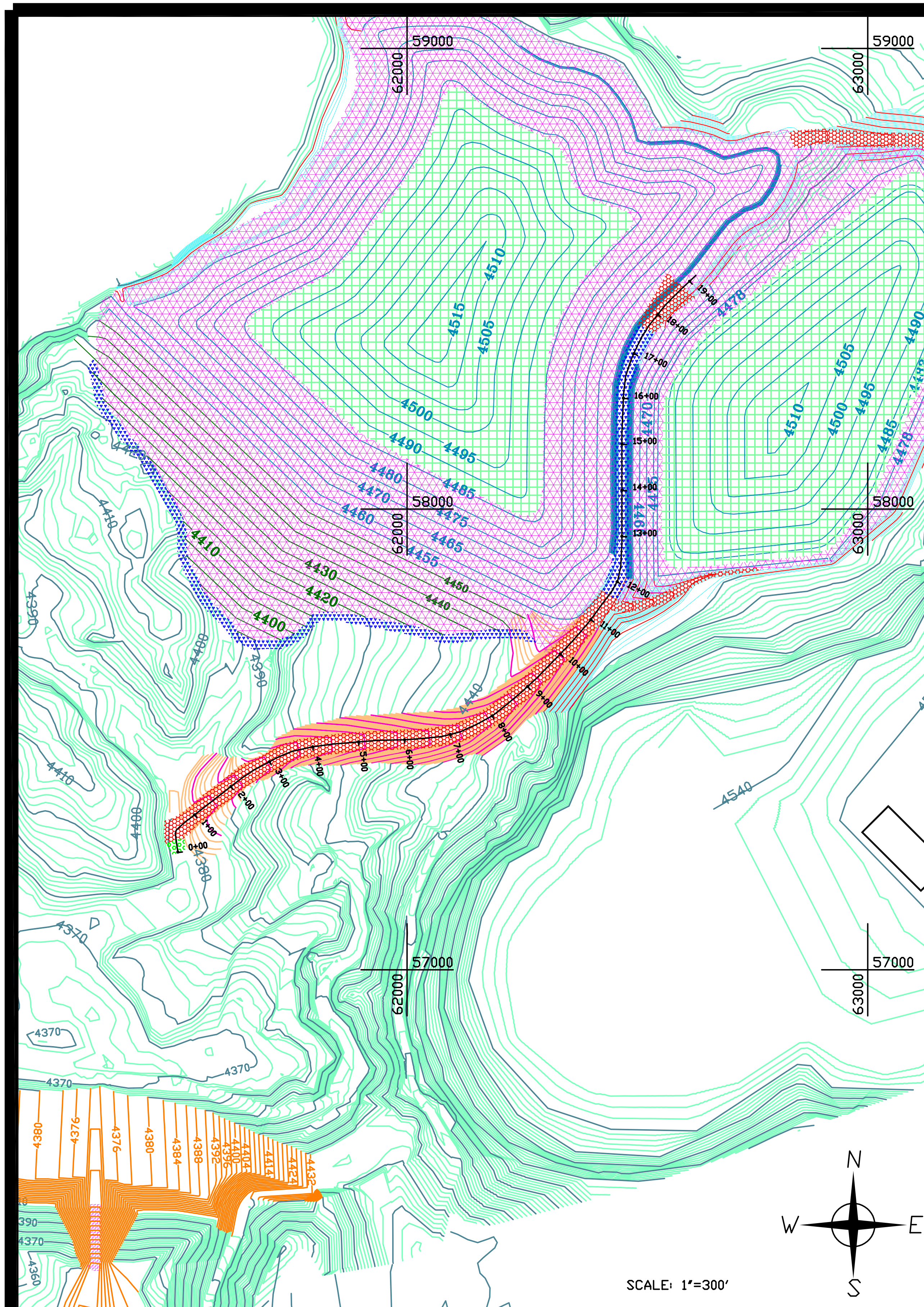
The potential sediment accumulation in the channel is discussed in Section 6.4.7. The primary feature that prevents any significant detrimental effects of sediment accumulation is the effective overtopping depth incorporated into the mildly sloping sections of channel. The major drainage channels are located at the base of a swale, and enormous depths of sediment can accumulate in the channels with no detrimental impacts on the drainage. The porous rock ledge is constructed of large enough rock that it will not function as a sediment dam.

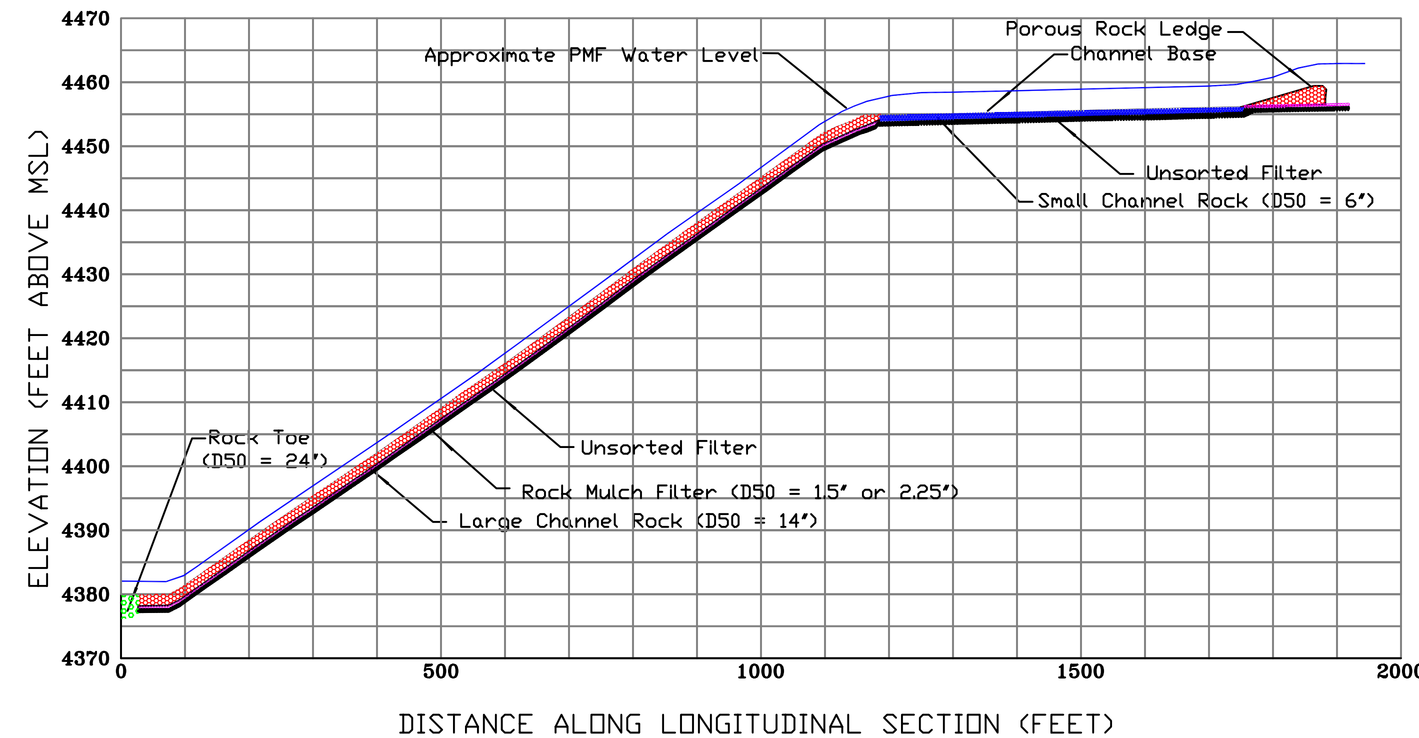
K.5 Rock Mulch Apron

A twenty foot wide rock apron (see Figure K-6) is included at the perimeter of the rock mulch to transition to the surrounding surface. The rock for this apron is the 6 inch D50 rock specified for channel sections HC-1 and HC-2. The typical apron installation is on a milder slope than the upstream rock mulch (D50 = 2.25 inch). The nearly three-fold increase in rock D50 for the apron is grossly conservative in that it will withstand flows several times greater than the PMF-designed rock mulch immediately upstream of it. At a slope of 5H:1V the 6 inch D50 rock will withstand a unit discharge of approximately 4.4 cfs/ft based on the Abt/Johnson method of rock sizing. This is several times greater than unit discharges presented in Tables 6-2-Cell-1 and 6-2-Cell-2.

K.6 References

U.S. Army Corps of Engineers (USACOE), 1970, Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Department of the Army, Office of the Chief of Engineers, Washington D.C.





HORIZONTAL SCALE: 1" = 300'
VERTICAL SCALE: 1" = 30'

LEGEND

- SMALL ROCK MULCH (D50 = 1.5 inches)
- LARGE ROCK MULCH (D50 = 2.25 inches)
- INTERMEDIATE RIPRAP (D50 = 6 inches)
- LARGE RIPRAP (D50 = 14 inches)
- CHANNEL TOE ROCK
- RIPRAP OUTFALL

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FIGURE K-1-CELL-1. LONGITUDINAL SECTION FOR CELL 1 RECLAMATION

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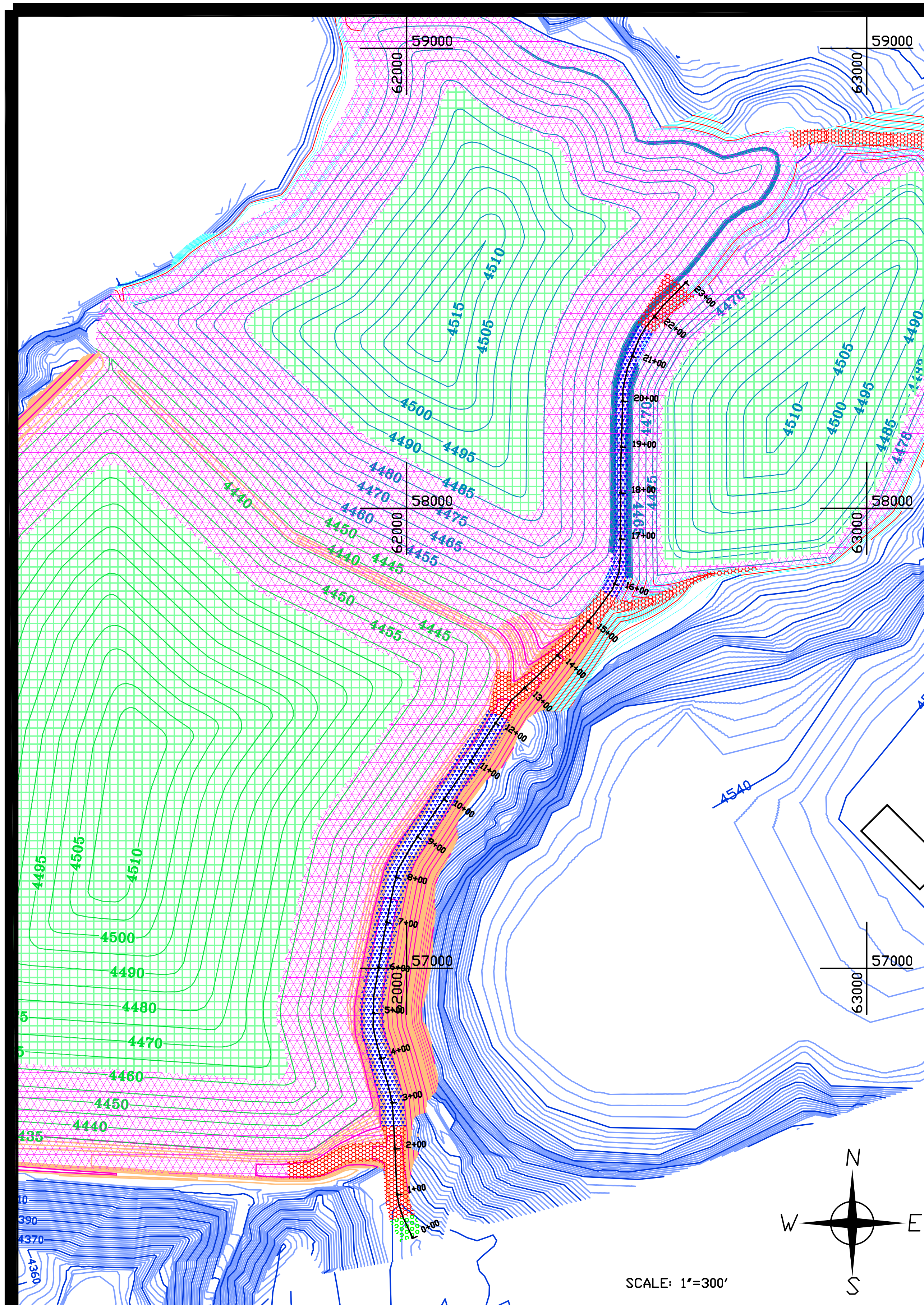

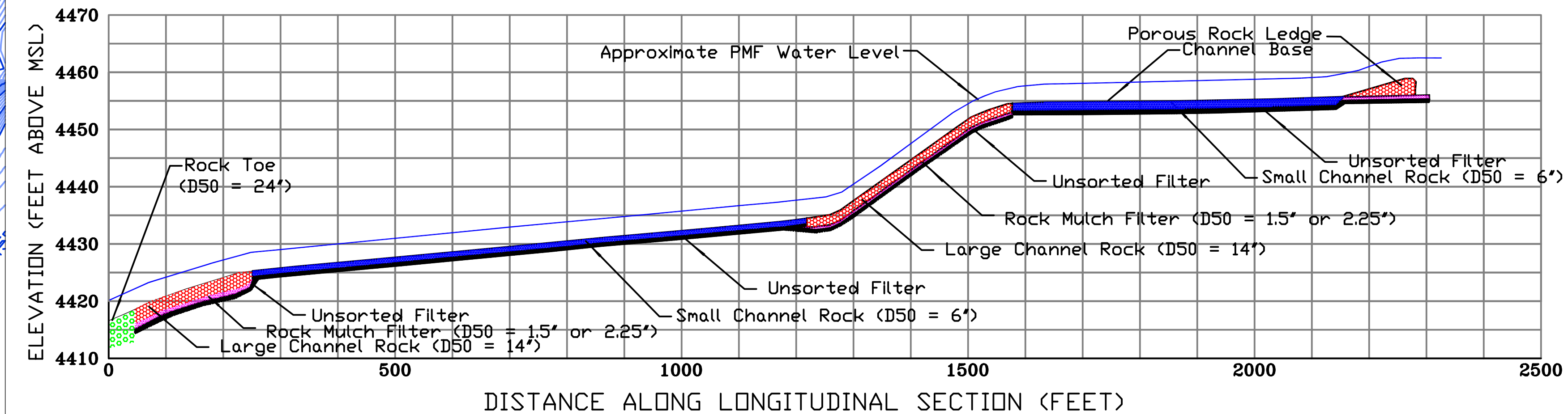

HORIZONTAL SCALE: 1" = 300'
VERTICAL SCALE: 1" = 30'

LEGEND

- SMALL ROCK MULCH (D50 = 1.5 inches)
- LARGE ROCK MULCH (D50 = 2.25 inches)
- INTERMEDIATE RIPRAP (D50 = 6 inches)
- LARGE RIPRAP (D50 = 14 inches)
- CHANNEL TOE ROCK
- RIPRAP OUTFALL

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FIGURE K-1-CELL-2. LONGITUDINAL SECTION FOR CELL 1 AND CELL 2 RECLAMATION

DATE: 12-2005	FIGK-1.DWG
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