

**A CASE STUDY
OF
A LARGE OPEN PIT URANIUM AML PROJECT
GAS HILLS, WYOMING¹**

**BY
Michael Koopman and Ronald Rash²**

Abstract:

The Abandoned Mine Lands Program (AML), authorized under the Surface Mining Control and Reclamation Act of 1977 provides funding for the abatement of health and safety hazards on lands disturbed by mining prior to enactment of the Act. A good example of the implementation of the AML Program in Wyoming is the A-8 Pit. The reclamation site is located in the East Gas Hills Uranium Mining district of Wyoming. Reclamation activities include selective handling of 3.5 million cubic yards of backfill, controlling pit dewatering and water treatment, installing second order drainage channel and riprap control structures, and salvaging sufficient coversoils and topsoils for site revegetation.

Additional Key Words:

Abandoned Mine Land Program, Surface Mining Control and Reclamation Act, Wyoming.

Introduction

The Surface Mining Control and Reclamation Act of 1977 established national standards for conducting coal mining and reclamation activities. In addition, Section IV of the Act created the Abandoned Mine Land (AML) Program which provides a funding mechanism and priority system for the reclamation of disturbed areas before the Act was enacted. The AML Program first encourages the reclamation of areas that pose a serious health and safety hazard to people, and areas with only environmental problems are reclaimed next. Funding for the AML Program is derived by a tax on active coal producers, to be collected from 1978 through 1992. Pending legislation will extend the program and adjust the current levied tax rates for mined coal. The tax is levied at a rate of 35 cents per ton on surface mined coal, 15 cents per ton on underground mined coal, and 10 cents per ton for lignite. At least 50% of the monies collected within each state are returned to that state for reclamation of abandoned mine sites.

Each year, States with a federally approved AML Programs select reclamation projects from their established inventories of eligible sites and submit grant requests to the Federal Government to conduct the necessary work. These requests include detailed descriptions of engineering costs for each project plus the anticipated benefits of reclamation.

In some States, particularly in the West, problems associated with non-coal mines are more severe than those caused by coal mines. Federal approval for the expenditure of AML monies on these lands is possible if the state certifies the presence of threats to public health and safety. Environmental concerns at non-coal mines may be addressed through the program only after all abandoned coal mines in the state have been reclaimed.

Because Wyoming has reclaimed all of its AML coal sites, reclamation of non-coal sites, including open pit uranium mines, is possible. Prior to 1977, spoil and associated ore were usually randomly mixed and stockpiled. These stockpiles generally have side slopes near the angle of repose. Geotechnical data of a few spoil piles in the Gas Hills region indicates silt/clay contents at about 35% and median particle sizes (sediment) of (D_{50}) 0.28 mm. Plastic Indexes (PI) are very high at 13-35. These soils are potentially highly erosive. Vegetation is sparse to non-existent. Wind and water borne sediments are transported offsite and impact streams and drainageways. Spoil materials may be rich in oxidized (sulfides) and/or radioactive elements. Reclamation of these sites usually requires grading and backfilling to bury unsuitable materials, and a re-establishment of drainage patterns. Application of specialized and innovative revegetation practices is necessary due to the lack of moisture, poor soils, and extreme weather conditions.

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² Michael Koopman is an AML Engineering Specialist, employed by the Wyoming Department of Environmental Quality, Cheyenne, Wyoming 82002; Ronald Rash is the Project Manager for the AML 16E-1 project, employed by Forsgren Associates as Area Manager in Casper, Wyoming 82601.

Another problem commonly seen in the Gas Hills region are highwalls resulting from open pit mining. These highwalls, comprised of coarse grained sandstones, conglomerate and claystone, often several hundred feet high are obvious hazards because of their height, steepness, and instability. There are often water impoundments left in the bottoms of these unreclaimed pits with the toes of highwalls submerged. Backfill and highwall reduction methods are complicated by the presence of pit water.

The A-8 open pit uranium mine as shown in Figure 1, was abandoned in the early 1970's, without any reclamation measures. Reclamation activities now are in progress to control hazards and further environmental degradation. Approximately 3.5 million cubic yards of backfill will be placed in the pits. Surface drainage channels will be constructed and cover soils placed to control Radium 226 emissions and to assist with revegetation.

Site Description

Reclamation efforts are complicated by the presence of an estimated 210 million gallons of pit water, varying in depths up to 85 feet. This pit water, the analysis of which is shown on Table 1., is acidic and radioactive and will require treatment when discharged. Additional complications result from several geologic faults that occur through the pit, as noted on Figure 1. Adequate quantities of spoils for backfill activities are stockpiled adjacent to the pit. However, the last materials removed from the pit, (lower 25 feet), are unsuitable for all backfill uses and will require selective handling. These unsuitable spoil materials have higher concentrations of arsenic, iron, aluminum, uranium (natural), and its daughter product Radium 226. Typical laboratory analysis of the spoils pile are represented on Table 2.

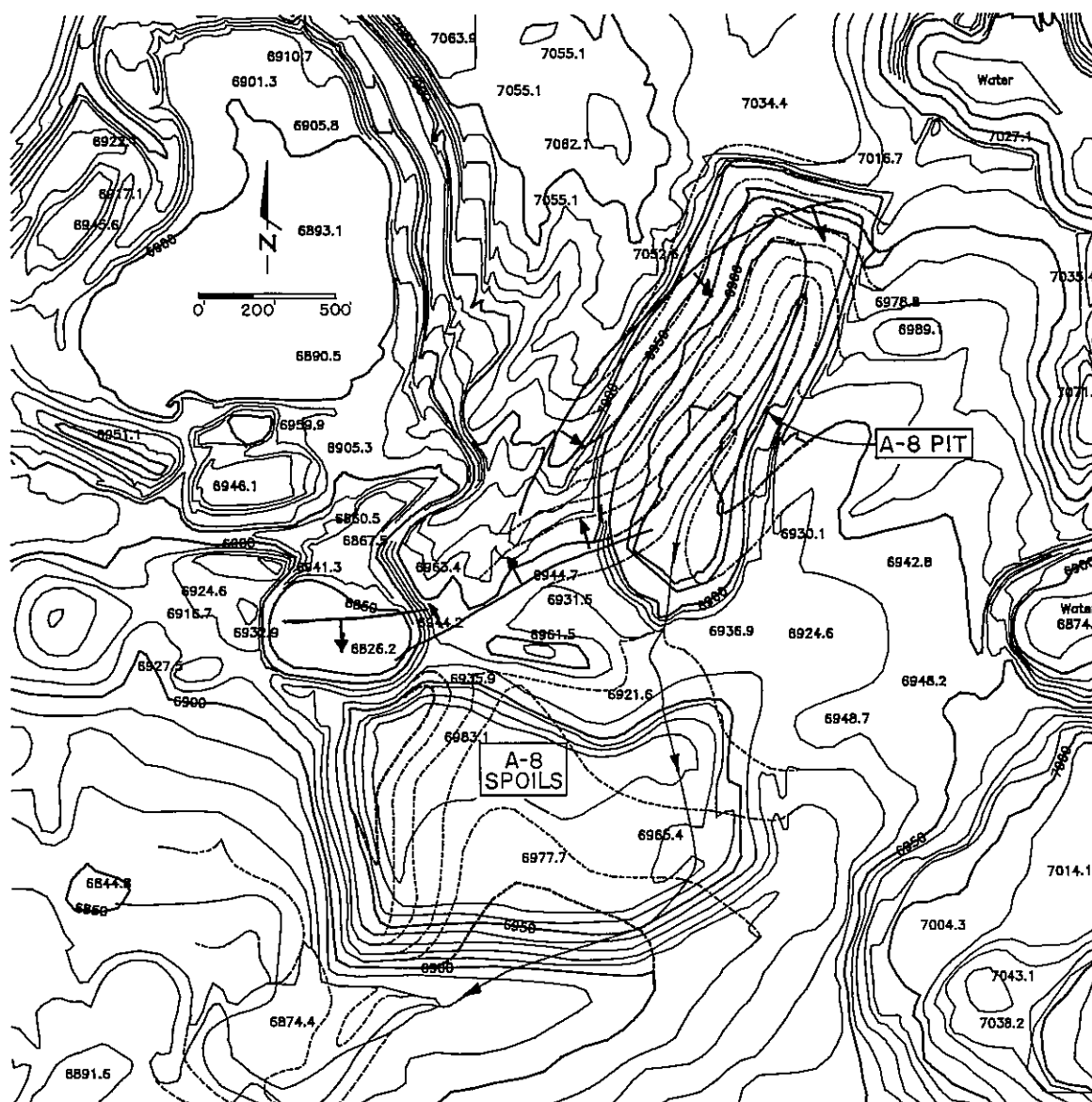


Figure 1. Site map of the A-8 Project as located in the East Gas Hills region of Central Wyoming.

Table 1. Existing water quality for pit water in the A-8 open pit uranium mine.

Testing Parameters	mg/l	Testing Parameters	mg/l
Total Suspended Solids	6.0	Boron (B)	0.08
Total Dissolved Solids	3017	Cadmium (Cd)	<0.01
Conductivity @ 25c, umho/cm	2608	Chromium (Cr)	<0.01
Sodium (Na)	58	Copper (Cu)	<0.01
Potassium (K)	23.6	Fluoride (F)	0.28
Calcium (Ca)	568	Iron (Fe)	<0.03
Magnesium (Mg)	99	Lead (Pb)	0.08
Chloride (Cl)	23	Manganese (Mn)	3.8
Sulfate (SO4)	1940	Mercury (Hg)	<0.001
Bicarbonate (HCO3)	3.1	Molybdenum (Mo)	<0.05
Carbonate (CO3)	0	Nickel (Ni)	<0.03
pH, Units	5.08	Nitrate (NO3 as N)	0.19
Aluminum (Al)	<0.1	Selenium (Se)	0.012
Ammonia (NH3 as N)	0.42	Uranium (U)	0.083
Arsenic (As)	0.001	Vanadium (V)	<0.1
Barium (Ba)	<0.05	Zinc (Zn)	0.19

		LLD
	pCi/l	uCi/ml
Radium 226	6.86 ± 0.45	2x10E-10
Gross Alpha	2.49 ± 47	1x10E-9
Gross Beta	105 ± 21	1x10E-9

Table 2. Typical soils laboratory analysis for the A-8 Spoils pile to be used as backfill.

Sample I.D:	A-8-4	A-8-4	A-8-4	Sample I.D:	A-8-4	A-8-4	A-8-4
Interval:	5-15	35-45	50-65	Interval:	5-15	35-45	50-65
Sample Date:	10-89	10-89	10-89	Sample Date:	10-89	10-89	10-89
Sample Number:	11-08-89	11-08-89	11-08-89	Sample Number:	11-08-89	11-08-89	11-08-89
Parameter List:	Long	Long	Short	Parameter List:	Long	Long	Short
pH, s.u.	7.3	7.3	7.4	Calcium, meq/l	30.8	27.2	
Moisture %	12.30	8.00	8.33	Magnesium, meq/l	7.65	4.02	
Saturation %	44.6	30.0		Sodium, meq/l	1.43	1.39	
				SAR	0.33	0.35	
Cond., mmhos/cm	2.94	2.81	2.80	**			
Sand %	54	68	60	Arsenic, ppm	29	27	18
Silt %	30	18	20	Aluminum, ppm	37000	27000	4400
Clay %	16	14	20	Boron, ppm	270	330	<1.0
Texture	SL	SL	SCL	Copper, ppm	11	9.4	10
				Iron, ppm	21120	15880	11660
Organic Matter %	0.4	0.4		Lead, ppm	23	13	12
Organic Carbon %	0.2	0.2		Manganese, ppm	57	44	49
				Molybdenum, ppm	3.5	6.1	<1.0
Nitrate as N, ppm	1.9	1.6		Selenium, ppm	4.2	5.9	3.8
				Zinc, ppm	38	28	18
Lime %	1.4	2.0	1.2				
Neut. Pot., ppt (1)	14	20	12	Uranium, pCi/gm	95.8	32.0	18.5
Acid Pot., meq/100g	86	33	26	Ra-226, pCi/gm	31.5	21.2	6.8
Acid Base Pot., (1)	-28	4	-1	Ra-226 Prec. +/-	0.6	0.5	0.3

(1) T. CaCO3/100 T.;

* indicates lime deficiency.

** Total Metals reported following SW-3050 digestion unless otherwise noted.

History

Mining activities for the A-8 Uranium Pit occurred between 1969 and 1973 and then again in 1975 when some limited underground mining occurred. Originally, the pit was designed to be 2000 feet by 450 feet and 200 feet deep. The pit was mined with scrapers, backhoes and trucks. When the excavation reached an elevation of 6,855, or a depth of 175 feet at the North end of the pit, the groundwater began flooding the pit at up to 600 gpm. When mining activities concluded at the South end of the pit the ore bearing roll front was 85 feet below the water table. The pit quickly filled with water after the mining activities ceased.

Most of the spoils removed from the pit were stockpiled down gradient from the pit in the A-8 Spoils pile. Some spoils were used to backfill the A-9 Pit, which is continuous with the A-8 Pit area. Because the A-8 Spoils pile was reaffected after 1977, it is not eligible for reclamation under the AML criteria. Predesign activities, which were completed during the Fall of 1989, are source documents for this report.

Existing Conditions

The A-8 Pit is a long narrow pit measuring about 1700 feet in the North-South direction and 500 in the East-West direction. Exposed highwalls (above the pit water surface) range from a height of about 80 feet at the South end to about 170 feet at the North. Sonar mapping of the pit bottom indicates the water depth is only about 15 to 20 feet near the North end, reaching a maximum of about 85 feet near the South end. The North wall of the pit is comprised of backfilled mine spoils, while the remainder is cut into bedrock. The slope of the backfill in the North end is between 33 to 35 degrees. Most of the West wall has been flattened to about 1.5:1, due to a fault which intersected that face. A major slope failure occurred after mining activities ceased.

The rock units exposed in the highwalls are members of the Upper Wind River Formation which are Tertiary sedimentary deposits and consist of fine to coarse grained sandstone, claystone and discontinuous conglomerate beds. These materials were deposited during a combination of marine and braided stream environments which were interrupted by periods of erosion. The resulting profile consists of discontinuous layers, with intermixing of soils within major layers. Following deposition, regional uplifting occurred to the South and West resulting in a series of faults in the Wind River Formation. The faulting frequency is variable but is locally intense in the project vicinity. These faults usually strike from East - West to Northeast - Southwest and may dip either North or South, usually at inclinations of 55 degrees or more. Several faults were mapped in the highwalls within the boundaries of the project as noted on Figure 1. Other faults were observed, but were not accessible for determination of strike and dip. Visual observations indicate highwall failures attributable to the faults approximately paralleling to and dipping toward the pit walls (Pool, 1989).

One of the primary factors influencing the surface water hydrology and geomorphic conditions in the Gas Hills is the Beaver Divide which is a prominent plateau. The A-8 Pit is located relatively close to the Beaver Divide and this results in high relief and steeper basin slopes at the site. The primary surface water and geomorphic design consideration is to reconstruct the drainage basins and channels in the disturbed areas. Of particular interest, is the reconstruction of the West Fork of the Canyon Creek drainage. The headwaters of this drainage were diverted by the historic mining operations. Presently the runoff is conveyed to a stock pond located just to the East of the A-8 Pit. Most of

the mining disturbances have intersected the Canyon Creek drainage and placement of spoil piles including the A-8 Spoils have blocked the historic drainage channel (Lidstone, 1989).

The site was evaluated for threatened and endangered plants because of the relatively high potential for the occurrence of such species, but none such species were observed. No special precautions are necessary for protecting threatened or endangered plant species on this site (Schreibels, 1989).

AML Project 16E Site A-8 does not provide critical habitat for threatened or endangered wildlife species. There are no active raptor nests on any of the highwalls or spoil piles. Reclamation should not adversely affect any threatened or endangered species.

The existing pit water is unavailable to most wildlife due to restricted access and the steep rim of the highwalls. The water is acidic (pH 4.84-5.50) with a high radium level (9.2 pCi/l). No wetland vegetation is present in the pit (Kling, 1989).

Two previously recorded archaeological sites had been reported in the area, but no evidence of either could be found. As such, no cultural resources were located, and clearance is recommended for the project (Frontier Archaeology, 1989).

The natural background Radium 226 (Ra-226) soil concentration in the Gas Hills was previously determined to be 3.7 +/- 1.7 pCi/g (Radiological Risk Assessment for Various Abandoned Mine Lands Clean-Up Criteria, Hersloff, 1988). The proposed EPA standard for mine waste of 5 pCi/g above background would then be 8.4 pCi/g. The linear correlation of gamma exposure rate at 5 cm above the surface and Ra-226 concentration in soil at the A-8 Project area is defined by:

$$\text{Ra-226, pCi/g} = 0.43 \times \text{uR/hr} - 10.54$$

A soil Ra-226 concentration of 8.4 pCi/g corresponds to a total unshielded gamma exposure rate of 44 uR/hr, with a certainty of 85% (Hersloff, 1989).

The Goose Egg (Triassic-Permian) formation has been deposited, on the surface, along the South limits of the project site. It is easily identified by the reddish color. The fine grained Goose Egg was transported down drainage channels to this deposition site from the South. These soils are an excellent plant growth medium source. Minimal surface disturbance would be required to obtain large quantities of these suitable coversoils. Finished reclaimed slopes should be no steeper than 5:1, and where winter time sun light exposures are most direct (South face), 6:1 slopes will help minimize erosion to slopes (Schreibels, 1989). The A-8 Spoils stockpile is unacceptable as a plant growth media. Acid-Base Potential and Radium 226 values are greater than Wyoming Department of Environmental Quality and Environmental Protection Agency guidelines. Examples of Acid Base Potentials and Ra-226 values for the A-8 Spoils are shown on Table 2.

Backfilling the A-8 Pit requires an evaluation of the impact on the groundwater quality. The existing pit water, which is solely fed from groundwater, is acidic and generally of poor quality. Groundwater around the site is less acidic, with fewer TDS, radionuclides and metals, are shown on Tables 1 and 2. Batch tests and column leach tests were conducted on the combinations of A-8 Spoils, pitwater and groundwater to determine the impact of down gradient groundwater quality as a result of backfilling. The interaction was evaluated by using a

geochemical program PHREEQE, which simulates mixing of different waters. It predicts resultant water quality at equilibrium conditions the results of these evaluations are shown on Table 3. The overall quality is not impacted significantly, and the A-8 Pit water will become more neutral resulting in the reduction in metal concentrations (e.g., Al, Fe, Pb Mn, Ni and Zn). However, concentrations of U, Ra-226, Se and Mo will increase due to the reaction with backfilled spoils. This can be seen by referring to Tables 3 and 4 for comparisons of water quality of pit water and predicted down gradient groundwater (Olsen, 1989).

The A-8 Spoils pile is segregated. The upper 25 feet was removed last in the mining operation and is a poorer quality material. The two critical metals (Selenium and Molybdenum) are elevated in the upper sequence, as are radionuclides, Uranium and Radium. Tables 4 and 5 represent the laboratory analysis of the A-8 Spoils pile by depths.

Table 3 Comparison of Predicted to Existing Groundwater Quality Down Gradient From A-8 Pit.

Parameter	Units	Existing	Predicted
<u>General</u>			
pH	S.U	7.36	7.26
TDS	mg/L	1,428	1,728
<u>Major Cations</u>			
Ca	mg/L	290	373.2
Mg	mg/L	40.4	45.0
K	mg/L	12.0	32.8
Na	mg/L	61.0	64.4
<u>Metals</u>			
Al	mg/L	<0.10	0.04
B	mg/L	0.11	0.5
Cu	mg/l	<0.01	<0.01
Ni	mg/L	<0.05	<0.01
Se	mg/L	<0.001	0.20
Zn	mg/L	0.04	0.04
U	mg/L	0.422	2.6
Ra-226	pCi/L	11.9	14.5

Table 4. Summary of Total Metal Constituents in the A-8 Spoils Pile.

	pH	EC	Lime	As	TOTAL METALS			
	<u>su</u>	<u>mmhos/cm</u>	<u>%</u>	<u>ppm</u>	<u>Mo</u>	<u>Se</u>	<u>U</u>	<u>Ra²²⁶</u>
					<u>ppm</u>	<u>ppm</u>	<u>pC/gm</u>	<u>pC/gm</u>
MEAN (A8)	6.7	2.8	2.2	23.5	2.9	5.2	33.7	12.1
SDEV (A8)	1.3	1.3	1.9	11.1	2.7	4.8	49.5	16.5
MIN (A8)	1.5	0.7	ND	3.4	1.0	0.2	3.0	0.9
MAX (A8)	7.9	10.2	11.4	77.0	12.0	27.0	368.0	118.0

Table 5. Statistical Analysis of the A-8 Spoils Chemistry by Depth

	pH	ABP	U	Ra ²²⁶
	<u>(s.u)</u>	<u>(TCaCO₃/1000T)</u>	<u>(pC/gm)</u>	<u>(pC/gm)</u>
MEAN 0-25' ^A	6.9	-13.2	74.3	16.3
MEAN 25-TD ^B	7.3	+15.0	26.9	11.2
SDEV 0-25'	1.0	8.6	102.5	18.0
SDEV 25-TD	0.2	14.8	15.7	8.1
MIN 0-25'	4.3	-28.0	11.3	2.7
MIN 25-TD	6.8	-10.0	4.0	2.2
MAX 0-25'	7.6	+2.0	368.0	46.9
MAX 25-TD	7.5	+40.0	84.9	33.9

^A n = 10 Samples

^B n = 30 Samples

TD = Total Depth

Results and Discussion

The overall goal of the Wyoming Abandoned Mine Lands program is to reduce safety and health hazards and to mitigate environmental disturbances. This goal is to be accomplished with the most cost effective reclamation plan. Based on the technical evaluation of the A-8 Pit site some specific reclamation criterion are:

- ▣ Pit highwalls are unstable and consequently should be regraded or backfilled to 23-28 degree slopes.
- ▣ Backfill should be accomplished by maintaining pit water level near present levels, by pumping while backfilling spoils into pit water starting at shallow (North) end building a pad towards deep (South) end.
- ▣ Construct backfill into 12-inch thick (loose) lifts.
- ▣ Limit fill slopes to 5:1, except on South exposures then use 6:1.
- ▣ Use erosion control ditches on longer slope faces.
- ▣ Topsoil and/or riprap all 2nd order channels.
- ▣ Design channel capacities for 100-year 24-hour rainfall runoff events and stability to 10 year 6-hour events.
- ▣ Selectively place A-8 Spoils in pit and backfill as to minimize groundwater degradation and concentrations of Radium 226 near finished ground levels.
- ▣ Coversoils and topsoils are limited at the project site. Strip and stockpile separately all sources especially the Goose Egg formation at the south end of A-8 Spoils.
- ▣ Utilize native seed mixes including western wheat grass (*Agropyron Smithii*), thick spike wheat grass (*Agropyron Cristatum*), bluebunch wheat grass (*Agropyron Spicatum*), indian ricegrass (*Oryzopsis Hymenoides*), among others.
- ▣ Pitting should be used in conjunction with seeding.
- ▣ Reconstruct access roadway through site and fence all reclamation.
- ▣ Maximum Radium 226 soil concentration criterion is 20 pico Curies / per gram (pCi/g), including background, with average Radium 226 soil concentration of 10 pCi/g in the top five feet of backfill.

Alternate Reclamation Plans

Three basic reclamation plans were developed for evaluation by technical staff and design engineers. The options ranged from: 1. complete backfill and recontouring to original condition; 2. partial backfill allowing for exterior drainage out of the pit; and 3. backfill most of pit leaving the groundwater (pond) exposed.

Option 1 This was considered the most costly of the three options. An additional one million cubic yards of backfill would be required over Option 2. The only advantage this plan had over Option 2 was surface grading could allow for dispersion of run off rather than concentrating the flows

to less stable channels.

Option 2 A partial backfill and external drainage plan accomplished all technical objectives, except for leaving an accessible water source to the surface. However, because the groundwater is a poor quality source and radionuclides are high it was not considered to have any environmental value.

Option 3 Partial backfill with an impoundment at the lower (South) end of the pit would require the least backfill the three options. But highwalls would need to be reduced and the fill slopes below water level would not be compacted leaving material loose and dangerous to anything attempting to access the pit water. Quality of the pit water is poor, limiting its value. Surface runoff generated within the reclaimed pit would be retained in the pond.

Even though Option 3 would be cheaper to construct than Option 2, problems would develop. Building a stable pond and constructing stable fill slopes steeper than 5:1 on the entire site would be difficult. Also, surface runoff is more useful in a proposed retention pond down gradient from the A-8 site make Option 3 less attractive than Option 2.

Final Reclamation Plan (Option 2)

The reclamation plan selected for implementation is represented in Figure 1. It reflects the general finished grading and surface drainage plan. The estimated construction cost is \$4,180,000. Construction is scheduled to occur between June, 1990 and November, 1991.

Basic elements of the reclamation plan are as follows:

Pit Dewatering Pit water will be removed (pumped) from the pit continually during construction. The static level of the pit water will be maintained at a constant level to minimize concerns for highwall failure due to saturation of highwalls. Pumping water will be about 2 cfs (1,000 gpm). Permitting for discharge of pit water will address treatment and channel degradation issues.

Existing Roadway The existing roadway, North and South along the West edge of the A-8 Pit to the South of A-8 Spoils, will be retained and/or reconstructed.

Fencing Field fencing will be constructed around the entire disturbance to act as a protection against over-grazing during the vegetation establishment period. Cattle guards in lieu of a gate will be installed at each crossing.

Existing Power Poles All existing power and telephone poles will be removed from the site and stockpiled for Landowner's use.

Backfilling of Project The A-8 Spoils will be used to backfill the pit. Some selective handling will be required. All spoils placed below the projected groundwater level and within five feet of finished ground surface is to be taken from the lower half of the spoils pile (top 25 feet of Spoils pile is to be sandwiched into the backfill). The backfilling activities in the A-8 Pit commence at the North end of the pit where existing water is shallow. The backfill pad which would be constructed 3-5 feet above the existing water level of the pit would be continually worked towards the South end.

A-8 Spoils The A-8 Spoils will be removed in quantities needed to complete the backfill operations at the A-8 Pit,

after which the spoils would be left in a reclaimable condition. Reclamation will be accomplished by others (Spoils pile is not eligible for AML reclamation).

Cover Soils There are adequate quantities of cover soils available just South of the A-8 Spoils. Materials consist of the Goose Egg formation. There are also some cover soils available at the South end of the A-8 Pit which will also be utilized to cover the site for revegetation. Small piles of topsoil were left along the North and East side of the A-8 Pit and also at the East side of the A-8 Spoils. There are some topsoils that have been salvaged by past mining operations and stockpiled or winrowed around the A-8 Spoils.

Drainage and Erosion Control Measures Drainage and erosion control measures will be accomplished by construction of stable earthen and riprapped channels. Some erosion control ditches will be constructed along the long fill slopes in the A-8 Pit to mitigate rilling and gulying which normally occur on such reclaimed slopes.

Conclusions

The purpose of the Abandoned Mine Lands program is to reduce safety and health hazards and to enhance the environment. Reclamation of the A-8 Pit in the East Gas Hills region of Central Wyoming accomplishes this goal, in the following ways:

- ▣ Existing unstable highwalls (200 feet) will be backfilled to eliminate safety hazards.
- ▣ Water quality of groundwater will be enhanced by backfilling the pit with select spoils to attenuate and buffer heavy metals and radionuclides present in the pit water.
- ▣ Construct stable externally draining surface channels to direct surface runoff to existing wetland areas.
- ▣ Revegetate site (29 acres) with wildlife cover and food source.
- ▣ Restore environment as near as possible to a stable yet natural looking condition.

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