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SUPPLEMENT TO THE SOURCE MATERIAL LICENSE AMENDMENT APPLICATION

ANALYSIS OF TAILINGS DISPOSAL FOR RANCHERS EXPLORATION AND DEVELOPMENT CORPORATION NATURITA, COLORADO

PREPARED BY

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1.0 INTRODUCTION

This report presents the results of an analytical study evaluating the post-operational management plan for the proposed heap leach processing of the abandoned Naturita tailings at Naturita, Colorado. The information herein is provided in support of Ranchers Exploration and Development Corporation's Source Materials License Application to the Colorado Department of Health.

Ranchers Exploration and Development Corporation reserves the right to change or disregard any or all of the results quoted herein should current legislative requirements be altered or others instituted.

The technology used in the evaluation of the post-operational management plan is considered "State of the Art". Future advances in reclamation may alter or negate the proposed management plan. Ranchers Exploration and Development Corporation reserves the right to alter or negate any of the conclusions in this report should future advances warrant such change.

The criteria used in evaluating methods for post-operational heap leach tank and evaporation pond settled solids management were:[1].

a. A reduction in the gamma radiation to essentially background levels.
b. A reduction in the radon emanation flux from the waste to not greater than twice background levels.
c. Minimum monitoring and minimum long-term maintenance.

2.0 BACKGROUND

2.1 Current Tailings Status

The current tailings area is located approximately two miles northwest of the town of Naturita, Colorado in the San Miguel River

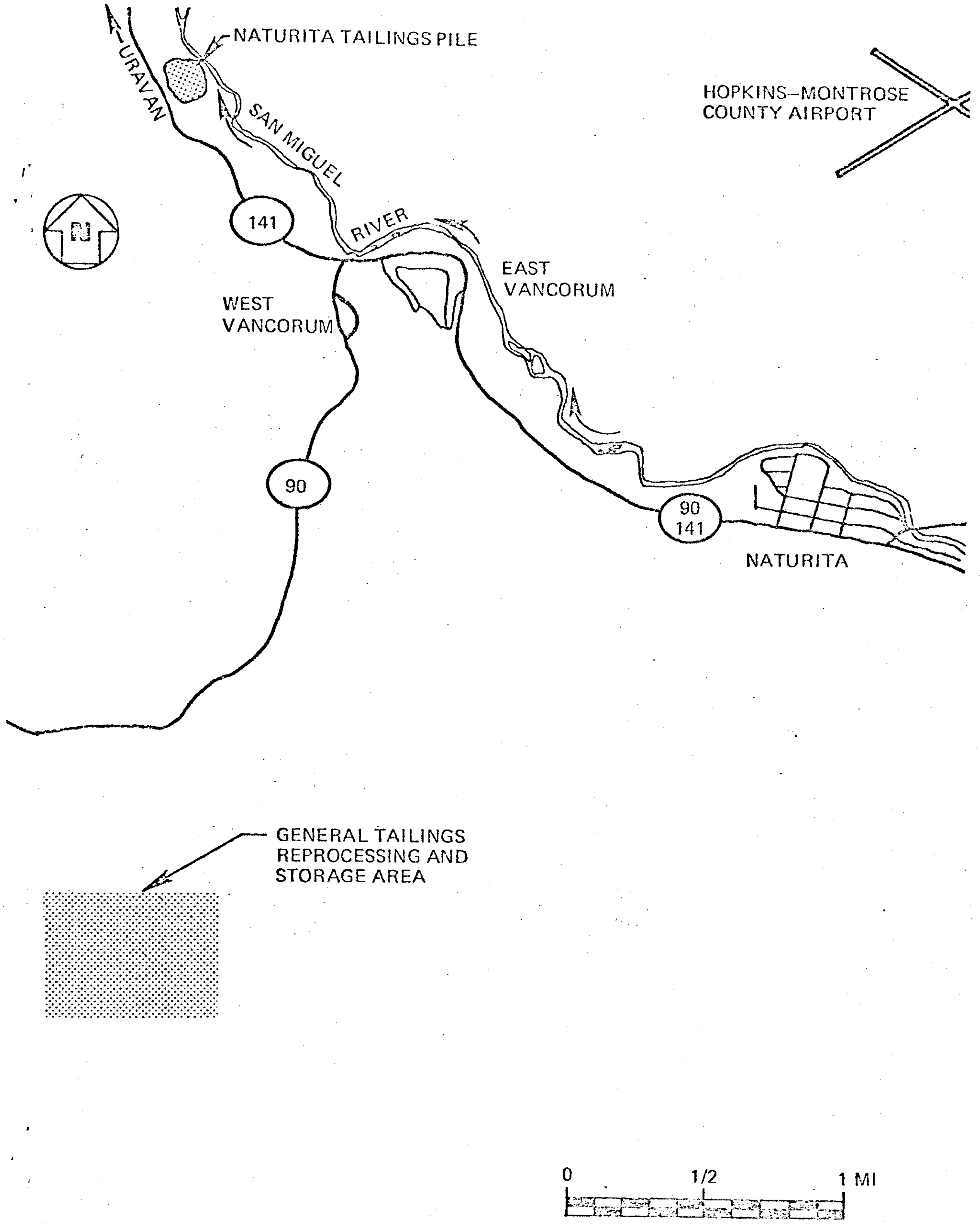

FIGURE 1

LOCATION OF PROPOSED REPROCESSING AND STORAGE SITE (From Ford Bacon & Davis, Inc.; Ref. 2)

Valley (Figure 1)[2]. The tailings occupy some 24 acres near the San Miguel River and are the product of 720,000 tons of ore processed during the years 1947 through 1963[2].

The tailings were stabilized in 1969 with approximately six inches of earth cover and revegetated. However, much of this cover has been eroded and vegetative cover is now estimated at 40%.

A more detailed description of the tailings and the site environs may be found in a report currently in preparation for the U.S. Department of Energy.[2]

2.2 Future Tailings Status

Ranchers Exploration and Development Corporation proposes to move the tailings to a suitable location away from the San Miguel River and process the tailings for uranium and vanadium. The entire removal operation is expected to be completed in about 18 months.[3]

Environmentally, the proposed operation would be a major step in removing the undesirable presence of tailings on the floodplain of the San Miguel River. The San Miguel is part of the Colorado River System, the water quality of which is currently of national and international concern. Removal of the tailings from the San Miguel Valley also would reduce any existing radon exposures to valley residents and open the possibility of normal long-term development of that section of the valley.[3]

The tailings will be moved by truck along State Highways 141 and 90 to a site in the Paradox Valley, where they will be blended and agglomerated, deposited in impermeable earthen tanks, and processed by leaching, ion exchange and/or solvent extraction to remove uranium, and solvent extraction to remove vanadium. The former tailings site and the leaching site will then be reclaimed in accordance with

Colorado Radiation Control Regulations and the recommendations of the Colorado Department of Health.

3.0 CURRENT TAILINGS IMPACT

3.1 Erosion and Aquatic Impact

As previously mentioned, the Naturita tailings pile is presently located on the southwest bank of the San Miguel River, which flows into the Dolores River and, in turn, into the Colorado. The Dolores River, particularly that section below its confluence with the San Miguel, is currently under study for possible Wild River designation.

Because of the proximity of the tailings to the San Miguel river, an attempt was made to quantify on a yearly basis the amount of material which may ultimately be eroded into the stream.[a]

The model used, "The Universal Soil Loss Equation" (USLE) was developed by W.H. Wischmeier and his collegues to estimate sheet and rill erosion for agricultural land east of the Rocky Mountains.[4] Recently, a modified equation base on the USLE has been developed by the Utah Water Research Laboratory for predicting soil loss due to water erosion on highway construction sites, and for determining the effectiveness of various erosion control measures in the southwest.[5]

The equation and the parameters used are described below:

$$A = R \cdot K \cdot LS \cdot VM \qquad (1)$$

where

A = Tailings Eroded in tons/acre

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[a] In subsequent discussions soils and tailings will be used interchangably.

R = Rainfall factor, a measure of the erosive forces of the rainfall and associated runoff

K = Tailings erodibility factor, a measure of the susceptibiliy of a particular soil to erode

LS = The topographic factor, the effect of length and steepness of slope on the soil loss per unit area. This factor may be calculated from the following expression

$$LS = \frac{(0.43 + 0.3s + 0.043\ s^2)}{6.613} \left\{ \frac{\partial}{72.6} \right\}^m \left\{ \frac{10^3}{10^3 + s^2} \right\} \qquad (2)$$

where

∂ = slope length in feet

s = slope steepness in percent

m = exponent dependent upon slope steepness (0.3 for slopes <0.5%, 0.5 for slopes 0.5% to 10%, 0.6 for slopes >10%)

VM = Erosion Control Factor, a function of all erosion control measures such as vegetation, mechanical manipulation of the surface, chemical treatments, etc.

Substituting the factors quoted for the site from Reference 5, two calculations were made using two different LS factors. (Figure 2). The first of these considered erosion basically perpendicular to the river while the second LS factor was calculated for a direction toward the stream feeding the San Miguel River.

The results of the calculations estimated the "A perpendicular", the possible loss in the San Miguel River, at 16.8 tons/acre year while "A parallel", the possible loss into the stream feeding the San Miguel, was 5.8 tons/acre year. The area influenced by "A perpendicular" was estimated at 1.16 acres resulting in a hypothetical loss of 19.5 tons of tailings per year. Similarly, the area influenced by A parallel was estimated at 24.3 tons/year.

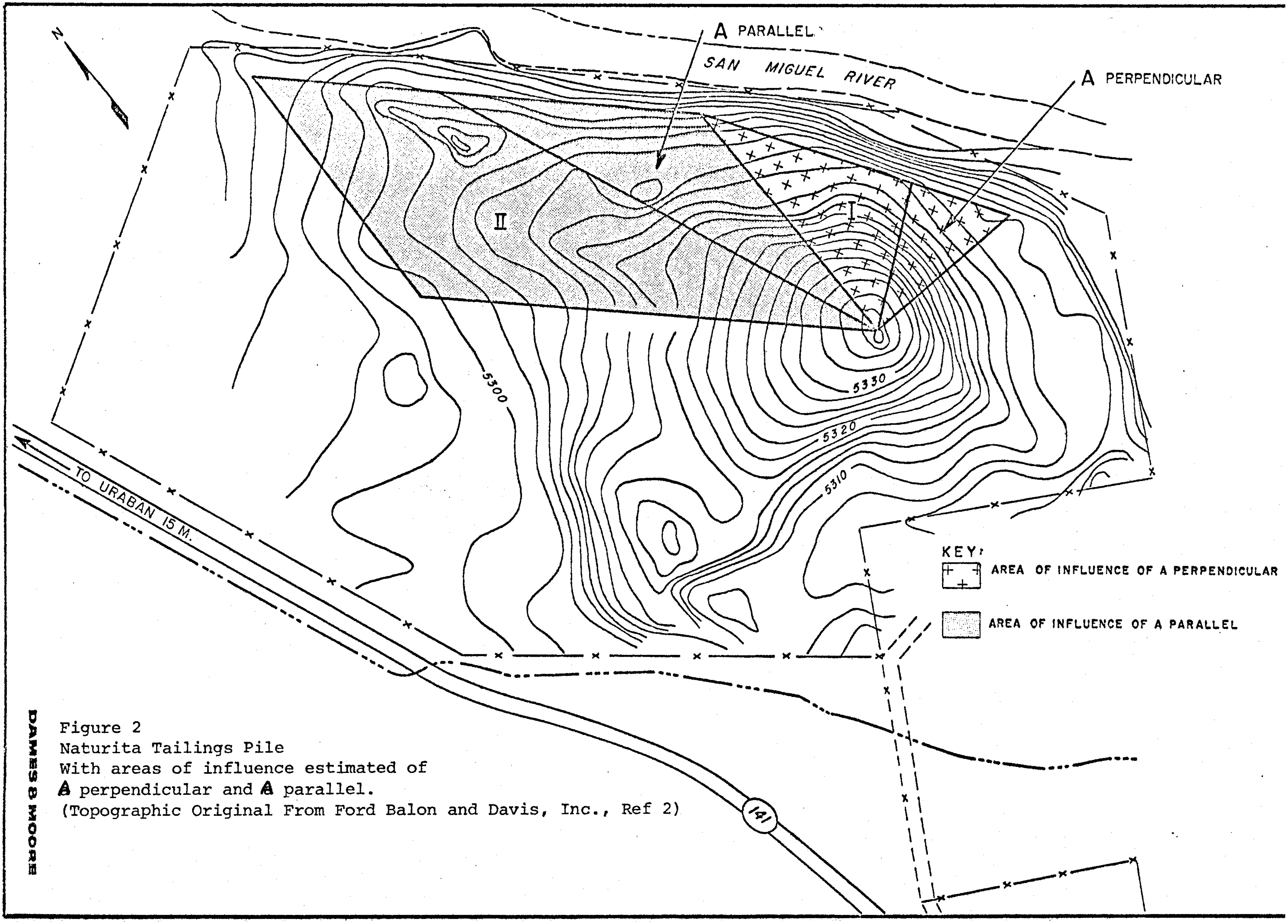

Figure 2
Naturita Tailings Pile
With areas of influence estimated of
A perpendicular and **A** parallel.
(Topographic Original From Ford Balon and Davis, Inc., Ref 2)

DAMES & MOORE

From the above erosion estimates and the average radium content of the tailings, an estimate of the possible radiological impact may be made as follows:

Perpendicular into River:

$$792.\ \frac{\text{pCi}}{\text{g tailings}}\ \text{Ra 226} \times 433.6\ \frac{\text{g}}{\text{lb}} \times 2000\ \frac{\text{lb}}{\text{T}} \times 19.5\ \frac{\text{T}}{\text{y}} = 14.0\ \text{mCi/y} \tag{3}$$

Parallel into Stream:

$$792.\ \frac{\text{pCi}}{\text{g tailings}}\ \text{Ra 226} \times 433.6\ \frac{\text{g}}{\text{lb}} \times 2000\ \frac{\text{lb}}{\text{T}} \times 24.3\ \frac{\text{T}}{\text{y}} = 17.5\ \text{mCi/y} \tag{4}$$

The estimates above, though first order, show that significant radiological impact could occur if the tailings are not stabilized or moved to another location. Similarly, these estimates use only average values. Erosion by snow, wind, or above average rainfall could significantly increase the above estimates.

3.2 Tailings Radioactivity

3.2.1 Tailings Radon Flux

The average radon flux from the current tailings site has been calculated from a series of measurements to be 1446.6 pCi/m^2-sec.[2]

This measured average agrees quite well with the theoretical value which may be derived as follows.

From the average concentration of the ores which were processed, 0.3% and 0.25%, and assuming secular equilibrium between the uranium and its daughters, the final tailings should have a concentration of between 873. pCi/g and 728. pCi/g of radium 226. The average value quoted is 792. pCi/g while the average value calculated is 800. pCi/g.

Using the conversion factor of 1.6 pCi/m^2-sec per gram of tailings radium as quoted in Radiation Data and Reports,[6] 1974, it is estimated that the radon flux is between 1397. pCi/m^2-sec and 1165. pCi/m^2-sec with an average of 1280. pCi/m^2-sec.

3.2.2 Tailings Gamma Radiation

Gamma measurements were also made at various places on the tailings pile. These range from a high of 976. μR/hr to a low of 73. μ R/hr.[2]

These values are lower than the theoretical expected average of 1980. μR/hr and quite possibly reflect attenuation due to the cover material still on the pile.[6]

3.3 Conclusion

The previous discussion, although theoretical, has described the possible radiological impacts from the current tailings area if left as is. These include possible erosion of radioactive material into the Colorado River system, and elevated radon flux and gamma ray emission from the tailings pile.

4.0 POST-OPERATIONAL TAILINGS MANAGEMENT

4.1 Introduction

Three leach tanks will be constructed to recover residual uranium tailings transported from the Naturita River site. The tanks will be lined with a one-foot thick liner of compacted shale to prevent ground water seepage. The tanks will accomodate 267,300 yd^3, 287,000 yd^3 and 173,000 yd^3 of tailings and encompass areas of 6.6 acres, 8.5 acres, and 5.0 acres, respectively, or a total of 20.1 acres which is somewhat less than the current area covered.[3]

More detailed discussion concerning the leach process and associated technology may be found in Reference 3.

It should be noted that although residual uranium is being recovered, there will not be an increase in the thorium, radium or other daughter products in the material. The extremely long half life of U-238 (4.51×10^{9} years) indicates negligible daughter product production in the time frame considered (30 years, 1947-1978). Thus, all previous concentrations of radium must be used in subsequent calculation.

The movement of the tailings should also improve their homogenity. Thus, pockets of slimes which may occur in the original tailings will be well mixed. As slimes contain the overwhelming amount of radionuclides in tailings this mixing will further reduce possible "hot spots" of gamma radiation.[7]

4.2 Background Radioactivity

In order to fulfill the previously mentioned radiological design criteria of:

a. A reduction in the gamma radiation to essentially background levels.
b. A reduction in the radon emanation flux from the waste to not greater than twice background levels.

it is necessary to determine the existing background. This may be done experimentally or calculated in the case of radon emanation from the radium concentration.

4.2.1 Background Radon Flux

There are no currently available measurements of the background radon flux for the site or its immediate environs. The background flux can be estimated, however, from the average radium concentration of soils at locations in the vicinity of the site by using a conversion factor of 1.6 pCi/m^2-sec of radon per pCi/g of radium-226 in the soil.[6] The average value of radium-226 in the soils from northwest Colorado is quoted as 1.52±0.78 pCi/g with a range of 0.48 to 3.4 pCi/g.[2]

This average gives rise to a background radon emanation flux of 2.4 pCi/m^2-sec.

4.2.2 Background Gamma Radiation

Background gamma radiation is attributable about equally to primary and secondary cosmic rays, natural radionuclides in the soils, and a man made component, fallout.

A value of 10 μR/hr was established as the average gamma background. This gives rise to an annual dose of approximately 88 mrem/year which is 2.5 times lower than what should be expected for an individual living in Colorado (as estimated in EPA 520/1-76-010 for Colorado).

4.3 Radioactivity Attenuation

4.3.1 Cover Material

The material selected for post-operational cover material is Mancos shale, a slate-gray marine shale which is abundant throughout the Paradox Basin.

Various parameters of this material have been measured by Ranchers Exploration and Development Corp.. These include a moisture content of 16% and a density of 1.89 g/cm^3.[9]

4.3.2 Radon Reduction

The model chosen for calculating the thickness of material necessary to reduce radon emanation to not greater than twice background is quoted from Clements, et.al.[10] The model consists of a uniform layer of material

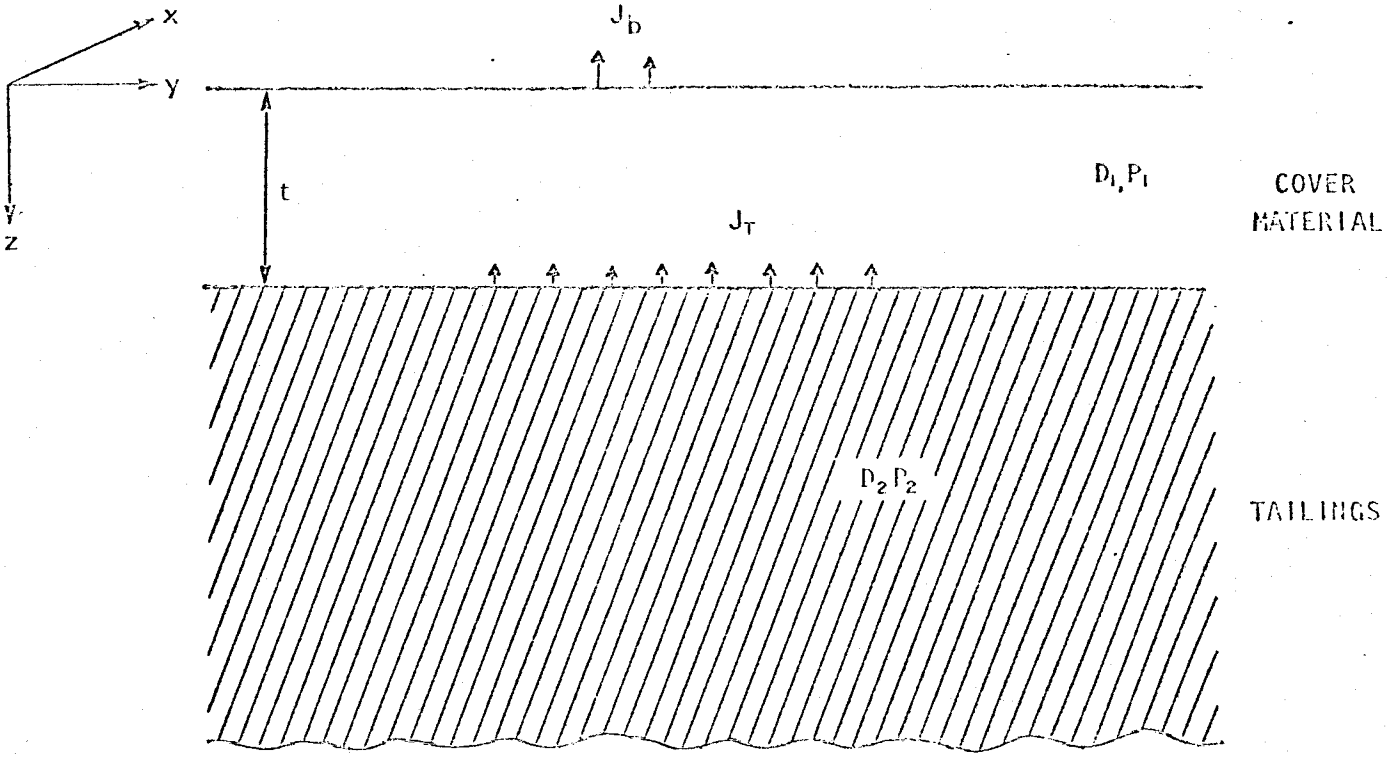

FIGURE 3

IDEALIZED SKETCH OF THE MODEL USED FOR GASEOUS DIFFUSION of finite thickness, covering a material of "infinite" thickness. (Fig. 3). Both materials are assumed to contain radium and are capable of producing and diffusing radon. The steady state equation governing the diffusion of radon into the atmosphere from these layers is:

$$D \frac{\partial^2 C}{\partial z^2} - \lambda C + P = 0 \tag{5}$$

where:

C = is the radon concentration in the interstitial space (pCi/cm^3)
D = is the effective diffusion coefficient, i.e., the diffusion coefficient divided by the porosity (cm^2/sec)
P = is the specific radon production rate in the interstitial space (pCi/sec cm^3)

The boundary conditions appropriate to the problem are:

$$C_1\ (z=t) = C_2(z=t) \tag{6}$$

$$-D_1 \frac{\partial C_1}{\partial z}\bigg|_{z=t} = -D_2 \frac{\partial C_2}{\partial z}\bigg|_{z=t} \tag{7}$$

$$C_1\ (z=0) = 0 \tag{8}$$

$$\lim_{z \to \infty} C_2(z) = P_2/\lambda \tag{9}$$

Substituting the solutions of (5) into (6)-(9) and noting

$$J_1(z=0) = -D_1 \frac{\partial C_1}{\partial z}\bigg|_{z=0} \tag{10}$$

gives

$$\frac{J(z=0)}{J_b} = -\left\{ \frac{(1-P_2/P_1) - (1+a)e^{r_1 t}}{\sinh(r_1 t) + a\cosh(r_1 t)} + 1 \right\} \tag{11}$$

where:

$J\ (z=0)$ = Surface Flux $(\mathrm{pCi/m^2\text{-}sec})$

J_b = Background Flux $(\mathrm{pCi/m^2\text{-}sec})$

i.e. the flux of the cover material

a = D_1/D_2 (Dimensionless)

r_1 = $\sqrt{\lambda/D_1}$ $(\mathrm{cm})^{-1}$

t = Thickness of Cover Material (cm)

Defining J_T as the flux from the uncovered tailings the above may be rearranged in the form

$$\frac{J(z=0)}{J_b} = -\left\{ \frac{(1-\exp(r_1 t)) - a\exp(r_1 t)\,[J_T \exp(-r_1 t)/Jb + 1]}{\sinh(r_1 t) + a\cosh(r_1 t)} + 1 \right\} \tag{12}$$

It should be noted that the term in the square brackets is the model used by Tanner, et.al, and others.[7,11,12] The other terms are correction terms which take into account the finite thickness and properties of the cover.

The term $J(z=0)/J_b$ represents the ratio of the surface flux to the background and must be less than 2.0 to fill the criteria on radon flux emanation.

Because of tediousness of substituting different values of thickness in the above equation a computer program was written to solve the right hand side for various increments of cover material thickness for various diffusion coefficients, and flux ratios, i.e., tailings to background flux. The code is designed to terminate when the thickness of cover reached is sufficient to reduce the ratio $J(z=0)/J_b$ to less than 2.0.

The unknown parameters in the model are the effective diffusion coefficients of the tailings and the cover materials.

- The effective diffusion coefficient of the ultimately dry tailings is estimated to be 1.02×10^{-2} cm^2/sec. This is a conservative estimate based on diffusion coefficient measurement of a similar type of material and the fact that the waste material is well mixed.

- The effective diffusion coefficient of the Mancos Shale cover was estimated at 1.32×10^{-4} cm^2/sec. This estimate was made by essentially doubling the value of the coefficient used for Montmorillonite clay as the moisture content is half.[13] The estimate did not take into account factors such as the relative densities of the two materials and as such is conservative.

Substitution of these values and the value of the ratio of the tailings to background flux in the right hand side of Equation 12 allows the determination of the radon reduction versus cover material. Table I and Figure 4 presents the results of these calculations for various thicknesses of Mancos Shale and Montmorillonite Clay..

It should be noted that nine inches of the proposed cover decreases the radon emanation by two orders of magnitude. The additional covers serves to reduce both the residual radon from the tailings and that being generated in the cover material. Also, as the thickness goes beyond approximately one foot, the slope of the curve begins to decrease which implies that nearly all the flux emanating from the waste is surpressed and only that being generated by the radium in the lower portion of the cover is prevented from diffusing, i.e.:

$$\lim_{t \to \infty} J(z=0)/J_b = 1$$

TABLE I

THICKNESS OF COVER VS. RATIO OF RADON SURFACE FLUX TO RADON BACKGROUND FLUX

Thickness of Cover (inches)	Ratio of Surface Flux to Background For Various Cover Materials	
	Montmorillonite Clay	Mancos Shale
2	96.0	133.7
4	34.0	59.1
6	13.7	30.3
8	6.0	15.3
10	2.9	9.1
12	<2.0	5.3
14		3.3
16		2.2
18		<2.0

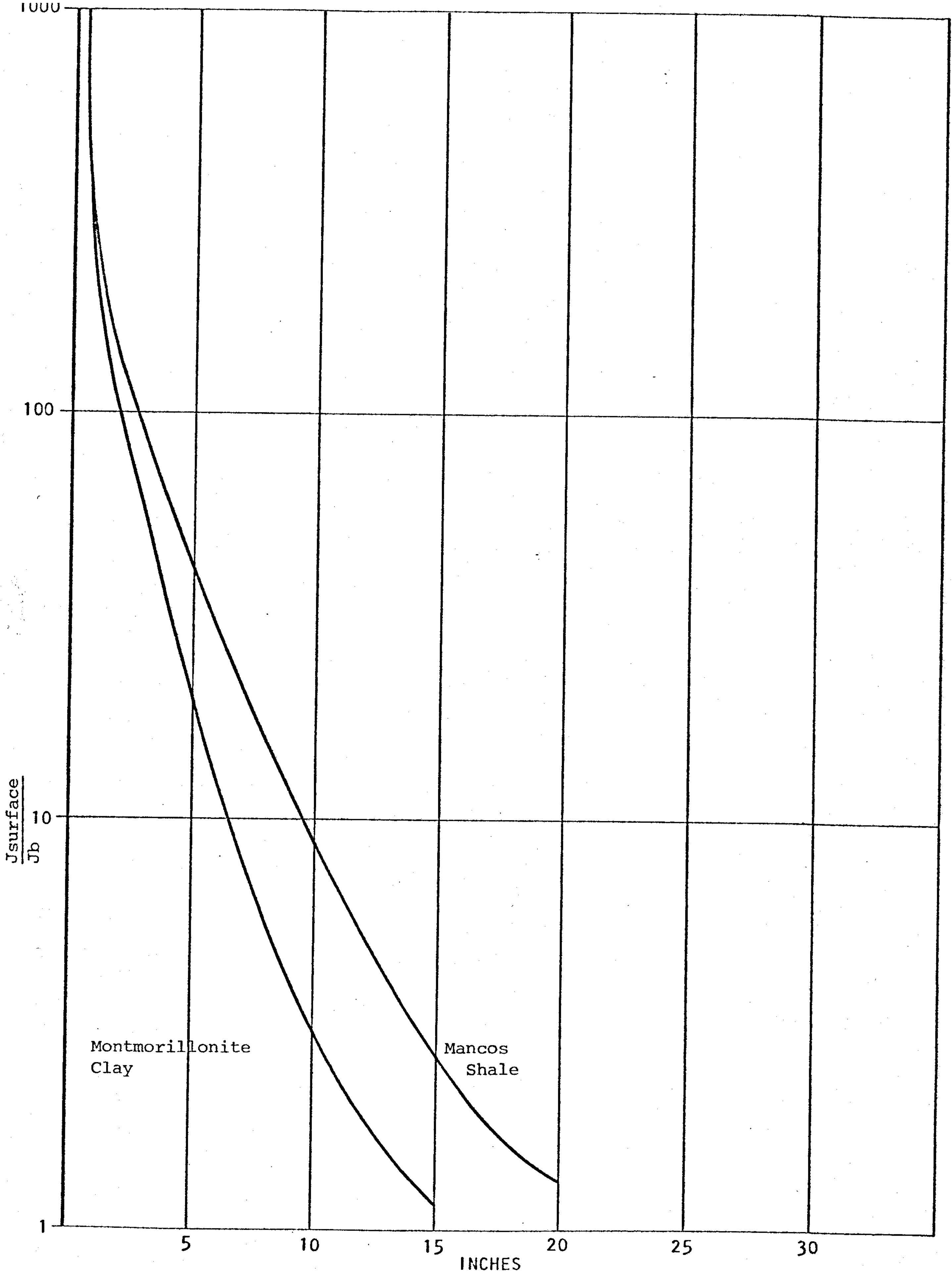

Figure 4 Ratio of Surface Flux to Background Flux versus Thickness of Cover For Various Materials

4.3.3 Gamma Radiation Attenuation

Theoretically, each foot of packed earth cover will reduce the gamma exposure rate by approximately an order of magnitude as shown in Figure 5.* Thus the proposed radon flux reduction cover and the 2 feet of soil for revegetation cover and erosion control will reduce gamma radiation to essentially background, i.e., only those natural sources in the soil will contribute.

5.0 SUMMARY AND CONCLUSIONS

On the basis of the analyses and evaluations herein the following recommendations and conclusions are presented.

1. The location and configuration of the current tailings pile represents a potential hazard to the San Miguel River from erosion. This hazard will be eliminated upon relocation of the pile.

2. Calculations predict 1.5 feet of Mancos Shale will reduce radon emanation from the reclaimed pile to less than twice background. Thus, the proposed two feet of this material is more than sufficient to fulfill this design criteria.

3. The proposed cover is sufficient to redduce the gamma ray exposure from the reclaimed pile to essentially background levels.

4. The addition of topsoil will promote the establishment of vegetation and increase stabilization to allow for minimum monitoring and minimum long-term maintenance.

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* Gamma Ray attenuation is heavily dependent on atomic electron interactions e.g., Compton collisions, photoelectric absorption, so that the absolute type of material, clay, etc., is irrelevant to this discussion.

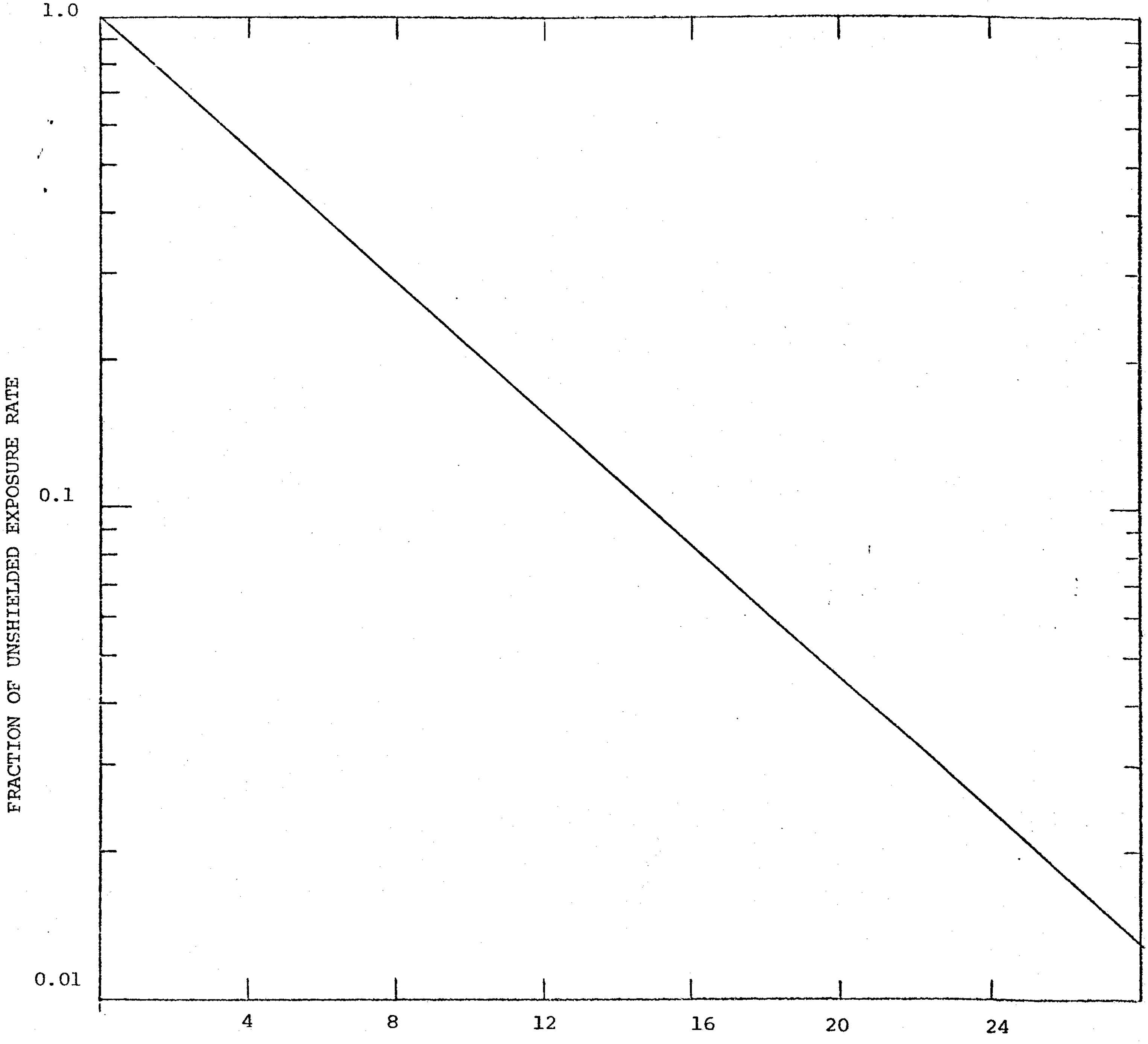

FIGURE 5

DEPTH OF OVERBURDEN (PACKED EARTH) INCHES
REDUCTION OF GAMMA EXPOSURE RATE RESULTING FROM EARTH COVER SHIELDING [(a)]

(a) From Ref.[6] originally from: C. R. Thruckmorton, "Environmental Gamma Ray Flux Analysis", disertation, Colorado State University, Fort Collins, Colorado, (1973).

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FINAL RECLAMATION PLAN

DURITA SITE

COLORADO RADIOACTIVE MATERIALS LICENSE NO. 317-02

VOLUME 1

TEXT, TABLES, AND FIGURES

OCTOBER, 1991

PREPARED BY AK GEOCONSULT, INC.

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RADIANT ENERGY MANAGEMENT

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1.0 INTRODUCTION

1.1 General

This document is the Final Plan for reclamation of the Durita Mill site owned by Hecla Mining Company. The submittal of this plan represents the completion of Phase II of the process of reclaiming the Durita site. Phase I, the Conceptual Reclamation Plan, was submitted to the Colorado Department of Health (CDH) in December, 1990. Phases III and IV are the implementation of the decontamination and demolition of the mill facilities and the reclamation of the site, respectively. Phase V is long-term care and surveillance. These phases are described in detail later in this document.

This plan has been prepared in accordance with Part XVIII, Appendix A of the Rules and Regulations Pertaining to Radiation Control of the State of Colorado. The plan also addresses specific concerns and objectives of the CDH made known through correspondence and meetings with Hecla Mining Company. The designs and procedures for reclamation are described at a level of detail appropriate for CDH review and approval. This submittal does not contain the construction specifications, drawings or construction management details that will be prepared during Phases III and IV after CDH approval of this Phase II reclamation plan.

The reclamation plan consists of two volumes. Volume I contains the description of the plan in a narrative text, tables and figures. It is organized into eight major sections. Volume II contains procedures, specifications for plan implementation, calculations and data used in the development of the plan and detailed support for the estimate of costs. Section 1.0 of Volume I, Introduction, contains this subsection as well as descriptions of the site, the geologic setting, and the history of operations. Section 2.0 describes facility decommissioning. It includes discussions about the disposition of buildings and equipment; descriptions of health and safety procedures; facility decontamination, demolition and disposal of nonsalvageable material; and contaminated soil cleanup. Section 3.0 describes the radiological surveys of the site, including both the pre-reclamation surveys already completed as well as the post-reclamation surveys to be performed in the future. Section 4.0, Byproduct Containment and Stabilization, describes the designs, materials, and construction activities to be used for the long-term stabilization of the leach tanks and the evaporation ponds. Section 5.0, Long-Term Protection, describes the measures to be implemented for control of both normal and extreme surface water runoff, erosion protection of the byproduct containment structures, and regrading and revegetation of the site. Section 6.0 describes the investigations of existing ground water conditions at the site, the assessment of impacts of Durita operations on ground water, and measures to be taken to protect ground water in the future. Section 7.0, Reclamation Plan Implementation, describes the five phases of reclamation, the schedule for the various reclamation phases, and the proposed policy for bond reduction and release. Section 8.0 provides a detailed cost estimate for the reclamation activities of Phases III and IV.

1.2 Site Description

The Durita site was constructed and operated as a secondary-extraction heap leach facility that recovered uranium and vanadium from mill tailings originally processed through the Naturita Mill. The Durita Site occupies 160 acres in the S 1/2, NE 1/4 and the N 1/2, SE 1/4 of Section 34, T 46 N, R 16 W. The site is in Montrose County, Colorado, about three miles southwest of the town of Naturita (see Figure 1). The site contains an ore preparation facility, a plant for leachate recovery, three leach tanks, and six evaporation ponds. Some components of the ore preparation and plant facilities have already been decontaminated and salvaged. The remaining equipment and buildings are described in Section 2.1. After cessation of operations in 1979, the site underwent preliminary decontamination prior to a planned relocation of the facility.

Figure 2 shows the location and layout of the site facilities. Site buildings and equipment are described in Chapter 2.0. The leach tanks contain tailings within earthen dikes, underlain by a clay liner and covered by 2-2.5 feet of compacted sandy clay soil. The evaporation ponds are at-grade to subgrade structures separated by earthen dikes and underlain by a natural clay liner. The evaporation ponds are presently uncovered.

1.3 Geologic Setting

The site is situated on gently north-sloping terrain at the southeast end of the Paradox Valley. The site is directly underlain by the Mancos Formation. Most of the site is blanketed with alluvial/colluvial sandy clay soil up to 20 feet thick and containing variable amounts of rock fragments, primarily sandstone of cobble-to-boulder size. Near the east-central part of the site, an uneroded remnant or outlier of the Mancos Formation forms a hill up to 100 feet high above the surrounding terrain. The Mancos is partially eroded in the site area, leaving its present thickness from about 20 feet at the southwest corner to more than 70 feet under the north edge of the site (excluding the hill). The Mancos overlies the Dakota Formation. The contact between these two formations is distinct in outcrops north and south of the site but less so under the site where it appears to be gradational in most places. Both formations are tilted toward the axis of a doubly-plunging syncline that trends west-northwest to east-southeast across the north one-third of the site (Figure D1, Appendix D). The dips are 1 to 5 degrees on the south flank of the syncline underlying the site. In general this structural tilting is steeper than the slope of the surface terrain, causing the Mancos/Dakota contact to outcrop approximately along the line shown on Figure D1. Geologic field reconnaissance and monitor well drilling, recorded in detail in Appendix D, revealed no discernible faulting or other abrupt structural changes in the Mancos or Dakota Formations under the site. Some minor faulting northwest of the site, reported previously (Fox, 1982), was confirmed by our field reconnaissance but does not appear to affect the Durita site.

The Mancos Formation under the site is a calcareous to carbonaceous gray shale with thin lenses or beds of ferruginous sandstone. The Dakota also contains some carbonaceous shale and coal but is mostly friable to moderately cemented, tan to gray sandstone at shallow depths below the site. A well-cemented durable sandstone bed marks the uppermost Dakota in stream beds northwest and south of the site. At least one sandstone bed within the basal Mancos is water-bearing under the site. Section 6.0 discusses the hydrogeology of the site in more detail.

No perennial streams exist on the site. Dry Creek, which passes near the northwest corner of site (Figures 2 and D1), has seasonal flows. Several intermittent drainages originate in, or cross through, the site. The hydrology of these drainages is discussed in detail in Section 5.1.1. Gully formation and active headcutting of some drainages in the vicinity of the site indicate that degradation is the predominant geomorphic process.

The Durita site is located in seismic zone 1 and is therefore considered to be aseismic.

1.4 History of Operations

The Durita facility was built in 1977 by Ranchers Exploration and Development Corporation, which also operated the facility from the fourth quarter of 1977 to May 22, 1979, when operations ceased. All of the feedstock "ore" for the mill came from the Naturita mill tailings, estimated at about 700,000 tons (FBD, 1977). These tailings were trucked to the Durita site and dumped through a grizzly into a crusher. From the crusher the tailings were conveyed to a stockpile, then carried by loader to a hopper which fed a conveyor leading to the agglomerator. In the agglomerator the tailings were mixed with sulfuric acid and blended. The tailings were then conveyed to the ore bin which loaded the trucks that hauled the tailings to the traveling conveyor at the leach tanks. This conveyor distributed the tailings in windrows within each leach tank until it was filled up. After each leach tank was filled, the tailing surface was flooded with dilute sulfuric acid solution. Percolating acidic solution leached the uranium and vanadium from the tailings. The pregnant solution was collected by slotted pipes in the bottom of each leach tank, then transferred by gravity flow through a network of subsurface pipes to the extraction plant. Uranium and vanadium were recovered by ion exchange and solvent extraction. The waste liquid was stored in six evaporation ponds located in the northeast quarter of the site.

After operations ceased, a 2-2.5 foot thick soil cover was placed over the leach tanks. The evaporation ponds were left uncovered due to the amount of standing liquid in the ponds and high moisture content in the salts precipitated in these ponds.

Operations since 1979 have consisted of custodial care, ground water monitoring, and some decontamination and salvage. Some plant components have been salvaged and removed off site. A formal radiological health and safety plan has been implemented during the past year.

2.0 FACILITY DECOMMISSIONING

2.1 General

Decommissioning of the Durita site will involve those activities and procedures that are required to safely remove the mill facilities and contaminated materials from the surface of the site. In the context of the Durita site, this also includes reduction of the evaporation pond space and consolidation of the salts in the remaining pond space. Both radiological and non-radiological hazards are associated with decommissioning for which procedures will be implemented to protect worker health and safety. The following sections describe these procedures in general (details are contained in Appendix A) and the decontamination and demolition activities to which they apply.

2.2 Health and Safety Radiation Procedures

Decommissioning of the Hecla tailings facility will be conducted in accordance with CDH License Condition #19.4 and with the programs listed in the *Health and Safety Radiation Program, Durita Project* (Umetco, 1990) pertaining to ALARA, quality assurance, bioassay, respirator protection, emission control and monitoring programs. The standard procedures already established for these programs are referenced in Appendix A of this plan. The primary internal radiological hazard associated with decommissioning and decontamination is resuspension of surface contamination resulting in concentrations of airborne radioactive material. The primary external radiological hazard is gamma and beta radiation exposure. Beta radiation exposure will be predominantly associated with areas and equipment where aged uranium may still exist.

The *Health and Safety Radiation Program* procedures require that each area in the mill building be inspected to evaluate potential hazards, especially radiological hazards, prior to sequential dismantling. In all cases the equipment and general work area will be de-energized (electricity shut off) and washed down with water, as necessary and appropriate, prior to work performance. This has been shown to be an effective method of reducing the resuspension of radioactive material.

The health and safety procedure contains the following sections:

- ◊ Management control
- ◊ Radiation safety training
- ◊ Radiation work permits
- ◊ Radiation protection and monitoring
- ◊ Non-radiological protection
- ◊ Security
- ◊ Hazard control

2.2.1 Management Control

Corporate management is responsible for all activities associated with the decommissioning of the Durita site. The Radiation Safety Officer (RSO) is responsible for the radiation protection programs and training including:

1) Compliance with established radiation protection measures;
2) Inspections to verify compliance with applicable requirements;
3) Collection and interpretation of monitoring data;
4) Training;
5) Suspension, postponement, or modification of any work activity that is or could be potentially hazardous to workers.

At least once a year an audit of all radiation activities associated with the decommissioning plan will be conducted. Results of the audit, with recommendations, will be provided to corporate management. The audit will also determine if workers' exposures are kept As Low As Reasonably Achievable (ALARA).
The Durita site has an active ALARA review program consisting of worker training in radiological hazards, independent inspections by management and RSO as well as individual and on-site monitoring programs. This ALARA program will continue during the facility decommissioning phase (Phase III) of reclamation. The RSO will provide corporate management with monthly reports on conditions and corrective actions to reduce worker exposures.

2.2.2 Radiation Safety Training

Radiation safety training will be conducted for all employees, including contractor employees, who are participating in the decommissioning, decontamination and site reclamation. The radiation training will comply with applicable CDH regulations as well as the NRC Regulatory Guide 8.31 "Information Relevant to Ensuring that Occupational Radiation Exposure at Uranium Mills Will Be As Low As Reasonably Achievable". Female workers of child-bearing age will be provided a copy of NRC Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure".

The radiation safety training program will include the following topics:

1) Fundamental radiation physics - primarily terms and definitions related to radiation;
2) What radiation is and what are its sources;
3) Types of radiation exposure;
4) Health effects;
5) ALARA definition and measures to maintain exposures ALARA;
6) Radiation protection regulations;
7) Site-specific radiation types;

8) Site-specific radiation hazards;
9) Fundamentals of good housekeeping and health protection;
10) Personal hygiene;
11) Facility-provided protection;
12) Health protection measurements and instrumentation.

A written test with questions directly relevant to the principles of radiation safety will be administered after the training course for individuals who could be exposed to air concentrations exceeding 25% Maximum Permissible Concentrations (MPC). The results will be reviewed, with incorrect answers discussed with the workers to assure workers' understanding of safety protection. During decommissioning, "safety huddles" will be held weekly to review radiological safety practices as well as hazard and task training.

All visitors will be instructed in industrial and radiological safety requirements relating to their specific function. All visitors admitted within the restricted area will be escorted by knowledgeable Hecla personnel or representatives.

2.2.3 Radiation Work Permits

An initial inspection of the areas to be decommissioned and decontaminated will be performed by the RSO or his delegate. The inspection results will be used to identify sources of radiation exposure, hazard, and protective equipment necessary to keep exposures ALARA. Mill facility dismantling activities for which a written procedure does not exist or in which an individual could be exposed to 25% or more of MPC will be conducted using radiation work permits (RWP's). The RWP will describe the following:

- ◊ Area(s) where the dismantling activities will be performed;
- ◊ Scope of work to be performed;
- ◊ Any potential residual radioactive materials and the precautions necessary to reduce exposure to radioactive material and other hazards;
- ◊ Protective clothing and equipment needed to perform the job;
- ◊ Supplemental radiological monitoring and sampling necessary prior to and following completion of the work;
- ◊ Maintenance of RWP file.

Upon completion of each dismantling activity under a specific RWP, the RSO or his designate will complete and sign the RWP together with the signature of the employee conducting the work. An exit interview will also be conducted. Hecla's operating procedures for RWPs are contained in the *Health and Safety Radiation Program, Durita Project* a copy of which has been provided to CDH.

2.2.4 Radiation Protection and Monitoring

To ensure that worker exposures are ALARA, Hecla will perform the following protection measures during mill decommissioning, decontamination, and reclamation. Details of the radiation protection monitoring procedures are contained in the *Health and Safety Radiation Program* and in Appendix A.

Internal Radiation Protection

The RSO will determine the need for individual personnel lapel sampling as well as area sampling for airborne radioactive material. If area sampling is required, calibrated high-volume samplers will be placed in the work area. The sample locations and frequency will be determined by the physical layout of the plant and the location of key equipment in the process areas in relation to the work being performed. The air samplers will be calibrated according to the manufacturer's specifications. In areas where high-volume samplers are not practical, workers will wear lapel samplers. The RSO will determine the internal exposure protection and monitoring required for the dismantling of tanks. As required, a specific RWP will be issued for tank entry.

Air sample filters from the high-volume samplers and personal lapel samplers will be analyzed for Gross Alpha based on uranium in accordance with Health and Safety Procedure B-2.7. Filters from the personnel lapel samplers will be analyzed after each shift. Results of both types of airborne samples will be used to calculate employee exposure.

Radon daughter samples will be taken on a monthly basis at key locations in the plant until dismantling activities in the area are completed. If the initial concentration at any sampling location exceeds 0.08 WL, weekly samples will be collected in conjunction with an investigation by the RSO to implement means to reduce radon daughter concentrations.

External Radiation Exposure

External radiation exposure, resulting from gamma and beta radiation, will be monitored for all employees by use of thermoluminescent dosimeter (TLD) badges. The badges will be worn during the working hours and stored in designated badge storage areas. Badges will be exchanged quarterly and returned to the supplier for processing. The supplier will provide immediate notification if a worker has been overexposed. If overexposure should occur, assignment of the individual will be changed, and a review by the RSO will be conducted.

Bioassay Program

Urine samples will be collected and analyzed in accordance with the *Health and Safety Radiation Program* Procedure B-2.4. Specimen containers will be handed to the individual before he leaves the facility. The container, filled with specimen, will be returned to appropriate management personnel upon return to work.

When respirators have been used where soluble uranium may be present, urine samples will be taken within 48 to 96 hours following respirator usage. For dismantling activities in areas of possible contamination, urine samples will be collected monthly, except for work conducted in areas previously identified by the RSO as requiring weekly bioassay.

Urine samples will be collected and sent to an outside laboratory. Blanks and splits will be submitted when possible with the samples. The laboratory will be requested to provide spiking to a certain percentage of the samples for quality assurance. The laboratory will report any analysis in excess of 15 micrograms/liter uranium within 48 hours of analysis.

Whole body counting (in-vivo) will be conducted on any individual suspected of exceeding the quarterly Maximum Permissible Exposure (MPE) for insoluble airborne uranium. The need for whole-body counting will be determined by the RSO.

Contamination Survey Program

Surface contamination surveys will be conducted on a monthly basis for areas designated for eating and changing. These surveys will be conducted by an alpha survey meter to determine the levels of total alpha contamination. Any alpha level exceeding 250 dpm/cm^2 will be cause for investigation by the RSO and subsequent decontamination of the area.

Workers involved with dismantling activities will be required to monitor themselves prior to leaving the restricted area. Written procedures for proper use of the personnel contamination monitoring equipment will be posted by the equipment and workers will be trained in equipment use. Results of exit monitor surveys will be documented. In the event that a worker's monitoring indicates 1000 dpm/100cm^2 removable α, the workers will shower and perform a follow-up survey.

The alpha survey meter will be calibrated according to the manufacturer's specifications and at any time that verification checks indicate deviation of the readings by more than 20% from the reference reading. The RSO will conduct a spot check of employee survey techniques and survey documentation at least quarterly.

Respirators and protective clothing will be made available to all workers. Protective clothing and respirators will be worn by workers when deemed appropriate by the RSO. The use of respirators will be in accordance with the *Health and Safety Radiation Program* Procedure B-2.5, Respirator Program.

Site Monitoring

Hecla will continue to monitor at the site in accordance with the CDH license conditions. This monitoring will continue throughout decommissioning and reclamation.

2.2.5 Non-Radiological Protection

Sampling and remedial activities associated with the evaporation ponds at the Durita facility will be conducted in strict compliance with the Mine Safety and Health Administration (MSHA) regulations, specifically Title 30 Code of Federal Regulations.

Hazard Evaluation

The primary non-radiological hazards which will be encountered during site reclamation are low pH materials and metals in the evaporation ponds. Pond materials have been analyzed and found to have a pH of approximately 2. In addition, lead and arsenic were identified in the pond materials.

Physical hazards will also exist during site activities. These include temperature extremes, noise, inclement weather, and the hazards associated with heavy equipment. Pond surfaces may also be hazardous due to disturbance from heavy equipment, wet conditions, and weather.

The overall hazard for the sampling activities is estimated to be low. However, due to the invasive and disturbing nature of the remedial activities, the overall hazard evaluation, including radiological hazards, for any remedial activities is moderate.

Responsibilities

Ultimate responsibility for non-radiological protection lies with Hecla's designated site manager or his representative. The site manager will have on-site responsibility for the health and safety of the site project and contract personnel. However, the entire project staff will have responsibility for conducting the project in a safe and healthful manner.

Training and Medical Surveillance

All site personnel and visitors who enter the evaporation pond areas of the Durita site will be required to have completed health and safety training in compliance with MSHA Part 48. Individuals who have not completed the required courses will not be permitted to work on the site.

In addition, the site manager or his designate will provide an initial site-specific training session to discuss the details of the site and the associated activities. The site manager or contracted project manager will also conduct daily start-of-work safety briefings to review the procedures specific to that day's work and to relay new information to site personnel.

All personnel who must wear respiratory protective devices will have received medical clearance from a qualified physician within the past year to wear respiratory protective devices. As appropriate, each project personnel will have on file a written clearance containing any restrictions which may affect his/her health.

A special medical examination will be conducted on personnel who are exposed or potentially exposed to elevated levels of contaminant.

Site and Hazard Control

Only authorized personnel will be permitted in the evaporation pond area. This restricted area will be defined before work starts there. Persons entering this area will be required to wear the appropriate level of protection. Upon leaving the evaporation pond area, personnel and equipment will enter the contamination reduction zone (CRZ). All decontamination activities will take place in the CRZ. The CRZ will be located in the area just to the southwest of the ponds. Located in the CRZ will be a shower facility and change area for the site workers involved in remedial activities. Sampling activities will not require a change of clothing or shower. Disposable clothing will be worn in most cases during remedial and sampling activities. This clothing will be disposed of prior to leaving the CRZ. All personnel will be required to, at a minimum, wash their face and hands prior to eating, drinking, smoking, or using rest room facilities. Some personnel may be required to shower before leaving the facility.

Heavy equipment will be steam-cleaned or high-pressure washed at a decontamination facility constructed in the CRZ. The pad will be designed to capture the wash water. As necessary, heavy equipment and vehicles will be cleaned prior to leaving the CRZ.

Lunch and office facilities will be established in the vicinity of the caretaker's office. Materials from the CRZ will not be permitted to enter this area unless they have been appropriately decontaminated or are adequately covered and sealed.

Due to the potentially dusty environment which may be created by remediation activities, airborne dust containing low pH materials, metals, and radiological hazards will require control. To control the emission of the particulate matter, the pond salt and clay liner materials will be kept slightly moist during excavation, relocation, or compaction. In addition, the spread of contamination through other modes of transport will be controlled and minimized through strict adherence to the decontamination procedures.

Levels of Personal Protection

Individuals conducting activities within the evaporation pond area at the Durita facility will be required to wear Level C or D protection as appropriate. This level has been based on non-radiological hazard evaluation and the presence of radiological hazards at the site.

Employee Exposure and Environmental Monitoring

Air monitoring will be conducted during remedial activities as designated by the RSO. Monitoring results will be utilized to determine if dust abatement measures are necessary.

Emergency Equipment and Contingency Procedures

First aid kits and fire extinguishers will be available at various locations of the site, as referenced in Appendix A. The site manager will be responsible for this equipment. In the event of a fire, the Naturita Fire Department will be called through the central dispatcher in Nucla.

The site manager will be the initial responder for site emergencies and will coordinate any other required response. Off-site emergency response personnel will be contacted through the central dispatcher in Nucla, Colorado at 864-7333. The dispatcher will call the appropriate agency and responder. Medical facilities are available in Naturita, Colorado through the Basin Clinic. The clinic is a 24-hour emergency clinic staffed by physicians two to three days a week. Physician assistants are on duty 24 hours a day, with doctors on call when not on duty. On-call physicians can be contacted through the central dispatcher. Medical assistance for serious injuries is provided through a "Flight for Life" from St. Mary's Hospital in Grand Junction.

2.2.6 Security

Hecla maintains strict control of access to the restricted area through fencing and posting. Access restrictions will be maintained until all surface reclamation is completed (end of Phase IV). Visitors will be required to register upon entering the site and will not be permitted into restricted areas without proper Hecla authorization or escort.

2.2.7 Hazard Control

At least daily inspections in areas of activity will be performed to identify potential hazards, including radiological safety hazards. Emergency responses to accidents involving radiological hazards will be the same as those described under section 2.2.5.

2.3 Decontamination

Before the mill can be demolished, some equipment and structures will be decontaminated sufficiently to eliminate potentially harmful levels of both radiological and non-radiological contaminants. All potentially hazardous non-radiological materials such as solvents, lubricants, and laboratory reagents will be used up on site or removed from the site and sent to licensed disposal facilities.

Radioactive materials were processed in the plant building, leaving some residual radioactive material on various equipment and structures. Decontamination will begin by de-energizing the buildings and washing down the equipment and structures. Follow-up radiological surveys will be performed to measure radiation levels in the various areas. Surfaces that show elevated levels of contamination after the initial cleaning will be rewashed prior to dismantling. With this clean-up effort in the process area, potential exposure from uranium decay products will be minimized. Radiation work procedures outlined in the *Health and Safety Radiation Program* will be utilized.

The mill process facilities and other miscellaneous structures that will be disposed of on-site will be buried in the leach tank outslopes, primarily in the north outslope of Leach Tank (LT) 201 and 203.

2.4 Facilities Demolition and Disposal

Some equipment and facilities in the plant and ore process areas have already been demolished or salvaged. The majority of the on-site material has had some initial clean-up work performed, and this clean-up work will continue through Phase III. Some tanks have been removed from their support structures and partially or completely decontaminated. The remaining demolition of the plant and shop buildings will occur during Phase III in 1992. The plant area and ore preparation areas will be dismantled by a demolition contractor under supervision of the RSO or his designate in accordance with demolition specifications (B1, Appendix B). In all cases electricity will be shut off, as necessary, and all surfaces cleaned prior to direct handling.

Buildings will be dismantled from the outside in, with the sides and roof removed first. This provides increased ventilation and reduces the potential of exposure to personnel. After the sides and roofs have been removed, the remaining material in the buildings will be removed for salvage or on-site burial. Any machinery or tanks with uncrushable components with significant void space will be filled with a sand-cement slurry grout before burial. The estimate of volumes and weights of demolition debris is included in Appendix E. A list of the major structures that will be dismantled during Phase III of the reclamation process is contained in Tables 1a and 1b, and their locations are shown in Figures 3 and 4.

2.4.1 Salvage

Hecla plans to salvage as much of the major process plant and ore preparation area equipment and material as possible. This equipment and material will be decontaminated in accordance with CDH License Condition 25.2. The salvaged items will be used by Hecla at another facility or sold.

A clean area will be established on site (Figure 5) to store the salvage material until removal from the site. This area was surveyed during the July 1991 radiological survey and was found to meet the CDH Criterion 6 requirements for soil Ra-226 content. The current list of equipment and material designated for salvage is indicated on Figures 3 and 4 and Tables 1a and 1b.

2.4.2 On-Site Disposal

The non-salvaged equipment and structures that will require on-site disposal include the concrete foundations, pads, support structures, tanks, or any material that cannot meet CDH License Condition 25.2 criteria. This material will be buried on-site in place or at the toe of Leach Tank 201 or 203, as discussed in Section 2.5.

2.5 Nonsalvageable Material Burial

Foundation slabs, equipment pads, and other structures at or below grade will be left in place for subsequent burial with clean soil. Concrete pads adjacent to the plant building will be buried in place along with the concrete pads and support structures within the ore storage area. Concrete support structures above grade within the plant area will be removed and placed in 1) the two fiber glass/metal tanks (No. 5, Figure 3), 2) the raffinate ponds (No. 25, Figure 3), or 3) at the toe of LT 201.

Tanks and other material with void spaces will be crushed or cut and placed in the toe of LT 201 or 203 for final burial. Those tanks that cannot be cut or crushed economically will be filled with a sand/concrete slurry and placed in the toe of the leach tanks. Miscellaneous material such as crushed pipes, motors, pumps, valves, etc. will be placed in the closest leach tank for burial. No nonsalvageable material will be placed in the reclaimed evaporation ponds.

Nonsalvageable material will be buried during the earthwork phase (Phase IV) of the reclamation process. Cover soil will be obtained from on-site borrow areas, primarily the PMF flood plains described in Section 5.0. Pond areas will be filled and foundation/pad areas covered with adequate soil to provide a plant growth medium (one to two feet). Material at the leach tank toes will be covered during reconfiguration of the outslopes from 2:1 to 5:1 slopes. The covered mill areas will be graded to provide positive sheet flow drainage, smooth contours, and minimum surface gradient. Final grades in the plant and ore preparation area will be as close as possible to the original grades in those areas, with surfaces sloping toward the surface water controls structures. Technical specification B3 for this work is included in Appendix B.

2.6 Contaminated Soil Clean-up

During the period of operation of the Durita mill, some tailings inadvertently spilled from haul trucks and from the several components of the ore preparation area. In addition, some radiological contamination occurred around the plant area. The pre-reclamation survey, described in the following section, has identified the areas where site soils have been contaminated to levels that exceed CDH limits. These areas are delineated on Figure 5. The contaminated soils in these areas will be excavated and disposed of within the outslopes of LT 201 and LT 203, where they will be covered with sufficient clean cover soil to limit subsequent radon emanations to allowable limits. The thickness of that cover will be determined when the actual thickness of contaminated soil deposited in the outslope is measured (end of Phase III). The clean-up excavation will be guided by field gamma metering and confirmed in accordance with post-reclamation survey procedures discussed below.

3.0 Radiological Surveys

Radiological surveys were performed in July, 1991 (pre-reclamation survey) and will be performed again after cleanup of radium-contaminated soil. The results of the pre-reclamation survey, using a 16-directional radial grid with 100-foot spacing along the radials, were used to delineate areas of excess radium content in soils, shown on Figure 5, contaminated by milling operations and windblown tailings. Additional gamma surveys will be conducted on a 10-meter grid covering the mill area after mill demolition. The post-reclamation survey will be used to verify the adequacy of soil clean-up and will include gamma measurements in conjunction with soil sample collection and analyses for Radium-226 and Uranium natural concentration.

3.1 Pre-Reclamation Survey

3.1.1 Procedure

Background Gamma and Radium Survey

Gamma readings were taken using a microR meter at five separate 100m^2 background sites, three to the south and two to the west of the Durita site. Ten gamma readings and ten soil samples were taken from each 100m^2 area. The soil samples from each 100m^2 area were composited into one sample for each background site. The average background gamma reading was 9.72 ± 0.83 μR/hr. The average Radium-226 concentration was 0.98 ± 0.24 pCi/g with an average Thorium-230 and Uranium-238 concentration of 0.76 ± 0.61 and 0.46 ± 0.16 pCi/g respectively. At the request of the CDH arsenic, lead, vanadium, cadmium, molybdenum, and selenium were also analyzed in the background soil samples. The average background concentrations of the above parameters are listed below:

Arsenic	9.82 ± 2.9 ppm
Lead	45.20 ± 13.2 ppm
Vanadium	0.03 ± 0.005 %
Cadmium	<5.0 ppm
Molybdenum	0.003 ± 0.0015 %
Selenium	0.52 ± 0.19 ppm

high lead

Site Gamma Survey

The pre-reclamation gamma survey was conducted using microR meters calibrated against a Pressurized Ionization Chamber and a Radium-226 source. The details of this procedure are described in Appendix A. For windblown material, gamma readings were made at 100 foot (30m) intervals along radials extending in 16 directions from the dryer/crushing area of the site. Gamma measurements plotted on Figure 5 were taken along each radial out to the point where there had been three consecutive measurements of 13 μR/hr or less. Transects across the radials were also surveyed to account for the spread in the radials with distance from the center point. Figure 5 shows the gamma readings at each survey point. The haul roads on site, as well as the access road to the site from the main road (Route 90), were also surveyed with gamma readings taken every 0.1 mile. From the cattle guard at the entrance of the site to Route 90, the gamma readings (listed on Table 2A) range from 34 μR/hr at 0.3 mile from the cattle guard to 15 μR/hr at the intersection of Route 90. On site, the gamma readings along the roads ranged from 21 to 95 μR/hr.

Soil Survey and Testing

Soil samples were collected in accordance with procedures described in Appendix A from 47 locations representative of the range of gamma readings measured on the site. Soil samples corresponding to the highest gamma readings were also analyzed for Thorium-230 as per CDH Draft document entitled "Policy on Soil Contamination Cleanup Pursuant to 40 CFR 192 Cleanup Requirements Within the State of Colorado". The Radium-226, Uranium-238 and Thorium-230 concentrations in these samples are listed in Table 2B. In addition, of the samples collected, 34% of them were split and sent to two different laboratories for Radium-226 and uranium analyses. These data are given in Table 2C. Of the 18 samples split for analysis between two laboratories, only 11% of the Radium-226 concentrations reported by the two laboratories exceeded the primary laboratory's analysis by two standard deviations.

3.1.2 Gamma/Radium Correlation

Elevated exposure readings, indicating Radium-226 concentrations in the surface soil in excess of 6 pCi/g (5 pCi/g above background), are indicated by an uncorrected gamma measurement of greater than 35 μR/hr and a delta reading of 25 μR/hr. The procedure used for the correlation of gamma/Radium-226 and presented in a paper entitled "Determination of Radium-226 Surface Soil Contamination" was developed by Radiant Energy Management. This procedure, previously submitted to the Colorado Department of Health on March 6, 1991, uses a statistical linear correlation between gamma readings and Ra-226 soil concentrations in the top six inches of soil. Delta measurements were made with and without a lead shield placed between the detector and the earth. This procedure, outlined in the previously submitted standard operating procedure entitled "Field Gamma Survey" developed by Radiant Energy Management, was employed in the survey of July, 1991. The correlations between gamma readings and Ra-226 soil concentrations ranged from 0.96 for the delta readings to 0.97 for the uncorrected readings. Table 2D gives the gamma readings and Radium-226 values used to determine the above limits. The table indicates that the uncorrected gamma reading corresponding to 6.0 pCi/g Ra-226 or greater is 35 μR/hr, the same value predicted above by the linear correlation. The area of contaminated soil that requires clean-up was determined by these correlations and is delineated on Figure 5.

3.2 Post Clean-up Survey

This survey will be performed for verification of clean-up after removal of all equipment and building material and contaminated soil material . The survey will cover the same area identified as contaminated in the pre-reclamation survey. The survey, using the procedures described in Appendix A, will include gamma readings using a microR meter at all pre-reclamation survey radial points within the cleanup area as well as a 10 m grid covering the cleanup area. Surface soil samples for Ra-226 testing will be collected at the pre-reclamation grid points. Ten soil samples will be collected from 10% of the 10 m X 10 m areas within the grid, composited and analyzed for Radium-226. Approximately 20% of the above composites will be split and analyzed by two different laboratories. Any soil still having excess radium levels, indicated by either gamma readings or soil analysis, will be removed for disposal.

4.0 BYPRODUCT CONTAINMENT AND STABILIZATION

4.1 General

The objective of the by-product containment and stabilization elements of the reclamation plan is to satisfy the relevant CDH Part XVIII, Appendix A criteria #2, 4C, 4D, 5, 6 and 7A. The goal of avoiding proliferation of disposal units in Criterion #2 will be implemented in this plan by the total removal of the raffinate ponds in the plant area and by elimination of two evaporation ponds and the reduction in area of the remaining four ponds. To satisfy the limitation of radon releases under Criterion #6, additional cover will be placed over the leach tanks and a soil cover will be placed on the evaporation ponds to limit the release of radon to 20 pCi/m^2s. In addition, all soils contaminated by tailings to levels greater than 6 pCi/g (Figure 5) will be excavated and placed in the leach tank outslopes for subsequent cover by a radon barrier. In order to control radiological hazards for 1000 years, as called for under Criterion #6, the reclamation plan will utilize natural earth materials for all containment and protection and use the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) in the design of surface water diversions and erosion protection structures. To meet the protection objectives under Criterion #4C, the final slopes of the leach tanks and the evaporation ponds will be flattened to not steeper than 5H:1V. The reclamation plan will also utilize a vegetative cover on the tops of the reclaimed leach tanks and rock cover on the outslopes, as described in Criterion #4D, to provide stability against erosional processes. In addition, the plan establishes diversion channels with slopes approximately the same as the original channel gradients, i.e. the gradients of channels prior to 1977. The plan also provides for riprap and scour protection along those portions of the surface water diversion structures which are adjacent to containment structures. The requirements of Criteria 5 and 7A which address the limitation of listed hazardous constituents in the uppermost aquifer at the point of compliance have been satisfied by the construction and monitoring of new monitor wells and testing of ground water samples for CDH's entire list of chemical constituents, as discussed in Section 6.0. The following subsections address the reclamation measures that implement the requirements of these criteria.

4.2 Leach Tanks

Presently, the leach tanks are rectangular enclosures formed by earth dikes with 20 foot-wide crests and 2H:1V outslopes. Tailings fill the space inside the dikes except for the western one-third of leach tank (LT) #203 (see Figure 2). Field and laboratory investigations were performed in April-May, 1991 on the leach tanks and site soils to provide the data necessary to design long-term containment and stabilization for these leach tanks. These investigations and the results are described in detail in Appendix D. The investigations showed that the tailings are relatively uniform sands with some silt and clay having average in-place densities of about 99 pcf directly under the soil cover (Table 3). However, laboratory tests for long-term moisture performed on "undisturbed" tube samples of the tailings indicate that existing densities at greater depths are lower, about 79-80 pcf. The tailings are moist but not saturated, with the possible exception of the bottom few feet in some locations. The existing cover soil is sandy clay to clayey sand with an average dry density of about 99-103 pcf and 28% average clay fraction.

Calculations documented in Appendix C indicate that the existing 2-2.5 feet of soil cover does no radon emanation to the required 20 pCi/m^2s. Additional cover will be placed to meet the ra standard using borrow soils from the excavation of the surface water diversions. The characteristics of these soils, which were investigated by the C and E series test pits (Appendix D and Figure D1), are well suited to use as radon barrier and outslope fill material. These soils are alluvial deposits classified as sandy clay (USCS Classification CL) to clayey sand (SC), with maximum dry densities averaging 116 pcf, average permeability of 1.9×10^{-7} cm/sec at 95% of maximum density, ND1 (nondispersive) by pinhole testing, and likely to have long-term moisture of about 10% based on 15-bar pressure plate tests. The applicable properties of tailings, existing cover and proposed additional cover soils are documented in Appendix D and listed in Table 3.

4.2.1 Outslope Reconfiguration

The outslopes of the leach tanks will be flattened to a 20% grade (5H:1V) by excavation and fill placement using standard earthwork procedures to meet requirements of Specification B3. The 20% grade will start at the top of the additional cover and 20 feet inboard from the outside edge of the original containment dike, as illustrated on Figures 6 and 7. This configuration will require a wedge of existing dike soil to be excavated in some locations, moved downslope, and placed there as fill. ~~At outslope locations~~ of LT-201 and LT-203 where demolition debris and other disposal materials will be placed, special placement and compaction methods will be used. Debris will be distributed as uniformly as possible, placed in lifts, and soil will be placed and compacted around the debris by hand-guided tampers (Appendix B).

only where the slope break

At outslope locations where contaminated soils are buried, a radon barrier thick enough to satisfy the 20 pCi/m^2s standard will be placed over the soils. The required thickness will be determined when the actual thickness of contaminated soils deposited in the outslope can be measured (end of Phase III). This barrier will be incorporated in the configuration of the 5H:1V outslope. The cover soil will be excavated from the surface water diversion areas and placed and compacted to not less than 95% of Standard Proctor Density, in accordance with Specification B3, Appendix B.

The reconfigured outslope with a gradient of 20% will be structurally stable under any conceivable set of circumstances, including earthquake and complete saturation, as indicated by calculation C1 in Appendix C. These calculations of slope stability were performed by the STABL5 computer code and use the Modified Bishop method of stability analysis, one of several slope stability calculational methods in common use. Under the extreme hypothetical conditions modeled (an earthquake with 0.1g peak acceleration and complete saturation of all leach tanks slopes and natural ground), the lowest factor of safety for the highest LT slope (27 feet) is 1.61. This is well above the limiting value of 1.00 for pseudostatic factor of safety.

4.2.2 Radon Barrier Enhancement

The properties of tailings and existing cover soils listed on Table 3, the procedures of USNRC Reg. Guide 3.64, and the computer code RADON were employed to determine the thickness of cover soil required to satisfy the limiting emanation criteria, i.e. maximum radon flux of 20 pCi/m^2s. These calculations (C2 in Appendix C) show that an additional 2.8 feet of CL and SC soils having the listed properties would be needed to meet the existing radon flux standard in Criterion #6 of RH XVIII, Appendix A, for radon flux from the leach tanks. Figures 6 and 7 show the configuration of the leach tanks after cover placement.

The additional cover will consist of soils excavated from the surface water diversion structure areas. Test pits and soil mechanics tests determined that these soils are mostly CL and SC. They will be placed in lifts of not more than 8" uncompacted thickness, moisture conditioned and compacted to achieve the required density and cover thickness. The top cover slopes have been designed for positive drainage of runoff and to limit the PMP runoff to velocities that will result in shear stresses below the allowable stresses for that soil, as listed on Table 3. This work will performed in accordance with Technical Specification B4, Appendix B.

4.3 Evaporation Ponds

The evaporation ponds, EP-601 through EP-606 on Figure 2, contain residual liquids and solids that are byproducts of the leachate-extraction processes. These ponds will be closed and reclaimed in accordance with Specification B5. This specification and the following subsections describe design option #1, reclamation involving reduction of pond area by concentration of salts and contaminated liner soils into a smaller area. Although this design approach appears to be attractive from the standpoint of cost and CDH reclamation criteria, its feasibility must be evaluated by field tests during Phase III, especially feasibility of dewatering and solidifying salts enough to make their excavation technically and economically practical. If these tests indicate that option #1 is not feasible or that cost or health and safety risks would be too high, then a design for covering the salts in place (option #2) will be developed.

4.3.1 Phase III Field Testing

The period of time available for the preparation of this Phase II final reclamation plan as well as excessively wet and humid weather during the summer of 1991 forced postponement of plans to conduct field tests of the properties of the evaporation pond salts and of methods for dewatering and handling them. Nevertheless, details of the properties and procedures to be used in dewatering, relocating, and compacting the salts must be developed by field testing. Due to the corrosive nature of the acid salts, Hecla and its consultants consider it inadvisable and potentially unsafe to try to transport the salts to laboratories for bench-scale testing. Instead, tests will be designed and implemented during Phase III to further characterize the salts in place with respect to their hydrogeologic properties, physical/mechanical properties, and, if necessary, their chemical properties. Some laboratory testing has been performed to determine the chemical constituents of the salts. These results are listed in Table 4. Using these listed chemical characteristics as a guide, a health and safety protocol has been developed for Phase III field tests. This protocol is contained in Appendix A and summarized in Section 2.2.5.

4.3.2 Dewatering

Figure 2 shows that the existing evaporation ponds are uncovered and occupy an extensive portion of the northwest quarter of the site. These evaporation ponds contain sulfuric acid salts and free liquid, which varies in concentration seasonally. Before any other containment and stabilization measures are initiated, these evaporation ponds will be dewatered; i.e. all standing liquid and free pore water must be removed.

The project schedule (Figure 16) shows that dewatering efforts will start early in Phase III. These efforts include some field testing and planning tasks that will precede the actual dewatering operations and are intended to evaluate and allow selection of the best methods and equipment.

Although field tests to determine its feasibility will be conducted as early as possible during Phase III, the prime-option dewatering method at this time is an evaporation system. The evaporation system will consist of sumps dug into the salts and a series of pumps, distributions lines, and spray nozzles to circulate the water from the interstices of the salts to the surface. While it is recognized that the rate of evaporation will decrease as the TDS level in the liquid increases, this evaporation system will be used as long as it remains both technically feasible and cost effective. After the evaporation process has reduced the liquid content of the ponds as much as possible, the final stage of dewatering will probably require mixing of dry soil solids with the residual brines until the mixture can be handled as a solid which will not release moisture ~~by gravity~~ drainage. This moist soil/brine mix will be excavated and placed on the surface of the salts ~~in these~~ portions of EP-601 to 604 that will remain in place.

water liberated by [illegible] differ[illegible] [illegible] lattice

4.3.3 Area Reduction

To reduce the area occupied by the acid salts, two evaporation ponds will be entirely removed, and the west and east ends of the other ponds will also be eliminated. After dewatering has reduced the moisture in the salts of each pond to a point at which the salts can be excavated and handled as a solid, the two northernmost ponds (EP-605 and EP-606) will be entirely excavated down to and including the clay liner to the depth necessary to remove all contaminated liner soils. The salts and contaminated soils will be transported to and placed in the central portions of EP-601-604. In a similar manner, the western and eastern-most portions of these four ponds, approximately 300 feet at each end, will be excavated down to clean natural soil; and the salts and contaminated soils will be placed in the central portions of these four ponds.

An earthfill berm consisting of non-contaminated soil will be placed to form a retention structure around the central portions of EP 601-604. This fill will be placed at a density as close as possible to that of the compacted salts to minimize the risk of differential settlements between the salts and the berm.

Specifications for the retention berms will be developed after Phase III field tests.

Figure 8 is the plan of the pond area after area and volume reduction and subsequent stabilization. Figure 9 illustrates the configuration of the reclaimed evaporation ponds in cross section.

4.3.4 Containment and Stabilization

The objectives of containment and stabilization of the evaporation pond salts and contaminated soils are the following:

a) elimination or reduction of liquid and interstitial pore space
b) reduction of total volume
c) reduction of radon emanation
d) protection against infiltration and erosion

Water?

Section 4.3.1 and 4.3.2, above, describe the proposed methods for eliminating moisture and for reducing the area of the evaporation pond salts. Volumetric reduction will be achieved by mechanical compaction using methods similar or identical to those used for soil compaction. Specifically, the relocated salts will be placed in the middle portions of EP-601-604 and compacted to break down the crystalline structure and to reduce, to the extent possible, the void space within the salts. No compaction standard is available by which to control or evaluate the compaction of these salts. Therefore, Hecla and its consultants will rely on field observations and measurements to evaluate the amount of compaction possible and the degree of compaction that is achieved by various compaction efforts and types of machinery.

The objective of containment and stabilization against radon emanation or infiltration and erosion will be achieved by placing a 2.0 foot thick soil cover over the top of the salts after they have been consolidated into a smaller area and compacted to the maximum extent reasonably achievable. The surface of these reconfigured salts will be sloped to allow placement of a soil cover that will drain precipitation runoff to the northwest and northeast. The soil cover will consist of CL-to-SC soils derived from excavation of the surface water diversion structures. The soils wil be placed and compacted in the same manner as those used for the leach tank cover.

Based on the average Ra-226 concentration of 13.22 pCi/g and average emanation coefficient of 0.406 in the salts (Table 4 and Appendix D), calculation C3 shows that no soil barrier is required to limit the radon flux to the 20 pCi/m^2s standard, i.e., the properties of the salts are sufficient to keep radon flux below the limit. The low permeability (10^{-7} cm/sec) and surface slope of the cover will effectively prevent infiltration. The 2.0 foot cover is not needed as a radon barrier but is needed to confine the salts and limit infiltration of precipitation.

The final slopes of the covered evaporation ponds will be designed to be free-draining and to keep shear stresses due to the runoff from the PMP to levels as low as reasonable. However, if the Phase III tests described in Section 4.3.3 above indicate that the salts might undergo long-term settlement due to consolidation, a thicker soil fill with steeper slopes will be placed initially over the evaporation ponds to compensate for the expected settlement. At this time, time-dependent consolidation and resulting settlements are not expected, but the soil cover will be designed with gradients steep enough to require a protective rock cover. The west, north and east edges of the covered evaporation pond will be protected by riprap and scour protection, as illustrated in Figures 8 and 9 and discussed in detail in the following section.

5.0 LONG-TERM PROTECTION

5.1 Surface Water Control

5.1.1 Site Vicinity Hydrology

The hydrologic characteristics of the Durita site are typical of the Colorado Plateau. The site has a semi-arid climate. It is located near the downstream end of several narrow watersheds with high relief. Consequently, although no perennial streams exist on or near the site, runoff tends to be seasonal and characterized by infrequent, extreme flows of short duration. Because the surface water channels on the site will occasionally carry high-velocity flows, and because some portions of the natural channels were changed by site development, erosion by surface water is a major issue in satisfying RH XVIII, Appendix A Criteria 1A, 1D, and 6.

Two specific objectives related to surface water control have been satisfied in this plan: a) to reestablish the pre-1977 fluvial regime to the greatest extent possible, and b) to protect the containment structures against erosion due to runoff from both normal and extreme precipitation events. No site-specific surface water hydrologic measurements exist or have been taken during the preparation of this plan because the surface water drainage in and around the site is intermittent in nature, providing no dependable opportunity to obtain surface water flow measurements. In addition, the period of time available for the preparation of this plan did not provide a suitable chronological base for representative surface water data acquisition. Therefore, pre-1977 surface water hydrologic conditions were evaluated using pre-1977 topography, 1989 aerial photography, and the assumption that rainfall and other climatic parameters have remained unchanged over the last several hundred years.

Prior to the construction of the site in 1977, five small tributaries to Dry Creek had watersheds which started upstream or south of the Durita site. These data were generated from measurements made on USGS topographic maps and the topography illustrated on the original facility construction drawings (Ortloff Minerals Corporation, 1977). Site construction caused the consolidation of discharges from the two eastern watersheds, East 1 and East 2, into one channel that is now called the East channel. The other three watershed channels have remained essentially unchanged in their upstream portions during and after the Durita site construction, with the exception that the west channel has been diverted around the southeast corner of LT-202. The gradients, channel lengths and other parameters used in the hydrologic analyses of these watersheds and channels are summarized in Table 5. The existing watersheds are shonw on Figure 10.

Hydrologic analyses to evaluate surface water parameters and the erosion potential of surface flows were performed using the procedures shown in Calculation C4. These were applied to specific calculations that are tabulated in calculations C6 - C10 and C12. All of these calculations are included in Appendix C.

The hydrologic parameters of these watersheds are characterized for the purposes of this plan by the following:

- watershed area
- length of longest flow path
- maximum change in elevation
- gradient along longest flow path
- flow concentration factor
- time of concentration
- PMP rainfall depth for 1-hour local storm
- discharge at time of concentration for PMP

These parameters are listed in Table 5, and the time versus rainfall depth for the local storm PMP is plotted on Figure 11.

5.1.2 Normal Runoff Control

Normal runoff has not been quantified during the investigations of this plan but is, instead, defined as that runoff which would be confined within the pre-1977 channels. These channels were V-shaped with narrow channel bottoms, usually less than 5 feet wide and up to 14 feet deep. The west channel drains the largest of the upstream watersheds and had a pre-1977 overall gradient of 0.026 within the Durita site and slightly greater, 0.027, if the channel several hundred feet upstream of the south site boundary is included (Calculation C5, Appendix C). The other channels were all steeper, ranging from 0.030 for the Mid-2 channel, as shown on Figure 10, to 0.047 on the pre-1977 East 2 channel. It is not possible to reestablish these channels to their pre-1977 gradients along the same drainage courses in all locations on the site because of the location of the leach tanks. Therefore, the reclamation design included the design of new normal flow channels in the vicinity of the leach tanks that would reestablish, as nearly as possible, the pre-1977 gradients and also follow alignments that would provide offsets from the leach tanks sufficient to protect the leach tanks from erosion due to normal flow as well as lateral migration and meander development that might evolve over long periods of time. The location of these redesigned channels is shown in Figure 12. The reclamation design for control of normal runoff will slightly reduce the overall gradient of the combined West, Mid-1 and Mid-2 channels (the Central channel) to approximately 0.021 over the controlled channel length of 2,643 feet. The control on the normal flows of the Central channel will be initiated at elevation 5620 at a point approximately 370 feet south of the site south fence line and will terminate at elevation 5547 at a point approximately 200 feet north of the location of the present raffinate ponds.

In addition to a slightly flattened overall gradient, this new channel will also have a 10-foot base width, wider than the average width of the existing or pre-1977 channels. This greater width will compensate somewhat for the shallower gradient by helping to reduce normal flow depths in the channel, thereby suppressing flow velocities and shear stresses on the channel bed.

The same design approach was used for the East channel. However, for the East channel it was possible to reestablish the pre-1977 gradient of 0.037 along the alignment shown on Figure 12. The normal flow control channel for the East channel begins at elevation 5620 at a point 230 feet south of the site south fence line and ends at a distance of 1482 feet at an elevation of 5560 at a point east of the ore preparation area shown on Figure 12. These channels will also be 10 feet wide at the base. Although not as necessary as a 10-foot width on the Central channel, the 10-foot width on the east channel is more of a construction expediency, i.e. the minimum practical width for dozer or scraper excavation. It will also allow normal flows to be diverted with shallower flow depths and, therefore, lower peak velocities and shear stresses than would have been the case in the previous natural channels.

The overall effect of the widened normal flow channels will be to reduce the potential for scour and enhance the conditions for aggradation, i.e. for sedimentation of traction and suspended load derived from upstream erosion. Conditions favoring aggradation of the channel beds provide additional protection against potential erosion during runoff events.

but not necessarily against lateral migration

5.1.3 PMF Runoff Control

The most severe storm event, the one-hour local Probable Maximum Precipitation (PMP) event applicable to watersheds up to one square mile, was derived from HMR 49 (Hansen et al, 1984). All watersheds above the site are less than one square mile in size (Figure 10). This storm would produce rainfall depths as shown on Figure 11, with one-hour total rainfall of 7.81 inches on the upstream watersheds and 8.15 inches on the site. The runoff or Probable Maximum Flood (PMF) resulting from this storm was calculated using the Rational Method per NUREG/CR-4620 (Nelson et al, 1984). The PMF parameters for the Durita site are tabulated in Calculation C6, Appendix C. The largest PMF rises in the West watershed, 4280 cfs. This PMF combines at the south side of the site with the PMF's of the Mid-1 watershed (528 cfs) and the Mid-2 watershed (1667 cfs). The locations and boundaries of these watersheds are delineated on Figure 10. It is conservative to assume that all PMF flood peaks arrive at the site at the same time, giving a combined PMF for the Central channel (i.e. the combined flows of the West, Mid-1 and Mid-2 channels) of 6475 cfs. The East watersheds cover a total of approximately 156 acres and have, by similar calculational methods, a combined PMF discharge of 1780 cfs. The PMF's of the combined Central and the East watersheds were used for the design of the PMF runoff controls within the site, to which were incrementally added the flows of on-site tributary areas (Calculation C7). It is also conservative to assume that each tributary area within the site adds its peak PMP runoff to the watershed at the same time as the control structure is carrying the PMF discharge from upstream runoff, producing progressively larger peak discharges from south to north across the site in both combined watersheds (Calculation C6 in Appendix C). In reality, concurrence of individual PMF peaks is extremely unlikely, making a cumulative peak discharge a true worst-case value.

The normal runoff control described in 5.1.2 above provides containment of normal flow within a constructed channel. For PMF control the peak discharge will be contained within a wide shallow channel that lies above and to each side of the normal flow channel. In effect, the PMF channel is really the flood plain of the normal flow channel. This flood plain is designed to keep the PMF peak discharge within the design boundaries illustrated in Figures 12 and 13.

The PMF channels, referred to hereafter as flood plains, are designed to satisfy the following objectives:

a) to contain the entire PMF peak discharge
b) to minimize the velocity and shear stresses at peak discharge
c) to provide maximum possible standoff distance from the protected containment structures

To satisfy these design objectives, the overall gradients have been kept as low as possible in reaches that are closest to containment structures. This results in overall gradients of 0.018 along the central flood plain and 0.031 along the east flood plain. Each of these gradients is flatter than their respective normal flow channel gradients. Both flood plains are designed to have depths at the shallowest points, i.e. along each bank, that are equal to or greater than the calculated water depth at peak PMF discharge in order to satisfy objective "a" above. Design objective "b" is satisfied by having the greatest width allowed by the terrain, the property boundaries, and the location of the containment structures, as well as by providing the flattest gradient compatible with the terrain to decrease both the velocity and shear stresses at peak discharge. The maximum possible standoff distances of objective "c" are dictated by the maximum width, shape and location of the flood plains and the normal flow channels. The design parameters for both normal flow channels and flood plains are tabulated in Calculation C8, Appendix C.

The flood plains will terminate at locations sufficiently downstream or laterally separated from containment structures to preclude the risk of erosion of those structures from the PMF's in the flood plains. The central flood plain ends downstream of the leach tanks and the reclaimed plant area and is topographically downslope from those locations. This flood plain widens after it passes through the constricted area between the leach tanks, then discharges onto the northwest quadrant of the site, which has no containment structures and consists of natural channels separated by unobstructed, relatively flat terrain. The east flood plain terminates north or downslope from the leach tanks and in the direction of a system of deep natural channels adjacent to and east of the east property line of the site. The evaporation ponds are protected from the PMF of either flood plain on the upstream side by the Mancos Hill and laterally by at least 300 feet of terrain that will be sloped away from the evaporation pond cover toward the flood plains. The technical specifications for the surface water control structures are contained in Specification B6, Appendix B.

5.2 Erosion Protection

5.2.1 Protection Against Flood Plain Scour

Due to the terrain and spatial constraints imposed by the site, it is not possible to provide protection against all erosion under all flow conditions. Normal flow channels will experience some bed and bank erosion during periods of high flow but should recover most, if not all, of the bed scour during subsequent periods of declining flows when sedimentation occurs because of the widened channel bed. Under peak PMF discharge, scour will occur along the bed of the flood plain, as shown in Appendix C, Calculation C9. Using methods developed for the U.S. Bureau of Reclamation (Pemberton and Lara, 1984), scour depths were calculated for reaches along both flood plains. Three methods were used and the results were averaged, as recommended in the referenced document, to determine design scour depths along the flood plain banks.

Each reach of flood plain that is formed by soil and is adjacent to the containment structure will be protected by rock-filled trenches from channel bed elevation to the calculated vertical scour depth (Figures 12 and 13). These scour trenches will be excavated to the design depth and slope, then backfilled with rock, as described in Specification B7, Appendix B and for riprap below, to a thickness of not less than 18 inches. Portions of flood plains in rock will not require scour protection. Rock is expected to form some or all of the flood plain beds south of the south fence, but the scour protection design assumes a soil bed in these locations until investigations can be performed on this BLM land to determine depth to rock.

5.2.2 Riprap

A riprap blanket will be used to protect flood plain banks in soil from lateral erosion under conditions up to the PMF discharge. Those portions of the banks cut in rock will not require riprap protection. The riprap will be applied to the banks in the same locations as specified for scour protection, adjacent to containment structure areas. The riprap layer will be a minimum of 18 inches thick and will be placed on a 2H:1V slope. The riprap material will be sized in accordance with methods described by the NRC (1990) and by Nelson et al, Abt et al, and COE, 1970. These methods generally rely on the calculation of shear stresses at the protected boundary and on the use of the Corps of Engineers or the Stephenson method to determine the d_{50} size of rock needed to resist movement under the PMF peak velocity. These calculations, shown in summary form in Appendix C, Calculation C10, indicate that the largest rock needed, $d_{50}=18.3$ inches, will be placed against soil exposed along the left bank of the Central channel from Station 0+00 to Station 5+22. The maximum d_{50} along the downstream reaches of the Central flood plain ranges from 5.6 inches to 11.7 inches. Along the East flood plain the maximum d_{50} is 10.2 inches along soil exposed in the left bank from Station 0+00 to Station 2+05, and downstream the d_{50} will range from 3.8 inches to 9.6 inches. Maximum rock sizes will be 1.5 times the d_{50}. The gradations needed for these applications are shown in Appendix C, Calculation C11.

The rock for the riprap and scour protection will be obtained from the site and from one or more sources along the San Miguel River valley near Naturita. Rock from the site soils and cobbles within on-site soil and one possible source, located three miles from the site, has been tested for gradation and durability. Test results are shown in Appendix D. The on-site rock was tested for specific gravity, absorption, sulfate soundness, and LA abrasion and has a composite durability score of 24.2%, indicating that it cannot be used without oversizing by 56% above design size (Appendix D). Rock from the nearest off-site source has a composite durability score of 81% and will not require oversizing. Preliminary evaluations of gradations suggest that larger rock sizes, i.e. greater than d_{50} of six inches, might have to be developed from on-site rock and oversized to compensate for the low durability scores of on-site rock. Off-site sources of larger rock of better quality are being investigated.

5.2.3 Containment-Structures Slope Protection

The outslopes of the leach tanks and the entire cover of the evaporation pond area will be protected by rock covers. The rock will be developed from the same sources along the San Miguel River valley as described above. The location and extent of leach tank outslope rock cover is shown on Figures 6 and 7. The cover will be not less than six inches thick, consisting of rock with composite durability score of 80% or more. Rock will have a d_{50} of 1.7 inches or more, per Calculation C12 in Appendix C, and cover all outslope surfaces. Rock will be screened and sized to meet the gradation criteria shown on Calculation C11, Appendix C and contained in Specification B7, Appendix B.

The evaporation pond cover will be protected by the same rock used on the leach tank outslopes (see Calculation C12, Appendix C) except that the required d_{50} is 0.9 inches. The rock will extend over the entire sloped cover to the top of the scour protection placed around the edge of the cover. Scour protection will be placed along the east, west and north edges of the evaporation pond cover and will extend to a vertical depth of 5.7 feet on the west, 3.0 feet on the north, and 3.0 feet on the east side of the evaporation pond cover, in accordance with calculated average scour depths (Calculation C9, Appendix C) for downstream reaches of central and east flood plains.

River rounded?

5.3 Regrading and Revegetation

5.3.1 Regrading

After all excavation, fill placement, erosion protection, and other earthwork have been completed, the disturbed areas of the site will be regraded in accordance with Specification B8, Appendix B, to establish positive drainage and create the flattest possible surface gradients compatible with positive drainage. Grading will be designed in the field to direct runoff away from containment structures and toward the surface water control structures. Exact slopes and contours cannot be determined until the contaminated soil excavation and other earthwork have been completed. However, the approximate form of regraded surfaces is shown on Figure 14.

5.3.2 Revegetation

After grading has been completed, disturbed areas of the site will be revegetated using seed mixes shown on Table 6. Areas to be revegetated will include the leach tank cover top surfaces, the cover over the plant area, the ore preparation area, and borrow area including flood plains.

Approximately 89 acres will be disturbed during the demolition and reclamation process. These areas include:

- Plant area, to include raffinate ponds (7 acres)
- Ore preparation area (11 acres)
- Flood plain areas (25 acres)
- Evaporation pond reclaimed area (15 acres) - area cleared of salt
- Leach tanks less outslopes (27 acres)
- Other soil clean-up areas (4 acres)

The revegetation plan is based on vegetation species recommended by the District Manager of the Norwood, Colorado, Soil Conservation Service (SCS) office (Stindt, 1991). These species will provide diversity and adaptability for the soil conditions on site. Both sod and bunch-grass species have been selected to help provide soil stability and minimize erosion. Optimum planting time is in the fall after October so that seeds will not germinate until the following spring. Early spring planting is acceptable.

The areas to be revegetated will have seedbeds prepared as follows:

- Plant and Ore Preparation Area: After soil placement over the in-place foundations and pads, the area will be disked or harrowed to provide a surface for drill or broadcast seeding. Any area outside of the burial area that has been compacted will be ripped by dozer or equivalent equipment with parallel cuts on the contour. The areas will then be disked or harrowed to provide a surface for seeding.

- Evaporation Pond and Leach Tank Areas: After final soil placement on leach tank covers, the covers will be scarified with a disk or harrow to provide a surface for drill or broadcast seeding. The areas previously occupied by EP 605, 606, and portions of 601-604, from which salts and contaminated soils have been removed, will be filled and regraded before being scarified for seeding.

- Flood Plain Areas: Areas that have been compacted through the use of heavy equipment during soil excavation will be ripped as discussed above. The total area affected will then be disked or harrowed to provide a surface for drill or broadcast seeding.

- Raffinate Ponds: Upon removal of the liner material and final grading, the area will be scarified as discussed above for preparation of drill or broadcast seeding.

All seeding will follow as closely as possible after seedbed preparation. Two methods of effectively seeding the area to be revegetated include drill and broadcast seeding. Drill seeding will be the primary method of seeding. Broadcast seeding is not as effective as drill seeding because of uneven seed distribution and seed desiccation if proper depth placement is not accomplished. Drill seeding offers uniform placement of seeds, requires fewer seeds per acre, and provides a uniform stand of seeding plants. All seeding will be conducted along the contour or at right angle to the prevailing wind.

It can be anticipated that during some years the revegetation program may not achieve the desired results. A yearly evaluation will be made during Phase V to determine revegetation success. If revegetation is not successful, the area(s) requiring revegetation will be reseeded with the appropriate seed mixture, contained in Table 6.

Mulch will be applied to all seeded areas to conserve soil moisture and protect against erosion. Application will immediately follow seeding and fertilization. Areas that were seeded with a preparatory crop may not require mulching when perenniel species are seeded due to the stubble stand. This will have to be determined on an area-by-area basis. All slopes within the affected area will be gentle, so no special mulch (e.g. cellulose wood fiber, burlap netting, etc.) will be required. Straw or hay mulch will be used, applied at a rate of 2,000 pounds per acre, and anchored with a straw crimper. A commercial fertilizer will be applied at a rate recommended by the manufacturer.

6.0 GROUND WATER PROTECTION

6.1 Background

During Phase I of the development of the reclamation plan, a preliminary evaluation was made of existing ground water data. This evaluation indicated that the uppermost aquifer or, more appropriately, the uppermost water-bearing unit on the Durita site had both poor hydrologic properties and poor water quality. Other water-bearing units under the site occur at several hundred feet depth and were not addressed in the Phase I studies. The nearest user of ground water is the Coke Oven Ranch located approximately one-half mile northwest of the northwest corner of the Durita site. The well at this property is reported to be developed in a water-bearing unit of the Morrison Formation. There are no other water users in the vicinity of the Durita site.

Phase I investigations also indicated that there was considerable question about the suitability of the existing monitor wells (MW-2 through MW-7) for ground water level and ground water quality monitoring. The data from these wells were examined, and it was determined that these data could not support a credible assessment of the natural hydrogeologic conditions as required by CDH Part XVIII, Appendix A, Criterion 5G, assessment of the uppermost water-bearing unit as a potential water resource (Criterion 5B) or the evaluation of the impact of the site on the uppermost water-bearing unit (Criteria 5B and 7). The old monitor wells, MW-2 through MW-7 (MW-1 was destroyed and/or abandoned prior to site development), were drilled in 1976 and have been sampled on a quarterly basis since then. These results have been submitted to CDH as part of the Durita license conditions. The documentation on the drill logs and installation (Coe and Van Loo, 1977) indicated that these wells were installed to relatively shallow depths at the base of the Mancos Formation. The installation records are incomplete but indicate that the screen portion of each well was not sand-packed, did not have a seal above the screen zone, and the wells were not backfilled to ground surface. The seal that was placed around the casing near ground surface appears to have been placed in all wells; however, its condition on some of the wells has deteriorated with time. Therefore, the possibility exists, and was considered in the evaluation of these wells, that the ground water level and ground water quality in these wells could have been influenced by in-flows of surface water through the defective seals and along the unbackfilled annulus of the well.

sets?

As a result of the uncertainty about the data being obtained from the old monitor wells, the Phase II investigations included installation of seven new wells (up to six had been originally proposed in the Phase I report). Three cycles of ground water measurements and sampling have been conducted on these new wells. The old monitor wells had been tested on a quarterly basis for TDS, chloride, ammonia as nitrogen, zinc, radium-226, lead-210, and uranium. The water sampled from the new wells during Phase II has been tested for many more constituents, as required under the new CDH Radiation Control Division policy (CDH, 1991). These constituents include the major cations and anions, more metals, and a suite of organic compounds in addition to several radiological species.

The objective of the ground water monitoring program has been to:

a) establish the hydrogeologic setting of the site
b) determine background water quality parameters of the uppermost water-bearing unit
c) evaluate the water quality impacts of the site
d) determine what, if any, ground water protection or restoration measures are required as part of the reclamation plan.

6.2 Ground Water Monitoring

6.2.1 Monitor Well Installation, Development and Testing

Seven new ground water monitoring wells, MW-8 through MW-14, were drilled and installed during April 23-28, 1991. The locations of these wells as well as the old monitor wells are shown on Figure 15. The drill logs and installation records and diagrams of the new wells are included in Appendix D. The locations of the new monitoring wells were selected to confirm the direction of ground water movement, as determined from historical data, and allow the evaluation of hydrogeologic characteristics and ground water quality in wells installed according to current standards. In order to satisfy the objectives of the ground water monitoring program, seven wells were installed to accommodate and address the uncertainty about the detailed direction of ground water flow, especially as it relates to the position of the leach tanks and the evaporation ponds. The locations of the new wells were selected to assure that at least one new well would be up-gradient, two of the new wells would be down-gradient, and the remainder of the new wells would be cross-gradient with respect to the impoundment structures.

The wells were drilled using hollow-stem auger and air rotary methods, as described in detail in Appendix D. When the uppermost water-bearing unit in each well was encountered, the well was drilled sufficiently below the initial contact with the water to allow placement of a 10-foot screen and a sand pack below and around the screen section. All well screen was 4-inch I.D. with filter sleeve, surrounded by sand pack. The 4-inch riser was extended to several feet above ground surface and capped. The annulus above the sand pack and the screen section was sealed with a bentonite seal, followed by bentonite/drill-cutting backfill. Surface casing was placed and sealed in the upper few feet of each well around the 4-inch riser. Each well was developed by surging methods. Pump tests were planned on two or more of the wells, but the yields from all wells were too low to permit effective pump testing. Slug tests were considered but also ruled out because of the effect they would have on the water quality of samples to be obtained from each of the wells.

6.2.2 Ground Water Level Measurements

Ground water level measurements were recorded three times on all new wells during Phase II. These measurements were made on May 1, June 20 and August 1, 1991. On the old wells, water level measurements were made in early April and again on August 1. The water levels for all wells on August 1 are depicted on Figure 15. The August 1 water levels are considered to be the most reliable, because slow recovery after drilling and well installation made the earlier ground water level measurements suspect, i.e. not enough time had passed to allow full recovery of natural water levels in some new monitor wells.

6.2.3 Water Sampling and Testing

On the same three dates that ground water levels were measured in the new monitoring wells, water samples were obtained for testing. Prior to acquisition of samples, the wells were purged. Then samples were obtained, handled, and preserved in accordance with RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD) of September, 1986. Samples were preserved using methods derived from Test Methods for Evaluating Solid Waste/Physical/Chemical Methods, Third Edition (SW-846). The specific procedures are described in detail in Appendix D.

The first and second rounds of samples (from May 1 and June 20, 1991) were tested for pH, TDS, chloride, sulfate, arsenic, barium, calcium, iron, lead, molybdenum, potassium, sodium, gross alpha, gross beta, radium, thorium, and uranium. The third round of samples from the new wells obtained on August 1 were tested for these constituents as well as for ammonia, alkalinity, beryllium, cadmium, chromium, magnesium, mercury, nickel, selenium, vanadium, and the suite of organics listed by the CDH, 1991. The samples were tested by both a primary lab (Core Laboratories) as well as a quality control laboratory (Barringer Laboratories, Inc.), which tested a percentage of sample splits. The test results from these two labs were generally corroborative. The tested constituents and their concentrations for the August 1 samples from each well are listed on Table 7. Sampling and testing methods and results are documented in detail in Appendix D.

6.3 Results of Ground Water Investigations

6.3.1 Hydrology of the Uppermost Water-Bearing Unit

The results of the Phase II ground water monitoring program indicate that there are two stratigraphic units under the site which appear to be hydraulically connected and constitute a single uppermost water-bearing unit. Over most of the site, with the exception of the northernmost portion, the uppermost water-bearing stratum is an interbedded sandstone-claystone unit, the top of which occurs from 20-55 feet below ground surface. This unit varies in thickness but appears to be at least 10 feet thick. The top and bottom of this unit are probably gradational. Along the north side of the site in the vicinity of MW-11 and MW-12, the uppermost water-bearing stratum is a one-foot thick sandstone which is also present but dry in the up-gradient wells. The piezometric surface elevations are higher than the upper stratigraphic boundaries of the water-bearing units, indicating that both of the uppermost water-bearing stratigraphic units are hydrologically confined.

The yields from these strata are extremely low, approximately one gallon per minute in MW-8, 9 and 10 and less than one gallon per minute for MW-11, 12, 13 and 14. The slow recoveries and very low yields of all these wells precluded performing those field tests that would be needed to quantitatively determine the permeability and transmissivity of the water-bearing strata, but it is evident from the performance of these wells that these hydrologic parameters are very poor.

The lateral extent of the uppermost aquifer is very limited. The recharge occurs in the local area, probably along the subcrop/outcrop of these strata south of the Durita site. Because no saturated zones were found in the alluvium in any of the monitor wells or test pits, it appears that there is no shallow ground water in the alluvium and, therefore, recharge to the uppermost water-bearing units is probably intermittent and results from seasonal infiltration in the slopes south and east of the site. The discharge of the water-bearing strata is probably limited to a short section of the Dry Creek channel or alluvium that crosses the deepest part of the syncline off the northwest corner of the site. Therefore, the Dry Creek channel is probably the western limit of ground water flow through these strata, and the northern and eastern limits are probably structurally defined by those limbs of the syncline. Therefore, this uppermost aquifer is very localized and exists over an area only slightly larger than the site itself.

6.3.2 Water Quality

The ground water quality of the uppermost aquifer is summarized on Table 7. All test results are tabulated in Appendix D. The water quality tests indicate that TDS are nearly 10 times above EPA's primary drinking water standard of 500 mg/L. Sulfates range from 580 to 3310 mg/L, from two times to more than 13 times EPA's drinking water standard. The pH ranges from 7.41 to 8.60, indicating that the water is slightly-to-moderately alkaline, with the highest levels in MW-13 and MW-14 being above the drinking water standard. The results of samples taken from the old wells are comparable to the results from the new wells described above.

The background water quality is represented by the samples from MW-8 and MW-14 in which the TDS and sulfate concentrations are lower than the cross-gradient or down-gradient well samples. The major anions and cations were evaluated to determine the geochemical characteristics of the ground water and to evaluate and assist in the interpretation of the geochemical origins of the major ground water chemical constituents. The ratios of major anions to cations are similar for wells MW-13 and MW-14 due to the preponderance of calcium and relatively high levels of bicarbonate compared to sulfate. Wells MW-11 and MW-12 exhibited similar geochemical characteristics based on their preponderance of calcium and sulfate as well as their relatively low levels of bicarbonate. The geochemical characteristics of the three remaining wells are also similar in that the preponderant constituents are calcium and sulfate, with higher levels of sodium and magnesium than other wells. The actual concentrations of the anions and cations are lower in MW-8 than in wells MW-9 and MW-10, although the relative percentages are similar between the three wells. These geochemical relationships and their variations down-gradient across the site indicate that the variation in major anions and cations from the locations of the background wells (MW-8 and MW-14) to the cross-gradient wells (MW-9 and MW-13) to down-gradient wells (MW-10, MW-11 and MW-12) result from ground water travel through, and longer residence time in, the water-bearing strata from up-gradient to down-gradient locations.

Most metals and other inorganic constituents included in the CDH list (1991) were determined to be below analytical detection levels in the third round of ground water samples. Molybdenum was generally below detection level except at MW-13 (0.08 ppm). Barium concentrations ranged from 0.01 to 0.05 ppm, well below drinking water limits. The concentrations of radiochemical parameters were all below drinking water standards and showed no significant difference between up-gradient and down-gradient locations. Gross alpha and gross beta activities were below the lower level of detection in third round samples. Thorium-230 levels were higher during the third round than in the previous sampling cycles but were only slightly above the lower level of detection and well below the drinking water standard of 60 pCi/L. Radium-226 activity levels were detectable but well below the drinking water standard of 5 pCi/L. Uranium activity was highest in the up-gradient and cross-gradient wells along the eastern side of the site. These concentrations are probably derived from host rock rather than from seepage from the surface. These results show that the CDH standards for alpha, thorium and radium far exceed any values in the ground water of the uppermost aquifer under the site.

All organic compounds listed by the CDH, 1991 were tested for in the August 1, 1991 samples. All these organic constituents were below detection limits and are therefore not listed in Table 7.

6.4 Ground Water Impact Assessment

The Phase II ground water investigations show clearly that the uppermost water-bearing unit under the site has been characterized adequately in accordance with Criteria 5G of Appendix A, RH Part XVIII, and that this characterization shows that this water-bearing unit is not a potential water resource under the applicable portions of Criterion 5B of Appendix A. The uppermost water-bearing unit has very limited lateral extent, contains water whose natural quality is below drinking water standards, and has had no detectable impact on its quality due to operations of the Durita site. Therefore, it is apparent, under the provisions of Criteria 5B and 7 of Appendix A Part XVIII, that the Durita site operation and the materials that reside on the site have had no adverse effects on ground water and that no corrective actions under Criteria 5D, 5E and 5F are required.

In view of the foregoing data and findings, Hecla proposes the following actions for ground water monitoring and protection:

1) Implementation of the reclamation plan as described in preceding sections and Section 7.0 of this document as sufficient measures for long-term protection of ground water.

2) Continuation of water level measurements and ground water sampling and testing on a quarterly basis through the completion of Phase IV of site reclamation with the exception that all analytes listed by CDH (1991) and listed on Table 7 of this document be eliminated from further testing with the exception of pH, TDS, sulfate, thorium, radium and uranium.

3) After the fourth quarter of 1991 the old monitoring wells (MW-2 through MW-7) be abandoned and sealed.

4) Exemption of ground-water monitoring from the long-term surveillance activities, i.e. ground water monitoring will cease at the conclusion of Phase IV of site reclamation.

7.0 RECLAMATION PLAN IMPLEMENTATION

Hecla is proceeding with the reclamation of the Durita site in a phased approach. This has and will continue to provide a logical sequence for the work required to satisfy the reclamation criteria. The following provides a discussion of the activities and schedule of each phase of the reclamation process. The schedule for the reclamation tasks of phases III and IV, including the critical path, is illustrated on Figure 16.

7.1 Conceptual Reclamation Plan (Phase I)

The conceptual reclamation plan contained Hecla's general reclamation approach and the measures that would be taken during Phase II to develop a final reclamation plan that would satisfy the regulatory reclamation criteria. This plan was submitted to the CDH in December, 1990. CDH's subsequent comments concerning the proposed site investigations were incorporated into the data collection and site investigations that were conducted as part of Phase II.

7.2 Final Reclamation Plan (Phase II)

The final reclamation plan contains the detailed description of reclamation measures that are based on CDH criteria and the results of Phase II site investigations. The investigations included development of a new base map, radiological surveys (soil and buildings/equipment), installation of new ground water monitoring wells, ground water analysis and impact assessment, characterization of tailings/soil/salts/rock, and inventory of on-site buildings and equipment.

From these Phase II field activities it was possible to develop the engineering analysis and designs used in the formulation of 1) final radon barrier and long-term stabilization, 2) surface water control and erosion protection, 3) decontamination/demolition, 4) salvage operations, 5) ground water protection, 6) evaporation pond stabilization, and 7) final regrading and revegetation of the site. The results of the Phase II efforts are contained in this final reclamation plan.

7.3 Facilities Decommissioning and Evaporation Pond Dewatering (Phase III)

The initial part of this phase will be the dewatering and stabilization of the salts in the evaporation ponds. This will begin in the fall of 1991 with planning activities and continue until the salts in the ponds can be moved as dry solids. In addition, field testing will be performed on the salts to determine potential solidification procedures, measures for movement, consolidation and long-term stabilization. The long time line for dewatering on Figure 16 includes time for planning and evaluation of dewatering methods and equipment as well as actual dewatering, which is expected to be intermittent during winter months and continuous thereafter.

Hecla has a program in place for decontamination of buildings and equipment that have potential salvage value. This program will continue during this phase, with the salvageable material being dismantled and stored in a designated clean area until removed from the site.

Demolition of nonsalvageable buildings/equipment/concrete will occur in 1992. The material will be buried in place or placed in the raffinate ponds and the toe of LT-201 and 203 embankments for burial during the earthwork portion of Phase IV. In addition, soils with elevated Ra-226 concentrations will be removed and placed in the LT-201 and LT-203 outslopes and covered by the necessary thickness of soil.

7.4 Earthwork and Related Construction (Phase IV)

During this phase, which will commence in 1993, the leach tanks will receive final radon barrier soil cover and side slope configuration. Normal flow channels and PMF flood plains will be constructed concurrently with the leach tank and evaporation pond cover placement. Upon completion of side slope grading and flood plain excavation, rock cover will be placed, where required, for scour and side slope protection.

The site will be regraded after the completion of the major earthwork. Revegetation will follow the regrading of the site.

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7.5 Post-Closure Care and Monitoring (Phase V)

After completion of Phase IV, site post-closure care and monitoring will be implemented. The post-closure care will consist of a two-year evaluation of the revegetation effort, the surface water control and erosion protection measures, and radon barrier integrity. Because of the characteristics of the stabilized materials (tailings and salts), settlement monitoring will not be required. From the pre-reclamation ground water monitoring program, it was shown that the leaching operation had not impacted the uppermost aquifer. Therefore, no extended ground water monitoring program or ground water restoration program will be conducted.

8.0 COST ESTIMATE AND SURETY

8.1 Estimated Cost of Reclamation

The estimated total cost for the reclamation tasks under Phases III, IV and V is $2,210,000. The major cost components are summarized on Table 8. Appendix E contains the details of unit prices, volumes, and other factors that were included in the cost estimate. The cost estimate is based on the assumption that all reclamation work will be done by outside contractors, i.e. that Hecla will not perform any of the reclamation work using its own staff. Therefore, all the unit prices include contractor overhead and profit.

The unit prices for major earthwork activities are based on the average of actual contract bids prepared within the last 18 months for similar work and similar quantities at a project location in the Four Corners area. Any unit prices required in the cost estimate that could not be based on actual bids were derived from the R.S. Means Site Work Cost Data for 1991. Due to the severely depressed economy on the western slope of Colorado, especially the construction sector, it is possible that Hecla will receive bids with lower unit prices than those used in this cost estimate.

8.2 Proposed Method of Financial Assurance

Hecla proposes to use the financial assurance instruments listed below to satisfy CDH's financial assurance requirements for costs associated with the completion of the reclamation of the Durita site.

1. Stabilization and Reclamation Bond 81 S 100465141 BCA, in the amount of $60,227.00, dated March 1, 1988, issued by Aetna Casualty and Surety Company.

2. Stabilization and Reclamation Bond 81 S 100465142 BCA, in the amount of $60,227.00, dated March 1, 1988, issued by Aetna Casualty and Surety Company.

3. A third surety bond, similar to the stabilization and reclamation bonds in numbers 1 and 2 above, in the amount of $2,089,546.00, issued by Aetna Casualty and Surety Company.

(Stabilization and Reclamation Bonds 81 S 100465141 BCA and 81 S 100465142 BCA are already held by the Colorado Department of Health.)

8.3 Incremental Release of Surety Bonds

As tasks or portions of tasks outlined in this reclamation plan are completed, it is proposed that CDH release the amount of surety that has been appropriated for that task or phase of that task as outlined in Table 8 of this reclamation plan. The proposed incremental surety bond release schedule is presented on Table 9. The surety release dates are based on the reclamation schedule presented in Figure 16 of this plan.

TABLE 8

SUMMARY OF RECLAMATION COST ESTIMATE

DURITA MILL

TASK	Activity/units	QUANTITY	ACTIVITY OR ITEM COST	TASK COST	
I.	FACILITY DECOMMISSIONING			$433,500	
	Decontamination		$5,000		
	Mill Demolition (see Appendix ~~C1~~) E 1 12/2		$32,600		• 1.
	Cover and regrade mill area		$17,700		• 2
	Soil Cleanup		$25,000		• 3
	Site Regrading (including 283,000 c.y. fill placement)		$353,200		• 4
II.	GROUND WATER RESTORATION AND WELL PLUGGING			$1,600	• 5
	Ground Water Restoration and Monitoring (expect finding of no impact)		$0		
	Well Plugging		$1,600		
III.	EVAPORATION POND DEWATERING AND EXCAVATION/RELOCATION OF SALTS			$58,400	– ~100,000 6
	Dewatering		$24,700		
	Excavation/relocation of salts		$33,700		
IV.	DIVERSION CHANNEL CONSTRUCTION			$528,400	(a bit low) ?
	Strip vegetation	25 acres	$12,000		• 7
	Excavate and grade	452000 c.y.	$516,400		• 8
V.	RADON COVER AND OUTSLOPE CONSTRUCTION			$555,300	≈ 650K
	Leach Tanks - slope and cover construction	192000 c.y.	$482,400		• 9
	Evaporation Pond - cover construction and grading	29000 c.y.	$72,900		• 10 (x2)
VI.	EROSION PROTECTION			$97,800	
	Excavate, screen, haul and dump rock	22640 c.y.	$81,100		• 11
	Place and spread rock on LT outslopes	12000 c.y.	$3,100		• 12
	Place and spread rock on Evap. pond cover	6000 c.y.	$1,600		• 13
	Construct riprap and scour protection	4200 c.y.	$12,000		• 14

TABLE 8
continued

TASK	Activity/units	QUANTITY	ACTIVITY OR ITEM COST	TASK COST	
VII. REVEGETATION				$49,000	.15
VIII. QUALITY CONTROL				$51,700	
	Quality Control Testing - 5mo x 22 days/mo x $320/day		$35,200		ok
	Surveying - 3 mo. x 22 days/mo x $250/day		$16,500		
IX. RADIOLOGICAL SURVEY AND ENVIRONMENTAL MONITORING				$14,000	
	Radiological Surveys (post-reclamation)				
	Soil surveys		$5,000		
	Gamma surveys		$3,000		
	Decommissioning Equipment Surveys and Smears		$3,000		
	Bioassays and TLD's , for contractor personnel		$3,000		
X. PROJECT MANAGEMENT	Project Mgr. ($60k/yr) + assistant ($16k/yr) x 1.5 yr. x 1.5 for Indirect Costs			$171,000	ok
XI. LABOR AND EQUIPMENT OVERHEAD, CONTRACTOR PROFIT	These costs included in the work units				yes
SUBTOTAL				$1,960,700	
MOBILIZATION / DEMOBILIZATION				$50,000	
CONTINGENCY	10% of Subtotal			$196,070	
TOTAL ESTIMATED COST FOR PURPOSES OF SURETY				$2,206,770	
			SAY	$2,210,000	

Someone else needs to do this

X 1.1 for '94 update

2.43M

≈ $\boxed{2,500,000}$

(look credit ones) ~ 175000 ?

plus

sol. / neat. / line evap pond / cell

E

PLANT AREA COVER

Assume $1.09 /c.y. to spread and compact soil that was excavated and hauled (cost under diversion excav.) from within 1000'. Cover thickness ave. 2.0 ft.

Plant area = 550'x300', x2'/27= 12222 c.y.
Ore prep. area, receiving
section only, 100x180', x 6' ave. to fill grizzly, bin
and tunnel= 4000 c.y.

Estimated cost is 1.09 /c.y. x 16222 c.y. = $17,682 • 2

CONTAMINATED SOIL CLEANUP

15 acres x ave. 1.0' excavation = 21300 c.y.
x $1.03/c.y. by scraper = $21,939
Service and supervision for 5 days $75.18/hr x 8 hr/day = $3,000

Total for soil cleanup = $24,939 • 3

SITE REGRADING

Fill placement to achieve rough grade, using soil excavated from surface water channels and flood plains, compaction by dozer while spreading soil. $1.23/ c.y. (R.S. Means, 1991, p.35) x 283000 c.y. = $348,090

Finish grading with CAT 14G, 62 acres/ 10 acres per day
6 days x 8 hrs/day x $69/hr = $3,312
Surveyor/grade checker, $37.83/hr x 6 x 8 = $1,816

Total for regrading = $353,218 • 4

WELL PLUGGING

Rig time 2 hrs. x $120/hr. + one bag readi-mix at $5.00 + one bag bentonite at $25 x 6 wells = $1,620 • 5

EVAPORATION POND DEWATERING AND EXCAVATION/RELOCATION OF SALTS

a) Complete pump and spray circuit around ponds, moved as necessary during dewatering:

2000 ft. Drisco 3" diam. pipe x 0.88/ft = $1760 $1,760
One spray head per 25 ft, $3.73/(head+riser) x 80 = $300
Two pumps and electric service, x $5000 = $10,000
Labor, 1000 hrs @, x $12.63/hr = $12,630

NO

Total for spray systems = ($24,690)

b) Excavation and relocation of salts
Assume D-8 dozer and CAT 633 scraper each moving half the salts. 19533 cy of salt and about 22229 cy contaminated clay liner to be moved, for total of 42000 c.y.

6

± 62000 cy @ ≥ 2$/cy

Scraper at $1.03 x 21000 c.y. = $21,630
D8L at $120/hr x 420 cy/hr, or $0.29/ c.y. x 21000 c.y. = $6,090
Supervision, health protection and monitoring, $50/hr x 120hr $6,000

≈ 124,000
- 24,000

total for evap. pond excavation $33,720

* ≈ $100,000 ⇐

* dependant on new cell design

E

CONSTRUCTION OF DIVERSION CHANNELS

a) Strip and remove vegetation - 25 acres

CAT D8L dozer to strip and windrow vegetation and topsoil
Each pass 10 ft wide, giving 4362 ft/acre travel x 25 acres
= 109050 ft., / [2.0 mph (Rust Tractor Co., 1990)
x 5280 ft/mi.] = 10.5 hrs, x 120/hr= $1,260
CAT 633D scraper to pick up, haul, and dump
25 acres x 0.5 ft cut x 43560/27 = 20170 c.y.
20170cy x 0.53/cy = $10,690 ← * seem a bit low

Total $11,950 •7

b) Excavate, haul ave. 500 ft, and dump soil using CAT 633D

452000 c.y. x $1.03 = $466,690
plus D8L ripping and excavation of 10%, or
45200 c.y. x $0.29 = $13,108 (efficiency factor?)

c) Finish grading with CAT 14G
24 acres / 5 acres per day x 8 hr x $69/hr = $2,650

d) Supervision, grade control, and maintenance
($37.35+$37.83)/hr x 8hr/day x 452000 /8000 $33,981

$516,429 •8

CONSTRUCTION OF RADON BARRIERS (SOIL COVERS) AND OUTSLOPES

a) Excavation to flatten outslopes, 25000 c.y. using
D8L at 420 c.y./hr, at $120/hr, or $0.29/ c.y. $7,250 – missed

b) Spread and compact cover soil (soil excavated from
diversion channels, hauled, and spread under that cost item)

Leach Tanks	192000 c.y. x	$2.51 =	$482,400 •9
Evaporation Ponds	29000 c.y. x	$2.51 =	$72,863 •10
Totals =	221000 c.y.	*	$562,513

CONSTRUCTION OF ROCK COVER AND RIPRAP

Assumes that all rock is excavated locally from San Miguel River valley
Rock is screened, then hauled by truck 3 mi., dumped and spread

a) Rock excavation -
Assume rock excavated by D8L ($120/hr) at 420 cy/hr,
loaded into screen plant by CAT 988 ($101/hr) at 270 cy/hr
Excavation cost is then $0.66/cy
Evap. pond vol. = 6000 c.y.
Outslope vol. = 12000 c.y.
Bank riprap + scour protection vol.= 4640 c.y.

Total vol 22640 c.y. x 0.66 = $14,942

b) Rock Screening 270 cy/hr capacity
Plant rental and operating costs per month

grizzly	$4,000
cone and screen	$15,000
conveyors, generators, etc.	$30,000
fuel and maintenance	$15,000
Total	$64,000 /mo

At 80% availability and 20 days/mo., monthly
output in c.y. is 34560
cost/c.y. = $1.85
For 22640 c.y., estimated cost is $41,884

c) Hauling

Assume highway haulers with 15 cy boxes, 50 min/hr,
6 mi roundtrip at 20mph ave. for 0.3 hr cycle time
Cost per truck = $45
2.8 cycles per 50 min = 42 cy/hr
Hauling cost per c.y. = $1.07

Total Cost to haul and dump 22640 c.y. of rock = $24,257

Unit Cost to excavate, screen, haul and dump= $3.58
Total cost to supply 22640 c.y. rock to placement location = $81,084 • 11

d) Spread Outslope Rock

Assume CAT 14G grader at $69/hr and 270 cy/hr, = $0.26/cy
For 12000 c.y. of rock cover, total cost = $3,120 • 12

e) Spread Evaporation Pond Cover Rock

Assume CAT 14G grader at $69/hr and 270 cy/hr, = $0.26/cy
For 6000 c.y. of rock cover, total cost = $1,560 • 13

f) Floodplain riprap and scour protection

Scour trench excavation and backfill - "V" trench using D8L at $120/hr and 470 cy/hr

Central floodplain - ave. bank ht. 2.25', trench depth 5.2', cut at 2:1 outside 0.5:1 inside, for 1700 feet west bank 1100 feet east bank, for total excav.= 3505 c.y. 916 cy fill +592

East floodplain - ave. bank ht. 1.5' trench depth 4.6', cut same as central trench, for 1100 west bank only for total excav.= 1080 c.y. 745 cy

Evaporation Pond - trench 5.7' deep on west and 3.0' deep on north and east
480'x40.6 ft^2 + (350+330+480)x11.25 ft^2 = 1205 c.y.

Total excav. 5790 c.y. at 470 cy/hr and $120/hr = $1,478
Total backfill ~~1585~~ 2253 c.y. at 470 cy/hr and $120/hr = ~~$405~~ 575

Riprap Placement

Assume riprap on bank and in scour trench is 1.5 ft thick, on 2H:1V slope. placement rate of 50 c.y./hr

Central/west side = 16.7'x1.5'x1700'/27= 1577 c.y.
Central/east side = 16.7'x1.5'x1100'/27= 1021 c.y.
East/west side = 13.7'x1.5'x1100'/27= 837 c.y.
Evaporation Pond perimeter = 480'x1.5'x12.7'
+(350+330+480)'x1.5'x6.7' = 430 338 = 770 cy

Placed with D8L at $120/hr and 50cy/hr 4205 c.y. = $10,092

Total riprap and scour protection placement cost $11,975 • 14

pg1 ↑
pg2 ↓

REVEGETATION

Estimate 89 acres x $550/acre (1986 cost x 1.1) = $48,950 • 15

E ④

ESTIMATES OF DEMOLITION QUANTITIES AND COSTS

DURITA MILL FACILITIES AND EQUIPMENT

Facility or Equipment	Map Location Number	--- Dimensions in feet --- Width/ Diameter	Length	Height ---	Dismantled Volume (1) ft^3	Tonnage (2)	Demolition Cost (3)	Foot Note Reference
PROCESS (PLANT) AREA								
Quonset Building	1	30	50		109	27	salvage	1a,2a,3a
Pumps (14)	1a					2.5	salvage	3c
Motors (25)	1b					3.0	salvage	3c
Valves (50)	1c					1.9	salvage	3c
Grating	2	6	8	0.5	14	4	salvage	1c,2a,3b
Tanks (2)	3	12		14	11	3	salvage	1c,2a,3b
Process (Plant) Building	4							
Structure		40	165	28	10739	2636	salvage	1a,2a,3b
Concrete Floor		40	165	0.5	3300	248	bury in place	3e
Boilers (2)		5.5		14.5	103	25	salvage	1b,3b
Heat Exchangers (7)								
					54	13	$10	1b,3b
					34	8	$6	1b,3b
					64	16	$12	1b,3b
					51	13	$10	1b,3b
					68	17	$13	1b,3b
					20	5	$4	1b,3b
					41	10	$8	1b,3b
Grating with Chute		20	40	0.25	32	8	$841	1c,2a,3b
Carbon Filter Press		5.5	15	5	124	30	salvage	1b,2a,3c
Plates (58)						4	salvage	1b,2a,3c
Tanks, below grade (2)	5	7.5	37	9	250	61	$722	1c,2a,3b
Concrete Pads with Columns	6							
Pads (2)		37	64	1	4736	355	bury in place	3e
Columns (70)		1.5	8	1	840	63	$3,469	3e
Tank	7	12		16	181	44	$900	1c,2a,3b
Tank/Agitator	8	6		5.5	16	4	salvage	1c,2a,3b
Water Storage Tank	9	4		11.5	14	4	$180	1c,2a,3b
Concrete Pad	10	14.5	33	1	479	36	bury in place	3e
Concrete Pad	11	15	49	0.5	368	28	bury in place	3e
Sodium Chloride Tank	12	8		8	40	10	salvage	1c,2a,3b
Sodium Chloride Tank	13	8		16	80	20	salvage	1c,2a,3b
Tank/Agitator	14	3		8	6	1	salvage	1c,2a,3b
Tank	15	4		25	31	8	$360	1c,2a,3b
Concrete Pad	16	11	20	0.5	110	8	bury in place	3e
Concrete Barriers (2)	17	3	26	0.67	105	8	$644	3e
Concrete Pad	18	26	26	0.5	338	25	bury in place	3e
Concrete Pad	19	30	76	0.5	1140	86	bury in place	3e
Concrete Pad	20	20	36	0.5	360	27	bury in place	3e
Laboratory Trailer	21	10	40	8	294	72	salvage	1a,3b
Metal Shed		10	10	6	67	16	salvage	1a,3b
Pad		11	11	0.5	61	5	$500	3e
Concrete Pad	22	20	20	0.5	200	15	bury in place	3e
Concrete Tank	23	8	24	3	112	8	$30	2b,3a
Concrete Pads (5)	24	12		1	565	42	bury in place	3e
Raffinate Pond Liners (4)	44	80	80	0.05	1280	51	$768	3f

E ⑤

ESTIMATES OF DEMOLITION QUANTITIES AND COSTS

DURITA MILL FACILITIES AND EQUIPMENT

Facility or Equipment	Map Location Number	--- Dimensions in feet --- Width/ Diameter	Length	Height	Dismantled Volume (1) ft^3	Tonnage (2)	Demolition Cost (3)	Foot Note Reference
ORE PREPARATION AREA								
Transformers	1	(to be salvaged)					salvage	
Ore Bin	2	11		26	247	61	$1,183	1c,2a,3b
Agglomerator	3	10		30	236	58	$1,446	1c,2a,3c
Steel Support Structure	4	8	30	30	72	18	$380	1e,2a,3g
Feeder Bin	5	11	18	5	99	24	$795	1c,2a,3b
Concrete Support	6							
one wall		18.5	8	1	148	11	$40	2b,3a
two walls		20	8	1	160	12	$43	2b,3a
Acid Tanks (8)	7	12		30	4072	1000	salvage	1c,2a,3b
Fuel Storage Tank	8	24		16	724	178	salvage	1c,2a,3b
Dryer	9							
(all components have been decontaminated and certified for release from site. Dryer will be salvaged.)								
Ore Receiving Section								
Grizzly	10a	10	30	0.5	45	11	bury in place	3b
Storage Bin	10b	10	15	7	50	12	bury in place	3a
Corrugated Metal Tunnel	10c	14	24		11	3	bury in place	
Grating	11	6	21	0.5	6	2	bury in place	1c,2a,3a
Crushing and Scale Section								
Concrete Pad	12	10	22	0.5	110	8	bury in place	3e
Crusher Pad	13	10	22	0.5	110	8	bury in place	3e
Crusher	14	3	2.5		5	1	$33	1b,3c
10 - 55 gal drums w/tailing	15				74	5	$50	4
Scale Pads (2)	16a	6	4	1	48	4	bury in place	3e
Scale Pads (3)	16b	6	1.5	1	27	2	bury in place	3e
Shop		5	5	4	30	7	$71	1b,3b
Building	17	42	42	18	1985	487	salvage	1a,3b
Trailers (2)	17a	8	40	8	364	89	salvage	1a,3b
Concrete Floor	17b	25	40	1	1000	75	bury in place	3e
Miscellaneous								
Concrete Barriers (11)	18	3	26	0.67	575	43	$3,544	3e
Pipe, 6"		0.5	600		9	2	$4,800	3d
Pipe, 4"		0.33	800		5	1	$4,480	3d
Pipe, 1-3"		0.25	400		2	0.4	$2,240	3d
Electrical Poles		(to be salvaged)						

ESTIMATED TOTAL COST OF DEMOLITION, INCLUDING $5000 FOR MOBILIZATION = $32,584

NOTES:

1) Estimates of dismantled volumes based on a) buildings - dimensions x 0.05 for interior, + steel wall area
x 0.1 or concrete wall area x 0.5, + 0.1 x 1.1 x roof dimensions; b) heavy equipment - volume x 0.3;
2) c) light equipment - volume x 0.1; d) concrete bins - volume x 0.2: e) 0.01 x volume for light frames
3) Tonnage = volume x a) 490/2000 for steel; b) 150/2000 for concrete and other materials
Demolition cost = a) $0.27/ft^3 for concrete; b) $0.19/ ft^3 for steel plus $2.61/ft x 40 ft/100 ft^2
of surface area for torch cutting of tanks and other large steel equipment; c) $25/T for machinery
removal; d) $5.60 to 11.20/ft. for steel pipe; e) $4.13/ft^2 for concrete slabs; f) $0.12/ft^2 for removal
and disposal of liner membranes and other fabrics; g) $95/hr for removal by dozer
4) To be buried under radon barrier in outslope of LT-201.

All unit prices except 3f from Means Site Work Cost Data, 1991, pp.19-22

See Figure 3 for plant facilities locations, Figure 4 for ore preparation facility locations.

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TABLE 1A

PROCESS AREA FACILITIES

Facility	Size	Salvage	On-Site Disposal
1. Quonset	30'w x 50'l x 15' at center	X	
1a. Pumps (14)		X	
1b. Motors (25)		X	
1c. Valves (50)		X	
2. Grating	6'w x 8'l x 0.5't with 4 legs	X	
3. Tanks (2)	12'dia x 14'l x 0.042't	X	
4. Process Building	40'w x 165'l x 28'h	X	
4a. Boilers (2)	5.5'dia x 14.5'l x 0.042't	X	
4b. Heat Exchangers (7)	1 ea. 54 sq.ft., 34 sq.ft., 64 sq.ft., 51 sq.ft., 67.5 sq.ft., 20 sq.ft. & 41 sq.ft.		
4c. Grating w/metal chute	40'w x 20'l x 0.25't		
4d. Carbon Filter Press	5.5'w x 15'l x 5'h	X	
5. Tanks below grade (2)	7.5'w x 37'l x 8'd		X
6. Concrete Pads (2) with 70 support structures	37'w x 64'l x 1.0't		X
7. Tank	12'dia x 16'l x 0.042't		X
8. Tank/Agitator	6'dia x 5.5'l x 0.042't		X
9. Tank/Water	4'dia x 11.5'l x 0.042't		X
10. Concrete Pad	14.5'w x 33'l x 1.0't		X
11. Concrete Pad	15'w x 49'l x 0.5't		X
12. Tank (Sodium Chloride)	8'dia x 8'h x 0.042't		X
13. Tank (Sodium Chloride)	8'dia x 16'h x 0.042't		X
14. Tank/Agitator	3'dia x 8'h x 0.042't		X
15. Tank	4'dia x 25'h x 0.042't		X
16. Concrete Pad	11'w x 20'l x 0.5't		X
17. Concrete Barriers (2)	3'base x 0.67' top x 26'l		X
18. Concrete Pad	26'w x 26'l x 0.5't		X
19. Concrete Pad	30'w x 76'l x 0.5't		X
20. Concrete Pad	20'w x 36'l x 0.5't		X
21. Laboratory Trailer	10'w x 40'l x 8'h	X	
22. Concrete Pad	20'w x 20'l x 0.5't		X
23. Concrete Tank	8'w x 24'l x 3'd		X
24. Concrete Pads (5)	12'dia x 1.0't		X
25. Raffinate Ponds (4)	80'w x 80'l x 10'd		X

TABLE 1B

ORE PREPARATION FACILITIES

Facility	Size	Salvage	On-Site Disposal
1. Transformers (3 lg. 2 small)		X	
2. Ore Bin	11'dia x 26'h x 0.042't		X
3. Agglonerator	10'dia x 30'l x 0.3't		X
4. Steel Support Structure	8'w x 30'h		X
5. Feeder Bin	11'w x 18'l x 5'h		X
6. Concrete Support			
- One Wall	18.5'l x 8'h x 1.0't		X
- Two Walls	20'l x 8'h x 1.0't		X
7. Acid Tanks (8)	12'dia x 30'h x 0.042't	X	
8. Fuel Storage Tank	24'dia x 16'h x 0.042't	X	
9. Dryer (certified clean for off-site removal)		X	
10. Ore Receiver Section			
10a. Grizzly	10'w x 30'l		X
10b. Metal Bin	100 ton capacity		X
10c. Metal Tunnel	14'dia x 24'l		
11. Grating	6'w x 22'l x 0.5't		X
12. Concrete Pad	10'w x 22'l x 0.5't		X
13. Crusher Concrete Pad	10'w x 22'l x 1.5't		
14. Crusher	3'dia x 2.5'l x 0.042't	X	
15. 55-gal Drums (10)			
16. Scale Pad (5)	6'l x 4'h x 1.0't		X
17. Shop	42'w x 42'l x 18'h	X	
17a. Trailers (2)	8'w x 40'l x 8'h	X	
17b. Concrete Floor	25'w x 40'l x 1.0't	X	
18. Concrete Barriers (11)	3'base x 0.67'top x 26'l		X

TABLE 2A

ROAD SAMPLE GAMMA READINGS

Hecla Gate to Hwy. 90 at 1/10-mile intervals

	uR/hr
Gate	24
0.1	17
0.2	30
0.3	34
0.4	32
0.5	20
0.6	19
0.7	13
0.8	13
0.9	22
1.0	18
Junction (1.1)	15

Hecla Gate to Process Facility (South Road) at 1/10-mile intervals

	uR/hr
0.1	32
0.2	50
0.3	48
0.4	20
0.5	23
Process Plant	21

Hecla Gate to Ore Receiving Section (North Road) at 1/10-mile intervals

	uR/hr
0.1	18
0.2	39
0.3	95
0.4	21

TABLE 2B

RADIOLOGICAL SOIL CHARACTERISTICS

Durita Site

-----Concentrations in pCi/G-----

Location	Radium-226		Uranium-238		Thorium-230
	0 - 6"	6 - 12"	0 - 6"	6 - 12"	0 - 6"
Center	17.0	48.0	5.2	13.5	
A 200	8.1	11.0	2.0	3.5	
A 300	2.9		1.4		
A 779	25.0	27.0	6.6	6.9	13.0
B 200	36.0	18.0	8.1	3.5	26.0
B 300	19.0		4.6		
B 600	25.0	2.7	1.4	1.7	
C 200	44.0		11.8		20.0
C 400	5.9		1.7		
C 700		38.0		9.5	
D 200	4.9	9.8	2.0	2.6	1.9
D 300	7.6		3.5		
D 500	2.3		1.15		
(0-3")	5.1		1.15		
(3-6")	1.8		0.58		
E 200	20.0	17.0	5.5	4.3	6.1
(12-18")	4.1		2.3		
E 500	1.7	2.1	1.15	0.58	
(0-3")	7.9		1.7		
(3-6")	3.9		1.15		
(12-18")	0.7		0.86		
F 200	62.0	25.0	17.0	7.5	40.0
F 400	8.5		2.6		
F 500	1.1			0.29	
(0-3")	1.6			0.29	
(3-6")	1.9			0.58	
G 200	88.0	17.0	28.8	7.5	82.0
G 500	0.8		0.58		
H 100	95.0	52.0	24.5	16.13	50.0
H 200	56.0	8.5	18.7	2.9	
H 400	18.0	26.0	5.47	6.6	
H 500	1.2		0.58		

TABLE 2B continued

RADIOLOGICAL SOIL CHARACTERISTICS

Durita Site

-----Concentrations in pCi/G-----

Location	Radium-226		Uranium-238		Thorium-230
	0 - 6"	6 - 12"	0 - 6"	6 - 12"	0 - 6"
I 200	2.2	2.3	1.4	1.4	
I 500	25.0	12.0	7.8	4.3	14.0
J 100	36.0	13.0	9.8	3.7	19
J 200	2.7	1.3	1.15	0.58	
J 600	2.7		0.58		
K 100	270.0	234.0	71.4	54.1	
K 200	1.3	2.8	0.86	1.15	
K 400	52.0	15.0	14.1	3.5	28.0
K 600	25.0	6.6			
K 800-900	1.2			0.58	
L 100	3.5	2.2	1.7	1.7	1.2
L 200	9.2	6.3	2.6	1.7	
L 700-800	0.5		0.58		
M 100	220.0	200.0	49.5	75.5	120.0
M 900	4.7		1.4		
M 1600		1.0	1.4		
N 100	18.0	13.0	5.2	3.5	
N 200 (3-8")		1.6		1.15	
N 1200	19.0	1.6	3.2	0.86	
N 1500		0.5		2.9	
O 1100-1200	2.1	1.2	0.86	0.58	
O 1300	2.2	1.2	0.86	0.58	
P 200 (3-8")		3.3		1.15	
P 700		2.9		1.7	
Arroyo W.	0.4		0.58		
Charcoal Wash	2.2	1.2	8.93	2.6	

TABLE 2C

QUALITY CONTROL SOIL SAMPLE ANALYSES

pCi/g

Location	Laboratory 1		Laboratory 2	
	Ra-226	U-238	Ra-226	U-238
A779 (0-6")	25.0	6.6	29.0	5.42
B300 (0-6")	19.0	4.6	25.0	4.74
C200*(0-6")	44.0	11.8	73.0	10.8
C400 (0-6")	5.9	1.7	6.3	0.43
E500 (0-6")	1.7	1.15	3.9	0.54
E500 (12-18")	0.7	0.86	1.6	0.51
F500 (0-6")	1.1	0.29	1.7	0.41
G500 (0-6")	0.8	0.58	1.2	0.135
H400*(0-6")	18.0	5.47	35.0	6.77
I200 (0-6")	2.2	1.4	4.8	0.71
I500 (0-6")	25.0	7.8	22.0	6.43
K800-900	1.2		1.0	
L700-800	0.5	0.58	2.0	0.61
N1200 (0-6")	19.0	3.3	22.0	4.1
O1300 (0-6")	2.2	0.86	1.8	0.37
O1100-1200	2.1	0.86	3.4	0.74
Baseline #1	1.1	0.57	2.6	0.41
Baseline #4	0.8	0.57	1.3	0.3

*indicates concentrations of Ra-226 reported by Laboratory 1 which differ from the concentration of Ra-226 reported by Laboratory 2 by more than 2 standard deviations (95% confidence level)

TABLE 2D

RADIOLOGICAL SURVEY OF DURITA SITE

Location	Gamma, uR/hr		Ra-226, pCi/g
		Delta	0 - 6"
O-1300'	11		2.2
K-800-900'	12		1.2
N-1500'	12		0.5
W of Leach tanks 13	13		0.4
O-1100-1200'	14		2.1
L-700-800'	16		0.5
F-500'	17		1.1
G-500'	17		0.8
Charcoal Wash	17		2.2
E-500'	18		1.7
			7.9 (0-3")
			3.9 (3-6")
H-500'	19		1.2
J-600'	20		2.7
M-900'	22		4.7
A-300'	24		2.9
K-200'	26	7	1.3
D-500'	27		2.3
			5.1 (0-3")
			1.8 (3-6")
B-600'	28		4.0
J-200'	29		2.7
I-200'	34		2.2
P-200'	34		3.3 (3-8")
N-1200'	36		19.0
N-200'	37	8	1.6 (3-8")
L-200'	40		9.2
C-400'	41		5.9
F-400'	42		8.5
E-200'	44	14	20.0
B-300'	44		19.0
L-100'	45	4	3.5
A-200'	55		8.1
D-200'	65	31	4.9
D-300'	65	31	7.6
N-100'	65	23	18.0
A-779'	70	47	25.0
B-200'	70		36.0
K-600'	70	51	25.0
Center	70	20	17.0
H-400'	75	53	18.0
C-200'	90		44.0
K-400'	105	65	52.0

TABLE 2D continued

RADIOLOGICAL SURVEY OF DURITA SITE

Location	**Gamma, uR/hr**		**Ra-226, pCi/g**
		Delta	0 - 6"
F-200'	110	60	62.0
J-100'	120	65	36.0
I-500'	128	83	25.0
H-200'	130	65	56.0
G-200'	160	90	88.0
H-100'	200	140	95.0
K-100'	375	255	270.0
M-100'	380	260	220.0
Background	10		1.0

Uncorrected:

R2 = 0.94; r = 0.97
Ra-226, pCi/g = μR/hr x 0.64 - 16.65
35 μR/hr = 5.75 pCi/g Ra-226

Corrected Correlation - (with delta readings)

R2 = 0.92; r = 0.96
Ra-226, pCi/g = μR/hr x 0.95 - 17.71
25 μR/hr = 6.05 pCi/g Ra-226

TABLE 3

PHYSICAL PROPERTIES OF TAILINGS AND SOILS

	Tailings	Existing Cover	Borrow Soil
USCS Classification	SM, SC	SC, CL	CL/SC
Average in-place dry density, pcf.	79-99 (1)	103 (2)	N/A
Maximum dry density, pcf	N/A	N/A	116
Porosity at in-place density	0.52 (1)	0.39 (2)	0.32 (3)
Long-term moisture, weight %	16.2 (1)	10.36 (4)	9.98 (4)
Dispersivity	N/A	N/A	ND1 (5)
Permeability, cm/sec	N/A	N/A	1.9×10^{-7} (6)
Allowable shear stress, psf	N/A	N/A	0.095 (7)

NOTES:

1) Based on calculation from -15 bar moisture tests by Daniel B. Stephens and Associates
2) From field density tests per ASTM D-1556 by Vinyard and Associates.
3) From compaction tests per ASTM Method D-698 by Vinyard and Associates.
4) Based on calculation using Egn. 5, USNRC Reg. Guide 3.64, and clay fraction from hydrometer tests by Vinyard and Associates.
5) Pinhole dispersivity test by Vinyard and Associates.
6) Falling head permeability tests on soil compacted to 95% maximum dry density, by Vinyard and Associates.
7) Based on soil classifications and methods in Calculation C4.

TABLE 4

CHEMICAL CHARACTERISTICS OF SALTS

		Evaporation Pond Samples[1]			
Analyte	Unit	EP1	EP2	EP3	EP4
pH	Unit	2.20	1.85	2.15	2.30
Chloride	mg/kg	7,500	8,000	13,000	10,500
Sulfate	mg/kg	220,000	178,000	218,000	220,000
Arsenic	mg/kg	144	380	4.5	350
Barium	mg/kg	4.0	6.5	<0.1	3.0
Calcium	mg/kg	2,580	9,800	35	2,140
Iron	mg/kg	4,900	24,200	43.3	6,930
Potassium	mg/kg	400	2,800	60	1,700
Molybdenum	mg/kg	<2	<2	<0.5	<2
Sodium	mg/kg	16,400	23,600	540	0.5
Lead	mg/kg	22	44	29,100	54
Gross Alpha	pCi/g	1225 ± 46.8	805 ± 38.2	872 ± 39.6	3171 ± 74.8
Gross Beta	pCi/g	112 ± 7.2	75.5 ± 6.2	96.3 ± 6.8	288 ± 10.7
Radium-226	pCi/g	4.9 ± 6.7	5.5 ± 0.7	6.1 ± 0.7	27.8 ± 10.7
Thorium-230	pCi/g	1091 ± 14.0	726 ± 11.4	467 ± 9.2	2294 ± 20.3
Uranium-234	pCi/g	22.0 ± 5.4	11.8 ± 4.2	28.2 ± 4.4	6.8 ± 2.4
Uranium-235	pCi/g	0.7 ± 1.2[2]	0.5 ± 1.1[2]	2.0 ± 1.7	0.1 ± 0.7[2]
Uranium-238	pCi/g	16.8 ± 5.6	5.6 ± 3.2	22.1 ± 3.8	4.6 ± 2.0

<u>Notes</u>:

[1] All ponds sampled on April 20, 1991.

[2] Activity less than lower level of detection.

TABLE 5

HYDROLOGIC PARAMETERS OF UPSTREAM WATERSHEDS

	WATERSHED			
PARAMETER	WEST	MID 1	MID 2	EAST
Area, acres	494.0	32.5	122.0	155.7
Longest Flow Path (channel), ft.	14500	3950	6900	9150
Maximum Change in Elevation, ft.	1705	469	904	1050
Longest Flow Path Gradient	0.1176	0.1187	0.1310	0.1148
Time of Concentration, tc, hrs.	0.47	0.17	0.26	0.34
PMP 1-hour Storm Rainfall Depth in tc, inches	6.85	4.70	5.85	6.40
PMF Peak Discharge, cfs	4280	528	1667	1780
Flow Concentration Factor	3	3	3	3

TABLE 6

REVEGETATION SEED MIXTURE

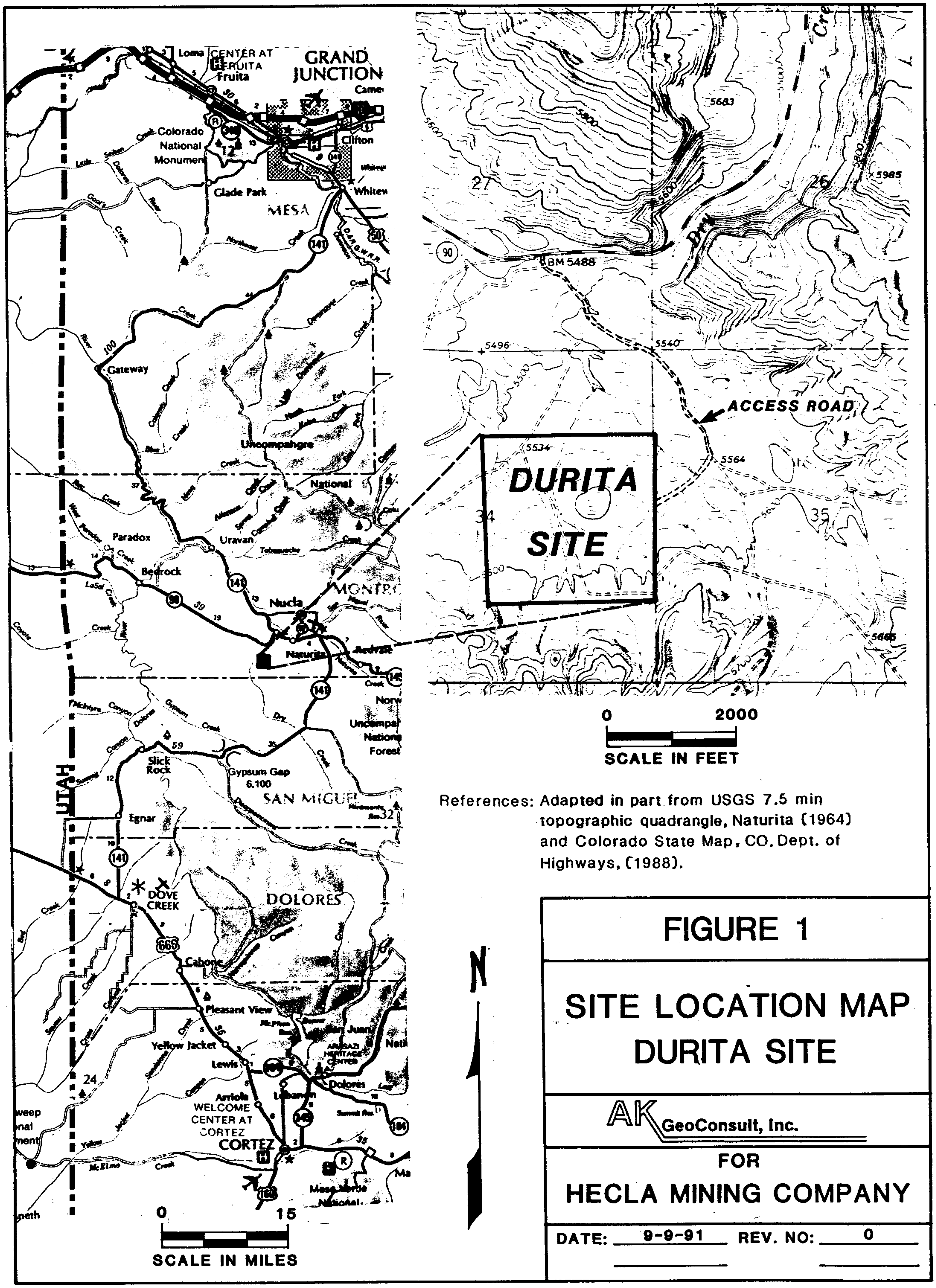
SCIENTIFIC NAME	COMMON NAME (1)	LBS PLS/ACRE
Hilaria jamesii	Galleta NS	1.0
Bouteloua gracillis	Blue Grama NB	1.0
Orizopsis hymenoides	Indian Ricegrass NB	2.0
Sporobolus cryptandrus	Sand Dropseed NB	0.25
Agropyron smithii	Western Wheatgrass NS	5.0
Agropyron desertorum	Crested Wheatgrass IB	3.0

(1)
NB - Native Bunch
NS - Native Sod
IB - Introduced Bunch
IS - Introduced Sod

TABLE 9

INCREMENTAL SURETY BOND RELEASE SCHEDULE

BOND RELEASE DATE	BOND RELEASE AMOUNT ($)	TASK NO.	TASK DESCRIPTION	TASK AMOUNT($)
7/30/92	33,440	I	Facility Decontamination	5,000
		II	Well Plugging (6/13)x($1600)	700
		III	Evaporation Pond Dewatering	24,700
			Contingency	3,040
12/15/92	175,240	I	Mill Demolition	32,600
			Soil Cleanup	25,000
		III	Excavation/Relocation of Salts	33,700
		IX	Radiological Surveys	8,000
			Decommissioning of Equipment/ Surveys/Smears	3,000
		X	Project Management (0.5 yr/1.5 yr) x ($171,000)	57,000
			Contingency	15,930
7/30/93	260,788	IV	Strip Vegetation	12,000
		V	Evaporation Pond Cover	72,900
		VI	Rock Screen, Haul, Dump	81,100
		VIII	Quality Control Testing (2 mo/5 mo) x ($35,200)	14,080
		X	Project Management (0.5 yr/1.5 yr) x ($171,000)	57,000
			Contingency	23,708
1/30/94	1,698,282		Release all of remaining bond except 25% of Task VII ($12,250) - Revegetation plus retain $30,000 for Hecla interim care prior to transfer of site to CDH. Remaining Bond $1,740,532 - $1,810,532 - $42,250 = $1,698,282	
12/31/95	42,250		Site transferred to the State of Colorado - Release remaining bond	



References: Adapted in part from USGS 7.5 min topographic quadrangle, Naturita (1964) and Colorado State Map, CO. Dept. of Highways, (1988).

FIGURE 1

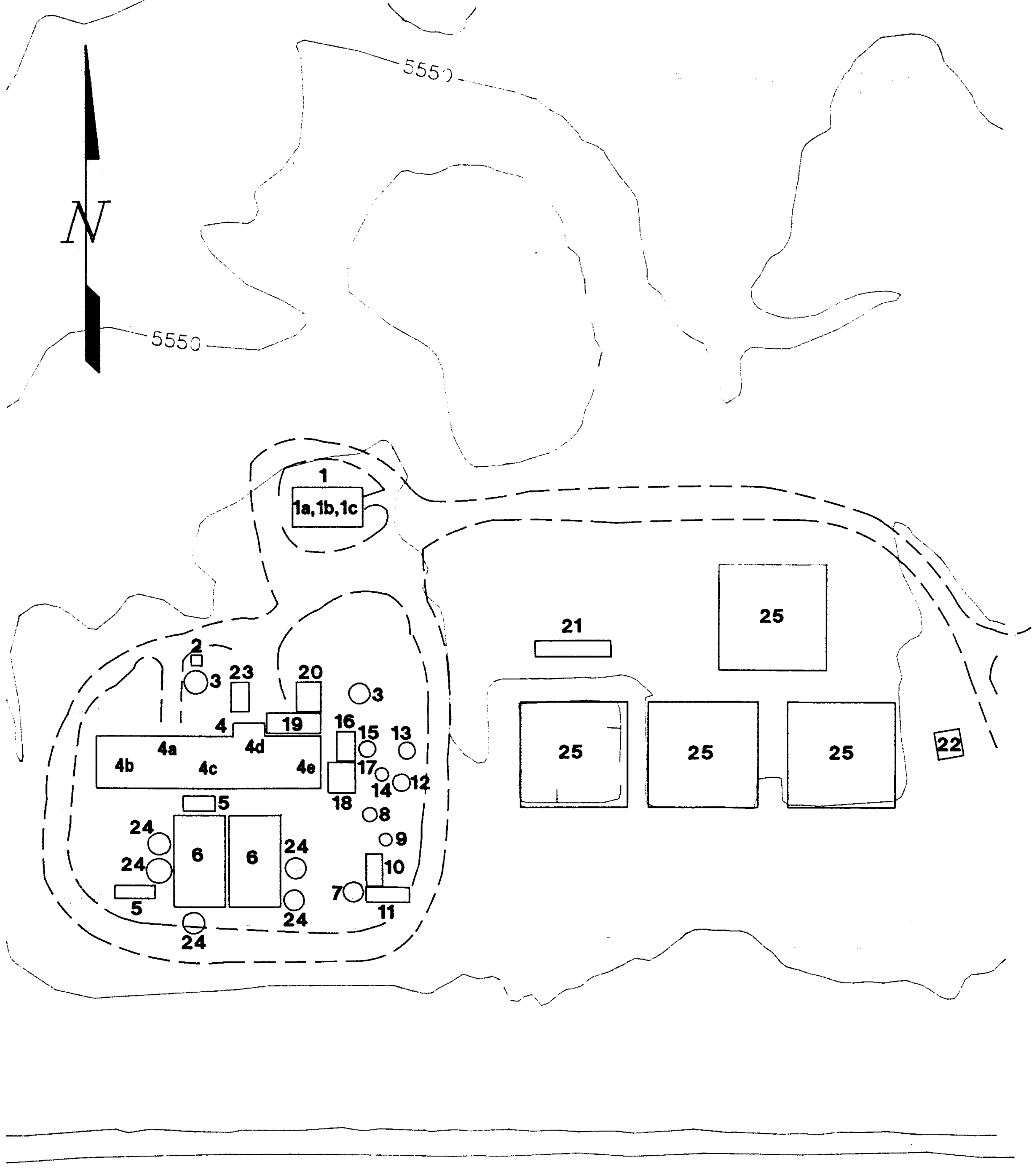
SITE LOCATION MAP
DURITA SITE

AK GeoConsult, Inc.

FOR

HECLA MINING COMPANY

DATE: 9-9-91 REV. NO: 0



EXISTING PLANT FACILITIES

1. QUONSET*
  1a. PUMPS*
  1b. MOTORS*
  1c. VALVES*
2. GRATING*
3. TANKS*
4. PROCESS BUILDING*
  4a. CONCRETE FLOOR
  4b. BOILERS*
  4c. HEAT EXCHANGERS
  4d. GRATING WITH METAL CHUTE
  4e. CARBON FILTER PRESS*
5. FIBERGLASS/METAL TANKS (BELOW GRADE)
6. CONCRETE PADS
7. TANK
8. TANK/AGITATOR*
9. WATER TANK
10. CONCRETE PAD
11. CONCRETE PAD
12. TANK (SODIUM CHLORIDE)*
13. TANK (SODIUM CHLORIDE)*
14. TANK/AGITATOR*
15. TANK
16. CONCRETE PAD
17. CONCRETE BARRIERS
18. CONCRETE PAD
19. CONCRETE PAD
20. CONCRETE PAD
21. LABORATORY TRAILER*
22. CONCRETE PAD
23. CONCRETE TANK
24. CONCRETE PADS
25. RAFFINATE PONDS

EXPLANATION

–5520– ELEVATION OF EXISTING SITE TOPOGRAPHY IN FT. MSL, CONTOUR INTERVAL=10FT

NOTES:

1) EXISTING TOPOGRAPHY BASED ON AERIAL PHOTOGRAPHY IN 1989 BY INTERMOUNTAIN TECHNICAL SERVICES.
2) SEE TABLE 1a FOR DETAILS OF EXISTING PLANT FACILITIES.
3) * DENOTES ITEM TO BE SALVAGED.

0 50 100 200 300
SCALE IN FEET

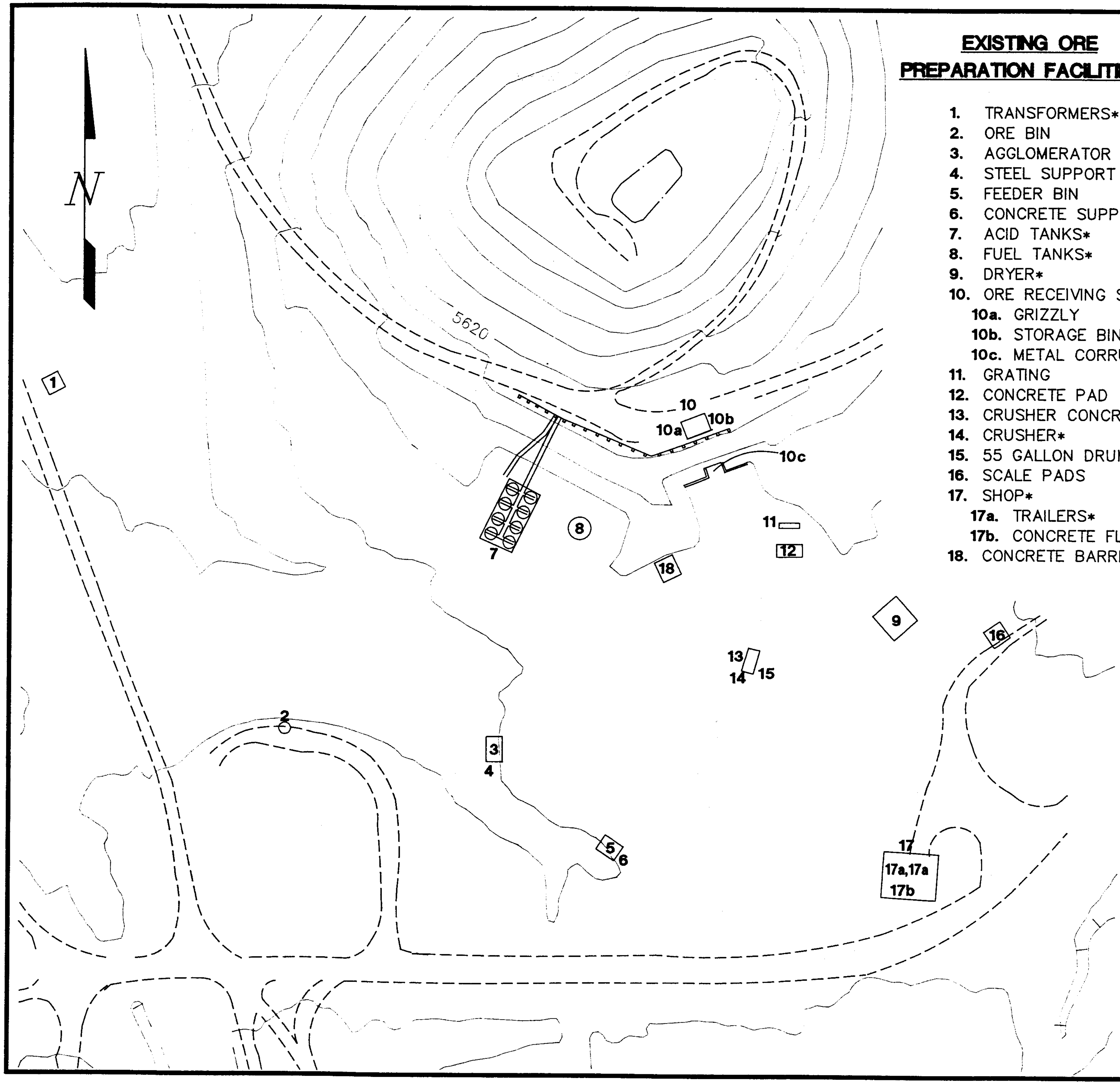
FIGURE 3

**EXISTING PLANT FACILITIES
DURITA SITE**

AK GeoConsult, Inc.

FOR
HECLA MINING COMPANY

DATE: 10-11-91 REV. NO.:



EXISTING ORE PREPARATION FACILITIES

1. TRANSFORMERS*
2. ORE BIN
3. AGGLOMERATOR
4. STEEL SUPPORT STRUCTURE
5. FEEDER BIN
6. CONCRETE SUPPORT
7. ACID TANKS*
8. FUEL TANKS*
9. DRYER*
10. ORE RECEIVING SECTION
    - **10a.** GRIZZLY
    - **10b.** STORAGE BIN
    - **10c.** METAL CORRUGATED TUNNEL
11. GRATING
12. CONCRETE PAD
13. CRUSHER CONCRETE PAD
14. CRUSHER*
15. 55 GALLON DRUMS
16. SCALE PADS
17. SHOP*
    - **17a.** TRAILERS*
    - **17b.** CONCRETE FLOOR
18. CONCRETE BARRIERS

EXPLANATION

—5520—	ELEVATION OF EXISTING SITE TOPOGRAPHY IN FT. MSL, CONTOUR INTERVAL=10FT

NOTES:

1) EXISTING TOPOGRAPHY BASED ON AERIAL PHOTOGRAPHY IN 1989 BY INTERMOUNTAIN TECHNICAL SERVICES.

2) SEE TABLE 1b FOR DETAILS OF EXISTING ORE PREPARATION FACILITIES

3) * DENOTES ITEM TO BE SALVAGED.

0 50 100 200 300
SCALE IN FEET

FIGURE 4

EXISTING ORE PREPARATION FACILITIES DURITA SITE

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FOR

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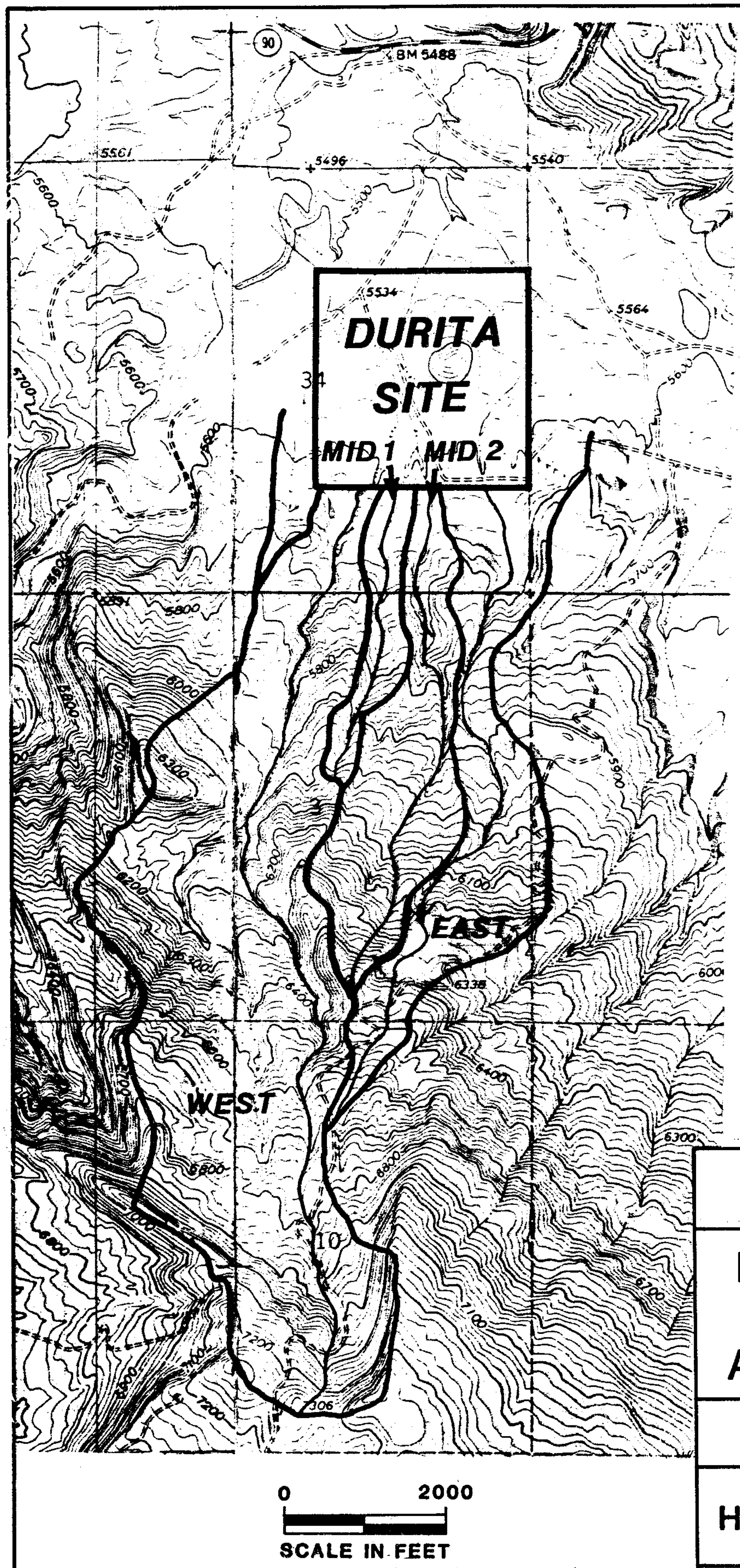
DATE: 09-19-91 REV. NO.:



N

LEGEND

Watershed Boundary

Longest Drainage Path in the Watershed

Note:

1) See Section 5.1.1 in text for explanation of watersheds

Reference: Adapted from USGS 7.5 min. topographic quadrangles, Naturita (1964) and Naturita NW (1948).

FIGURE 10

MAP OF UPSTREAM WATERSHEDS ABOVE DURITA SITE

AK GeoConsult, Inc.

FOR

HECLA MINING COMPANY

DATE: 9-9-91 REV. NO: 0

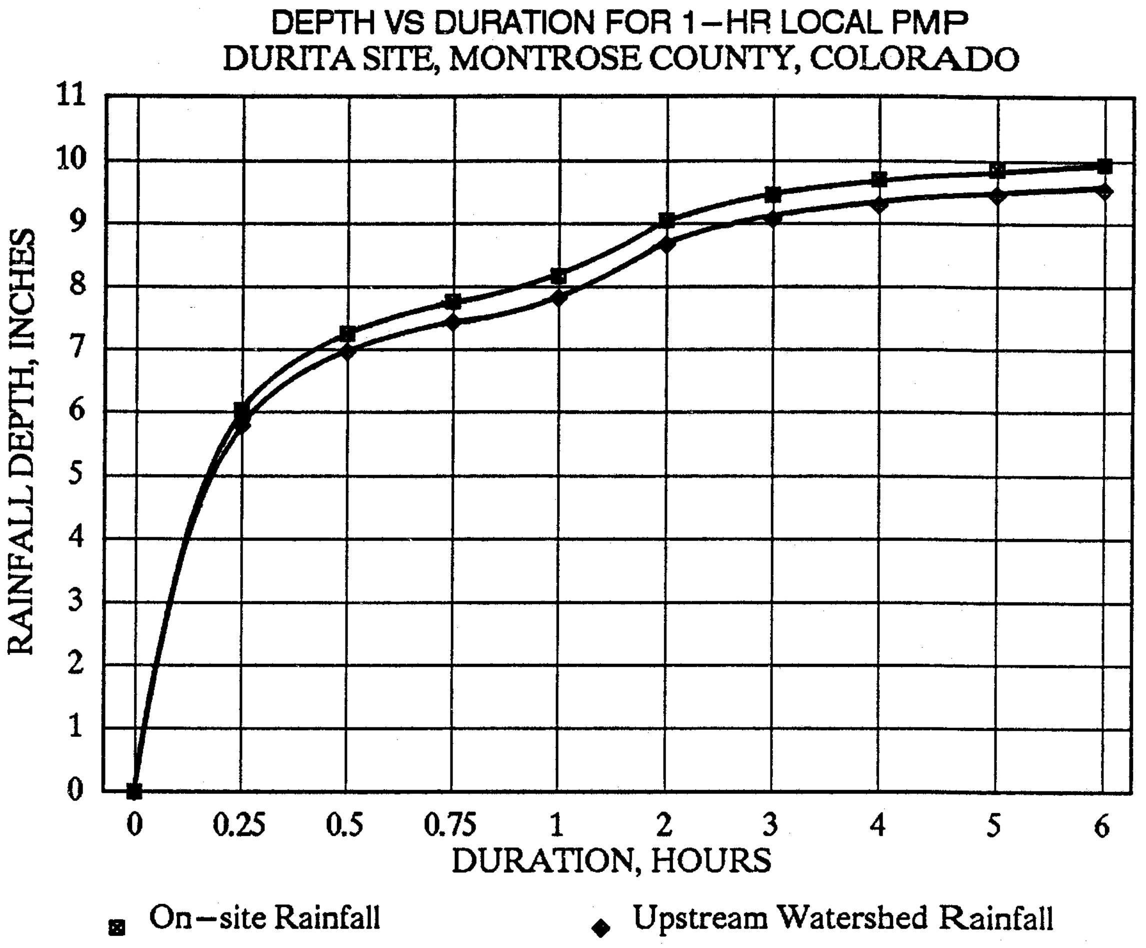


TABLE OF ONE-HOUR LOCAL PMP RAINFALL DEPTH VS DURATION (After Table 4.4, HMR 49)

6/1 Hr Ratio for Durita is 1.22 (Figure 4.7, HMR 49)

ONE-HOUR PMP IS: 8.4 inches at 5000 ft. elevation
97.0% or 8.15 inches at 5600 ft. elevation (1) Table 6.3A, HMR 49
92.7% or 7.81 inches at 6454 ft. elevation (2) Table 6.3A, HMR 49

DURATION HOURS	% OF 1-HR PMP	RAINFALL DEPTH, IN INCHES, AT AVERAGE ELEVATION OF: 5000 ft	5600 ft	6454 ft
0	0	0.00	0.00	0.00
0.25	74	6.22	6.03	5.78
0.5	89	7.48	7.25	6.95
0.75	95	7.98	7.74	7.42
1	100	8.40	8.15	7.81
2	111	9.32	9.05	8.67
3	116	9.74	9.45	9.06
4	119	10.00	9.70	9.29
5	121	10.16	9.86	9.45
6	122	10.25	9.94	9.53

Plot of data is adaptation of Figure 12.10, HMR 55A, to site rainfall

(1) Average elevation of site in vicinity of leach tanks
(2) Average elevation of watershed upstream of site

FIGURE 11

PMP RAINFALL DEPTH VS DURATION

Submitted by Hecla 12/3/93

Datum M.S.L.

Monitor Well #	Bearing	Distance(FT)	Elevation(FT) Collar	Elevation(FT) Ground	Legal Subdivision Corner
8	N19°47'-07"E	4024.22	5611.68	5609.31	N.E COR. SEC 34 T46N R16W N.M.P.M.
9	N50°55'-11"E	3383.84	5548.77	5545.98	N.E COR. SEC 34 T46N R16W N.M.P.M.
10	N59°45'-18"E	3046.38	5533.95	5531.22	N.E COR. SEC 34 T46N R16W N.M.P.M.
11	N53°08'-56"E	2115.66	5530.36	5527.41	N.E COR. SEC 34 T46N R16W N.M.P.M.
12	N13°58'-59"E	1317.21	5532.81	5530.23	N.E COR. SEC 34 T46N R16W N.M.P.M.
13	N01°22'-47"E	2250.60	5559.77	5556.71	N.E COR. SEC 34 T46N R16W N.M.P.M.
14	N02°22'-33"	3766.94	5615.32	5612.68	N.E COR. SEC 34 T46N R16W N.M.P.M.

COLORADO REGISTERED PROFESSIONAL LAND SURVEYOR
RICHARD ODOM
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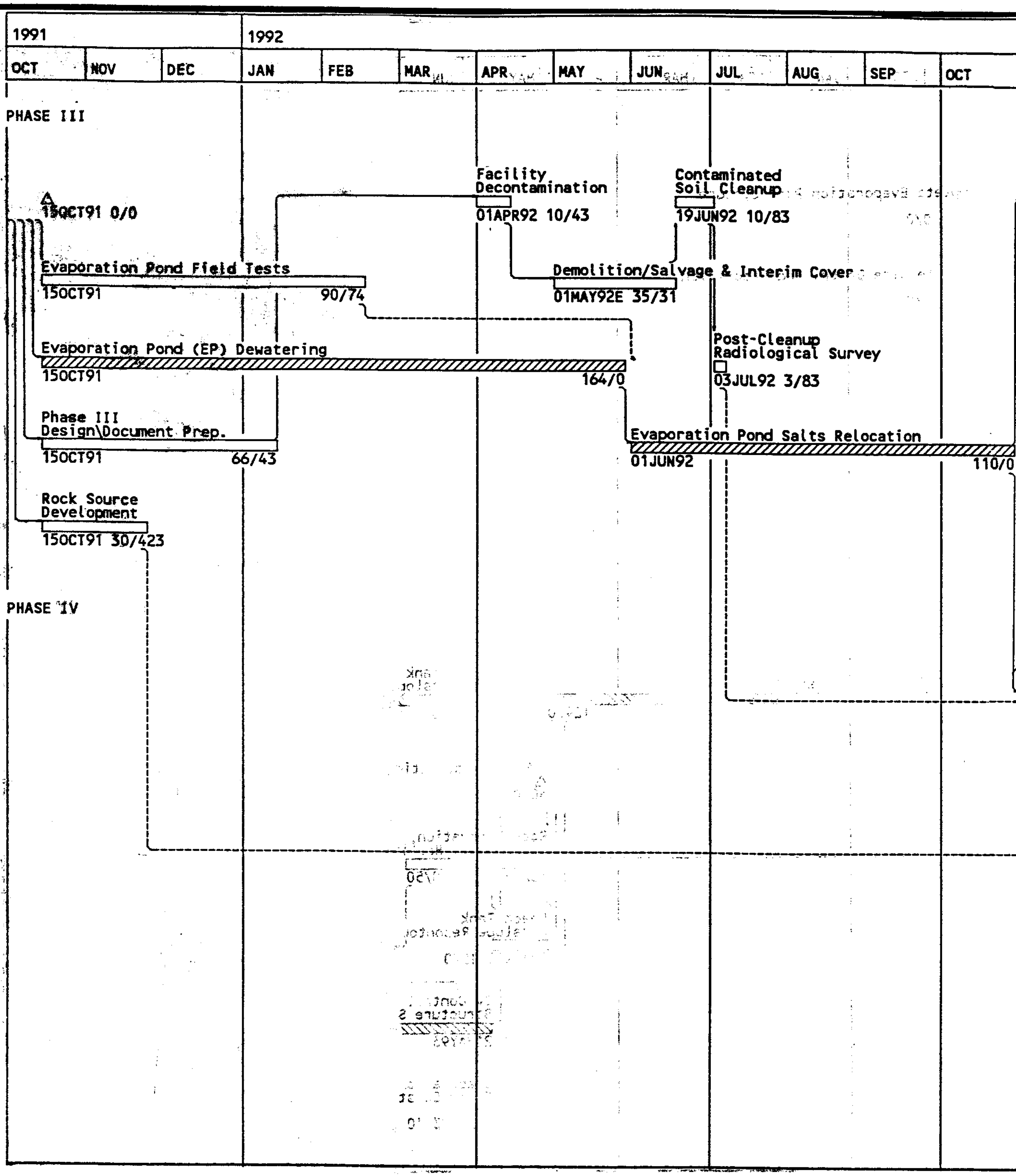
Richard H. Odom


1991
1992
OCT
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JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
PHASE III
15OCT91 0/0
Facility Decontamination
01APR92 10/43
Contaminated Soil Cleanup
19JUN92 10/83
Evaporation Pond Field Tests
15OCT91
90/74
Demolition/Salvage & Interim Cover
01MAY92E 35/31
Evaporation Pond (EP) Dewatering
15OCT91
164/0
Post-Cleanup Radiological Survey
03JUL92 3/83
Phase III Design\Document Prep.
15OCT91
66/43
Evaporation Pond Salts Relocation
01JUN92
110/0
Rock Source Development
15OCT91 30/423
PHASE IV