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THIRD SUPPLEMENT TO THE ENVIRONMENTAL REPORT FOR THE URANIUM MILL OF ATLAS MINERALS DIVISION OF THE ATLAS CORPORATION AT MOAB, UTAH

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FOR THE URANIUM MILL OF ATLAS MINERALS

DIVISION, ATLAS CORPORATION AT MOAB, UTAH

SECTION 1

INTRODUCTION

This document has been prepared as a supplement to the Environmental Report to assist the Atlas Minerals Division of the Atlas Corporation in complying with the U. S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.23, "Stabilization of Uranium-Thorium Milling Waste Retention System," for their Moab, Utah facility. Whereas, Supplement 2 to the Environmental Report presented the various alternatives for stabilization and their respective cost/benefit analysis, this third supplement delineates the radiological implications of the various stabilization schemes.

The purpose of this document is to define the potential radioactive contaminents characteristic of the milling tailings retention system and evaluate the radiological consequences of the various alternative stabilization programs. In addition, the monitoring and surveillance programs to be proposed during the long-term (at least 50 years) are presented in Section 6.

As previously discussed in the Safety Analysis Report, Environmental Report, and second supplement to the Environmental Report, the alternative stabilization programs proposed are evaluated to assure that the resulting dose exposures due to the presence of the tailings retention system after stabilization will be "as low as practicably achievable."

SECTION 2

TAILINGS RETENTION SYSTEM

2.1 INTRODUCTION

Uranium ores utilized in milling operations, such as the Atlas Moab Facility, contain various quantities of naturally occurring radionuclides. As shown in Figure 1, natural Uranium-238 decays into a series of other radioactive isotopes. Therefore, in the milling of the Uranium from the ore, many other radioactive isotopes are still present after the chemical Uranium extraction. These radioactive materials are contained in the liquid and solid wastes generated during the milling operation.

Since the concentrations of various radionuclides in the liquid and solid wastes (tailings) are often in excess of the U. S. Nuclear Regulatory Commission, 10CFR20, Appendix B, Table II, Maximum Permissable Concentrations (MPC), the tailings material is discharged into a large earth dam retention system. There are no releases of the tailings wastes from the tailings retention system. When milling operations are terminated, the liquid (water) gradually evaporates, leaving solid wastes within the retention system.

2.2 PHYSICAL CHARACTERISTICS

The tailings retention system was initiated upon plant startup in 1956. Since 1956, approximately three million tons of tailings material have been deposited into the tailings retention system (Safety Analysis Report, Section 1). During the next 15 years of proposed plant operation, approximately four million tons of tailings material are anticipated to be added to the tailings retention system (Safety Analysis Report, Section 1).

The proposed expansion to the tailings retention system to receive the future mill tailings, would result in a system comprising 115 acres and storing seven million tons of tailings.

A complete discussion of the engineering parameters (slope stability, etc.) is contained in the Safety Analysis Report, Environmental Report, and second supplement to the Environmental Report.

2.2.1 Tailings Properties

The ore utilized in the milling operation at the Moab Facility, contain a Uranium content (U_3O_8) of .20 to .25 percent (Safety Analysis Report, Section 1). The recovery of the Uranium from the ore is approximately 95 percent (Safety Analysis Report, Section 3). The tailings are therefore expected to contain .01 percent U_3O_8 and the same concentrations of other radionuclides present prior to milling.

Sampling of tailings material, cover material used on the tailings retention system embankments, tailings solution and well-water from wells around the tailings retention system have been obtained.

2.2.1.1 Sampling and Analysis

To document the radiological properties of the tailings material, soil samples were obtained from the tailings pile. Analysis of uranium and radium present indicate the content of uranium in the tailings material after drying.

Determination of the radiological properties of the liquid waste discharged into the tailings system was conducted to delineate

the levels of thorium and radium. Since thorium and radium are in secular equilibrium in the ore, it is conservative to assume secular equilibrium in the tailings waste.

Although the addition of the proposed acid-leach operation will result in an acid pH tailings waste, the acidity is expected to promote deposition of gypsum from the tailings solution. The gypsum deposition is expected to effectively seal the tailings retention system from ground seepage. Therefore, well water samples were taken to document the radium levels in ground water. These levels are not expected to change significantly.

2.2.1.2 Results

The results of the soil samples from the tailings material are presented in Table 2.1. The results indicate removal of the uranium from the ore and the presence (and non-removal) of radium and other uranium-decay products.

The results of the tailings solution samples are presented in Table 2.2. The results indicate a high concentration (above MPC) of radium and other uranium-decay products.

Well water sample results are presented in Table 2.3. The results indicate a reduction of several orders of magnitude from the radium concentration discharged into the tailings retention system presented in the previous table.

It can be concluded that the tailings material sampled clearly indicates the 95 percent U_3O_8 removal efficiency of the milling operation and the presence and secular equilibrium of thorium radium, and radon.

2.3 CALCULATED CONCENTRATIONS

As discussed in the previous section, the tailings material present in the tailings retention system consists of the anticipated concentrations and quantities of uranium, thorium, radium, and radon. To determine the concentrations of these radionuclides at the time of stabilization, calculations were made based upon design parameters, known concentrations and radon concentration model from Adams & Lowder, The Natural Radiation Environment.

2.3.1 Uranium Concentration in Tailings Solution

The concentration of natural uranium (U_3O_8) present in the tailings material is determined from the assay concentration of .20 to .25 percent and 95 percent removal. A resulting assay concentration of .01 percent or 2×10^{-7} μCi/ml (Table 4.2-1, Safety Analysis Report).

2.3.2 Thorium Concentration in Tailings Solution

The concentration of thorium (nat.) is expected to be in secular equilibrium with the uranium present in the original ore. This would result in a concentration of 1×10^{-7} μCi/ml (Table 4.2-1, Safety Analysis Report).

2.3.3 Radium Concentration in Tailings Solution

The concentration of radium-226 is expected to be in secular equilibrium with the thorium in the tailings material. This would result in a concentration of 1×10^{-7} μCi/ml (Table 4.2-1, Safety Analysis Report).

2.3.4 Radon Release Rate From Tailings Pond

Since Radon-222 is a noble gas it is expected to emanate as a constant source over the life of the tailings retention system. In addition, the long halflife of the radium parent nuclide (1600 years) assures that the production and secular equilibrium of the radon gas will remain relatively uniform over the long-term (50 year) maintenance period.

To calculate the radon rate released the following equation (Adams & Lowder) is utilized.

$$\text{Release} = A \left[-BC\sqrt{\frac{\lambda}{B/D}} \; e^{-\sqrt{\frac{\lambda}{B/D}}\,X} \right]$$

Where:

A = Area of tailings retention system = 115 acres = $4.65 \times 10^5\ m^2$

B = Effective diffusion coefficient = $\left(\text{Radon Diffusivity } \frac{cm^2}{sec}\right)^{1/}\left(\text{Voids in Tailings Solids}\right)$

$$\left(1.13 \times 10^{-5}\ \frac{cm^2}{sec}\right)\left(.5\right)^{2/} = 6 \times 10^{-6}\ \frac{cm^2}{sec}$$

C = Equilibrium concentration of radon with .25 percent ore = $\left(\text{Density } \frac{g}{ml}\right)\left(.0025\right)\left(2.16 \times 10^{-12}\ \frac{\text{parts Rn}}{\text{parts U}}\right)$ $\left(1.54 \times 10^5\ \frac{\text{RnCuries}}{g}\right) = (2.25)(.0025)(2.16 \times 10^{-12})$

$(1.54 \times 10^5) = 1.87 \times 10^{-3}\ \mu Ci/ml$

λ = Decay constant = $2.1 \times 10^{-6}\ sec^{-1}$ for Rn

D = Voids in cover material solids [2/] = .20

X = Distance from air into deposited tailings

[1/] From Adams & Lowder, The Natural Radiation Environment

[2/] Foundation Engineering, Peek, Hansen & Thornborn

Therefore, the diffusion of radon can be expressed:

$$\text{Release in } \mu\text{Ci/sec} = -12.8 \ \frac{\mu\text{Ci}}{\text{sec}} \ e^{-.26X}$$

where the negative sign indicates upward movement of the radon gas.

TABLE 2.1

RADIOLOGICAL PROPERTIES OF SOILS COLLECTED FROM TAILINGS PILE, ATLAS MINERALS, MOAB, UTAH FACILITY

Sample Site	Uranium	Radium
	----------------ml/g----------------	
Test Pit 5	6-20	354 ± 15
Test Pit 4	14-40	289 ± 7
Natural Soil Upstream from Facility (reference soil)	2-16	214 ± 15
River Bank	8-34	467 ± 15
Composite Tailings	negative*	212 ± 20

*Released uranium.

Taken from Table 2.4-7, Safety Analysis Report

TABLE 2.2

RADIOLOGICAL PROPERTIES OF WASTE WATER DISCHARGED INTO TAILINGS PILE, ATLAS MINERALS, MOAB, UTAH FACILITY

Time		Radium 226 In Discharge Water Into Tailings Pile µCi/ml
1967	Average Yearly	10.65
	Maximum	53.94
	Minimum	1.19
1968	Average Yearly	9.54
	Maximum	16.46
	Minimum	Nil
1969	Average Yearly	1.76
	Maximum	3.71
	Minimum	0.42
1970	Average Yearly	3.25
	Maximum	8.49
	Minimum	1.03
1971	Average Yearly	3.10
	Maximum	6.12
	Minimum	0.41
1972	Average Yearly	4.49
	Maximum	9.99
	Minimum	1.72

Taken from Appendix B, "Report on Engineering Studies, Ta[illegible]ings Pond Embankment System, Moab, Utah, For Atlas Mi[illegible]rals," Dames & Moore, 1973

TABLE 2.3

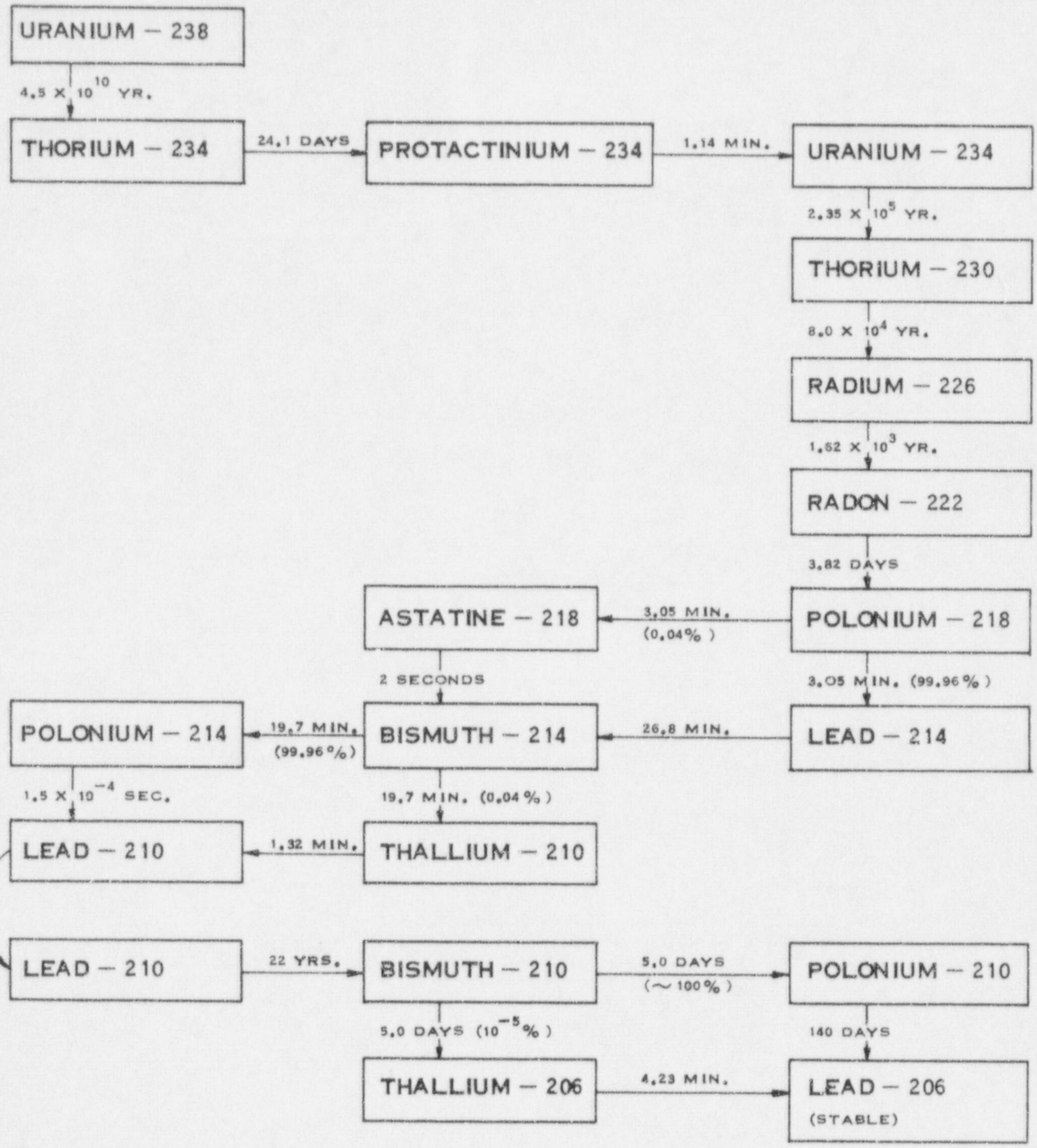
RADIOLOGICAL PROPERTIES OF WELL WATER SAMPLES TAKEN FROM TEST WELLS AROUND THE TAILINGS PILE, ATLAS MINERALS, MOAB, UTAH FACILITY

	Radium 226 in 10^{-8} Microcuries Per Milliliter	
Sample Locations*	December 18, 1972 Samples	February 8, 1973 Samples
B-1	-----	5.240
B-2	2.180	1.630
B-3	-----	5.750
B-4	5.000	4.770
B-5	1.330	1.640
B-6	2.610	2.140
B-7	1.480	-----
TP-1	0.530	0.230
TP-2	0.037	0.004
TP-3	1.250	0.820
TP-4	0.100	0.130
TP-5	2.570	1.790
TP-6	-----	-----

All assays were performed by Atlas Minerals

*As per Figure 2.3-3 in the Safety Analysis Report.

Taken from Appendix B, "Report on Engineering Studies, Tailings Pond Embankment System, Moab, Utah, For Atlas Minerals," Dames & Moore, 1973.



NOTE: IN THIS DIAGRAM, VERTICAL DIRECTION REPRESENTS ALPHA RADIATION, WHILE HORIZONTAL MOVEMENT INDICATES BETA RADIATION. TIMES SHOWN ARE HALF LIVES.

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MOAB URANIUM MILL

FIGURE 1

RADIOACTIVE DISINTEGRATION OF URANIUM

SECTION 3

DIFFUSION PARAMETERS

3.1 INTRODUCTION

There are two methods by which the tailings material can leave the restricted area: ground seepage, and airborne suspension. As previously discussed, it is expected the ground seepage will be reduced to near zero due to sealant by deposited gypsum. The airborne suspension is produced by wind velocities in excess of eleven miles per hour (for fugitive dust) and normal wind (for radon gas).

As presented in the Safety Analysis Report the frequency of occurrance for wind velocities in excess of eleven mph is less than 22 percent.

3.2 ANNUAL AVERAGE DIFFUSION FACTORS

The annual average diffusion factors (X/Q) are presented as follows:

800 meters	1.5×10^{-5} sec/m^3
1200 meters (restricted area boundary distance to nearest residence)	7.7×10^{-6} sec/m^3
Moab	1.0×10^{-6} sec/m^3

The diffusion factors were reported from Section 2.2 of the Safety Analysis Report based upon six-months on-site meteorological data.

Since no structures are present to the tailings retention system, no buildup of radon daughter products by entrainment are expected. The resultant transport of radionuclides will be by annual average long-term radon gas release, and periodic short term suspension of material from aeolian erosion and transport.

SECTION 4

ANALYSIS OF ALTERNATIVE STABILIZATION PROCEDURES

4.1 INTRODUCTION

As presented in the second supplement to the Environmental Report, five alternatives for stabilization were presented. These alternatives are as follows:

Alternative I:	Apply one foot of cover material to exposed tailings
Alternative II:	Shape to 3:1 slope and apply one foot of cover material
Alternative III:	Shape to 3:1 slope, apply cover material and seed
Alternative IV:	Smooth tailings and apply chemical sealant
Alternative V:	Shape to 3:1 slope, apply cover material, seed, and chemically seal

4.2 RADIOLOGICAL CONSEQUENCES OF ALTERNATE STABILIZATION

To provide a comparison of the various stabilization alternatives, each alternative was evaluated as to the radiological consequences of each alternative. However, to gain a prespective as to the non-stabilized radiation levels the following analysis is presented:

A. Fugitive Dust

Volume eroded per year [1/] .... 2000 lbs

Annualized release .... 3×10^{-2} g/sec

Uranium release (weight) .... 3×10^{-6} g/sec

Uranium release (activity) .... 1×10^{-6} μCi/sec

Thorium release (activity) .... 2×10^{-5} μCi/sec

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[1/] Based upon previous monitoring results at Moab Facility, Safety Analysis Report, Table 5.5-3.

Radium release (activity) .... 2×10^{-5} µCi/sec

Uranium Dose Factor 1/ .... $10^4 \frac{mR}{yr} / \frac{pCi}{m^3}$

Thorium Dose Factor .... $1.1 \times 10^4 \frac{mR}{yr} / \frac{pCi}{m^3}$

Radium Dose Factor .... $1.1 \times 10^4 \frac{mR}{yr} / \frac{pCi}{m^3}$

$$Dose_{(1200m)} = (7.7 \times 10^{-6}) \left[(1 \times 10^{-6})(10^4) + (1.1 \times 10^4)(2 \times 10^{-5}) + (1.1 \times 10^4)(2 \times 10^{-5})\right] \text{mR/yr}$$

$$Dose_{(lung)} = 42 \text{ mRem/yr}$$

B. Radon

Distance of cover material .... 0 cm

Release Rate .... 12.8 µCi/sec

Radon Dose Factor .... $4 \frac{mRem/yr}{pCi / m^3}$

$$Dose_{(1200m)} = (7.7 \times 10^{-6})(12.8 \ \mu Ci/sec)(4)$$

$$Dose_{(lung)} = 393 \text{ mRem/yr}$$

4.2.1 Alternative I

The effect upon the unstabilized radioactive releases from the alternative stabilized tailings retention pond system proposed covering of the tailings retention system with one foot of coarse material is as follows:

- eliminate fugitive dust containing tailings material
- reduce radon concentrations by providing 30 centimeters of diffusion retarding material

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1/ Dose factors from the Safety Analysis Report, Table 6.1-1

The reduction of the radon concentration release rate is provided in the additional depth of soil the radon must diffuse before either reaching the atmosphere or decaying into chemically active daughter products. The density of the rock cover is partially reduced when consideration is given to the compaction and surface water erosion into the soil cover. An effective cover thickness of .5 of the actual cover distance was assumed (based upon Foundation Engineering, Peck, Hansen & Thornburn) to reduce the 30 centimeters soil cover to a 15 centimeter effective distance.

The exposure at 1200 meters is therefore calculated to be:

Distance of cover material .... 15 cm

Release Rate .... $12.8\ e^{-.23(15)} = 4.1 \times 10^{-1}$ μCi/sec

$\text{Dose}_{(1200m)} = (7.7 \times 10^{-6})(4.1 \times 10^{-1}\ \mu\text{Ci/sec})(4)$

$\text{Dose}_{(\text{lung})} = 12.5$ mRem/yr

4.2.2 Alternative II

The shaping of the tailings retention system when covered with one foot of cover material will not significantly alter the projected dose from Alternative I.

4.2.3 Alternative III

The addition of seeding would reduce the availability of precipitation erosion into the cover material. The effective cover distance can be therefore expected to increase slightly to approximately .55 of the actual cover distance. This would increase the distance of cover material to 16.5 centimeters.

The exposure is therefore calculated to be:

Distance of cover material .... 16.5 cm

Release Rate .... $12.8\ e^{-.23(16.5)} = 2.9 \times 10^{-2}$ μCi/sec

$Dose_{(1200m)} = (7.7 \times 10^{-6})(2.9 \times 10^{-2})(4)$

$Dose_{(lung)} = 8.8$ mRem/yr

4.2.4 Alternative IV

The application of a chemical scalant would effectively preclude fugitive dust if properly maintained. The diffusion of radon through the chemical sealant would be a function of the permeability of the chemical crust. It is anticipated the crust would form a three to four centimeter thick layer. The layer could be expected to provide an effective layer of one centimeter for radon diffusion.

The exposure calculated for a one centimeter distance is:

Distance of cover material .... 1 cm

Release Rate .... $12.8\ e^{-.23}$ .. 10.17 μCi/sec

$Dose_{(1200m)} = (7.7 \times 10^{-6})(10.2)(4)$

$Dose_{(lung)} = 314$ mRem/yr

4.2.5 Alternative V

The combination of shaping of the tailings pile, cover material, and chemical sealant with seeding would be expected to preclude fugitive dust and provde a slightly greater effective distance. A cover distance factor of .6 was assumed to result from the combination of all types of programs.

The exposure is therefore calculated to be:

Distance of cover material .... 18 cm

Release rate .... $12.8\ e^{-.23(18)} = 2.0 \times 10^{-1}$ µCi/sec

$\text{Dose}_{(1200m)} = (7.7 \times 10^{-6})(2.0 \times 10^{-1})(4)$

$\text{Dose}_{(lung)} = 6.2$ mRem/yr

SECTION 5

PROPOSED STABILIZATION

5.1 RANKING OF ALTERNATIVE STABILIZATION PROCEDURES

The guidelines for the maximum permissible exposures in non-restrictive areas as stated in 10CFR20, limit exposure in these areas to a maximum of 500 mRem/yr. However, continuous exposure to low-level radiation has been documented to constitute a health hazard. Therefore, reduction of the resultant exposure to a few percent of the naturally occurring radiation (background), is clearly consistent with the objective to limit exposure "to as low as practicably achievable." Table 5.1 delineates each alternative stabilization associated dose.

The various alternative stabilization programs clearly reduce the radon and fugitive dust from non-stabilization. Only Alternative IV can be considered outside the "as low as practicably achievable" criteria. The remaining alternative stabilization programs can be considered acceptable.

5.2 PROPOSED STABILIZATION PROGRAM

It is proposed to implement Alternative I for the tailings retention system stabilization. The program would follow the procedures outlined below once the mill is decommissioned:

1. Allow sufficient time for surface water to evaporate from the tailings pond;
2. Bury fines of tailings pond area with coarse beach material;
3. Add a one foot layer of cover material to the top surface of the tailings material;

4. Shape top surface to form a crown which will facilitate water runoff to the sides;
5. Maintain the stability of the waste retention system by adding cover material as needed when erosion channels start to form.

In addition to the stabilization program outlined above, a radiological monitoring and surveillance program would be initiated. The monitoring program, as specified in the following Section 6, would provide information on the post-stabilization radiation levels actually occurring on-site.

The initial radiation results would be analyzed to assure the present restricted area fence would meet all appropriate radiation guidelines concerning exposure to individuals in unrestricted areas. As indicated in the calculated 12.5 mRem/yr at the 1200 meter restricted area boundary, it is anticipated no additional fencing will be required.

The Atlas Minerals Division of the Atlas Corporation plan to assure that suitable protective covenants will be inserted into the future chain of title of the subject property to restrict future land use and access.

5.3 COSTS OF PROPOSED STABILIZATION PROGRAM

As previously specified in the Second Supplement to the Environmental Report, the cost of the proposed stabilization program is $422,000.

The long-term monitoring program for a 50 year period is estimated as follows:

Monitoring:

2 Man Days in Field @ $300	$ 600
5 Man Days Report Preparation @ $200	$1,000
Subtotal Manpower	$1,600
8 Air Samples @ $20 for particulate analysis	$ 160
8 Air Samples @ $25 for radon analysis	$ 200
5 Water Samples @ $75 for radioactivity	$ 375
5 Water Samples @ $200 for chemical analysis	$1,000
Subtotal Analyses	$1,735
TOTAL MONITORING	$3,335/year
or say	$3,500/year

The long-term maintenance of the cover is based on the assumptions that one percent of the cover might be eroded in any given year and that the cover would be replaced at a cost of $4,144 per acre as discussed under Section 3.1.1.2 of the Second Supplement to the Environmental Report. The annual cost would be:

(115 acres)(1% or .01)($4,144/acre) = $4,765.60

or say $5,000/year

The annual cost for monitoring of $3,500 per year plus that for maintenance of $5,000 per year totals $8,500. For contingency purposes this is rounded to $10,000 per year or a total of $500,000 for the 50 year program.

The cost of covering the tailings pile at the time of decommissioning is estimated in Table 3.1 of the Second Supplement to the Environmental Report at $422,000. Adding the cost of the 50 years monitoring and maintenance program would bring the total cost to $922,000.

TABLE 5.1

RADIOLOGICAL ESTIMATES OF FIVE ALTERNATIVE FOR TAILINGS PILE STABILIZATION

Alternative	Dose Radon mRem/yr	Dose Fugitive Dust mRem/yr
No Stabilization	393.0	42
Alternative I	12.5	--
Alternative II	12.5	--
Alternative III	8.8	--
Alternative IV	314.0	--
Alternative V	6.2	--

SECTION 6

MONITORING PROGRAMS

6.1 INTRODUCTION

During the long-term (at least 50 year) maintenance period after stabilization, a monitoring program will be initiated to assure the integrity of the stabilized tailings retention system. A program for the periodic inspection and maintenance work has been presented in the Second Supplement to the Environmental Report. The non-radiological maintenance and inspection is anticipated to utilize a $5,000 per year budget for at least annual inspection and erosion maintenance.

The radiological monitoring program will be comprised of air and water samples and non-radiological water quality testing. The anticipated budget for the radiological monitoring program is $3,500 per year.

The total budgeted cost per year for the maintenance program is $10,000 per year, including provision of $1,500 for contingincies.

6.2 AIRBORNE SAMPLING

A airborne sampling program will be conducted at least annually at eight locations on the restricted area boundary geometrically situated circling the stabilized tailings retention pond.

6.2.1 Particulates

Determination of uranium, thorium, radium and radon daughter products present in fugitive dust at the air sampling locations will be collected. The samples will be collected and analyzed utilizing the latest state-of-the-art technology to meet all regulatory standards and criteria.

6.2.2 Radon

Determination of the levels of radon gas present at the air sampling locations will be made utilizing the latest in the state-of-the-art technology. All applicable standards and criteria for radon sampling will be observed.

6.3 WATER SAMPLING

A water monitoring and surveillance program will be conducted to assure the integrity of the stabilized tailings retention system against seepage into the ground aquifer. Test wells utilized in the operational monitoring radiation program will be sampled at least annually. Sampling techniques and analytical instrumentation will reflect the latest state-of-the-art technology. All appropriate regulatory requirements will be observed.

6.3.1 Chemical Properties

Although the chemical analysis of well water is not radiological, it is appropriate to determine the chemical properties of well water to ascertain if applicable water quality standards are being met. A comprehensive water quality examination of the samples will be performed to determine all constituents as required by appropriate state and federal regulatory agencies.

6.3.2 Radiological

A complete isotopic inventory of the well water samples will be performed. The isotopes selected for analysis will be determined based upon operational radiological monitoring data and appropriate state and federal standards.

SECTION 7

LIST OF REFERENCES

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