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ENVIRONMENTAL REPORT

FOR

FEDERAL-AMERICAN PARTNERS

GAS HILLS MINING DISTRICT

FREMONT COUNTY
WYOMING

consolidating previous materials per B. Fisher 12/18/79

TO ACCOMPANY APPLICATION FOR THE RENEWAL OF
NRC SOURCE MATERIALS LICENSE SUA - 667

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PREPARED BY
KAISER ENGINEERS, INC.

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ENCLOSURES

REMARKS

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PREFACE

This environmental report was prepared by Kaiser Engineers, Inc. of Oakland, California, and is based on information consolidated and updated from previous FAP submittals to the NRC, on other documents, and on information developed by Kaiser Engineers, Inc.

Much of the information included in the environmental report was taken from the following submittals and documents.

- "Federal-American Partners Source Material License Renewal Application Data," FAP, December 1975.
- "Environmental Report for Federal-American Partners," FAP, December 1977.
- "Supplemental Information for Environmental Report," FAP, June 1978.
- "Radiation Safety Report," FAP.
- "Baseline Geotechnical Investigation for the Subsurface Disposal of Millwaste," F. M. Fox and Associates, Inc., January 1979.
- "Environmental Report and Radiation Safety Report, Additional Information," FAP, September 1979.
- "Major Modification Request," FAP, November 1979.

These submittals and documents were prepared in support of the application for renewal of Source Material License No. SUA-667 under Docket No. 40-4492. Kaiser Engineers consolidated information from the above submittals and documents, and modified and updated the information as necessary.

Portions of the information included in this environmental report were developed by Kaiser Engineers, Inc. This information includes emission calculations, cost estimates and descriptions of the process, waste effluent control systems, project alternatives, environmental impacts of construction, portions of the environmental impacts of operations, portions of the monitoring programs, the mill decommissioning programs, and cost benefit data.

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1. PROPOSED ACTIVITIES

Federal-American Partners (FAP) is a partnership consisting of two corporations. The managing partner, holding a 60 percent interest, is Federal Resources Corporation, a Nevada corporation with offices in Salt Lake City, Utah. American Nuclear Corporation, a Colorado corporation with offices in Casper, Wyoming, holds a 40 percent interest. The Tennessee Valley Authority (TVA) of Chattanooga, Tennessee is the 100 percent leaseholder.

FAP has operated a uranium mill in the Gas Hills Mining District of Wyoming since 1959 under NRC (AEC) Source Material License No. SUA-667. FAP is currently applying under Docket No. 40-4492 to renew this Source Materials License, and to obtain approval for a mill expansion and a modification to the tailings disposal system. This environmental report identifies and defines the potential environmental impact of the expanded mill and modified tailings disposal system. It is submitted to the Nuclear Regulatory Commission to satisfy requirements established under the National Environmental Policy Act of 1969. (Public Law 91-190).

The current mill (Ore Processing Area A) is located in Fremont County on the Gas Hills route approximately 80 kilometers (50 miles) east of Riverton, Wyoming. It is licensed for 860 metric tons (950 short tons) per day. The mill uses occasional ore drying, dry crushing, wet grinding, acid leach, sand-slimes separation, resin ion exchange, solvent extraction, and yellow cake precipitation, thickening, and drying processes to recover U_3O_8 from the ore. Tailings are disposed in conventional surface impoundments. The mill is currently processing ore from reserves leased by the TVA in the Gas Hills area. These reserves are being mined by FAP and processed through the FAP mill under mining and milling agreements between FAP and the TVA. Ore from these mines is transported to the mill by ore trucks operated over ore haulage roads.

Product yellow cake from the mill would be shipped approximately 1,800 kilometers (1,100 miles) to Kerr McGee's uranium enrichment plant located in Gore, Oklahoma. Transportation would be by trucks operated by an independent interstate trucking company.

Current plans call for the expansion of the mill to 2,680 metric tons (2,950 short tons) per day by expanding the mill process area to include Ore Processing Area B at the existing site. In addition, the existing ore drying, dry crushing, and wet grinding processes would be replaced with a

semi-autogenous grinding mill designed to feed both Ore Processing Areas A and B. Yellow cake precipitation, thickening, and drying systems provided for Ore Processing Area B would also be designed to process the loaded strip solution from Ore Processing Area A. Therefore, the expanded mill would only use the acid leach, sand-slimes separation, resin ion exchange, and solvent extraction processes in Ore Processing Area A. Ore Processing Area B would use acid leach, sand-slimes separation, resin ion exchange, and solvent extraction processes that are metallurgically very similar to those in Ore Processing Area A.

Ore would be processed from surface and underground mines operated by FAP in the Gas Hills area. All of these ore reserves are leased by the TVA and would be mined and milled under agreements with the TVA. Current ore reserves are sufficient for approximately ten years of mill operation at the expanded rate. However, exploration, drilling and reserve evaluations are continuing so that additional ore reserves may be located. This may allow the project life to extend beyond the currently projected ten years, depending on economics and the demand for the product.

The mill is expected to process ore 24 hours per day, 340 days per year. At the expanded ore processing rate of 2,680 metric tons (2,950 short tons) per day the mill is expected to process approximately 910,000 metric tons (1,003,000 short tons) of ore per year. The ore grade is expected to average approximately 0.12% U_3O_8 over the life of the project. The uranium recovery rate is expected to be approximately 91 percent. The U_3O_8 content of the yellow cake product is expected to be approximately 96 percent. Under these conditions, annual yellow cake production would be approximately 1,035 metric tons (1,140 short tons) per year.

Under current plans, the tailings disposal system would be modified to include a subsurface disposal area in an existing mine pit. Tailings from both ore processing areas would be combined in a common sump and pumped to the subsurface disposal area. Water would be decanted from the disposed tailings and pumped back to the mill for reuse or disposal in the solar evaporation pond or excess process water disposal system.

2. THE SITE

This section gives a baseline description of the physical, socioeconomic and cultural environment that might be affected by the Gas Hills project. Figure 2.1-1 shows the location of the site with respect to the nearest cities, towns, and highways within Wyoming.

2.1 SITE LOCATION AND LAYOUT

The mill is located in the south half of section 28 and the north half of section 33 of Township 33 north, range 90 west of the 6th principal meridian, Puddle Springs quadrangle, Fremont County, Wyoming. The site is approximately 80 kilometers (50 miles) east of Riverton, 40 kilometers (25 miles) north of Jeffery City, and 128 kilometers (80 miles) west of Casper, Wyoming. Figure 2.1-1 shows the location within this area.

Employees living in the Riverton area travel State Highway No. 136 to its end, then a short distance over mine haulroads to the FAP facility. Some employees live at the FAP village located approximately 0.8 kilometers (1/2 mile) southwest and upwind of the mill.

Figure 3.1-1 in section 3 shows the topography of the area in which the mill site and tailings disposal areas are located. Figure 2.1-2 shows the site in relationship to the surrounding property, including ownership, and the location of the FAP village. (Also see figure 2.2-1).

The general region in which the mill is located is used primarily for mining, mineral exploration, lifestock grazing, and as a wildlife range. The area is characterized by rolling terrain, broken by dry washes typical of the Wyoming high plains. Elevation at the mill site is 2,012 meters (6,490 feet) above sea level.

The FAP mill facilities encompass 107 hectares (265 acres) which include tailings disposal areas. This area is protected by a four-strand barbwire fence. Entrance to the property is via roads to the parking area and then by the main office to the mill property. Entrance to the tailings area is either through the mill yard or a locked gate.

The uranium mill layout is shown in section 3 on figure 3.4-1.

2.2 USES OF ADJACENT LANDS AND WATERS

Land use within a five mile radius of the site is primarily uranium mining and exploration with the principal mining method being open pit. Oil and gas exploration activities have been in progress in the area for many years with the drilling of a number of dry holes but no production of petroleum products has been reported within this five mile radius (U.S. Geological Survey, 1971). Three small oil fields are located approximately eight miles north-northwest of the site.

The U.S. Bureau of Land Management has jurisdiction over approximately 80 percent of the land which is public domain. State land consists of 10 percent and private property the remaining 10 percent. Figure 2.2-1 shows generalized land use and figure 2.2-2 shows land ownership with surface and mineral rights.

Currently there is little or no farming in this area. Within an area of 360 square miles there are 3,500 graze animals as reported by the BLM, Lander, Wyoming. This (360 square miles) area as defined by BLM is 32 kilometers (20 miles) north, 25.6 kilometers (16 miles) south, 6.4 kilometers (4 miles) east, and 9.6 kilometers (6 miles) west of the FAP mill site. Depending on the time of year, amount of rainfall, and mood of the animal, there could be anywhere from 6 to 238 graze animals within a 4.8 kilometer (3 mile) radius of the mill. The grazing season is 6 months. All of the annual feed is pasture graze. The average grazing area (AUM-animal unit month) needed to support one animal unit (450 kilograms) for one month is 7 acres.

Livestock grazing is the only agricultural land use due to annual precipitation and lack of irrigation water (Colby, Hembree, and Rainwater, 1956). Other land use of the area includes hunting, rock collecting, and like activities.

Figure 2.2-3 shows the uranium processing facilities located within a 80 kilometer (50 mile) radius of the site. They are Pathfinder Mines Corp., Lucky-Mc Mine and Mill, 2.4 kilometers (1 1/2 miles) north of the site; Union Carbide Corp., 12.8 kilometers (8 miles) northeast; and Western Nuclear, 35.2 kilometers (22 miles) south.

2.3 POPULATION DISTRIBUTION

Population of the area surrounding the mill facility is sparse and limited to 250 to 300 permanent residents within a five-mile radius of the site. These residents consist of mining company personnel and families who are housed in

mobile homes and company houses at company-based camps, plus intermittent occupants of ranches by livestock herders. One ranch, the George Homestead, is now abandoned; another ranch Puddle Springs, is occupied 300 days per year by two people employed by Union Carbide Corp.

Table 2.3-1 presents the population data for the Gas Hills region per the 1970 Census, with the exception of FAP village which is more current (12/6/79). The population increases in Fremont and Natrona Counties have occurred in or near the urban centers with a decrease in population of eastern Fremont (44 percent) and western Natrona (38 percent) Counties between 1960 and 1970.

Population density for Fremont County, within which the mill is located, is generally low (3.1 persons per acre), but energy exploration and development is expected to stimulate regional population growth during the next 10 to 20 years. Table 2.3-2 presents recent population projections for Wyoming and Fremont County. During the next two decades, the Fremont County population may increase by 29 percent of its 1975 level.

2.4 REGIONAL, HISTORIC, SCENIC, AND CULTURAL LANDMARKS

2.4.1 Historic Landmarks

The nearest landmark, located 16 kilometers (10 miles) north of the site, listed in the National Register of Historic Places, is the Castle Garden Petroglyphs. This site contains rock carvings and evidence of prehistoric Indian inhabitation. There are no other known historic sites located on or near the mill property. The FAP mill site was received by K.A.L. Lippincott, a TVA staff archeologist, and found to be suitable for the project's development [ref.1.].

2.4.2 Scenic Landmarks

There are no scenic landmarks within five miles of the site. The only unusual change in the rolling hills topography is the Beaver Rim, which is an erosional escarpment. This rim has a topographic relief of about 155 meters (500 feet) extending from approximately 2,325 meters (7,500 feet) Mean Sea Level (MSL) to roughly 2,170 meters (7,000 feet) MSL on the lower, north side of the escarpment. The current geographic position of this rim is due to localization along pre-existing faults, striking roughly east-west across the southern part of the Gas Hills Mining District.

2.4.3 Cultural Landmarks

In a study prepared during the summer of 1976 by the Department of Anthropology, University of Wyoming, Mr. George M. Zeimens, Associate State Archaeologist, states: "We found that most of these lands (T, 33N., R.90W.) had been highly disturbed years ago. There are several archaeological sites in the general vicinity, but anything that may have been on the lands in question is now gone."

2.5 GEOLOGY AND SOILS INFORMATION

2.5.1 Geology

The Gas Hills area is bound by the Rattlesnake Mountains uplift on the east where Paleozoic and Mesozoic sediments surround a centrally uplifted granite core. Uplifts, as part of the Laramide deformation, occur in faulted sequence with Cretaceous rocks of the eastern part of the district itself.

The southern boundary is delineated as the north flank of the Sweetwater granite uplift along the Sweetwater River and at the extreme southern boundary of the Wind River Basin. This uplifted arch is mainly granite structure of Pre-Cambrian age emplaced by major uplift during the general Laramide revolution which subsequently subsided along a low angle thrust fault in late Tertiary time.

The northern boundary of the area is essentially formed near Castle Gardens, with deposition of the Lance, Lewis, and Mesa Verde formations of the latest Cretaceous age and the Fort Union Formation of Paleocene age.

The western boundary of the Gas Hills is a nebulous Tertiary northward extension of the Beaver Rim. The area is on a small subsurface anticlinal structure related to the Conant Creek anticline about 10 miles west of this somewhat arbitrary boundary.

Within the structural boundaries of the Gas Hills, there are two parallel striving anticlinal structures which form the main deformational features in the area. The first is the uplifted and subsequently eroded escarpments of hard ridge forming formations and interspaced soft valley forming layers of the Dutton Basin anticline. The visible formations involved range from the Triassic rockbeds of the Chugwater formation to the late Cretaceous black shales of the Frontier and Cody shale units. This structure parallels the NW to SE strike of the Rattlesnake Mountain uplift and is the main Pre-Tertiary surface structure of the Gas Hills area.

A minor upwarped anticlinal structure occurs several miles west of the Dutton Basin anticline. This structure, the Puddle Springs anticline, probably involves rocks ranging in age from middle lower Cretaceous through late Cretaceous age. The structure is covered by rocks of Tertiary age and is not visibly expressed surfically.

The Wind River Formation was deposited upon the rising flanks Pre-Tertiary formations. Initially as silts and variegated clays of the lower Wind River Formation developed from the soft silts of previous valley forming formations like the Chugwater and Sundance Formations. Later deposition developoped the Conglomerate and Arkosic sandstones of the upper Wind River Formation. This unit contains the Puddle Springs Arkose member which is the uranium host rock in the area.

Post Wind River rocks are recognized in the Beaver Rim erosional-fault escarpment south of the major uranium producing area. This feature involves rocks ranging in age from Middle and Upper Eocene to tuffaceous sediments of Oligocene age in cliff forming phase, capped by rocks of Miocene age. Some Pliocene rocks do occur south of this rim often overlapping directly upon granites of the Sweetwater arch. The present geographic location of this escarpment involves in general hundreds of feet of topographic relief due to erosional retreat of the post Wind River rocks to a current location along joints, fractures, and Tertiary faults, which in turn may be part of pre-existing Laramide or older fault structures. (See figure 2.5-1.)

The entire mill and tailings disposal site lie directly upon the fine grained upper facies of the upper Wind River formation of lower Eocene age. Very little alluvium occurs in the area with the exception of a north-south trending zone paralleling and including the Willow Creek drainage (figure 2.5-2 and 2.5-3).

The area baserock is the impervious shales of the Cody formation of upper middle Cretaceous age. These shales form a minor syncline between the major anticlinal Dutton Basin on the east and the Puddle Springs anticlines on the west. This shale is unconformably overlain by a very low permeable silt and mudstone sequence belonging to the lower Eocene, lower Wind River formation. The time hiatus between the two is sufficiently long to have permitted the establishment of paleo-dendric stream patterns and considerable erosion upon the underlying shale.

The lower Wind River silts are variegated white, yellow, red, and green silts and clays that form low rounded relief badlands northeast of the proposed site.

The upper Wind River formation disconformably overlies the lower unit with a sufficient time lapse to form a considerable period of erosion. This upper Wind River formation is conglomerates and Fluvatile Arkosic sandstones derived from the surrounding mountains, predominately in the Sweetwater granites.

2.5.2 Soils Information

Soils in the vicinity of the Federal-American Partners mill site have developed from various parent materials by weathering processes typical of a cool, semi-arid climate.

Five soil associations were identified in the vicinity of the mill site by a U.S. Soil Conservation Service Reconnaissance Soil Survey [ref 1]. The five associations are the Havre-Forelle-Component sl complex (201), the Component 23 - 85 - 83 association (223), the Diamondville-Forelle association (277), the Component 21 - 83 - 85 association (283), and the Rock outcrop - High-point association (290). The numbered components have been tentatively co-related with designated soil series as follows: Component sl Absher, Component 23 - Mildren, Component 85 - Gravather, Component 83 - Cather, and Component 21 - Bosler.

Figure 2.5-4, shows the soil associations present in an area extending one mile around the mill site, and figure 2.5-5 shows a soil profile. The area shown in the soils map contains 262 hectares (648 acres) of the Havre-Forelle-Component sl complex, 28 hectares (70 acres) of Component 23 - 85 - 83 association, 1,093 hectares (2,702 acres) of Diamondville-Forelle association, 52 hectares (128 acres) of Component 21 - 83 - 85 association, and 25 hectares (62 acres) of Rock outcrop - High-point association. Table 2.5 gives a summary of the soil characteristics.

Descriptions of the soil associations are as follows:

a) Havre-Forelle-Component sl Complex - Mapping Unit 201

This complex consists of nearly level to sloping floodplains that have alluvial fans encroaching upon them at elevations between 1,860 to 2,200 meters (6,000 and 7,000 feet). The annual precipitation is about 12 inches. The mean annual soil temperature is about 46°F. The frost-free season is 90 to 120 days. This association is about 50 percent Havre clay loam, 1 to 6 percent slopes; about 15 percent Forelle sandy clay loam, 1 to 6 percent slopes; and about 10 percent Component sl sandy clay loam, 1 to 6 percent slopes. The Havre soil is located on floodplains, the Forelle soil is located on alluvial fans, and the Component sl soil is located on floodplains.

Included with this complex in mapping are areas of Havre, saline, Elkol; and a coarse-loamy, mixed, frigid Ustic Torriorthent. These inclusions make up about 25 percent of the total acreage.

The Havre series consists of very deep, well drained soils formed in alluvium on floodplains. Typically, the surface horizon is brown clay loam about 15 centimeters (6 inches) thick. The underlying layer is pale brown clay loam stratified with lenses of loam, very fine sandy loam, and silt loam to 152 centimeters (60 inches) or more.

The Havre soil has moderate permeability. The effective rooting depth is 152 centimeters (60 inches) or more. Available water capacity is high. Surface runoff is slow and the erosion hazard is slight.

The Forelle series consists of very deep, well drained soils formed in alluvium on fans and uplands. Typically, the surface horizon is grayish brown sandy clay loam about 5 centimeters (2 inches) thick. The subsoil is brown to dark brown clay loam about 61 centimeters (24 inches) thick. The substratum is light yellowish brown clay loam to 152 centimeters (60 inches) or more.

The Forelle soil has moderate permeability. The effective rooting depth is 152 centimeters (60 inches) or more. Available water capacity is high. Surface runoff is slow to medium and the erosion hazard is slight to moderate.

The Component sl series consists of very deep, well drained soils formed in alluvium on fans and floodplains. Typically, the surface horizon is pale brown sandy loam about 10 centimeters (4 inches) thick. The subsoil is pale brown to very pale brown clay about 43 centimeters (17 inches) thick. The substratum is yellowish brown to pale brown sandy clay loam and coarse sandy loam to 152 centimeters (60 inches) or more.

The Component sl soil has slow permeability. The effective rooting depth is 152 centimeters (60 inches) or more. Available water capacity is high. Surface runoff is slow to medium and the erosion hazard is slight to moderate.

The Havre soil has native vegetation that consists mainly of western wheatgrass and big sagebrush. The Forelle soil has native vegetation that consists mainly of western wheatgrass, bluebunch wheatgrass, and big sagebrush. The Component sl soil has native vegetation that consists mainly of big sagebrush, phlox, cactus, Canby bluegrass, and needleandthread.

These soils are used primarily for livestock grazing, wildlife habitat, and community uses. Proper grazing management can help offset or minimize the deterioration caused by overutilization.

Management of the vegetation supported by the Havre soil should be designed to increase the production of basin wildrye, green needlegrass, slender wheatgrass, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them product more desirable plant species.

Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

Management of the vegetation supported by the Forelle and Component sl soils should be designed to increase the production of bluebunch wheatgrass, Indian ricegrass, needleandthread, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them produce more desirable plant species. Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

This complex is in capability unit Vle; Havre part: Lowland, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site; Forelle part: Loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site; and Component sl part: Loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site.

b) Component 23, Component 85, Component 83 Association - Mapping Unit 223

This association consists of nearly level to moderately steep terraces and uplands at elevations between 2,200 to 2,400 meters (7,000 and 8,000 feet). The annual precipitation is about 12 inches. The mean annual soil temperature is about 46°F. The frost-free season is 90 to 120 days. This association is about 50 percent Component 23 loam, 1 to 10 percent slopes; about 20 percent Component 85 gravelly loam, 3 to 20 percent slopes; and about 10 percent Component

83 clay loam, 6 to 25 percent slopes. The Component 23 soil is located on broad, nearly level terraces. The Component 83 soil is located on sloping to moderately steep upland hillsides.

Included with this association in mapping are areas of Component 72 and Component 21. These inclusions make up about 20 percent of the total acreage.

The Component 23 series consists of deep, well drained soils formed in alluvium on terraces. Typically, the surface horizon is brown loam about 7.5 centimeters (3 inches) thick. The subsoil is grayish brown clay about 53 centimeters (21 inches) thick. The upper substratum is light yellowish brown very gravelly sandy clay loam about 53 centimeters (21 inches) thick. The lower part is pale olive very gravelly sandy loam to 152 centimeters (60 inches) or more.

The Component 23 soil has moderately slow permeability. The effective rooting depth is 152 centimeters (60 inches) or more. Available water capacity is high. Surface runoff is slow to medium and the erosion hazard is slight.

The Component 85 series consists of moderately deep, well drained soils formed in local alluvium and residum from conglomerate.

Typically, the surface horizon is dark brown gravelly loam about 5 centimeters (2 inches) thick. The subsoil is yellowish brown sandy clay loam about 18 centimeters (7 inches) thick. The substratum is brown and light gray very gravelly coarse sandy clay loam about 38 centimeters (15 inches) thick and is underlain by conglomerate at 61 centimeters (24 inches).

The Component 85 soil has moderately slow permeability. The effective rooting depth is 51 to 102 centimeters (20 to 40 inches) or more. Available water capacity is moderate. Surface runoff is slow to medium and the erosion hazard is slight to moderate.

The Component 83 series consists of moderately deep, well drained soils formed in residum on hills and upland side slopes from claystones. Typically, the surface horizon is pale brown loam about 8 centimeters (3 inches) thick. The substratum is pale brown gravelly clay loam about 30 centimeters (12 inches) thick and is underlain by mudstone at 71 centimeters (28 inches).

The Component 83 soil has moderately slow permeability. The effective rooting depth is 51 to 102 centimeters (20 to 40)

inches. Available water capacity is moderate. Surface runoff is medium to rapid and the erosion hazard is moderate to severe.

The Component 23 soil has native vegetation that consists mainly of prairie junegrass, western wheatgrass, threadleaf sedge, Sandberg bluegrass, big sagebrush, and needleandthread. The Component 85 soil has native vegetation that consists mainly of green needlegrass, threadleaf sedge, big sagebrush, and western wheatgrass. The Component 83 soil has native vegetation that consists mainly of western wheatgrass, threadleaf sedge, big sagebrush, phlox, and forbs.

These soils are used primarily for livestock grazing, wildlife habitat, and community uses. Proper grazing management can help offset or minimize the deterioration caused by overutilization.

Management of the vegetation supported by the Components 21 and 85 soils should be designed to increase the production of bluebunch wheatgrass, Indian ricegrass, needleandthread, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them produce more desirable plant species. Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

Management of the vegetation supported by the Component 83 soil should be designed to increase the production of bluebunch wheatgrass, green needlegrass, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them produce more desirable plant species. Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

Component 23 part: Capability unit VIe2, dryland; Loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site. (Woodland Site Index.) Component 85 part: Capability unit VIe2, dryland; loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site. (Woodland Site Index.) Component 83 part: Capability unit VIe1, dryland; Clayey, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site.

c) Diamondville, Forelle Association - Mapping Unit 277

This association consists of undulating to hilly uplands at elevations of 1,705 to 2,170 meters (5,500 to 7,000 feet) in the eastern part of the survey area. The average annual precipitation is about 33 centimeters (13 inches); the mean annual soil temperature is about 46°F; and the frost-free season is 90 to 120 days. Slopes range from 3 to 30 percent, the steeper slopes occurring on breaks along draws and drainageways. This association is about 40 percent Diamondville sandy clay loam, 3 to 10 percent slopes; about 25 percent Forelle sandy clay loam, 3 to 10 percent slopes; and about 10 percent Crownest sandy loam, 10 to 30 percent slopes. The Diamondville soil is a medium depth soil over soft, calcareous, fine grained sandstone or sandy shale. The Forelle soil is a very deep soil on alluvial fans and in the uplands. The Crownest soil is a shallow soil over hard, noncalcareous sandstone.

Included with this association in mapping are areas of Delphill, Blazon, Blackhall, Havre, and Elkol soils and Rock outcrops. These inclusions make up about 25 percent of the total acreage.

The Diamondville soil is a medium depth, well drained soil over soft, calcareous, fine grained sandstone or sandy shale in the uplands. In a representative Diamondville profile the surface layer is light brownish gray to brown sandy clay loam about 8 centimeters (3 inches) thick. The subsoil is brown to pale brown clay loam about 23 centimeters (9 inches) thick. The substratum is light gray loam underlain by soft, fine grained sandstone at about 56 centimeters (22 inches).

The Diamondville soil has moderate permeability. Available water capacity is moderate. Effective rooting depth is 51 to 102 centimeters (20 to 40 inches). Surface runoff is medium and erosion hazard is moderate.

The Forelle soil is a very deep, well drained soil developing in alluvium on alluvial fans in the uplands.

In a representative Forelle profile the surface layer is grayish brown sandy clay loam about 5 centimeters (2 inches) thick. The substratum is light yellowish brown clay loam to a depth of 152 centimeters (60 inches) or more.

The Forelle soil has moderate permeability. Available water capacity is high. Effective rooting depth is 152 centimeters (60 inches) or more. Surface runoff is medium and erosion hazard is moderate.

The Crownest soil is a shallow, well drained soil over hard sandstone in the uplands. In a representative Crownest profile the surface layer is pale brown loamy sand about 8 centimeters (3 inches) thick. The substratum is brown sandy loam underlain by hard, noncalcareous sandstone at about 30 centimeters (12 inches).

The Crownest soil has moderately rapid permeability. Available water capacity is low. Effective rooting depth is 10 to 20 inches. Surface runoff is rapid and erosion hazard is moderate to severe. These soils are used for rangeland.

The Diamondville and Forelle soils have native vegetation that consists of western wheatgrass, bluebunch wheatgrass, and big sagebrush. The Crownest soil has native vegetation that consists of bluebunch wheatgrass, Sandberg bluegrass, and big sagebrush.

Diamondville part: Dryland land capability unit Vle; Clayey range site. Forelle part: Dryland land capability unit Vle; Clayey range site. Crownest part: Dryland land capability unit Vle; Shallow Sandy range site.

d) Component 21, Component 83, Component 85 Association - Mapping Unit 283

This association consists of nearly level to moderately steep uplands and outwash terraces at elevations between 1,860 to 2,325 meters (6,000 and 7,500 feet). The annual precipitation is about 12 inches. The mean annual soil temperature is about 46°F. The frost-free season is 90 to 120 days. This association is about 40 percent Component 21 loam, 1 to 10 percent slopes; about 30 percent Component 83 clay loam, 3 to 30 percent slopes; and about 10 percent Component 85 gravelly loam, 2 to 15 percent slopes. The Component 21 soil is located on terraces and alluvial outwash. The Component 83 soil is located on hills and upland side slopes. The Component 85 soil is located on the alluvial side slopes.

Included with this association in mapping are areas of Unnamed 72, Unnamed 93, and Rock outcrop. These inclusions make up about 20 percent of the total acreage.

The Component 21 Bosler series consists of deep, well drained soils formed in mixed alluvium on terraces and outwashes. Typically, the surface horizon is brown loam about 8 centimeters (3 inches) thick. The subsoil is yellowish brown sandy clay loam about 23 centimeters (9 inches) thick. The substratum is light brownish gray very gravelly loam sand to 152 centimeters (60 inches) or more.

The Component 21 soil has moderate permeability. The effective rooting depth is 152 centimeters (60 inches) or more. Available water capacity is low. Surface runoff is slow to medium and the erosion is slight to moderate.

The Component 83 series consists of moderately deep, well drained soils formed in residuum on hills and upland side slopes from claystone. Typically, the surface horizon is pale brown loam about 8 centimeters (3 inches) thick. The subsoil is grayish brown clay about 33 centimeters (13 inches) thick. The substratum is pale brown gravelly clay loam about 30 centimeters (12 inches) thick and is underlain by mudstone at 71 centimeters (28 inches).

The Component 83 soil has moderately slow permeability. The effective rooting depth is 51 to 102 centimeters (20 to 40 inches). Available water capacity is moderate. Surface runoff is medium to rapid and the erosion hazard is moderate to severe.

The Component 85 series consists of moderately deep, well drained soils formed in local alluvium and residuum from conglomerate. Typically, the surface horizon is dark brown gravelly loam about 5 centimeters (2 inches) thick. The subsoil is yellowish brown sandy clay loam about 18 centimeters (7 inches) thick. The substratum is brown and light gray very gravelly coarse sandy clay loam about 38 centimeters (15 inches) thick and is underlain by conglomerate at 61 centimeters (24 inches).

The Component 85 soil has moderately slow permeability. The effective rooting depth is 51 to 102 centimeters (20 to 40 inches). Available water capacity is moderate. Surface runoff is slow to medium and the erosion hazard is slight to moderate.

The Component 21 soil has native vegetation that consists mainly of western wheatgrass, big sagebrush, threadleaf sedge, needleandthread, phlox, and birdfoot sagebrush. The Component 83 soil has native vegetation that consists mainly of western wheatgrass, threadleaf sedge, big sagebrush, and phlox. The Component 85 soil has native vegetation that consists mainly of green needlegrass, threadleaf sedge, big sagebrush, and western wheatgrass.

These soils are used primarily for livestock grazing, wildlife habitat, and community uses. Proper grazing management can help offset or minimize the deterioration caused by overutilization.

Management of the vegetation supported by the Components 21 and 85 soils should be designed to increase the production

on bluebunch wheatgrass, Indian ricegrass, needleandthread, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them produce more desirable plant species. Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

Management of the vegetation supported by the Component 83 soil should be designed to increase the production of bluebunch wheatgrass, green needlegrass, and western wheatgrass. The application of management practices such as proper grazing use, deferred, or deferred rotation grazing can help offset or minimize the limitations of these soils and help them produce more desirable plant species. Such accelerated practices as brush management, cross fencing, and water development can be used to utilize these soils more effectively without damaging them. Bed grounds, seismograph trails, pipelines, and similar disturbed areas can successfully be reseeded as part of a reclamation program.

Component 21 part: Capability unit Vle2, dryland; Loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site. Component 83 part: Capability unit Vle1, dryland; Clayey, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site. Component 85 part: Capability unit Vle1, dryland; Loamy, 25 to 36 centimeter (10 to 14 inch) precipitation zone, range site.

e) <u>Rock Outcrop, Highpoint Association - Mapping Unit 290</u>

This association consists of steep and very steep escarpments associated with monoclinal ridges. The bedrock is hard, fossil shale. These soils occur in foothills and uplands at elevations of 1,612 to 2,015 meters (5,200 to 6,500 feet) in the eastern part of the survey area. The average annual precipitation is about 13 inches, the mean annual soil temperature is about 46°F, and the frost-free season is 90 to 120 days. Slopes range from 20 to 70 percent. This association is about 60 percent Rock outcrops and about 25 percent Highpoint channery silty clay loam, 20 to 50 percent slopes. The Rock outcrops are hard, fossil shale. The Highpoint soil is a very shallow channery soil over bedrock.

Included with this association in mapping are areas of Diamondville, Forelle, and Patent soils. These inclusions make up about 15 percent of the total acreage.

The Rock outcrop is principally fossil shale but may include outcrops of soft clay shale and thin sandstone ledges.

The Highpoint soil is a very shallow, well drained soil over fossil shale.

In a representative Highpoint profile the surface layer is grayish brown channery silty clay loam about 18 centimeters (7 inches) thick underlain by fossil shale.

The Highpoint soil has moderate permeability. Available water capacity is low. Effective rooting depth is less than 10 inches. Surface runoff is medium to very rapid and erosion hazard is moderate to severe.

These soils are in range areas but have little value as rangeland because of steepness of the slope and sparseness of vegetation. Some areas are used as pits for shale to use as road surfacing.

The Highpoint soil has native vegetation that consists of bluebunch wheatgrass, threadleaf sedge, and Sandberg bluegrass.

2.5.3 Topographic Information

Topographic maps on a scale of 1 inch = 400 feet with 5 foot contour intervals were used for general orientation and drainage area measurements. The topographic maps were based on aerial photography and control field surveys using U.S.G.S. published information. Surface topography is classified as rolling hills lying between the Dutton Basin anticline to the northwest and Beaver Rim to the south.

2.6 SEISMOLOGY

Faulting is not known to occur within the immediate confines of the mill and tailings disposal site. Tertiary faults ranging in age to Quaternary time to occur in the Gas Hills. These are indicated on figure 2.5-1 of this report, for the area adjoining the dam site.

The normal throw on Tertiary faults in the Gas Hills is 0-120 ft. Usually there is almost no fault gauge in the zone which may be up to a few inches thick. Such zones are frequently much finer grained material and may well be the lowest permeable zone in the vicinity of their occurrence. [One Tertiary fault occurs about one-half mile southwest of the site but hinges out south of the area.]

Seismic events in the Wyoming basin region have been few and of low magnitude. Only 14 earthquakes of any significance

have occurred within a 200 kilometer radius (see table 2.6-1) of the area of interest during the period from 1897 through 1974 [ref 1 and 2]. The area is in Zone 1 on the seismic risk map of the United States, indicating earthquakes are mild and cause only slight damage [ref 3].

The Gas Hills district in central Wyoming is an area of low seismicity. Wyoming as a whole is a relatively inactive region and most of the seismic activity may be associated with the extreme northwestern and west-central Wyoming area and the Medicine Bow Range area [ref 4].

The nearest earthquakes to the site were located 40, 50, and 70 miles from the site on February 13, 1928, November 23, 1934, and February 25, 1963 respectively. All were maximum Modified Mercalli Intensity V events at their epicenters [ref 5] (see table 2.6-1).

Also of significance were the earthquakes reported at Casper, some 75 miles from the site. The 1894 and 1897 events were reported in Casper, respectively, as Intensity V and Intensity VI-VII [ref 4]. Some structural damage resulted from the 1897 event and it was felt by all in the city (Eppley, 1965). Other Intensity V events have occurred in central Wyoming. Most of the Intensity V earthquakes were probably not even felt near the site, and if so, only to an extremely small degree. The Intensity VI-VII event at Casper may have produced ground motion at the site up to Intensity III [ref 6].

The large, regional earthquake which occurred at Hebgen Lake, Montana in 1959 was just at the limits of perceptibility at the site. This Magnitude 7.1 earthquake occurred about 288 kilometers (180 miles) away, had an epicentral of Intensity X, and was felt over 600,000 square miles [ref 6].

Almost all of the activity in Wyoming is concentrated in two areas. One area, a portion of the intermountain seismic belt, comprises a narrow, north-south trending strip in the western-most part of the state and includes the Yellowstone area. The other area is an extension of a trend northward from Colorado and coincides with the general area of the Medicine Bow Mountains [ref 2]. These belts are areas of "greater seismicity", defined as having four Intensity VII or greater events per 10 years per square degree.

The remainder of Wyoming can be divided into regions of "lesser seismicity" and "no seismicity." The site is located in a region of "no seismicity." The tectonic framework and geologic history must also be evaluated to determine the possible effects of earthquakes near the site.

However, seismogenesis is not well understood in this region and, therefore, an earthquake similar in size to other regional events must be postulated to occur near the site.

The largest earthquake which is likely to occur near the site would therefore produce ground motion of Intensity V, although the site has probably experienced ground motion no more than Intensity III in historic time [ref 6]. This would correlate with horizontal ground accelerations of less than 5 percent gravity at foundation level. Such a value coincides with the proposals of the National Oceanic and Atmospheric Administration and the Uniform Building Code which places the site in Zone 1, minor earthquake damage (see figure 2.6-2).

2.7 HYDROLOGY

The Gas Hills area is dissected by numerous drainage courses. Beaver Rim is the divide between the watersheds of the Sweetwater and Wind Rivers. Most of the drainage is to the north and northwest. The generally dry drainage courses are characterized by meandering channels, silt or sandy bottoms, and some bank cutting and caving in the lower reaches.

2.7.1 Ground Water

Ground water in the Gas Hills originates as precipitation. No estimate of recharge is available, but the average annual recharge rate for the Powder River Basin to the northeast has been estimated to be about 9 millimeters (0.36 inches) [ref 1]. It is likely that the recharge rate in the Gas Hills area is similar.

Runoff during a storm recharges alluvial deposits along stream courses, and this in turn is a recharge source for underlying shallow formations. Other sources of recharge to shallow aquifers include flow from small springs, mostly near the face of Beaver Rim, flow from a few wells, and mine water, which is stored in holding ponds, and treated before being discharged to local watercourses.

The regional waterlevel gradient is to the northwest at about 0.014 over a 32 kilometer (20 mile) distance in the southeastern part of the Wind River Basin [ref 2]. The water level gradient in the Gas Hills area also shows a general northwestward trend at a gradient of about 0.028 over a 13 kilometer (8 mile) distance [ref 3].

Discharge of ground water is principally by water-supply wells and mine dewatering.

Other than for seven stock-water wells, all of the wells in the area are used for uranium industry purposes. Three of these wells now supply domestic water for use by mining company employees. Table 2.7 shows the ground water use within five miles of the mill site. Figure 2.7-2 shows the area water well locations.

Ground water in the Wind River formation occurs under both water table and artesian conditions, in intergranular pore spaces and in permeable zones formed along fractures. Cementation of grains by iron oxide and calcium carbonate appears extensive enough to have substantially decreased primary porosity. Secondary porosity created by fracturing may be more significant. Normal faults of displacements of 5 meters to 15 meters (16 to 49 feet) locally affect the occurrence of ground water.

Ground water apparently leaches, transports, and deposits uranium in the Gas Hills area. Most above-normal concentrations of uranium in the Wind River formation usually occur at water table depressions or where the water table flattens [ref 3]. Impermeable strata dispersed throughout the Wind River formation act as perching layers. Some of the spring flow in the region, as well as seepage into the mine pits, probably moves along these perching beds. Below the Cody shale, several confined aquifers are present.

The principal surface drainage direction is to the north and west, toward the Wind River. The regional water table trends generally in the same direction at a gradient of 80 to 100 feet per mile. The water table gradient locally changes near the contact of rocks of different permeability and faults, and conforms with the structure along some anticlines. Contours of the regional ground water table as shown in figure 2.7-1 and as interpreted from wells less than 415 feet in depth, do not reach the ground surface within five miles of the site.

2.7.2 Surface Water

The area is drained by Willow Springs draw and its varied tributaries, all intermittent streams, flowing north or northwestward to join other streams which eventually flow into Boysen Reservoir on the Wind River.

Near the site, the average annual runoff is estimated to be 1.3 centimeters (0.5 inches) [ref 4]. Because the annual water losses nearly equal the annual precipitation, runoff is extremely variable in terms of percent.

Runoff from the Gas Hills occurs from snowmelt during the peak of the spring runoff period (April-May) or as the

result of rare cloudbursts. Most of the stream channels carry water less than 15 days each year. Annual runoff from the area, as indicated by records at the U. S. Geological Survey stream gauge, Muskrat Creek near Shoshoni, Wyoming, is very low, averaging 1.65 millimeters (0.065 inches) per year. Annual runoff at this location has ranged from zero to 10.2 millimeters (0.40 inches) [ref 5].

The central and northwestern edge of the area is drained by several intermittent tributaries of Muskrat Creek. Muskrat Creek flows northward and northwestward for 58 airline kilometers (36 miles) and empties into the Wind River about 4.8 kilometers (3 miles) upstream from Boysen Reservoir.

The maximum known flood during the period of record, June 1950 to September 1958 and October 1959 to September 1973, at the Muskrat Creek near Shoshoni, Wyoming, stream gauge [ref 6] occurred on February 10, 1962, when the peak discharge was 377 cubic meters (13,300 cubic feet) per second.

During periods of moderate to high flow, the streams carry very large quantities of suspended sediments. To help protect Boysen Reservoir from siltation, the BLM has constructed a number of spreader and detention systems in the Muskrat Creek drainage basin.

A number of very small stock watering ponds, an industrial water supply reservoir, and several tailings retention embankments are located on drainages within five miles of the site. Aside from some of the small stockwatering ponds, all of these water bodies are in watersheds not on the site.

2.8 METEOROLOGY

The climate of the site is typical of the Wyoming high plains and is influenced by elevation, topography, and distance from the oceans. Wyoming is in the latitudes of prevailing westerly winds. Air movement in this direction is most pronounced during the winter, causing greater precipitation on the western slopes of mountains such as the Wind River Range. During the spring and summer, circulation patterns bring moist air and precipitation to Wyoming from the Gulf of Mexico. In the summer when the air is generally much warmer and thus higher in moisture-carrying capacity, precipitation often evaporates before it reaches the ground. (See figure 2.8 for wind direction and speed information).

Daily precipitation and temperature data since 1963 are available for the Gas Hills 4E weather station located about six miles east of the site. A summary of selected data is shown on table 2.8-1. The mean annual precipitation for the period of record (15 years) is 25 centimeters (9.86 inches).

Over half the annual precipitation usually occurs during the months of April through June, while less than a third occurs during the period of October through March [ref 1]. Table 2.8-2 shows the monthly precipitation in the Gas Hills area. The seasons are distinct. Summers are mild with warm to hot days and cool nights. Winters are harsh with cold temperatures, high winds, and infrequent blizzards. The spring and fall are transition periods between the large contrast of summer and winter. Warm days and cold nights are experienced during both spring and fall; wet, heavy snowfalls can be expected in both these seasons. The growing season is short (between 90 and 120 days, from late May to early September). July is the warmest month and January the coldest. For the site area, the mean maximum and mean minimum for July are estimated to be 28° and 11°C (83° and 52°F) respectively [ref 3]. The mean maximum and mean minimum temperatures for January are estimated to be 28 and 10 degrees Fahrenheit. Tables 2.8-3 and -5 show the monthly temperatures for the Gas Hills area. The highest and lowest temperatures recorded since 1963 are 95 and minus 34 degrees Fahrenheit (Environmental Data Service, 1963-1974). The average potential evapotranspiration rate for the site is estimated to be 56 centimeters (22 inches) annually [ref 2]. Average lake evaporation is estimated to be 107 centimeters (42 inches) annually (Kohler and others, 1959). Table 2.8-3 gives the relative humidity 2.4 kilometers (1 1/2 miles) north of the FAP site. Due to the area's high elevation and extensive stretches of rolling plains, wind is an important climatological factor. Wind data available for Casper are probably representative of the site. At Casper, the mean hourly wind speed varies from 16 kilometers (10 miles) per hour in July to nearly 27 kilometers (17 miles) per hour during December through February. The prevailing wind direction is south-southwest to southwest.

Table 2.8-6 presents a summary of meteorological data available for Casper which has the closest representative first order weather station to the site. Data are also available for Lander, but these are probably not representative of the site because of Lander's sheltered position near the Wind River Mountains.

Until 1963, there had been no meteorological monitoring equipment in operation in the vicinity. The nearest official weather stations are at Lander 88 kilometers (55 miles) west and Casper 93 kilometers (58 miles) east. The meteorologists at both stations advised that the meteorology in the Gas Hills area is probably more similar to that of Casper, the means and extremes of precipitation and humidity are probably less, and the temperatures are probably lower. The <u>1974 Annual Summary of Local Climatological Data</u> for Casper provides data on the means and extremes of various

meteorological parameters. Sufficient data have not yet been generated to permit determination of wind characteristics or storm frequencies for the Gas Hills area.

2.8.1 Probable Maximum Precipitation

Data for the hypothetical 6 hour and 24 hour precipitation period--100 year frequency, for this area and the site, indicates 16 centimeters (6.3 inches) of precipitation for a 6 hour period with 8.5 centimeters (3.34 inches) of runoff [ref 4 and 5]. Utilizing these same sources of information, a 24 hour probable maximum flood would produce 13.23 inches of precipitation with 9.92 inches of runoff.

Without the use of diversion ditches, total runoff to pond no. 1 would be 109,000 cubic meters (88.45 acre-feet) maximum, leaving a freeboard of 1.5 meters (4.88 feet).

2.9 ECOLOGY

2.9.1 Vegetation

A map of the vegetation communities within one mile of the restricted area is presented in figure 2.9-1. A flora species list is located in section 2.9.1.1. Vegetation studies have not been conducted on such a scale as to identify the various communities in each stage of ecological succession. Within each of the communities mapped there is a significant range in the successional state. With every seismograph trail or temporary road that has been constructed in the last 30 years the ecological succession has started anew at each site. Most of these disturbances are linear in shape and are not easily studied on a quantitative basis. Plant species that occur in the pioneer successional state are given for the individual communities.

For vegetation mapping purposes, the vegetation is divided into eight major natural vegetation types: (1) big sagebrush-medium stand, (2) big sagebrush-heavy stand, (3) bottomland, (4) rough breaks, (5) grass bottom, (6) greasewood bottom, (7) pine-juniper, and (8) ecotone of big sagebrush-medium stand, big sagebrush-heavy stand, and rough breaks.

The big sagebrush-medium stand vegetation type covers the largest area surrounding the mill site. It is a mixed stand of shrubs and grass occurring on terrain ranging from level to rolling hills. This type is dominant both north and south of Beaver Rim. North of Beaver Rim, the vegetation

type includes most areas not classified as rough breaks or bottomland. South of Beaver Rim, the type includes most of the area not classified as ecotone or big sagebrush-heavy stand vegetation types. The big sagebrush-medium stand is fairly evenly distributed throughout the Gas Hills area, being most predominant south of Beaver Rim.

The dominant plant species in the community are big sagebrush (Artemisia tridentata), thickspike wheatgrass (Agropyron dasystachyum), and needleleaf sedge (Carex eleo charis). The subordinate plant species are western wheatgrass (Agropyron smithii), Sandberg bluegrass (Poa secunda), bluebunch wheatgrass (Agropyron spicatum), and needleandthread (Stripa Comata).

Plans pricklypear (Opuntia polycantha) and Hood's phlox (Phlox hoodii) are minor components of the community that are thought to increase in the frequency of occurrence due to over grazing by domestic livestock. Range site inventories have not been conducted on a scale so as to estimate range condition for the entire area within one mile of the restricted area.

Areas that have been disturbed by the activities of man are in various stages of ecological succession. The species composition depends upon the degree of the disturbance and the length of time that has elapsed since the land was returned to the natural environmental forces. With this community, grasses such as Bottlebrush squirreltail (Sitanion hystrix), Cheatgrass brome (Bromus tectorum), and the shrub rubber rabbitbrush (Chrysothamnus nauseosus) are the major pioneer species that would occupy an area soon after a surface disturbance. Approximately 15-25 percent of the community is in the early stages of secondary succession and could be termed as a seral community.

The big sagebrush-heavy stand vegetation type is the fourth largest type and was generally restricted to gullies and bottom. The largest portion of this type is located south of Beaver Rim and includes most of the gullies, bottoms, and draws. Areas of big sagebrush-heavy stand north of Beaver Rim are generally restricted to draws and gullies along the upper reaches of most drainages. This type composes a very small portion of the area north of Beaver Rim. This type is fairly evenly distributed south of Beaver Rim, but is found only occasionally north of the rim where it is restricted generally to areas immediately north of the rim. Big sagebrush (Artemisia tridentata) and western wheatgrass (Agropyron smithii) are the dominant plant species. Subordinate plant species include Thickspike wheatgrass (Agropyron dasystachyum), Idaho fescue (Festuca idahoensis), Mutton bluegrass (Poa fendleriana), sedge (Carex sp.) and western yarrow (Achillea lanulosa).

Within this community big sagebrush often forms such a dense canopy that other competing plant species are completely excluded. The locations of the community in draws and gullies allows the plants to draw on higher moisture availability due to snow drift accumulation and collection of surface runoff in the draws. When this community is in a seral ecological stage, rubber rabbitbrush (Chrysothamnus nauseosus) is subdominant.

The bottomland vegetation type is the fifth largest type and is generally restricted to bottomlands, draws, and gullies. The largest portion of this type is located north of Beaver Rim and composes most of the gullies, bottoms, and draws not included in the big sagebrush-heavy stand type. A small area south of Beaver Rim is classified as bottomland and is included together with the grass-bottom type. These areas are located in the bottoms along the southern-most extremities of the permit boundaries and make up only a small portion of the total area mapped. The bottomland type is much more extensive than the big sagebrush-heavy stand north of Beaver Rim, while the opposite was true south of the rim.

Major species of this type include thickspike wheatgrass, big sagebrush, rubber rabbitbrush, shadscale, saltbush, Distichlis spicata var. stricta (inland saltgrass), black greasewood, mutton bluegrass, and numerous sedges and forbs. Other plant species included big sagebrush (Artemisia tridentata), rubber rabbitbrush (Chrysothamnus nauseosus), basin wildrye (Elymus cinereus), and Thickspike wheatgrass (Agropyron dasystachyum).

At one area in Willow Springs draw where ground water is very close to the surface, willows (Salix sp.), currants (Ribes sp.) and rushes (scirpus sp.) form a sub-type at the bottomland community.

The rough breaks vegetation type is the second largest type. Beaver Rim and immediate areas to the north are composed predominantly of this vegetation type. The rough breaks type is generally limited to areas north of and including Beaver Rim. The rough breaks type generally includes most moderate to steep slopes, barren ridges and hilltops, and areas with high erosion. In contrast to the big sagebrush-medium stand type, the rough breaks type is not evenly distributed throughout the permit area, but is concentrated mainly along and immediately north of Beaver Rim.

The dominant plant species are bluebunch wheatgrass (Agropyron spicatum), prairie junegass (Koeleria cristata), and big sagebrush (Artemisia tridentata). Subordinate plant species are phlox (Phlox sp.), black sagebrush (Artemisia nova), and Canby bluegrass (Poa canbyi).

After a land disturbance in this community, rubber rabbitbrush (Chrysothamnus nauseosus) and Douglas rabbitbrush (Chrysothamnus viscidiflorus) tend to replace the sagebrush species, and bottlebrush squirreltail (Sitanion hystrix) generally becomes the dominant grass.

The grass-bottom type composes less than 2.0 percent of the total area mapped and is restricted mainly to the southern extremities of the area.

The greasewood bottom type also composes less than 2.0 percent of the total area mapped and is the smallest major vegetation type. This type is restricted to areas north of Beaver Rim, generally along the western and northwestern edges of the Gas Hills area. It usually occupies land that is level to gently sloping with alkaline or Saline soil conditions.

The dominant plant species are greasewood (Sarco-batus vermiculatus) and Thickspike wheatgrass (Agropyron dasystachyum). Subordinate plant species are Shadscale saltbush (Atriplex confertifolia), Gardner saltbush (Atriplex gardneri), rubber rabbitbrush (Chrysothamnus nauseosus), and silver sagebrush (Artemisia cana). Pioneer species include bottlebrush squirreltail (Sitanion hystrix) and inland saltgrass (Distichlis spicata stricta).

The pine-juniper type, covering only a slightly larger area than the last two types, is generally found along Beaver Rim, on steep slopes north of the Rim, or along the edges of high ridges above creek drainages. Most of the pine-juniper type is along either the west or east sides of the Gas Hills area. This type is not extensive, composing less than 2.0 percent of the total area mapped.

The dominant plant species are limber pine (Pinus flexilus), black sagebrush (Artemisia nova), prairie junegrass (Koeleria cristata), thickspike wheatgrass (Agropyron dasystachyum), and common juniper (Juniperous communis).

The ecotone type is the third largest type. Beaver Rim marks the northern-most boundary for this type; the type is restricted to areas south of the rim. This type is an ecotone between the big sagebrush-medium stand, the big sagebrush-heavy stand, and the rough breaks vegetation types. The type is generally located in areas north of Beaver Rim considered to have the steepest slopes and highest erosion, i.e. areas with the most rugged terrain. Dominant vegetation varied within the type. In gullies and bottoms, the dominant vegetation is similar to the dominant vegetation on the big sagebrush-heavy stand type. On hiltops, ridges, and steep slopes, the dominant vegetation is

similar to that found on the rough breaks type, and on moderate slopes, ridges, and bottoms, the dominant vegetation is similar to that found on the big sagebrush-medium stand type. In general though, dominant species represented members from each of the three types, thus forming an ecotone. Major species include big sagebrush, thickspike wheatgrass, sandberg bluegrass, threadleaf sedge, hoods phlox, hooker sandwort, mutton bluegrass, douglas rabbitbrush, bluebunch wheatgrass, milkvetch, prairie junegrass, and wildbuckwheat.

A few relatively small areas with a dominance of Artemisia ped atifida (birdsfoot sagewort) appear on portions of the alluvial deposits north of Beaver Rim. This phenomenon is apparently due to soil characteristics (the soil type was classified as 88A-type soil).

Rubber rabbitbrush is generally found along stream banks from near the bottom of the stream bed to the base of the nearest hills. Inland saltgrass is often found along flat bottomlands where the surface is wet for only part of the year. Black sagebrush is generally restricted to rough, south- or west-facing slopes. On areas south of Beaver Rim, mutton bluegrass is found in significant amounts in draws but is replaced on hillsides and hilltops by bluebunch wheatgrass, thickspike wheatgrass, and hoods phlox.

The area surrounding the mill site includes a potential habitat for Artemisia porteri which is listed as a threatened plant species. The plant has been identified in the Sand Draw area 44 air kilometers (27.6 air miles) west of the mill and the Lost Cabin area 48 air kilometers (30.0 air miles) north of the mill. Even though a similar plant habitat is found approximately 1.5 miles north of the mill, no specimens of the plant have been identified in the Gas Hills area. The known habitat characteristics include a clayey shale outcrop land surface with a range in altitude between 1,674 to 1,860 meters (5,400 and 6,000 feet).

2.9.1.1 Flora Species List

Northern Desert Shrub Association

Gas Hills Area of Wyoming

GRASSES

Scientific Name	Common Name
Agropyron cristatum	Crested wheatgrass
Agropyron dasystachyum	Thickspike wheatgrass
Agropyron intermedium	Intermediate wheatgrass
Agropyron smithii	Western wheatgrass
Agropyron spicatum	Bluebunch wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Agrostis alba*	Redtop bent
Bromus tectorum	Cheatgrass brome
Deschampsia caespitosa*	Tufted hairgrass
Distichlis spicata stricta**	Inland saltgrass
Elymus cinereus**	Basin wildrye
Festuca idahoensis	Idaho fescue
Hilaria jamesii	Galleta Hilaria
Hordeum caespitosm	Bobtail barley
Hordeum jubatum**	Foxtail barley
Koeleria cristata	Prairie junegrass
Muhlenbergia richardsonis	Mat muhly
Orzopsis hymenoides	Indian ricegrass
Poe fendleriana	Mutton bluegrass

*Occurring primarily along streams or areas with water or snow accumulation.
**Occurring primarily in wet saline areas

Grasses continued

Scientific Name	Common Name
Poa pratensis*	Kentucky bluegrass
Poa secunda	Sandberg bluegrass
Puccinellia distans**	Weeping alkaligrass
Sitanion hystrix	Bottlebrush squirreltail
Sporobolus airoides**	Alkali sacaton
Stipa lettermanii	Letterman needlegrass
Stripa columbiana*	Subalpine needlegrass
Stripa Comata	Needleandthread
Stripa viridula	Green needlegrass

GRASSLIKE

Scientific Name	
Carex eleocharis	Needleleaf sedge
Carex filifolia	Threadleaf sedge
Carex nebraskensis*	Nebraska sedge
Juncas spp.*	Rush
Sisyrinchium idahoense	Idaho blueyedgrass
Triglochin palustrus**	Marsh arrowgrass
Triglochin maritima**	Seaside arrowgrass

*Occurring primarily along streams or areas with water or snow accumulation.
**Occurring primarily in wet saline areas.

FORBS

Scientific Name	Common Name
Achillea lanulosa	Western yarrow
Agroseris glauca	Pale agoseris
Allium textile	Prairie onion
Antennaria rosea	Rose pussytoes
Arabis canescens	Silver rockcress
Arenaria hookerii	Hooker sandwort
Artemisia ludoviciana*	Louisiana sagewort
Artemisia pedatifida	Birdfoot sagewort
Aster parryi	Parry woodyaster
Astragalus bisulcatus	Twogroved milkvetch
Astragalus kentrophyta	Nuttall kentrophyta milkvetch
Astragalus spatulatus	Spoonleaf milkvetch
Atriplex argentea	Tumbling saltbush
Balsamorrhiza sagittata*	Arrowleaf balsamroot
Castilleja chromosa	Desert indianpaintbrush
Castilleja linariaefolia	Wyoming indianpaintbrush
Chenopodium album	Lambsquarter goosefoot
Chenopodium leptophyllum	Narrowleaf goosefoot
Cirsium canescens	Platte thistle

*Occurring primarily along streams or areas with water or snow accumulation.

Forbs continued

Scientific Name	Common Name
Cirsium vulgare	Bull thistle
Cleome lutea	Yellow beeplant
Cleome serrulata	Rockymountain beeplant
Cordylanthus ramosus	Bushy birdbeak
Cryptantha flava	Yellow cryptantha
Cryptantha spp.	Cryptantha
Delphinium geyeri	Geyer larkspur
Descurainia pinnata	Pinnate tansymustard
Erigeron spp.	Fleabane
Erysimum spp.	Wallflower
Gilia aggregata	Skyrocket gilia
Gilia congesta	Ballhead gilia
Glycyrrhiza lepidota*	American licorice
Grindelia squarrosa	Curlycup gumweed
Haplopappus acaulis	Stemless goldenweed
Iva axillaris	Poverty sumpweed
Kochia scoparia	Fireweed summercypress
Lactuca scariola	Prickly lettuce
Lappula redowskii	Bluebur stickseed
Leptodactylon pungens	Granite pricklygilia
Lesquerella argentea	Silver bladderpod
Lesquerella condensata	Bladderpod
Linum lewisii	Lewis flax

*Occurring primarily along streams or areas with water or snow accumulation.

Forbs continued

Scientific Name	Common Name
Lithospermum incisum	Narrowleaf gromwell
Lithospermum multiflorum	Manyflower gromwell
Lupinus argenteus	Silvery lupine
Lupinus laxiflorus	Spur lupine
Machaeranthera spp.	Machaeranthera
Machaeranthera grindeliodes	
Mentzelia chrysantha	Blazing star
Mertensia foliosa	Leafy bluebells
Monolepis nuttalliana	Nuttall monolepis
Oenothera trichocalyx	
Orthocarpus luteus	Yellow owlclover
Penstemon fremontii	Fremont penstemon
Phacelia spp.	Phacelia
Phlox glaberrima	Smooth phlox
Phlox hoodii	Hood's phlox
Phlox multiflora	Flowery phlox
Plantago major**	Common plantain
Potentilla anserina*	Silverweed cinquefoil
Potentilla rivalis*	Brook cinquefoil
Psoralea tenuiflora	Slimflower scurfpea
Rannunculus sceleratus*	Blister buttercup
Rumex venosus	Veiny dock

*Occurring primarily along streams or areas with water or snow accumulation.
**Occurring primarily in wet saline areas.

Forbs continued

Scientific Name	Common Name
Rumex spp.	Dock
*Salicornia rubra***	Rockymountain glasswort
Salsola kali	Common Russianthistle
Sedum stenopetalum	Wormleaf stonecrop
Senecio spp.	Groundsel
Silene menziesi	Menzies silene
Sphaeralcea coccinea	Scarlet globemallow
*Suaeda depressa***	Pursh seepweed
Tanacetum capitatum	Rock tansy
Taraxacum officinale	Common dandelion
Thelypodium laciniatum	Cutleaved thelypody
*Thermopsis rhombifolia**	Prairie thermopsis
Vicia americana	American vetch
Viola spp.*	Violet
Xanthium spinosum	Spiny cocklebur
Zygadenus venenosus	Meadow deathcamus

*Occurring primarily along streams or areas with water or snow accumulation.
**Occurring primarily in wet saline areas.

HALF-SHRUBS

Scientific Name	Common Name
Artemisia frigida	Fringed sagewort
Ceratoides lanata	Common winterfat
Eriogonum acaule	Wildbuckwheat
Eriogonum caespitosum	Mat wildbuckwheat
Eriogonum cernuum	Nodding wildbuckwheat
Eriogonum ovalifolium	Cushion wildbuckwheat
Eriogonum umbellatum	Sulfur wildbuckwheat
Kochia americana	Greenmolly summercypress
Xanthocephalum sarothrae	Broom snakeweed

SHRUBS

Scientific Name	Common Name
Amelanchier alnifolia*	Saskatoon serviceberry
Artemisia cana	Silver sagebrush
Artemisia nova	Black sagebrush
Artemisia spinescens	Bud sagewort
Artemisia tridentata*tridentata	Basin big sagebrush
Artemisia tridentata*Vaseyana	Mountain big sagebrush
Artemisia tridentata*wyomingensis	Wyoming big sagebrush
Arctostaphylos uva-ursi	Bearberry manzanita
Atriplex canescens	Fourwing saltbush
Atriplex confertifolia	Shadscale saltbush
Atriplex nuttallii	Nuttall saltbush
Cercocarpus montanus	True mountain mahogany
Chrysothamnus nauseosus	Rubber rabbitbrush
Chrysothamnus vicidiflorus	Douglas rabbitbrush
Eleagnus argentea**	Silverberry
Grayia spinosa	Spiny hopsage
Juniperous communis	Common juniper
Juniperous osteosperma	Utah juniper
Prunus virginiana melanocarpa*	Black chokecherry

*Occurring primarily along streams or areas with water or snow accumulation.
**Occurring primarily in wet saline areas.

Shrubs continued

Scientific Name	Common Name
Purshia tridentata	Antelope bitterbrush
Ribes spp.	Currant
Sarcobatus vermiculatus	Black greaseweed
Symphoricarpos spp.	Snowberry
Tetradymia canescens	Gray horsebrush
Tetradymia inerme	Spineless horsebrush
Tetradymia spinosa	Cottonthorn horsebrush
SUCCULENTS	
Opuntia polyacantha	plains pricklypear
TREES	
Pinus flexilis	Limber pine
Populus tremuloides*	Quaking aspen

*Occurring primarily along streams or areas with water or snow accumulation.

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2.9.2 Wildlife

The state of Wyoming is overlapped by four biotic provinces: the Kansan, Saskatchewan, Coloradan, and Montanian. The Gas Hills region lies at the north edge of the Coloradan province and near the Saskatchewan and Montanian.

There are 72 species of mammals and 197 species of birds known to be in the central Wyoming (Gas Hills) area (See section 2.9.2.17, Fauna Species Lists). Several of these are important hunting resources and all fulfill various niche roles in the ecosystem.

2.9.2.1 Pronghorn (Antilocapra americana)

In 1970 there were an estimated 435,329 pronghorns in North America. Seventy-nine percent of these (344,933) were found within the region of southern Alberta, Saskatchewan, western North and South Dakota, Montana, and Wyoming. This region covers the Saskatchewan biotic province and parts of the Montanian and Coloradan. It is considered to be the zone of maximum pronghorn abundance (Kerdeigh, 1961, Sundstrom it al, 1973). This zone correlates with the distribution of big sagebrush (Artemisia tridentata) and silver sagebrush (Artemisia Cana).

Within this sagebrush zone, long-term antelope fawn to doe ratios are high (approximately 70 fawns:10 does). Outside this zone the fawn to doe ratio drops considerably.

Antelope dependence on the sagebrush-bunchgrass prairie is not simply based on a need for certain species, but on the whole scheme of ecological conditions which exist there - climate, topography, total plant cover, and water distribution. Optimum habitat has been summarized by Sundstrom et al as follows:

- Relatively open vegetative cover (40-60%).
- Browse plant height not over 18 inches.
- Vegetative composition consisting of:
  - 10-20% Artemisia species
  - 5-15% Other browse species
  - 23-35% Forbs
  - 40-60% Grasses
- Preferred browse species are:
  - Big sagebrush
  - Silver sagebrush
  - Douglas rabbitbrush (Chrysothamnus viscidiflorus)

- A source of three to five quarts of water per animal per day.

- A combination of flat, rolling, and rough topography.

In 1970 approximately 200,000 head of antelope were estimated in Wyoming. Forty-four percent (87,210) of these were found in the sagebrush and saltbush/greasewood (Atriples/Sarcobatus) vegetative types. Forty percent (80,570) were found in the grama-needlegrass-wheatgrass (Bouteloua-Stripa-Agropyron) types. In the Red desert (south of the Gas Hills), big sagebrush (Artemisia tridentata wyomingensis) and douglas rabbitbrush were the principal forage species of antelope diet. Big sagebrush received maximum use in the winter, while Douglas rabbitbrush received maximum use in the spring. Sandberg bluegrass (Poa secunda) was the most important grass in the spring diet (Severson et al, 1973). Antelope spend about fifty percent of their time feeding, with peak periods at daybreak, midday, and evening (Taylor, 1972). In this study on the Red desert, Taylor found that browse (principally sagebrush) made up ninety-two percent of the antelope's diet in winter and sixty-two percent in the spring. Forbs ranked twenty-nine percent in the spring and summer, and only one percent in the fall and winter. Grasses made up nine percent of the diet in the spring and two percent during all other seasons. These diet studies in Wyoming tend to verify antelope dependence on the sagebrush savannah habitats. This does not mean that antelope do not take advantage of other habitat conditions. Field research in the Powder River Basin has shown that antelope utilize cultivated hay (alfalfa) extensively during the summer, however, undisturbed sagebrush habitat is used again in the winter months.

The pronghorn antelope is the primary wildlife specie of economic value in the Gas Hills region. Ground census counts done in the fall and winter indicate a density of approximately 12.9 head per section. This compares favorably with densities in antelope-rich areas such as the Powder River Basin.

Wildlife census summary indicates a fawn to doe ratio of approximately 109 fawns to 100 does and a 57.5 bucks to 100 does ratio (see table 2.9-1). Group sizes ranged from 19 to 43 in the fall and from 11 to 154 head in the winter. The high fawn to doe ratios indicate healthy populations in good habitat. A lowering trend lasting over two years could indicate unhealthy conditions, eventually leading to a total population reduction due to natural causes.

According to the Bureau of Land Management, the whole Gas Hills area is located on important antelope summer range. The heaviest winter concentrations, however, lie northwest of the lease. Migrations apparently are seasonal and involve distances of only a few miles.

The Gas Hills area lies within the Sand Draw, Split Rock, and Deer Creek antelope hunting areas. Total 1974 harvest for these three areas, consisting of 6,700 square kilometers (2,586 square miles), was 933 animals (92 percent bucks).

This results in one animal killed per 7.2 square kilometers (2.77 square miles). Fremont and Natrona Counties had a total combined 1974 antelope harvest of 5,341 , or approximately one per 5.3 square kilometers (2.04 square miles) (excluding the Wind River Indian Reservation). Hunter success in the two counties averaged 94.77 percent while on the Sand Draw, Split Rock, and Deer Creek hunting areas it averaged 95.41 percent.

Antelope permits are sold on a quota system. The quota for the Sand Draw, Split Rock and Deer Creek hunting areas averages one hunter per 6.7 square kilometers (2.58 square miles) of area. An average of one hunter per 7.1 square kilometers (2.74 square miles) is allowed on the remaining units in Fremont County. The above hunting areas for antelope generally correspond to the Beaver Rim and Hiland antelope management units. In 1969 the estimated total antelope population on these units was 4,900 head (Wyoming Game and Fish W-27-R-28, Planning Report 6-G).

2.9.2.2 Rocky Mountain Mule Deer (Odocoileus hemionus hemionus)

There were an estimated 270,600 mule deer in the state of Wyoming in 1968. A large variety of habitat is utilized ranging from sagebrush-grassland to heavy timber and mountainous regions. Percent composition of shrubs, forbs, and grass in the diet varies seasonally. In general, shrubs and trees average 74 percent of the mule deer's winter diet, dropping to around 50 percent in the spring and summer and rising to 60 percent in the fall. Big sagebrush, mountain mahogany (Cerco-carpus montanus), quaking aspen (Populus tremuloides), bitterbrush (Purshia tridentata), and juniper (Juniperous communis) are heavily utilized. Grass and forb each average around 25 percent use in the spring. Forb use rises to 47 percent in the summer while grass use drops to three percent. A very large number of forb species are utilized. The most commonly used species of grasses are bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), Kentucky bluegrass (Poa pratensis), and other wheatgrass, bluegrass, and brome (Bromus spp.) genera (Kufeld, 1973).

The western edge of the Gas Hills area, below and to the west of Beaver Divide, nearly all of Township 33N, Range 90W, is classed as crucial deer habitat by the Bureau of Land Management. The portion of Beaver Divide crossing the lease is considered as marginal to poor deer habitat, according to the Bureau of Land Management Lander Office, January 1976.

Fall and winter ground census north of Beaver Rim in T33, R89, and R90, indicates a deer density of 0.26 head per section. The fawn to doe ratio is about 60:100 does.

The Gas Hills area falls within the Muskrat and Sweetwater Rocks hunting areas. In 1974 a total of 46 deer (bucks) were harvested from each area, resulting in a mean harvest of one animal per 28.8 square miles. A total of 460 hunters were on the areas, giving a success of 19.7 percent.

These hunting areas are located within the Muskrat and Split Rock big game management units. Total deer population wintering on these units in 1969 was estimated at 2,650 head. Note that a large number of these wintering deer may be migratory and not part of the resident, huntable population (Wyoming Game and Fish W-27-R-28, Planning Report 6-G).

2.9.2.3 Elk (Cervus canadensis)

The Gas Hills area is not located within an elk management area and any elk found in the Gas Hills is probably accidental. The closest elk areas are the Rattlesnake (east), Ferris-Seminoe, and Green Mountain areas (south). These areas encompass 1,083 square kilometers (418 square miles) and yielded a total harvest of 146 elk in 1974 (one head per 25.1 square kilometers (9.71 square miles). These areas are all hunted on a special permit basis (a total of 290 allowed). Total estimated winter population on these areas was 475 head in 1969 (Wyoming Game and Fish W-27-R-28, Planning Report 6-G).

No elk were sighted in the Gas Hills area during the fall 1975 or winter 1976 field surveys.

2.9.2.4 Bighorn Sheep (Ovis canadensis)

An estimated 50 bighorn sheep occupy the Sweetwater management unit, which includes the Seminoe and Ferris Mountains in Natrona County as well as the arid Sweetwater rocks area south and east of the Gas Hills. No bighorns were sighted on the lease area during the 1975-76 studies. Increased human activity in the area could disturb the few sheep which exist in the Sweetwater rocks. The bighorn sheep in all of the Sweetwater unit are protected from hunting. Poaching,

however, is a real problem when such a desired species is close to human activity (Wyoming Game and Fish W-27-R-28, Planning Report 6-G).

2.9.2.5 Wild Horse (Equus caballus)

According to Bureau of Land Management biologists in Lander (January 1976), a population of wild horses frequent the area west and north of the Gas Hills. They have been seen by Bureau of Land Management personnel, specifically in sections 7, 15, and 19 of T33N, R91W. Horses are gregarious herd animals, usually relying on grass for their year-long diet. Because their diet is competitive with livestock and their distribution is difficult to control, they are generally not welcomed by land managers. They are not classified as wildlife by any state agency, but are protected by Federal statute and controlled by the Bureau of Land Management.

2.9.2.6 Upland Game

The upland game bird species present in the Gas Hills region are sage grouse (Centrocercus urophasianus), chukar partridge (Alectoris chukar), gray partridge (Perdix perdix), and mourning doves (Zenaida maroura).

The sage grouse species is considered to be the primary upland game bird in the state of Wyoming, and was the only upland game bird sighted on and around the Gas Hills lease area during the fall and winter field studies of 1975 and 1976. Bureau of Land Management surveys indicate strutting grounds present in the Willow Springs draw (R90W, T33N, sections 5, 6, 7, and 8) and in the Canyon Creek drainage (R89W, T33N, section 4), northwest and north of the area. Wyoming Game and Fish Department grouse census along Sage Hen Creek showed a density of 1.4 birds per mile in 1973 (Wyoming Game and Fish 1974 Spot Report).

Optimum sage grouse habitat is associated with vast expanses of sagebrush, which the birds use for feed and cover under natural conditions. Migrations (seasonal) of up to 40 miles have been known, and a large flock of several hundred birds may easily require 40 to 50 sections as a home range (Wyoming Game and Fish Warden Manual).

Sagebrush is consumed year round; however, forbs and insects are also eaten during the spring and summer. If alfalfa (standing) is available, the birds will make extensive use of that crop. The young depend on an insect diet during their first few weeks of life.

Sage grouse hunting is important in Fremont County where 1,449 hunters harvested 6,072 birds in 1974. The area

around the Gas Hills, however, has been closed to sage grouse hunting for several years. (Wyoming Game and Fish W-50-R-23, Ibid Game Warden Manual).

The chukar are an introduced Asiatic species which have adapted to arid lands in much of the western United States. An estimated 12,910 of these birds were harvested in Wyoming in 1974; 1,556 of which were taken in Fremont County and 942 in Natrona County. These birds are found in the Gas Hills, but none were sighted during the field studies of 1975-76.

Artificial watering points (guzzlers) are helpful in maintaining chukar populations in arid areas.

Home range may vary from 8-80 kilometers (5 to 50 miles). Principal food consists of grass and weed seeds, grass and forb leaves and, where available, alfalfa leaves. Sagebrush is used as cover, and good cover is necessary for winter survival, the season of highest natural mortality.

The chukar is a valued game bird; however, if populations are thin and scattered, hunters lose interest. Population densities in the Gas Hills area are not as high as in other areas where irrigated farming supports more birds (Wyoming Game and Fish W-50-R-23, Ibid. Game Warden Manual, Ibid. District VI, Spot Report).

The gray partridge, also known as the Hungarian partridge or "Hun", is also an introduced species. Its distribution range covers the Gas Hills area, but in low densities. Highest huntable populations are found in Sheridan Park and Big Horn Counties. The bird is sought after by hunters, but only 124 birds were taken in Fremont County in 1974.

The gray partridge thrives around irrigated farming country, as its diet consists mainly of cultivated crop seeds and leaves. No gray partridge were sighted in or near the Gas Hills during the 1975-76 field studies (Wyoming Game and Fish W-50-R-23, Ibid. Game Warden Manual, Ibid. District VI Spot Report-Bird Survey).

Other game birds include the ring-necked pheasant (Phasianus colchicus), blue grouse (Dendrasapus obscurus), and ruffed grouse (Bonasa umbellus). Distribution ranges do not cover the Gas Hills region. Mourning dove distribution does cover the Gas Hills, but none were sighted during the 1975-76 field studies. Doves generally need water within a two to five mile radius, and their use of guzzlers has been notedby Wyoming Game and Fish Department biologists in Fremont County. In 1974, 966 hunters harvested 6,537 doves in Natrona and Fremont Counties (Wyoming Game and Fish W-50-R-23).

The list of threatened species also known as the "Red Book", published in 1973 by the Office of Endangered Species of the U.S. Fish and Wildlife Service, lists the Prairie Falcon as a threatened wildlife species. (Table 2.9-2 provides a list of the birds, mammals, fish, reptiles, and amphibians which are on the rare and endangered list.) One Prairie Falcon was sighted in May 1978 approximately 13 kilometers (8 miles) east of the mill along the Beaver Rim. There is no nesting habitat for Prairie Falcons within a one mile perimeter of the restricted area, and there have been no sightings in that area.

2.9.2.7 Small Game

Small game in Wyoming is a term synonymous with the cottontail rabbit (Sylvilagus spp.). This animal was designated as a game animal in 1969. Very little management is directed toward this species, and no harvest data are available from the Gas Hills area to date. Two species of cottontails, the desert cottontail (Sylvilagus audobonii) and Nuttall's cottontail (Sylvilagus mutallii) are known to exist in the Gas Hills. None were sighted during the 1975-76 field studies.

2.9.2.8 Waterfowl and Shorebirds

The fauna species list section 2.9.2.17 enumerates waterfowl species whose ranges encompass the Gas Hills. No waterfowl or shorebirds were seen during the 1975-76 field studies. However, field work in other arid sagebrush areas of the state (Powder River Basin) has shown that the most common species are mallards (Anas platyrhinchos), teal (Anas spp.), pintail (Anas acuta), and the killdeer (Charadrius vociferus). Almost any small body of water will serve as a nesting site if cover is available, and sagebrush serves as excellent cover.

No field data are available on waterfowl in the Gas Hills area; however, Wyoming Game and Fish Department breeding ground surveys (1973) show a total of 340,000 ducks and coots in the state at that time. This was above the previous long term average. Total duck harvest in Wyoming in 1974 was 61,022 birds. Of this total, 7,622 were taken in Fremont County. The long term average duck harvest (1962-1971) for Fremont and Natrona Counties was 4,785 birds. State distribution data indicates during the spring, summer, and fall waterfowl density is high along the Sweetwater River south of the Gas Hills. Density in the Gas Hills area itself however, is low to nonexistent (Wyoming Game and Fish W-50-R-23).

2.9.2.9 Raptors

A list of raptorial species whose range includes the Gas Hills is shown in section 2.9.2.17. Of these, the bald eagle (Haliaeetus leucocephalus) and prairie falcon (Falco mexicanus) are rare and possibly endangered. The pygmy owl (Glaucidium gnoma), and short-eared owl (Asio flammeus) are rare in Wyoming. The Swainson's hawk (Buteo swainsoni), red-tailed hawk (Buteo jamaicensis), rough-legged hawk (Buteo lagopus), marsh hawk (Circus cyaneus), prairie falcon (Falco mexicanus), merlin (Falco columbarius) and kestrel (Falco sparverius), and all birds of open country whose range includes the Gas Hills. The Goshawk (Accipiter gentilis), sharp-shinned hawk (Accipiter striatus), and Cooper's hawk (Accipiter cooperii) ranges cover the Gas Hills, but they occur only during migration as their preferred habitat is forests and mountains (McCreary, 1937).

2.9.2.10 Predatory Mammals and Fur-bearers

A list of Wyoming's fur-bearing and predatory mammals is given in section 2.9.2.17. Also included is the legal designation, status, and general habitat requirements of each species. The swift fox (Vulpes velox) and black-footed ferret (Mustela nigripes) whose ranges could include the Gas Hills, are considered endangered species.

In numbers, the jackrabbit (Lepus spp.) is the most important fur-bearer of the group, whereas in dollar per pelt value the bobcat leads (section 2.9.2.17). Some species are extremely cyclic in nature, such as the jackrabbit, bobcat, and mink. Population cycles in rabbits have been observed extensively; however, reasons for the cycles remain elusive. Density-dependent factors such as disease, parasitism and predation are thought to play important roles in rabbit declines. In simple ecosystems (i.e. arctic), predators usually follow suit. In Wyoming however, bobcat and coyote population have not declined with the jackrabbit since 1968. In the grassland-shrub ecosystem there are enough buffer species to fill the food gap for predators.

Fur trapping is still an economically important vocation or hobby in Wyoming. Total reported revenue from the sale of furs was $386,913.00 in 1974 (Wyoming Game and Fish Planning Report 8-G).

2.9.2.11 Mountain Lion (Felis Concolor)

The mountain lion is listed as a possible endangered species by Federal authorities (section 2.9.2.17). It is classed as a trophy game animal in Wyoming, and a limited harvest is allowed. The range of the mountain lion could cover the Gas Hills or Sweetwater Rocks area.

2.9.2.12 Small Mammal Trappings

A census was conducted in September 1975, January 1976, and May 1976. Twenty-one sites were trapped for two consecutive nights in September 1975 and May 1976. A 333 meter (1,000 foot) transect of 100 snap-traps placed 3.3 meters (10 feet) apart was used, resulting in a total of 6,300 trap-nights. Bait consisted of a mixture of animal fat and peanut butter.

Transect lines were used in order to cover a wide variety of microhabitats within a general community. Trapping methods may be considered stratified random sampling. Since the kill-traps were used, sampling was without replacement. Equal sampling effort was used at every trapping site so that the numbers of animals caught at each site (expressed as numbers/100 trap-nights) resulted in an index of small mammal populations and species diversity. The map in figure 2.9-2 shows the locations of the trapping sites.

Rodent trapping resulted in an overall catch rate of 3.4 animals per 100 trap-nights (table 2.9-3). The highest catch rate was obtained in the Big Sagebrush vegetative type (table 2.9-3). The deer mouse was the most often trapped rodent in all vegetative types (tables 2.9-4 and 2.9-5).

2.9.2.13 Species Diversity

Species diversity is an index of numbers of species in relation to numbers of individual present in an area. The rodent species diversity, by vegetation type is provided in tables 2.9-6 through -8. If an area has a relatively low number of species but a large population, the species diversity is said to be low when compared to an area which carries a high number of species in relation to its total population. In general, the tropics carry communities with the highest diversity of species of plants and animals. At higher latitudes the diversity becomes less until, in the Arctic regions ecosystems are ecologically simple - very low diversity of species.

It is logically simple to compare species diversity of various communities. For example, trap site numbers 5 in big sagebrush, produced only 16 deer mice. Trap site number 1 produced 10 deer mice, one chipmunk and one 13-line ground squirrel - a total of 12 animals but three species. The species diversity of site number 1 is obviously higher than that of site number five. The Shannon-Weiner index is one method of calculating this comparison in a quantitative manner. This index provides a measuring stick for diversity. A measuring stick is of no use without a standard for comparison. The standard is expressed in terms of the maximum possible diversity given a certain number of species and a

certain population. The diversity index is then also given in terms of percentage of the total possible.

The average Shannon-Weiner index of species diversity for all sites trapped was 0.330. This represents only 35 percent of the maximum possible ecological diversity of species (Lloyd and Ghelardi). The range of species diversity spread from zero (deer mice only caught at 11 sites) to 0.693 (two species caught in equal numbers at two sites). Percentages of maximum possible diversity indices ranged from 56 percent to 93 percent where it could be calculated. The average of 35 percent for all sites is because eleven sites produced large numbers of only one species - deer mice.

In terms of ecological communities, the open shale ledges (sites 15 and 16) produced the highest index of species diversity with two species - deer mice and chipmunks. The big sagebrush communities produced all four species, but the preponderance of deer mice gave them a lower index. The two sites with the highest individual diversity were numbers 16 (shale ridge) and 21 (big sagebrush).

High species diversity is a sign of a stable community. The baseline data presented should serve as a guide for measuring reclamation results in future years if the object is to return the land to natural, or near natural, ecosystems.

The Wyoming Game and Fish publication, "Current Status on Inventory of Wildlife in Wyoming", July 1977, lists the blackfooted ferret as rare in Wyoming with the population on decline. The Wyoming Game and Fish further state that it is likely that "ferrets have always been present throughout Wyoming, but have been overlooked because of their habits and the greater amount of research and mammal collection conducted in eastern Wyoming."

No black-footed ferrets have been sighted in the Gas Hills area and it is unlikely that they will be sighted due to the lack of prairie dog communities.

2.9.2.14 Fish

According to the Wyoming Game and Fish Planning Report 2-F, there are 361 streams in the Wind-Sweetwater Rivers drainage (Management Area 2) that have been classified. The streams have been divided into five classes from Class 1 streams with a high potential as a fishery to Class 5 streams with little fishery potential or fishing pressure. Trout populations are present in all stream classes. Waters within the Gas Hills lease are either in Class 4 or unsuitable for a fishery. Table 2.9-9 gives the miles of stream for each class in Fremont and adjacent counties.

Fishing opportunity in the Wind-Sweetwater Rivers drainage ranges from the highly aesthetic experience of wilderness area Alpine Lake and stream fishing to the more commonplace angling provided by waters in the lower elevations. The predominant trout species in the fisherman's catch is the rainbow with brook, cutthroat, and brown entering the catch in that order. Within the drainage area the higher elevation waters have populations of six different trout species, grayling, and ling while the lowland reservoirs contain 29 species of game fish, including some trout species. Waters in both elevation zones contain a variety of non-game species.

Fishing pressure within the counties, by stream class, is shown in table 2.9-10.

Current fishing pressure in Drainage Area 2 is estimated at 44,394.2 fisherman days annually which is approximately 20 percent of the estimated fishing capacity of existing waters.

At the present time there is no market for the commercial harvest of non-game fish species.

According to the records of the Wyoming Game and Fish (Lander Office, January 1976) there are brook trout in Sage Hen Creek, Deer Creek, and Diamond Springs.

The Wyoming Game and Fish census data for the water pertinent to the Gas Hills area are as follows:

West Sage Hen Creek Abundant brook trout population within the one-half mile of permanent stream in section 29 of Township and Range 89W, 32N. The water above this location is unsuitable for fish production. Electrofishing data shows 2,022 brook trout per mile of stream, with an average length of 7.96 inches (range 4.7 to 10.6 inches) and an average weight of 0.21 pounds (range 0.1 to 9.32 pounds).

Middle Fork Sage Hen Creek From Sage Hen Creek to section 3 of Township and Range 89W, 32N, there is a good brook trout population. Proceeding into section 3, the creek channel is normally dry. Electrofishing data from section 10 (89W, 32N) show 1,124 brook trout per stream mile (16 fish per 75 feet), with an average length of 8.1 inches (range 6.3 to 9.3 inches) and an average weight of 0.23 pounds (range 0.1 to 0.32 pounds).

East Fork Sage Hen Creek From the junction at Sage Hen Creek to near the small reservoir in section 36 (89W, 32N) there is permanent water. The stream immediately above the reservoir is dry. The stream starts again in section 13 (89W, 32N) and stops again within the same section. No fish

are above this point. Electrofishing data (section 2 (89W, 31N) lower part) gives two brook trout per 140 feet sample, or 75 trout per stream mile with ranges in lengths and weights similar to the middle fork of Sage Hen Creek of 9.4 to 6.4 inches and 0.32 to 0.13 pounds, respectively. The upper stream portion (section 35 of 89W, 32N) shows higher populations of 2,460 brook trout per mile with an average length of 5.5 inches (range 1.0 to 10.5 inches) and an average weight of 0.16 pounds per fish (range 0.03 to 0.46 pounds).

Sage Hen Creek The main stream channel is normally dry from its mouth southwest. From section 16 (90W, 30N) to the Murphy Ranch (section 15, 90W, 30N) a good brook trout population exists. Above Spring Creek, the main channel is dry to section 11 (89W, 31N) and from that point permanent water with brook trout normally exists to the stream head. Electrofishing data below the Murphy Ranch (State land) shows six brook trout per 200 foot sampling section or 158 fish per stream mile, with an average fish length of 7.6 inches (range 1.5 to 10.9 inches) and an average weight of 0.41 pounds (range 0.01 to 0.58 pounds). In section 15 (89W, 32N) the trout population increases to 1,161 brook trout per mile with an average length and weight of 7.1 inches (range 1.8 to 8.4 inches) and 0.17 pounds (range 0.07 to 0.27 pounds), respectively.

East Diamond Springs East Diamond Springs is unsuitable as a fishery according to Wyoming Game and Fish, but the Bureau of Land Management data indicates that Diamond Springs Draw (upper part) has brook trout populations and receives fishing pressure.

Middle Diamond Springs Successful plantings of brook trout have been accomplished but population determinations are not available.

West Diamond Springs West Diamond Springs are unsuitable as a fishery; however, Bureau of Land Management data indicates fisherman usage and the existence of brook trout.

2.9.2.15 Fish (acquatic life) Impacts

Aquatic life can be affected by changes in water quality and water quantity. The water quality is affected by the introduction of sediments and minerals into the streams and ponds. Quantity may be reduced by disrupting water-bearing geologic structures or by holding ponds. Even if the actual quantity or quality of the water is unchanged, aquatic life may be harmed by habitat destruction such as channelization, streambank vegetation removal, or water temperature change.

Pollutants may affect aquatic life in several ways, directly or indirectly by:

- An increase in osmotic pressure
- An increase in acidity
- A decrease in oxygen content
- Specific toxic ingredients
- Destruction of spawning grounds
- Mechanical injury to gills from silt [ref 3]

The maximum non-lethal concentration of sodium chloride in terms of osmotic pressure in fish blood is 7,000 parts per million [ref 3]. Recommended pH in waters supporting fish life is 6.0 to 8.5 [ref 4]. Dissolved oxygen should be no less than 4.0 milligrams per liter for warm water fish or 5.0 milligrams per liter for cold water fish [ref 4]. Table 2.9-11 presents data on metal toxicity to fish [ref 4]. Silt, otherwise non-toxic, can alter the bottom characteristics rendering spawning grounds useless or clog the gills of fish [ref 3].

Table 2.9-12 shows effects of turbidity on various fish species [ref 4].

Studies in the Powder River Basin on a stream affected by run-in from a coal strip-mined area show a decrease in numbers and species diversity of aquatic organisms related to the concentration of non-toxic dissolved solids.

2.9.2.16 Water Quantity

A reduction of water quantity will obviously result in a reduced number of aquatic organisms able to live in a particular stream or pond, assuming a maximum population to begin with. Slight reductions in flow for short periods of time may have little impact. Reduced flow results in reduced water velocity and reduced "drift" of food organisms for fish. Turbulence is lowered and so are available oxygen and nutrients. The concept of "minimum flow" is important, i.e. by how much can stream flow be reduced without detriment to aquatic life. As far as fish are concerned, minimum streamflow is defined as that flow which will maintain the fish population prior to disturbance, or that flow which is greater than the flow range in which the rate of decrease of habitat is greatest [ref 6]. For trout in Wyoming mountain streams, it has been shown that a streamflow representing 12.5 percent to 25 percent of the average daily flow (normal flow) produces the greatest rate of habitat destruction. Therefore, minimum flow should never be allowed to fall below 25 percent of the normal average daily flow (ADF) [ref 6]. Twenty-five to 30 percent of the average discharge

should maintain the fishery and associated biota in a stream [ref 6 and 7]; however, the following quotation is worth noting:

> "Recommending the meager, all-time historic minimum flow would be like prescribing a person's all-time worst health condition as a recommended level for a portion of his future well-being." [ref 8]

General habitat considerations include stream riffles which are important for the production of larval forms of aquatic life. Undercut banks, boulders, and streambank vegetation are essential for fish protection and cover [ref 3]. Changes in these physical features nearly always result in a deterioration of aquatic life. Water temperature is a critical parameter to be considered. It is a component of water quality which is directly related to quantity (velocity) and physical changes in the stream bed. Table 2.9-13 shows recommended water temperatures for various species of fish and associated biota.

2.9.2.17 <u>Fauna Species Lists</u>

These lists include:

- Revised List of Common and Scientific Names of Wyoming Birds
- A Checklist of Mammals of Wyoming
- Wyomings Furbearing Mammals
- Insect Species List

REVISED* LIST OF COMMON AND SCIENTIFIC NAMES OF WYOMING BIRDS

	GAVIIFORMES	
	Gaviidae	
UM*	Common Loon	Gavia immer
UR	Red-throated Loon	Gavia stellata
	PODICIPEDIFORMES	
	Podicipedidae	
UM*	Red-necked Grebe	Podiceps grisegena
OM*	Horned Grebe	Podiceps auritus
CR*	Eared Grebe	Podiceps nigricollis
CR*	Western Grebe	Aechmophorus occidentalis
CR*	Pied-billed Grebe	Podilymbus podiceps
	PELECANIFORMES	
	Pelecanidae	
CR	White Pelican	Pelecanus erythrorhynchos
A	Brown Pelican	Pelecanus occidentalis
	Phalacrocoracidae	
UR*	Double-crested Cormorant	Phalacrocorax auritus
	CICONIIFORMES	
	Ardeidae	
CR*	Great Blue Heron	Ardea herodias
UR	Green Heron	Butorides virescens
A	Common Egret	Casmerocius albus
UR*	Black-crowned Night Heron	Nycticorax nycticoras
OM*	Snowy Egret	Egretta thula
UM*	Least Bittern	Ixobrychus exilis
UR*	American Bittern	Botaurus lentiginosus
	Ciconiidae	
A	Wood Ibis	Mycteria americana
	Threskiornithidae	
RM*	White-faced Ibis	Plegadis chihi
	ANSERIFORMES	
	Anatidae	
	Subfamily-Cygninae	
UM	Whistling Swan	Olor columbianus
UR	Trumpeter Swan	Olor buccinator
	Subfamily-Anserinae	
CM*	Canada Goose	Branta canadensis
RM*	Black Brant	Branta nigricans
RM*	White-fronted Goose	Anser albifrons
RM*	Blue Goose	Chen caerulescens
	Subfamily-Anatinae	
	Egyptian Goose	Alopochen aegyptians

CR*	Mallard	Anas platyrhynchos
A	Black Duck	Anas rubripes
CR*	Gadwall	Anas strepera
CR*	Pintail	Anas acuta
CR*	American Green-Winged Teal	Anas crecca carolinensis
CR*	Blue-winged Teal	Anas discors
CR*	Cinnamon Teal	Anas cyanoptera
A	European Wigeon	Anas penelope
CR*	Americal Wigeon	Anas americana
CR*	Northern Shoveler	Anas clypeata
A	Wood Duck	Aix sponsa
	Subfamily-Aythyinae	
CM*	Redhead	Aythya americana
RM*	Ring-necked Duck	Aythya collaris
	Tufted Duck	Aythya fuligula
CM*	Canvasback	Aythya valisineria
RM*	Greater Scaup	Aythya marila
CM*	Lesser Scaup	Aythya affinis
CM*	Common Goldeneye	Bucephala clangula
UM*	Barrow's Goldeneye	Bucephala islandica
CM*	Bufflehead	Bucephala albeola
OM	Oldsquaw	Clangula hyemalis
UR	Harlequin Duck	Histrionicus histrionicus
A	White-winged Scoter	Melanitta deglandi
A	Surf Scoter	Melanitta perspicillata
A	Black Scoter	Melanitta nigra
	Subfamily-Oxyurinae	
RM*	Ruddy Duck	Oxyura jamaicensis
	Subfamily-Merginae	
RM*	Hooded Merganser	Lophodytes cucullatus
CR*	Common Merganser	Mergus merganser
UM*	Red-breasted Merganser	Mergus serrator
	FALCONIFORMES	
	Cathartidae	
CR*	Turkey Vulture	Cathartes aura
	Accipitridae	
RR*	Goshawk	Accipiter gentilis
UR*	Sharp-shinned hawk	Accipiter striatus
CR*	Cooper's Hawk	Accipiter cooperii
CM*	Red-tailed Hawk	Buteo jamaicensis
UM*	Harlan's Hawk	Buteo jamaicensis harlani
CM	Broad-winged Hawk	Buteo platypterus
CR*	Swainson's Hawk	Buteo swainsoni
UR*	Rough-legged Hawk	Buteo lagopus
CR*	Ferruginous Hawk	Buteo regalis
CR*	Golden Eagle	Aquila chrysaetos
RR*	Bald Eagle	Haliaeetus leucocephalus

	CR*	Marsh Hawk	Circus cyaneus
		Pandionidae	
	RR	Osprey	Pandion haliaetus
		Falconidae	
	RM	Gyrfalcon	Falco rusticolus
	RR*	Prairie Falcon	Falco mexicanus
	RM	Peregrine Falcon	Falco peregrinus
	UR*	Merlin	Falco columbarius
	CR*	American Kestrel	Falco sparverius
		GALLIFORMES	
		Tetraonidae	
	CR	Blue Grouse	Dendragapus obscurus
	UR	Spruce Grouse	Canachites canadensis
	UR	Ruffed Grouse	Bonasa umbellus
	UR	White-tailed Ptarmigan	Lagopus leucurus
	RR	Greater Prairie Chicken	Tympanuchus cupido
	RR	Sharp-tailed Grouse	Pedioecetes phasianellus
	*	Sage Grouse	Centrocercus urophasianus
		Phasianidae	
Introduced		Bobwhite	Colinus virginianus
		Scaled Quail	Callipepla squamata
		California Quail	Lophortyx californicus
		Gambel's Quail	Lophortyx gambelii
		Ringed-necked Pheasant	Phasianus colchious
	*	Chukar	Alectoris chukar
	*	Gray Partridge	Perdix perdix
		Meleagrididae	
	CR	Turkey	Meleagris gallopavo
		GRUIFORMES	
		Gruidae	
	A	Whopping Crane	Grus americana
	CR*	Sandhill Crane	Grus canadensis
		Rallidae	
	CR	Virginia Rail	Rallus limicola
	UR*	Sora	Porzana carolina
	CR*	American Coot	Fulica americana
		CHARADRIIFORMES	
		Charadriidae	
	OM*	Semipalmated Plover	Charadrius semipalmatus
	A	Piping Plover	Charadrius melodus
	RM	Snowy Plover	Charadrius alexandrinus
	CR*	Killdeer	Charadrius vociferus
	CR*	Mountain Plover	Charadrius montanus
	A	American Golden Plover	Pluvialis dominica
	*	Black-bellied Plover	Pluvialis scuatarola
	A	Ruddy Turnstone	Arenaria interpres
		Scolopacidae	
	A	American Woodcock	Philohela minor

RR*	Common Snipe	<u>Capella gallinago</u>
CM*	Long-billed Curlew	<u>Numenius americanus</u>
A	Whimbrel	<u>Numenius phaeopus</u>
CR*	Upland Plover	<u>Bartramia longicauda</u>
CR*	Spotted Sandpiper	<u>Actitis macularia</u>
CM*	Solitary Sandpiper	<u>Tringa solitaria</u>
CM*	Willet	<u>Catoptrophorus semipalmatus</u>
CM*	Greater Yellowlegs	<u>Tringa melanoleuca</u>
CM*	Lesser Yellowlegs	<u>Tringa flavipes</u>
UM*	Pectoral Sandpiper	<u>Calidris melanotos</u>
OM	White-rumped Sandpiper	<u>Erolia fuscicollis</u>
CM*	Baird's Sandpiper	<u>Erolia bairdii</u>
CM*	Least Sandpiper	<u>Erolia minutilla</u>
A	Dunlin	<u>Erolia alpina</u>
CM*	Long-billed Dowitcher	<u>Limnodromus scolopaceus</u>
*	Stilt Sandpiper	<u>Micropalama himantopus</u>
*	Semipalmated Sandpiper	<u>Calidris pusilla</u>
*	Western Sandpiper	<u>Calidris mauri</u>
*	Buff-breasted Sandpiper	<u>Tryngites subruficollis</u>
*	Marbled Godwit	<u>Limosa fedoa</u>
*	Hudsonian Godwit	<u>Limosa haemastica</u>
*	Sanderling	<u>Calidris alba</u>
	Recurvirostridae	
*	American Avocet	<u>Recurvirostra americana</u>
OM	Black-necked Stilt	<u>Himantopus fulicarius</u>
	Phalaropodidae	
A	Red Phalarope	<u>Phalaropus fulicarius</u>
*	Wilson's Phalarope	<u>Steganopus tricolor</u>
*	Northern Phalarope	<u>Lobipes lobatus</u>
	Laridae	
A	Glaucous Gull	<u>Larus hyperboreus</u>
	Thayer's Gull	<u>Larus thayeri</u>
CR*	California Gull	<u>Larus californicus</u>
CR*	Ring-billed Gull	<u>Larus delawarensis</u>
A	Mew Gull	<u>Larus canus</u>
OM	Franklin's Gull	<u>Larus pipixcan</u>
OM	Bonaparte's Gull	<u>Larus philadelphia</u>
A	Black-legged Kittiwake	<u>Rissa tridactyla</u>
A	Sabine's Gull	<u>Xema sabini</u>
CM	Forster's Tern	<u>Sterna forsteri</u>
A	Common Tern	<u>Sterna hirundo</u>
CR*	Least Tern	<u>Sterna albifrons</u>
RR	Caspian Tern	<u>Hydroprogne caspia</u>
CM	Black Tern	<u>Chlidonias niger</u>

COLUMBIFORMES

Columbidae

CR*	Rock Dove	Columba livia
CR*	Mourning Dove	Zenaida macroura

CUCULIFORMES

Cuculidae

A	Yellow-billed Cuckoo	Coccyzus americanus
RR	Black-billed Cuckoo	Coccyzus erythropthalmus

STRIGIFORMES

Tytonidae

UR*	Barn Owl	Tyto alba

Strigidae

UR*	Screech Owl	Otus asio
CR*	Great Horned Owl	Bubo virginianus
RM	Snowy Owl	Nyctea scandiaca
RM*	Hawk Owl	Surnia ulula
RR*	Pygmy Owl	Glaucidium gnoma
UR*	Burrowing Owl	Speotyto cunicularia
CR*	Barred Owl	Strix varia
RR	Great Gray Owl	Strix nebulosa
A	Boreal Owl	Aegolius funereus
RR	Saw-whet Owl	Aegolius acadicus

CAPRIMULGIFORMES

Caprimulgidae

UR*	Poor-will	Phalaenoptilus nuttallii
CR*	Common Nighthawk	Chordeiles minor

APODIFORMES

Apodidae

OM	Chimney Swift	Chaetura pelagica
CR*	White-throated Swift	Aeronautes saxatalis

Trochilidae

OM	Ruby-throated Hummingbird	Archilochus colubris
UR	Black-chinned Hummingbird	Archilochus alexandri
CR*	Broad-tailed Hummingbird	Selasphorus platycercus
UM*	Rufous Hummingbird	Selasphorus rufus
UR	Calliope Hummingbird	Stellula calliope

CORACIIFORMES

Alcedinidae

CR*	Belted Kingfisher	Megaceryle alcyon

PICIFORMES

Picidae

CR*	Common Flicker	Colaptes auratus
CR*	Red-shafted Flicker	Colaptes auratus cafer

UR*	Red-headed Woodpecker	*Melanerpes erythrocephalus*
CR	Lewis' Woodpecker	*Asyndesmus lewis*
CR*	Yellow-bellied Sapsucker	*Sphyrapicus varius*
UR	Williamson's Sapsucker	*Sphyrapicus thryroideus*
CR*	Hairy Woodpecker	*Dendrocopos villosus*
CR*	Downy Woodpecker	*Dendrocopos pubescens*
A	White-headed Woodpecker	*Dendrocopos albolarvatus*
RR	Black-backed Three-toed Woodpecker	*Picoides arcticus*
CR	Northern Three-toed Woodpecker	*Picoides tridactylus*
	PASSERIFORMES	
	Tyrannidae	
CR*	Eastern Kingbird	
CR*	Western Kingbird	
OR	Cassin's Kingbird	
A	Great-crested Flycatcher	*Myiarchus crinitus*
A	Ash-throated Flycatcher	*Myiarchus cinerascens*
A	Eastern Phoebe	*Sayornis phoebe*
CR*	Say's Phoebe	Sayornis saya
CR*	Willow Flycatcher	*Empidonax traillii*
CR*	Alder Flycatcher	*Empidonax alnorum*
OM*	Hammond's Flycatcher	*Empidonax hammondii*
CR*	Dusky Flycatcher	*Empidonax oberholseri*
CR*	Gray Flycatcher	*Empidonax wrightii*
OR*	Western Flycatcher	*Empidonax difficulis*
CR*	Western Wood Pewee	*Contopus sordidulus*
UR*	Olive-sided Flycatcher	*Nuttallornis borealis*
	Alaudidae	
CR*	Horned Lark	*Eremophila alpestris*
	Hirundinidae	
CR*	Violet-green Swallow	*Tachycineta thalassina*
UR*	Tree Swallow	*Iridoprocne bicolor*
CR*	Bank Swallow	*Riparia riparia*
CR*	Rough-winged Swallow	*Stelgidopteryx ruficollis*
CR*	Barn Swallow	*Hirundo rustica*
CR*	Cliff Swallow	*Petrochelidon pyrrhonota*
CR*	Purple Martin	*Progne subis*
	Corvidae	
CR	Gray Jay	*Perisoreus canadensis*
CR*	Blue Jay	*Cyanocitta oristata*
CR	Steller's Jay	*Cyanocitta stelleri*
CR	Scrub Jay	*Aphelocoma coerulescens*
CR*	Black-billed Magpie	*Pica pica*
CR*	Common Raven	*Corvus corax*
CR*	Common Crow	*Corvus brachyrhynchos*
UM*	Pinon Jay	*Gymnorhinus cyanocephalus*
CR	Clark's Nutcracker	*Nucifraga columbiana*
	Paridae	
CR*	Black-capped Chickadee	*Parus atricapillus*

CR*	Mountain Chickadee	Parus gambeli
CR	Plain Titmouse	Parus inornatus
A	Bushtit	Psaltriparus minimus
	Sittidae	
RR	White breasted Nuthatch	Sitta carolinensis
CM	Red-breasted Nuthatch	Sitta canadensis
UR	Pygmy Nuthutch	Sitta pygmaea
	Certhiidae	
UM*	Brown Creeper	Certhis familiaris
	Cinclidae	
UR*	Dipper	Cinclus mexicanus
	Troglodytidae	
CR*	House Wren	Troglodytes aedon
RR*	Winter Wren	Troglodytes troglodytes
UR	Bewick's Wren	Thryomanes bewickii
CM*	Long-billed Marsh Wren	Telmatodytes palustris
A	Short-billed Marsh Wren	Cistothorus platensis
UR*	Canon Wren	Catherpes mexicanus
CR*	Rock Wren	Salpinctes obsoletus
	Mimidae	
UR	Mockingbird	Mimus polyglottos
CR*	Gray Catbird	Dumetella carolinensis
CR*	Brown Thrasher	Toxostoma rufum
CR*	Sage Thrasher	Oreoscoptes montanus
	Turidae	
CR*	American Robin	Turdus migratorius
A	Varied Thrush	Ixoreus naevius
CM*	Hermit Thrush	Catharus guttata
CM*	Swainson's Thrush	Catharus ustulata
RM*	Gray-cheeked Thrush	Catharus minima
CR*	Veery	Catharus fuscescens
OR	Eastern Bluebird	Sialia sialis
OR*	Western Bluebird	Sialia mexicana
CR*	Mountain Bluebird	Sialia currucoides
CR*	Townsend's Solitaire	Myadestes townsendi
	Sylviidae	
RR	Blue-gray Gnatcatcher	Polioptila caerulea
CM*	Golden-crowned Kinglet	Regulus satrapa
CM*	Ruby-crowned Kinglet	Regulus calendula
	Motacillidae	
CR	Water Pipit	Anthus spinoletta
CR	Sprague's Pipit	Anthus spragueii
	Bombycillidae	
UM*	Bohaemian Waxwing	Bombycilla garrulus
UR*	Cedar Waxwing	Bombycilla cedrorum
	Laniidae	
RR*	Northern Shrike	Lanius excubitor
UR*	Loggerhead Shrike	Lanius ludovicianus
	Sturnidae	

CR*	Starling	*Sturnus vulgaris*
	Vireonidae	
UR	Solitary Vireo	*Vireo solitarius*
UM*	Red-eyed Vireo	*Vireo olivaceus*
CR*	Warbling Vireo	*Vireo gilvus*
	Parulidae	
OM	Black-and-White Warbler	*Miniotilta varia*
A	Prothonotary Warbler	*Protonotaria citrea*
CM	Tennessee Warbler	*Vermivora peregrina*
CM	Orange-crowned Warbler	*Vermivora celata*
UM*	Nashville Warbler	*Vermivora ruficapilla*
OM	Northern Parula	*Parula americana*
CR*	Yellow Warbler	*Dendroica petechia*
UM	Magnolia Warbler	*Dendroica magnolia*
A	Black-throated Blue Warbler	*Dendroica caerulescens*
UM	Yellow-rumped Warbler	*Dendroica coronata*
CR	Audubon's Warbler	*Dendroica coronata auduboni*
CM	Black-throated Green Warbler	*Dendroica virens*
*	Townsend's Warbler	*Dendroica townsendi*
UR	Black-throated Gray Warbler	*Dendroica nigrescens*
A	Blackburnian Warbler	*Dendroica fusca*
A	Grace's Warbler	*Dendroica graciae*
A	Chestnut-sided Warbler	*Dendroica pansylvanica*
UM	Blackpoll Warbler	*Dendroica striate*
A	Palm Warbler	*Dendroica palmarum*
CR	Ovenbird	*Seiurus aurocapillus*
UM*	Northern Waterthrush	*Seiurus noveboracensis*
CR*	MacGillivray's Warbler	*Oporornis tolmiei*
CR*	Common Yellowthroat	*Geothlypis trichas*
CR*	Yellow-breasted Chat	*Icteria virens*
CR	Wilson's Warbler	*Wilsonia pusilla*
CR*	American Redstart	*Setophaga ruticil*
	Ploceidae	
CR*	House Sparrow	*Passer domesticus*
	Icteridae	
CR	Bobolink	*Dolichonyx oryzivorus*
CR*	Western Meadowlark	*Sturnella neglecta*
CR*	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
CR*	Redwinged Blackbird	*Agelaius phoeniceus*
UR	Orchard Oriole	*Icterus spurius*
OM	Northern Oriole	*Icterus galbula*
CR*	Bullock's Oriole	*Icterus galbula bullockii*
OM	Rusty Blackbird	*Euphagus carolinus*
CR*	Brewer's Blackbird	*Euphagus cyanocephalus*
CR	Common Grackle	*Quiscalus quiscula*
CR*	Brown-headed Cowbird	*Molothrus ater*
	Thraupidae	
CR*	Western Tanager	*Piranga ludoviciana*
A	Scarlet Tanager	*Piranga olivacea*
A	Hepatic Tanager	*Piranga slava*

Fringillidae

A	Cardinal	*Cardinalis cardinalis*
A	Rose-breasted Grosbeak	*Pheucticus ludovicianus*
CR*	Black-headed Grosbeak	*Pheucticus melanocephalus*
CR	Blue Grosbeak	*Guiraca caerulea*
OM	Indigo Bunting	*Passerina cyanea*
CR*	Lazuli Bunting	*Passerina amoena*
CR	Dickcissel	*Spiza americana*
CM*	Evening Grosbeak	*Hesperiphona vespertina*
CR	Cassin's Finch	*Carpodacus cassinii*
CR*	House Finch	*Carpodacus mexicanus*
Cr	Pine Grosbeak	*Pinicola enucleator*
CR	Gray-crowned Rosy Finch	*Leucosticte tephrocotis*
UR	Black Rosy Finch	*Leucosticte atrata*
UR	Brown-capped Rosy Finch	*Leucosticte australis*
UR*	Common Redpoll	*Acanthis flammea*
CR	Pine Siskin	*Spinus pinus*
CR	American Goldfinch	*Spinus tristis*
CR*	Lesser Goldfinch	*Spinus psaltria*
CR	Red Crossbill	*Loxia curvirostra*
OM	White-winged Crossbill	*Loxia leucoptera*
CR*	Green-tailed Towhee	*Chlorura chlorura*
CR*	Rufous-sided Towhee	*Pipilo erythrophthalmus*
CR*	Lark Bunting	*Calamospiza melanocorys*
CR*	Savannah Sparrow	*Passerculus sandwichensis*
CR	Grasshopper Sparrow	*Ammodramus savannarum*
OM	Baird's Sparrow	*Ammodramus bairdii*
CR*	Vesper Sparrow	*Pooecetes gramineus*
CR*	Lark Sparrow	*Chondestes grammacus*
OM*	Black-throated Sparrow	*Amphispiza bilineata*
CR*	Sage Sparrow	*Amphispiza belli*
CR	White-winged Junco	*Junco hyemalis aiken*
UR*	Dark-eyed Junco	*Junco hyemalis*
CR*	Oregon Junco	*Junco hyemalis oreganus*
CR*	Gray-headed Junco	*Junco caniceps*
CR*	Tree Sparrow	*Spizella arborea*
CR*	Chipping Sparrow	*Spizella passerina*
CM	Clay-colored Sparrow	*Spizella pallida*
CR*	Brewer's Sparrow	*Spizella breweri*
UM*	Harris' Sparrow	*Zonotrichia querula*
CR*	White-crowned Sparrow	*Zonotrichia leucophrys*
A	White-throated Sparrow	*Zonotrichia albicollis*
CR	Fox Sparrow	*Passerella iliaca*
CR*	Lincoln's Sparrow	*Melospiza lincolnii*
CR*	Song Sparrow	*Melospiza melodia*
CR*	McCown's Longspur	*Calcarius mocownii*
CR*	Lapland Longspur	*Calcarius lapponicus*
CR	Chestnut-collared Longspur	*Calcarius ornatus*
CR*	Snow Bunting	*Plectrophenax nivalis*

Code:

First letter:

C - Common in Wyoming
U - Uncommon in Wyoming
O - Occasional in Wyoming
R - Rare in Wyoming

Second letter:

M - Migrant
R - Resident in Wyoming for at least one season

"Rare" does not necessarily mean "rare and endangered"

* - Range and/or habitat of this species covers the Gas Hills area

A - Accidental in Wyoming

* Check-List of North American Birds, Committee of the American Ornithologists' Union. Fifth Edition, Baltimore, Maryland. 1957.

Thirty-Second Supplement to the American Ornithologists' Union Check-List of North American Birds. A.O.U. Committee on Classification and Nomenclature, The Auk, Vol. 90, No. 2, pp. 411-419. April 1973.

Corrections and Additions to the Thirty-Second Supplement to the Check-List of North American Birds. A.O.U. Committee on Classification and Nomenclature, The Auk, Vol. 90, No. 4, p. 887. October 1973.

Distribution taken from:

McCreary, O. 1937. Wyoming Bird Life. Burgess Publishing Company. 133 pp.

Robbins, C. S., B. Brunn, H. S. Zim. 1966. Guide to Field Identification Birds of North America. Golden Press, N.Y. 340 pp.

A check list of mammals of Wyoming. The mammalian fauna of Wyoming consists of 172 kinds (subspecies) of which five were introduced directly or indirectly by man; these 172 kinds belong to 101 species, 58 genera, and 22 families of 7 orders. This list will only include the list of species; the information is taken from: The Mammals of Wyoming by C. A. Long, University of Kansas Publication; Museum of Natural History, Vol. 14 #18. pp. 493-758

Hoffman, R. S. and D. L. Pattie. 1968. A Guide to Montana Mammals. University of Montana. 133 pp.

Blair, W. F., Blair, A. P., Brodkorb, P., Casle, R. R., and G. A. Moore. 1957. Vertebrates of the United States. McGraw-Hill. 819 pp.

Wyoming Game & Fish Department. 1974. Current Status and Inventory of Non-Game Mammals. Planning Report #1-N. 33 pp.

ORDER MARSUPIALIA - Marsupials

FAMILY DIDELPHIDAE - Opossums

Didelphis marsupialis	Opossum

ORDER INSECTIVORA - Insectivores

FAMILY SORICIDAE - Shrews

*Sorex cinereus	Masked Shrew
*Sorex vagrans	Vagrant Shrew
*Sorex nanus	Dwarf Shrew
*Sorex palustris	Water Shrew
*Sorex merriami	Merriam's Shrew

FAMILY TALPIDAE

Scalopus aquaticus	Eastern Mole

ORDER CHIROPTERA - Bats

FAMILY VESPERTILIONIDAE - Vespertilonid Bats

Myotis lucifugus	Little brown Myotis
*Myotis leibii	Small-footed Myotis
*Myotis thysanodes	Fringed Myotis
*Myotis velifer	Cave Myotis
*Myotis volans	Long-legged Myotis
*Myotis evotis	Long-eared Myotis
Myotis keenii	Keen's Myotis

*Lasionvotoris noctivagans	Silver-haired Bat
Lasiurus borealis	Red Bat
*Lasiurus cinereus	Hoary Bat
*Plecotus townsendii	Townsend's Big-eared Bat
*Euderma maculatum	Spotted Bat
*Eptesicus fuscus	Big Brown Bat
*Pipistrellus hesperus	Western pipistrel

ORDER LAGAMORPHA - Pikas, Rabbits, Hares

FAMILY OCHOTONIDAE - Pikas

Ochotona princeps	Pika

FAMILY LEPORIDAE - Rabbits, Hares

Sylvilagus floridanus	Eastern Cottontail
*Sylvilagus nuttallii	Nuttall's Cottontail
*Sylvilagus audubonii	Desert Cottontail
*Lepus americanus	Snowshoe Rabbit
*Lepus townsendii	White-tailed Jack Rabbit
*Lepus californicus	Black-tailed Jack Rabbit

ORDER RODENTIA - Rodents

FAMILY SCIURIDAE - Squirrels

*Eutamias minimus	Least Chipmunk
Eutamias amoenus	Yellow-pine Chipmunk
Eutamias dorsalis	Cliff Chipmunk
Eutamias umbrinus	Uinta Chipmunk
*Marmota flaviventris	Yellow-bellied Marmot
*Spermophilus armatus	Uinta Ground Squirrel
*Spermophilus richardsonii	Richardson's Ground Squirrel
Spermophilus spilosoma	Spotted Ground Squirrel
*Spermophilus tridecemlineatus	Thirteen-lined Ground Squirrel
*Spermophilus lateralis	Golden-mantled Ground Squirrel
Cynomys ludovicianus	Black-tailed Prairie dog
*Cynomys Leucurus	White-tailed Prairie dog
*Tamiasciurus hudsonicus	Red Squirrel
Sciurus niger	Fox Squirrel
Glaucomys sabrinus	Northern Flying Squirrel

FAMILY GEOMYIDAE - Pocket Gophers

*Thomomys talpoides	Northern Pocket Gopher
Geomys bursarius	Plains Pocket Gopher

FAMILY HETEROMYIDAE - Heteromyids

*Perognathus fasciatus	Olive-backed Pocket Mouse
*Perognathus flavus	Silky Pocket Mouse
Perognathus parvus	Great Basin Pocket Mouse
Perognathus hispidus	Plains Pocket Mouse
*Dipodomys ordii	Ord's Kangaroo Rat

FAMILY CASTORIDAE - Beavers

*Castor canadensis	Beaver

SUBORDER MYOMORPHA

FAMILY CRICETIDAE - Cricetids

SUBFAMILY CRICETINAE

*Reithrodontomys montanus	Plains Harvest Mouse
*Reithrodontomys megalotis	Western Harvest Mouse
*Peromyscus crinitus	Canyon Mouse
*Peromyscus maniculatus	Deer Mouse
*Peromyscus leucopus	White-footed Mouse
*Peromyscus truei	Pinon Mouse
*Onychomys Leucogaster	Northern Grasshopper Mouse
*Neotoma cinerea	Bushy-tailed Wood Rat

SUBFAMILY MICROTINEA

*Clethrionomys gapperi	Gapper's Red-backed Vole
*Phenacomys intermedius	Heather Vole
*Microtus pennsylvanicus	Meadow Vole
*Microtus montanus	Montana Vole
*Microtus longicaudus	Long-tailed Vole
*Microtus richardsoni	Richardson's Vole
*Microtus ochrogaster	Prairie Vole
*Lagurus curtatus	Sagebrush Vole
*Ondatra zibethicus	Muskrat

FAMILY MURIDAE - Murids

*Rattus Norvegicus	Norway Rat
*Mus musculus	House Mouse

FAMILY ZAPODIDAE - Jumping Mice

Zapus hudsonius	Meadow Jumping Mouse
*Zapus princeps	Western Jumping Mouse

SUBORDER HYSTRICOMORPHA

FAMILY ERETHIZONITIDAE - Porcupines

*Erethizon dorsatum	Porcupine

ORDER CARNIVORA - Carnivores

SUBORDER FISSIPEDA

FAMILY CANIDAE - Canids

*Canis latrans	Coyote
canis lupus	Gray Wolf
*Vulpes vulpes	Red Fox
*Vulpes Velox	Swift Fox (Plains Kit Fox)
*Urocyon cinereoargenteus	Gray Fox

FAMILY URSIDAE - Bears

Ursus americanus	Black Bear
Ursus arctos	Grizzley Bear

FAMILY PROCYONIDAE - Procyonids

Bassariscus astutus	Ringtail
*Procyon lotor	Racoon

FAMILY MUSTELIDAE - Mustelids

Martes americana	Marten
Martes Pennanti	Fisher
*Mustela erminea	Ermine (Shorttail Weasel)
*Mustela frenata	Long-tailed Weasel
*Mustela vision	Mink
*Mustela nigripes	Black-footed Ferret
Gulo gulo	Wolverine
*Taxidea taxus	Badger
*Spilogale gracilis	Western Spotted Skunk
*Spilogale putorius	Eastern Spotted Skunk
*Mephitis mephitis	Striped Skumk
Lutra canadensis	River Otter

FAMILY FELIDAE - Cats

*Felis concolor	Mountain Lion
Lynx canadensis	Lynx
*Lynx rufus	Bobcat

ORDER ARTIODACTYLA - Artiodactyls

SUBORDER RUNINANTIA

FAMILY CERVIDAE - Deer

Cervus canadensis	Wapiti or American Elk
*Odocoileus hemionus	Mule Deer
Odocoileus virginianus	White-tailed Deer
Alces alces	Moose

FAMILY ANTILOCAPRIDAE - Pronghorn

*Antilocapra americana	Pronghorn

FAMILY BOVIDAE - Bovids

Bison bison	Bison
Oreamnos americanus	Mountain Goat
*Ovis canadensis	Mountain Sheep

*Indicates those animals apt to be present in the Gas Hills area.

Reptiles and amphibians: The following lists species whose range covers the Gas Hills. One species of salamander, two of toads, two of frogs, two of lizards and six species of snakes are known to exist in the Gas Hills area (Wyoming Game and Fish Planning Report 3N). All are common except the Great Basin Gopher snake (Pituophis melanoleucas deserticola), which may be rare (status undetermined in Wyoming). This snake is adapted to a great variety of habitats and feeds mainly on rodents.

REPTILES AND AMPHIBIANS OF WYOMING

Taken from: Wyoming Game & Fish Department 1974. Current Status and Inventory of Amphibians and Reptiles. Planning Report 3-N.

Stebbins, R. 1954. Amphibians and Reptiles of Western North America. McGraw-Hill.

*Found in the Gas Hills area

CLASS AMPHIBIA

ORDER URODELA

FAMILY AMBYSTOMIDAE

Ambystoma tigrinum melanosticum	Blotched Tiger Salamander
Ambystoma tigrinum mavortium	Barred Tiger Salamander
Ambystoma tigrinum utahensis	Utah Tiger Salamander

ORDER ANURA

FAMILY PELOBATIDAE

Scaphiopus bombifrons	Plains Spadefoot
**Scaphiopus intermantanus*	Great Basin Spadefoot

FAMILY BUFONIDAE

**Bufo boreas boreas*	Boreal Toad
Bufo cognatus	Great Plains Toad
Bufo hemiophrys baxteri	Laramie Basin Toad
Bufo woodhousei woodhousei	Rocky Mountain Toad

FAMILY HYLIDAE

**Pseudacris triseriata maculata*	Boreal Chorus Frog

FAMILY RANIDAE

Rana catesbeiana	Bullfrog
**Rana pipiens*	Leopard Frog
Rana pretiosa	Spotted Frog
Rana maslini	Wood Frog

CLASS REPTILIA

ORDER SQUAMATA

SUBORDER LACERTILIA

FAMILY IGUANIDAE

Holbrookia maculata	Lesser Earless Lizard
**Phroynosoma douglassi brevirostre*	Eastern Short-horned Lizard
**Sceloporus graciosus graciosus*	Sagebrush Lizard
Sceloporus undulatus elongatus	Northern Plateau Lizard
Sceloporus undulatus erythrocheilus	Red-lipped Plateau Lizard
Sceloporus undulatus garmani	Northern Prairie Lizard
Uta stansburiana stansburiana	Northern Side-blotched Lizard
Urosaurus ornata	Tree Lizard

FAMILY TEIDAE

Cnemidophorus sexlineatus	Six-lined Racerunner

FAMILY SCINCIDAE

Eumaces multivirgatus multivirgatus	Northern Many-lined Skink

SUBORDER SERPENTES

FAMILY VIPERIDEA

**Crotalus viridis viridis*	Prairie Rattlesnake
Crotalus viridis concolor	Midget Faded Rattlesnake

FAMILY BOIDAE

Charina bottae utahensis	Rocky Mountain Rubber Boa

FAMILY COLUBRIDAE

*Coluber constrictor flaviventris	Eastern Yellow-bellied Racer
Coluber constrictor mormon	Western Yellow-bellied Racer
Heterodon nasicus nasicus	Plains Hognose Snake
Lampropeltis triangulum multistrata	Pale Milk Snake
Opheodrys vernalis blanchardi	Western Smooth Green Snake
*Pituophis melanoleucas deserticola	Great Basin Gopher Snake
*Pituophis melanoleucas sayi	Bullsnake
Storeria occipitomaculata	Red-bellied Snake
*Thamnophis elegans vagrans	Wandering Garter Snake
Thamnophis radix haydeni	Western Plains Garter Snake
*Thamnophis sirtalis parietalis	Red-sided Garter Snake
Thamnophis sirtalis fitchi	Valley Garter Snake

ORDER CHELONIA

FAMILY CHELYORIDAE

Chelydra serpentina	Snapping Turtle

FAMILY TRIONYCHIDAE

Trionyx spiniferus hartwegi	Western Spiny Softshell

FAMILY TESTUNIDAE

Chrysemys picta	Painted Turtle
Terrapene ornata ornata	Ornate Box Turtle

Taken from Wyoming Game and Fish 1974 Planning Report 8-G. Current Status and Inventory of Fur Animals

WYOMING'S FURBEARING MAMMALS

Common Name Order	Scientific Name	No. of Sub-Species in State	Legal Designation	Current Status	General Habitat Requirements
Marsupialis					
Opossum	Didelphis marsupialis	1	Wildlife	Peripheral in the State. Known only from extreme eastern sections. Possibly increasing.	Deciduous forest
Lagomorpha					
Jackrabbit					
White-tailed Jackrabbit	Lepus townsendii	2	Predator	Common. Populations cyclic. Distributed Statewide.	Northern grass and shrub lands
Black-tailed Jackrabbit	Lepus californicus	1	Predator	Populations cyclic. Occurs in S.E. portions of the state.	Southern grass and shrub lands
Rodentia					
Beaver	Castor canadensis	2	Furbearer	Common. Distributed statewide in suitable habitat.	Riparian
Porcupine	Erethizon dorsatum	2	Predator	Common. Distributed statewide in suitable habitat.	Evergreen forest

- continued -

Common Name Order	Scientific Name	No. of Sub-Species in State	Legal Designation	Current Status	General Habitat Requirements
Rodentia					
Muskrat	*Ondatra zibethicus*	2	Furbearer	Common statewide. Populations are generally cyclic.	Riparian
Carnivora					
Coyote	*Canis latrans*	2	Predator	Common throughout the state. Possibly increasing.	Ubiquitous
Grey wolf	*Canis lupus*	3	Predator	Undetermined. Presently restricted to Yellowstone ecosystem. Possibly extinct.	Ubiquitous
Red fox	*Vulpes vulpes*	2	Predator	Common. Apparently increasing its range and numbers within the state.	Ubiquitous
Swift fox	*Vulpes velox*	1	Wildlife	Uncommon. Restricted to eastern grassland areas. More information on this species is needed.	Grass and shrub lands

- continued -

Common Name Order	Scientific Name	No. of Sub-Species in State	Legal Designation	Current Status	General Habitat Requirements
Grey fox	Urocyon cinereoargenteus	1	Wildlife	Peripheral. Only one record of occurrance in extreme eastern Wyoming.	Deciduous forest
Ringtail	Bassariscus astutus	1	Wildlife	Peripheral. Known only from extreme southwestern portions of the state.	Rocky desert
Raccoon	Procyon lotor	1	Predator	Common in eastern portions of the state. Apparently increasing range and numbers.	Semi-riparian
Marten	Martes americana	2	Furbearer	Status undetermined. Known to occur in most mountainous areas of the state.	Evergreen forest
Fisher	Martes pennati	1	Protected	Peripheral. Only known records are 1 taken in Yellowstone Park in 1893, 2 from the Beartooth Plateau "in the early 1920's" and 1 taken in Sheridan County in the 1960's.	Forest

- continued -

Common Name Order	Scientific Name	No. of Sub-Species in State	Legal Designation	Current Status	General Habitat Requirements
Skunk					
Spotted skunk	Spilogale putorius	2	Predator	Uncommon. Distributed throughout much of the state.	Rocky desert or semi-desert
Striped skunk	Mephitis mephitis	1	Predator	Common throughout Wyoming.	Ubiquitous
River Otter	Lutra canadensis	1	Protected	Uncommon. Known from Yellowstone Park and surrounding area and selected riparian habitat throughout the state.	Riparian
Lynx	Lynx canadensis	1	Protected	Northern and western portions of the state. Population status undetermined in Wyoming but known to be cyclic elsewhere.	Forest
Bobcat	Lynx rufus	1	Predator	Distributed statewide. Populations may be declining.	Foothill canyon and "broken" areas.

* Based on Long, C.A., 1965. The mammals of Wyoming. U. of Kansas Publ. 14(18): 493-758

Common Name Order	Scientific Name	No. of Sub-Species in State	Legal Designation	Current Status	General Habitat Requirements
<u>Weasel</u>					
Ermine	<u>Mustela</u> <u>erminea</u>	1	Predator	Distributed statewide in suitable habitat.	Ubiquitous
Long-tailed weasel	<u>Mustela</u> <u>frenata</u>	4	Predator	Distributed statewide in suitable habitat.	Ubiquitous
Mink	<u>Mustela</u> <u>vison</u>	2	Furbearer	Distributed statewide in suitable habitat.	Riparian
Black-footed ferret	<u>Mustela</u> <u>nigripes</u>	1	Protected	Rare and endangered. Known only from eastern portions of the state. Current population status unknown.	Prairie dog towns
Wolverine	<u>Gulo</u> <u>gulo</u>	1	Protected	Rare in Wyoming. known from northwestern mountains. Population status undetermined.	Forest
Badger	<u>Taxidea</u> <u>taxus</u>	1	Furbearer	Common. Distributed statewide in suitable habitat.	Plains, deserts and open mountain areas.

- continued -

INSECT SPECIES LIST

Gas Hills Area of Wyoming

COLEOPTERA

Chrysomelidae

- Chaetocnema cribrifrons (Le Conte)
- Chaetocnema sp., nr. denticulata (Illiger)
- Pachybrachis sp.
- Phyllotreta sp.

Cicindelidae

- Cicindela decemnotata (Say)
- Cicindela denverensis (Casey)
- Cicindela lengi (W. H.)
- Cicindela punctulata (Oliver)
- Cicindela purpurea auduboni (Le Conte)

Coccinellidae

- Brumoides septentrionis (Weise)

Curculionidae

- Cimbocera pauper (Horn)
- Ophryastes sordidus (Le Conte)

Hydrophilidae

- Sphaeridium sp.

Nitidulidae

- Carpophilus pallipennis (Say)

Scarabaeidae

- Aphodius granarius (L.)
- Aphodius vittatus (Say)
- Cremastocheilus saucius (Le Conte)
- Dichelonyx backii (Kirby)
- Dichelonyx truncata (Le Conte)

Tenebrionidae

- Araeoschizus armatus (Horn)
- Asidopsis opaca (Say)

Eleodes tricostata (Say)
Glyptasida sordida (Le Conte)
Gonasida elata comprar (Casey)

DIPTERA

Agromyzidae

Phytomyza sp.

Anthoyiidae

Hylemya cinerella (Fallen)
Hylemya neomexicana (Malloch)
Hylemya platura (Meigen)

Asilidae

Ablautus mimus (Osten Sacken)
Asilus gilvipes (Hine)
Asilus mesae (Tucker)
Efferia benedicti (Bromley)
Efferia bicaudata (Hine)
Efferia costalis (Williston)
Efferia frewingi (Wilcox)
Efferia pallidula (Hine)
Efferia staminea (Williston)
Efferia helenae (Bromley)
Heteropogon wilcoxi (James)
Leptogaster parvoclava (Martin)
Lestomyia sabulona (Osten Sacken)
Mallophorina guildiana (Williston)
Proctacanthella cacopiloga (Hine)
Proctacanthus rodecki (James)
Promachus dimidiatus (Curran)
Scleropogon coyote (Bromley)
Scleropogon neglectus (Bromley)
Stenopogon inquinatus (Loew)
Stenopogon martini (Bromley)

Bombyliidae

Aphoebantus marcidus (Coquillett)
Aphoebantus sp., nr. marginatus (Cole)
Geron sp.
Mythicomyia rileyi (Coquillett)
Phthiria sp.
Villa nugator (Coquillett)

Calliphoridae

Phormia regina (Meigen)

Cecidomyiidae

Anarete sp.
Lestremia sp.
Neolasioptera sp.
Winnertzia sp.

Chloropidae

Olcella sp., nr. punctifrons (Beck)
Oscinella sp.

Culicidae

Aedes dorsalis (Meigen)
Aedes idahoensis (Theobald)

Dolichopodidae

Asyndetus sp.
Medetera veles (Loew)

Heleomyzidae

Schroederella fuscopicea (Gill)

Milichiidae

Leptometopa halteralis (Coquillett)

Muscidae

Coenosia sp.
Haematobia irritans (L)

Otitidae

Ceroxys lutiusculus (Loew)

Pipunculidae

Tomosvaryella coquilletti (Kertesz)
Tomosvaryella lepidipes (Hardy)
Tomosvaryella similis (Hough)
Tomosvaryella sylvatica (Meigen)

Sarcophagidae

Blaesoxipha sp., prob. reperta (Reinhard)
Rabinia planifrons (Aldrich)
Ravinia querula (Walker)
Sarcophaga cooleyi (Parker)
Senotainia rubriventris (Macquart)
Senotainia trilineata (Wulp)
Taxigramma heteroneura (Meigen)

Scenopinidae

Belesta sp.
Brevitricnia sp.
Scenopinus cochisel (Kelsey)

Sepsidae

Saltella sphondylii (Schrank)
Sepsis neocynipsea (Melander and Spuler)

Sphaeroceridae

Leptocera sp.

Syriphidae

Eupeodes volucris-Osten Sacken
Volucella (Copestylum) caudata (Curran)

Tabanidae

Chrysops carbonarius (Walker)
Hybomitra pediontis (McAlpine)

Tachinidae

Dinera grisescens (Fallen)
Euthersia sp.
Paradidyma sp.
Sitophaga sp.
Spallenzania sp.
Spathidexia reinhardi (Arnaud)

Tephritidae

Procecidochares anthracina (Doane)

Therevidae

Psilocephala aldrichii (Coquillett)
Psilocephala literalis (Adams)

Tipulidae

Tipula sp.

Trixoscelis flavens (Melander)

HEMIPTERA

Alydidae

Alydus eurinus (Say)
Stachyoncnemus apicalis (Dallas)

Coreidae

Chelinidea vittiger (Uhler)

Lydaeidae

Lygaeus kalmii (Stal)

Miridae

Europiella decolor (Uhler)

Nabidae

Nabis alternatus (Parshley)

Pentatomidae

Chlorochroa persimilis (Horvath)

HOMOPTERA

Aphididae

Pemphigus sp.

Cicadellidae

Aceratagallia uhleri (Van Duzee)
Athysanella magdalena (Baker)
Balclutha punctata (Thunb.)
Ballana sp.
Cabrulus labeculus (DeLong)
Commellus sexvittatus (Van Duzee)
Empoasca aspersa (Gillette & Baker)
Empoasca decora (DeLong & Davidson)
Empoasca neaspersa (Oman & Wheeler)

Empoasca nigra, (Car.) typhlocyboides (Gillette & Baker)
Flexamia abbreviata (Osborn and Ball)
Endria inimica (Say)
Flexamia flexulosa (Ball)
Frigartus frigidus (Ball)
Hardya dentata (Osborn & Ball)
Hebecephalus rostratus (Beamer & Tuthill)
Laevicephalus exiguus (Knull)
Laevicephalus tantalus (Knull)
Macrosteles fascifrons (Stal)
Rosenus cruciatus (Osborn & Ball)

Cicadidae

Okanogana synodica (Say)

Issidae

Aphelonema rugosa (Ball)
Bruchomorpha suturalis (Melichar)

Margarodidae

Margarodes sp.

Psyllidae

Aphalara minutissima (Crawford)

HYMENOPTERA

Apidae

Apis mellifera (L.)
Bombus sp.
Nomada sp., nr. texana (Cresson)
Zacosmia maculata (Cresson)

Bethylidae

Epyris sp.

Braconidae

Apanteles sp.
Chelonus sp.
Microctonus sp.
Microplitis sp.
Orgilus sp.

Eumenidae

Pterocheilus morrisoni (Cresson)

Figitidae

Trischiza sp.

Formicidae

Formica sp.
Lasius sp.
Myrmica sp.
Pogonomyrmex occidentalis (Cresson)
Tapinoma sessile (Say)

Halictidae

Agapostemon cockerelli (Crawford)
Dialictus sp.
Halictus ligatus (Say)

Ichneumonidae

Centeterus sp.
Enicospilus purgatus (Say)
Ophion sp.

Mutillidae

Dasymutilla sp.

Pompilidae

Anoplius sp.
Aporinellus taeniatus sp. (Rufus Banks)
Evagetes padrinus (Viereck)
Pomplius sp.

Proctotrupidae

Proctotrupes florissatensis (Rohwer)

Scelionidae

Scelio calopteni (Riley)

Sphecidae

Diodontus sp.
Lindenius columbianus (Kohl.)
Podalonia sp.
Prionyx canadensis (Provancher)
Solierella sp.
Tachysphex sp.

Tiphiidae

Brachycistis sp.
Tiphia intermedia (Malloch)

LEPIDOPTERA

Acrolophidae

Acrolophus cockerelli (Dyar)

Aegeridae

Zenodoxus canescens

Coleophoridae

Coleophora sp.

Gelechiidae

Filatima xanthuris (Meyr)
Gnorimoschema sp.
Lita negrens (Hodges)
Lita sp., prob. variabilis

Hesperiidae

Hesperia nevada (Scudder)
Hesperia uncas uncas (Edwards)

Lyonetiidae

Bucculatrix sp.

Noctuidae

Agrotiphila sp.
Euclidina cuspidea (Hubner)

Euxoa sp., nr. ridingsiana (Grote)
Peridroma saucia (Hubner)
Pseudaletia unipuncta (Haw.)
Spaelotis sp.
Therasea flavicosta (Sm.)

Oecophoridae

Semioscopis sp.

Olethreutidae

Eucosma sp., prob. argentialbana (Wlsm.)
Eucosma sp., prob. argenteana (Wlsm.)
Eucosma sp., prob. serpentana (Wlsm.)

Pieridae

Pieris beckerii beckerii (Edwards)

Pyralidae

Homoeosoma sp.
Loxostege sp.
Melitara dentata (Grote)
Thaumatopsis repandus (Grote)

Scythridae

Scythris sp.

Tortricidae

Choristoneura conflictana (Wlsm)

Yponomeutidae

Plutella xylostella (L.)

NEUROPTERA

Chrysopidae

Chrysopiella sp.

Myrmeleontidae

Hesperoleon blandis (Hagen)

ODONATA

Lestidae

Lestes sp., prob. unguiculatus (Hagen)

ORTHOPTERA

Acrididae

Ageneotettix deorum (Scudder)
Cordillacris crenulata (Bruner)
Cordillacris occipitalis (Thomas)
Derotmema haydenii (Thomas)
Melanoplus angustipennis (Dodge)
Melanoplus bivittatus (Say)
Melanoplus cincreus (Scudder)
Philbostroma quadrimaculatum (Thomas)
Phoetaliotes nebrascensis (Thomas)
Psoloessa delicatula (Scudder)
Trachyrhachys kiowa (Thomas)
Trimerotropis gracilis (Thomas)

Mantidae

Litaneutria minor (Scudder)

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2.9.3 Environmental Stresses

Environmental stresses on wildlife may be natural or man-induced. Stress can be related to the environmental tolerance of a species or population. Environmental stresses can include poaching, fish and aquatic life disturbance from drainage manipulation, overgrazing, and air quality changes.

Poaching refers to the killing, or taking, of a wildlife species contrary to legal limitations. It is difficult to measure the amount of poaching that occurs, or its effect on a wildlife population. The seriousness of poaching effects depends on the season in which it occurs and the population dynamics of the species involved. Pre-hunting season poaching may only reduce the legal hunter's success, whereas poaching during or after the birth of young could seriously deplete the population.

Violations of wildlife laws are directly related to human population densities, especially in areas of industrialization and mineral development [ref 1].

In the Gas Hills area, roads will be traveled by shift workers through antelope and sagegrouse habitat. Poaching and accidental road-kill could be a problem, especially at night. Measures to control poaching could include the establishment of unannounced road blocks or checking stations by Game and Fish enforcement officers.

Mining company employees are very conscious of conservation efforts and are normally not the poaching offenders.

The roads, if dry and dusty, can cause fugitive dust emissions in the areas traveled by FAP shift workers. However, these roads are currently traveled by the workers, and since only 20 additional workers will be required by the mill expansion, the amount of additional dust created by the expansion is nominal.

The plant, because of the air pollution control and substitution of wet crushing and grinding in place of the existing dry crushing, is not anticipated to cause any additional environmental stresses or fish or aquatic life disturbances from drainage manipulation. There may be, however, short-term stresses on the environment during the expansion activities when construction materials, personnel, and activities will be ensuing.

2.10 BACKGROUND RADIOLOGICAL CHARACTERISTICS

The background radiological characteristics of the site reflect the influence of extensive uranium exploration,

open-pit mining, and spoil areas over the past years. This feature, together with the natural condition of a so-called "Halo" extending over the entire Gas Hills area, results in a gamma radiation level of 0.02 millirems per hour to 0.06 millirems per hour background count.

Table 6.2-2 in section 6.2 shows the operational radiological environmental monitoring program for the FAP uranium mill. The type of sample, such as radon or particular matter for air and surface water, direct radiation, soil, groundwater, or vegetation or forage is also given. Figure 2.10 Gamma Radiation Survey, indicates these monitoring points

Results of monitoring programs by FAP over the past several years are presented in tables 2.10-1 through 2.10-3. These data represent results from monitoring water wells, airborne dust, and gamma surveys. Details of survey methods are presented in section 6.1.

2.11 BACKGROUND NON-RADIOLOGICAL CHARACTERISTICS

The present air quality is currently being determined for 24 hour periods, weekly at different locations near the FAP Mill site. High volume air sampling is currently being conducted at three locations. These locations are: Clyde Bret Station, approximately 8 kilometers (5 miles) southwest of the mill site; Sagebrush Tablestakes Station, approximately 1/2 kilometer (less than a mile northwest of the mill site); and Buss Cap Station over 11 kilometers (7 miles northeast of the mill site). Data from the Sagebrush-Tablestakes monitoring station show that the particulate matter averaged about 65 micrograms/cubic meter, with a low 2.7 micrograms/cubic meter and a high of 470 micrograms/cubic meter. Table 2.11 shows the results of the data collection from June 1, 1978 to August 1, 1979.

The data show that the air quality as to particulate matter is good. Particulate matter would be the main non-radiological air pollutant in the area and could affect the water quality in the vicinity.

Since this air sampling stations are located in areas where various mining and milling activities are occurring, they reflect the effects of several activities which could affect the environmental quality of the area. Since FAP is currently operating a mill in the area, it is not anticipated that the expansion of the facilities would have any appreciable affect on the environment. In fact, the substitution of wet crushing/ grinding in the expanded mill complex in place of the present dry crushing would create an incremental reduction in fugitive dust potentially generated at the mill ore stockpile area.

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TABLE 2.3-1

GAS HILLS ENVIRONS
POPULATION DATA*

	1960 Population	1970 Population	Change in Percent
Fremont County	26,168	28,352	+ 8.3
Natrona County	51,264	49,623	- 3.3
Casper & Vicinity	42,806	43,558	+ 1.8
Hudson	369	381	+ 3.3
Lander	4,182	7,125	+70.4
Riverton	6,845	7,995	+16.8
Shoshoni	766	562	-26.6
Lucky-Mc Camp	125-150 (1976 estimate)		
FAP Village	172	326**	

*Source: Bureau of Census (1970)
**Estimate (12/6/79)

TABLE 2.3-2

GAS HILLS AREA
POPULATION PROJECTIONS (1975-1976)*

Year	Fremont County	State of Wyoming
1970	28,352	332,416
1975	31,000	374,000
1980	33,509	443,411
1985	36,241	474,694
1990	38,999	496,698
1995	40,030	503,296
2000	40,005	501,674

*Source: Wyoming Department of Economic Planning and Development. Economic Research Unit. (1976)

TABLE 2.5

Characteristics of the Soils within 1 Mile of the Federal-American Partners Mill Site (Re[illegible]

Soil Series Name	Parent Material	Profile Characteristics of Typical Pedon	Depth of Solum, inches (cm)	Topography and Slope	Erosion Hazard	Permeability	Vegetation
Havre	Alluvium	Strongly Calcareous. Ap: 0-6" Clay Loam, pH 7.8 C: 6-60", Clay Loam, pH 8.4	60 (152) or more	Nearly level to gently sloping Slope 1-6%	Slight	Moderate	Sagebrush
Forelle	Alluvium	A: 0-2" Sandy Clay Loam B: 2-26" Clay Loam C: 26-60" Clay Loam	60 (152)	Nearly Level to gently sloping Slope 1-6%	Moderate	Moderate	Western wheat-grass, bluebunch wheatgrass, sage-brush
Component sl	Alluvium	A: 0-4", Sandy Loam B: 4-21", Clay C: 21-60", Sandy Clay loam to coarse Sandy Loam	60 (152)	Nearly Level to gently sloping Slope 1-6%	Slight to Moderate	Slow	Sagevrush, phlox, cactus, canby bluegrass and needleand thread
Component 23	Alluvium	A: 0-3" Loam B: 3-24" Clay C: 24-45" Very Gravelly Sandy Clay Loam C: 45-60" Very Gravelly Sandy Loam	6 (152) or more	Terraces and uplands Slope 1-10%	Slight	Moderately Slow	Prairie junegrass Western wheatgras Threadleaf sedge, Sandberg bluegras Sagebrush, and Needleandthread
Component 85	Alluvium & Residiuum	A: 0-2" Gravelly Loam B: 2-9" Sandy Clay Loam C: 9-24" Very Gravelly Coarse Sandy Clay Loam	24 (61)	Nearly level to moderately steep terraces and uplands Slope 3-20%	Slight to moderate	Moderately Slow	Green needlegrass Threadleaf sedge, Sagebrush, and Western wheatgras

TABLE 2.5 Continued

Soil Series Name	Parent Material	Profile Characteristics of Typical Pedon	Depth of Solum, inches (cm)	Topography and Slope	Erosion Hazard	Permeability	Vegetation
Component 83	Residiuum & Claystone	A: 0-3" Loam B: 3-16" Clay C: 16-28 Gravelly Clay Loam	28 (71)	Moderately steep uplands and terraces Slope 6-25%	Moderate to Severe	Moderately Slow	Western wheatgrass, threadleaf sedge, sagebrush, phlox and forbs
Diamondville	Limestone, sandstone, shale	A: 0-3" Sandy Clay Loam B: 3-12" Clay Loam C: 12-22" Calcareous Loam	22 (56)	Gently sloping to moderately steep Slope 3-10%	Moderate	Moderate	Western wheatgrass, blue bunch wheatgrass, sagebrush
Crownest	Hard, noncalcareous sandstone	A: 0-3" Loamy Sand C: 3-12" Sandy Loam	12 (30)	Uplands Slope 10-30%	Moderate to Severe	Moderately Rapid	Bluebunch wheatgrass, sandberg wheatgrass, sagebrush
Component 21	Alluvium	A: 0-3 Loam B: 3-12 Sandy Clay Loam C: 12-60" Very Gravelly Sandy Loam	60 (152) or more	Terraces and outwash Slope 1-10%	Slight to Moderate	Moderate	Western wheatgrass, threadleaf sedge, needleand thread, phlox, and birdfoot sage
Highpoint	Hard Shale	Noncalcareous Al: 0-7", Channery silty Clay Loam pH 7.2 Cr: 7-20", bedrock with silty Clay loam, ph 7.2	7 (18)	Steep Slope 20-50%	Moderate to Severe	Moderate	Bluebunch wheatgrass, threadleaf sage, sandberg bluegrass

TABLE 2.6-1

EARTHQUAKES WITHIN A 200 MILE RADIUS OF THE PROJECT AREA

Date	Location	North Lat.	West Long.	Intensity	Associated Tectonic Features
1892	Casper, Wyoming	42.9	106.3	VI-VII	Casper Arch
1894, June 25	Casper, Wyoming	42.9	106.3	V	Casper Arch
1895, October 11	Black Hills, South Dakota	43.9	103.3	IV-V	Black Hills Uplift
1910, July 25	Rock Springs, Wyoming	41.5	109.3	V	Rock Springs Uplift
1915, October 23	Kadoka, South Dakota	43.8	101.5	V	
1925, November 17	Wyoming	44.6	107.0	V	Big Horn Uplift
1928, February 13	Central Wyoming	43.5	108.2	V	Owl Creek Uplift
1928, November 16	Black Hills, South Dakota	44.0	103.7	V	Black Hills Uplift
1934, July 30	Chadron, Nebraska	42.7	103.0	VI	Chadron Arch
1934, November 23	Lander, Wyoming	43.0	109.0	V	Wind River Uplift
1954, January 20	Southeastern, Wyoming	41.5	105.5	V	Denver Basin
1955, February 10	Northwestern Colorado	40.5	107.0	V	North Park Basin
1959, December 25	Foxpark, Wyoming	41.1	106.2	V	Medicine Bow Uplift
1961	Wyoming	41.9	107.7	IV-V	Great Divide Basin
1963, February 25	Western Wyoming	42.6	109.2	V	Wind River Uplift
1964	Kadoka, South Dakota	43.9	101.6	V	
1964	Kadoka, South Dakota	43.7	102.1	VI	
1964, March 28	Nebraska	42.9	101.6	VII	Kennedy Basin
1964	Nebraska	42.9	101.6	VII	Kennedy Basin
1964, August 21	Eastern Wyoming	42.9	104.7	V	Hartville Uplift
1965	Wyoming	43.5	106.3	V	Casper Arch
1966, June 26	South Dakota	44.3	103.4	VI	Black Hills Uplift
1967	Wyoming	43.4	108.8	IV-V	Wind River Basin
1967	Wyoming	43.6	109.1	V	Washakie Uplift
1967	Wyoming	43.8	105.7	V	Powder River Basin
1968	Wyoming	42.7	106.7	IV-V	Wind River Basin
1969, May 23	Commerce City, Colorado	40.1	104.2	V	Denver Basin
1970, December 12	Wyoming	44.0	107.5	VI	Big Horn Basin
1971, January 7	Glenwood Springs, Colorado	40.8	107.0	V	Sierra Madre Uplift
1972, February 18	Wyoming	44.3	105.1	V	Black Hills Uplift
1972, December 8	Western Wyoming	43.7	108.4	V	Owl Creek Uplift
1973	Wyoming	42.7	107.9	V	Sweetwater Uplift

TABLE 2.7

GROUND WATER USE

(Within 5 Miles of Site)

Well	Total Depth (Ft.)	Reported Yield (GPM)	Main Aquifer	Static Water Level Depth (Ft.)	Ground Water Use (C=Culinary) (I=Industrial) (S=Stockwatering)
Puddle Springs 17-3	175	5	Wind River Fm	35	C,S
Puddle Springs 17-1	150	5	Wind River Fm	40	S
Lucky Mc #8	1500	80	Cloverly Fm	392	I
Lucky Mc #4	112	300	Qal or Twd	28	I,C
Lucky Mc #5	995	350	Cloverly Fm	100	I
Lucky Mc #11	2140	120	Cloverly Fm	186	I
Lucky Mc #7	1720	150	Cloverly Fm	28	I
Lucky Mc #1	90	10	Alluvium?	30	C
Lucky Mc #6	1340	350	Cloverly Fm	53	I,C
Lucky Mc #9	1362	625	Phosphoria & Tensleep Fms	26	I,C?
Lucky Mc #2	110	350	Wind River Fm	20	C
Jay #1	206	100	Sandstone	80	I
George #1	130	450	Wind River	Open Pit	I
Federal #8	270	100	Wind River	70	I
Federal #6-A	40	61	Wind River Fm	70	I
Federal #13	295	70	Wind River Fm	250	Monitor

TABLE 2.7 Continued

Well	Total Depth (Ft.)	Reported Yield GPM	Main Aquifer	Static Water Level Depth (Ft.)	Ground Water Use (C=Culinary) (I=Industrial) (S=Stockwatering)
Federal #5	289	40	Wind River Fm	85	I
Federal #16	338	60	Wind River Fm	170	C,I
Sagebrush #1	180	70	Wind River Fm	126	C
Federal #1	371	76	Wind River Fm	125	I
U.C.C. Shop	355	25	Wind River Fm	120	I
APPLICATIONS:					
Sagebrush 1	250	225	Wind River Fm	Open Pit	I
Tablestakes 1	200	225	Wind River Fm	Open Pit	I

WELLS UNFILED UPON:

Near Willow Springs Draw - no data available

Near Coyote Creek - no data available

At George Homestead - no daca available

SPRINGS:

No water rights for springs within 5 miles of the site have been filed.

No data on springs in the area is available.

TABLE 2.8-1

SELECTED WEATHER DATA

JULY, 1975 THROUGH APRIL, 1977 - GAS HILLS AREA

	Temperature (°F)	Precipitation (inches)	Relative Humidity (%)
July 1975	72.4	0.68	
August	68.7	0.17	
September	58.7	0.29	
October	47.0	0.21	
November	31.5	0.30	
December	28.8	0.05	70.3
January 1976	23.4	0.17	73.3
February	28.1	0.22	65.3
March	30.3	0.25	62.5
April	43.9	1.09	58.7
May 1976	55.9	1.03	50.3%
June	61.9	2.05	42.8%
July	74.2	1.41	37.1%
August	68.6	0.93	36.8%
September	60.9	0.33	46.2%
October	45.2	1.46	50.6%
November	35.0	0.04	53.8%
December	23.1	0.04	58.3%
January 1977	21.5	0.16	65.4%
February	32.2	0.39	53.6%
March	29.8	0.84	63.8%
April	43.3	1.06	53.2

TABLE 2.8-2

MONTHLY PRECIPITATION - measured in inches

GAS HILLS, WYOMING

LOCATION: 4 miles east of the Gas Hills (Union Carbide Mill)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	
1963	.14	.02	.49	1.40	.45	3.34	.40	1.55	.58	.70	.10	.23	9.40	
1964	.65	.58	.38	3.49	2.28	2.47	.10	.00	.14	.28	.44	.45	11.26	
1965	.72	.16	.18	.79	2.96	.76	1.14	.26	.68	T	.00	.27	7.92	
1966	.33	.23	.12	.47	.09	.56	.00	.70	.20	1.07	.20	.66	4.63	
1967	.69	.16	.38	.60	.84	4.20	E .99	T	1.33	.56	.63	.60	E 10.98	
1968	.20	.43	.44	.45	2.17	2.03	1.22	.16	.06	.15	.66	.34	8.31	
1969	.10	.12	.28	1.29	.61	2.38	.40	.21	.21	.58	.46	.64	7.28	
70	.32	.15	1.48	.72	1.35	3.50	1.36	.38	.30	.18	.33	.33	10.40	
1971	.30	.48	.42	1.68	2.49	.51	.60	.36	1.60	1.38	T	.13	9.95	
1972	.34	.70	.53	.70	.58	1.91	.06	2.01	.16	1.68	.42	.65	9.74	
1973	.55	.46	1.35	2.63	.54	.57	.87	.30	2.62	.35	.16	.98	11.38	
1974	.78	.70	.41	6.30	.12	.69	2.80	T	T	1.36	1.07	.47	14.70	
1975	.17	.83	3.65	.86	1.92	.76	.16	.43	.14	.73	1.23	.97	11.85	
Mean Monthly Precip.	.41	.39	.78	1.64	1.26	1.82	.78	.49	.62	.69	.44	.51	9.83	Mean Annua Preci

TABLE 2.8-3

MONTHLY TEMPERATURES - °F

GAS HILLS, WYOMING

LOCATION: 4 miles east of the Gas Hills

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
1963	12.0	30.7	29.7	37.8	52.4	60.5	69.4	67.1	61.1	51.7	34.2	22.3	44.1
1964	17.8	16.2	19.9	36.2	50.3	56.4	70.7	62.3	54.6	46.9	29.0	19.9	40.0
1965	24.1	20.8	18.5	40.1	45.7	56.9	66.8	63.5	45.6	51.2	37.3	25.1	41.3
1966	18.2	20.2	30.7	38.3	53.8	59.4	72.3	64.4	58.3	42.1	32.7	21.4	42.7
1967	20.8	22.5	32.3	39.0	45.6	55.2	M	67.4	58.1	46.2	29.9	15.1	41.7
1968	M	M	31.8	34.6	46.1	M	67.7	62.0	55.1	45.6	28.1	18.1	40.8
1969	23.7	23.6	25.1	43.1	54.0	53.9	69.1	71.5	61.5	34.9	31.3	25.7	43.1
1970	21.9	30.5	25.8	31.2	50.6	60.0	68.5	70.6	53.0	38.3	28.3	19.8	41.5
1971	21.6	23.0	22.3	37.4	48.1	61.1	65.2	69.9	51.4	39.0	25.7	17.3	40.6
1972	16.4	23.5	36.5	39.7	49.5	61.8	M	65.4	54.4	43.5	25.7	15.5	41.7
1973	15.3	21.0	25.5	31.7	48.3	60.7	69.2	68.3	52.6	47.4	28.6	24.9	41.7
1974	14.1	22.0	31.7	39.8	49.8	62.6	68.7	63.9	53.3	47.5	30.7	21.1	42.1
MEAN MONTHLY TEMP.	18.7	23.1	27.5	37.4	49.5	59.0	68.8	66.4	55.1	44.8	30.6	21.0	41.8

MEAN ANNUAL TEMPERATURE

TABLE 2.8-4

RELATIVE HUMIDITY (%)

Lucky-Mc Mill Area*

Day	June 1975			July 1975			August 1975		
	Avg.	High	Low	Avg.	High	Low	Avg.	High	Low
1	Chart Out No Data			19.6	21	18	Chart Out No Data		
2	Chart Out No Data			40.4	57	21	Chart Out No Data		
3	60.7	82	40	43.0	59	27	Chart Out No Data		
4	54.6	81	36	50.7	66	33	Chart Out No Data		
5	41.2	59	26	55.0	76	36	Chart Out No Data		
6	37.8	53	30	50.8	68	31	30.9	46	21
7	62.5	96	49	62.0	81	38	26.5	31	23
8	82.5	100	65	67.8	88	42	26.5	33	21
9	82.2	100	65	63.5	79	50	35.6	57	24
10	69.8	98	42	62.4	88	34	24.7	29	22
11	47.8	69	29	53.2	73	35	31.0	40	25
12	38.1	48	27	40.5	48	29	42.9	50	31
13	35.8	45	31	37.1	48	30	58.1	92	49
14	55.6	92	34	43.3	64	28	72.0	98	49
15	40.0	78	25	45.5	60	34	69.1	99	42
16	60.9	84	38	52.8	74	36	46.8	68	30
17	68.5	88	53	54.2	81	32	38.3	54	26
18	81.4	94	52	43.5	54	32	32.4	47	24
19	66.5	88	52	46.5	84	34	26.5	33	22
20	55.2	78	35	45.7	63	28	40.4	50	32
21	76.2	100	58	45.1	65	29	47.1	60	34
22	58.8	89	40	49.1	70	31	45.9	66	31
23	43.2	57	31	49.4	71	31	37.2	50	28
24	34.0	49	21	49.2	86	25	39.4	56	31
25	30.2	48	22	34.2	44	25	39.9	52	30
26	45.9	69	26	31.8	39	25	33.5	44	26
27	27.1	32	22	34.0	42	26	29.6	34	24
28	27.1	34	22	33.9	41	26	37.3	53	24
29	25.6	37	20	39.4	48	33	28.9	36	24
30	29.5	58	19	56.0	83	34	25.8	30	26
31	-	-	-	42.7	62	29	24.3	34	22
Monthly Average	51.4	71.6	36.1	46.5	64.0	31.0	38.1	51.6	28.5

*Location: 1½ miles north of Federal American Partners site.

TABLE 2.8-5

TEMPERATURE (^{o}F)

Lucky-Mc Mill Area*

Day	June 1975 Avg.	June 1975 High	June 1975 Low	July 1975 Avg.	July 1975 High	July 1975 Low	August 1975 Avg.	August 1975 High	August 1975 Low
1	Chart Out No Data			78.5	90	67	62.4	77	51
2	Chart Out No Data			74.6	86	62	65.6	82	50
3	56.9	70	46	74.9	92	61	70.8	84	54
4	56.2	68	47	73.0	86	62	74.3	87	59
5	62.4	74	48	71.6	87	61	75.8	91	60
6	67.0	81	56	73.5	87	60	78.1	93	67
7	59.2	68	52	70.7	87	62	75.9	86	61
8	74.9	54	38	69.2	86	57	68.0	83	54
9	41.4	50	36	69.9	80	62	73.1	88	59
10	44.3	54	38	67.0	78	58	76.9	90	62
11	53.4	68	42	66.3	79	57	73.8	85	62
12	62.2	74	51	69.8	84	54	66.7	76	61
13	65.1	75	56	75.3	88	66	63.9	73	54
14	57.4	66	48	75.3	89	62	59.4	75	51
15	63.2	74	52	74.1	84	67	58.8	73	49
16	54.3	68	46	71.9	81	63	64.5	81	51
17	48.7	53	44	66.9	81	54	70.0	83	56
18	51.5	60	46	71.3	82	62	73.5	86	58
19	48.4	59	39	70.9	82	54	72.5	84	61
20	53.7	67	42	72.9	87	60	68.1	77	60
21	50.1	58	44	72.0	88	63	68.8	79	61
22	57.7	68	46	70.7	83	57	65.7	77	59
23	63.1	74	52	69.6	85	56	68.2	80	56
24	70.8	82	60	70.7	86	57	59.2	67	50
25	63.2	76	48	76.4	90	65	57.5	71	46
26	56.7	71	42	78.6	91	65	66.9	82	52
27	68.0	81	57	78.5	92	69	72.0	85	62
28	68.0	82	55	77.4	90	70	68.4	81	57
29	72.7	85	60	75.5	87	66	67.2	79	53
30	74.7	88	58	69.9	83	60	69.7	83	54
31	-	-	-	68.0	78	58	72.8	85	59
Monthly Average	58.5	69.8	48.2	72.4	85.4	61.2	68.7	81.4	56.4

*Location: 1½ miles north of Federal American Partners site.

TABLE 2.8-6

WEATHER SUMMARY

June 1979 through October 1979

	June	July	August	September	October
Monthly Average Temperature	62.8°F	70°F	66°F	63°F	47°F
Monthly Average High Temperature	74.9°F	84°F	78°F	77°F	59°F
Monthly Average Low Temperature	48.9°F	56°F	54°F	48°F	35°F
High Temperature During Month	92°F	89°F	95°F	88°F	79°F
Low Temperature During Month	29°F	49°F	44°F	35°F	10°F
Total Precipitation	.67"	1.46"	2.66"	0.02"	0.55"
Maximum Daily Precipitation	.51"	0.97"	0.87"	0.01"	0.36"
Peak Gust	52 mph	42 mph	38 mph	36 mph	54 mph

TABLE 2.9-1

WILDLIFE CENSUS SUMMARY*

SPECIES	NUMBER	NUMBER PER SQUARE MILE (Estimated)
Antelope		
bucks	19	
does	33	12.90
fawns	36	
unclassed	721	
Mule Deer		
bucks		
does	10	0.26
fawns	6	
unclassed		
Sage grouse	4	
Golden eagle	1	

Ratios:

Antelope
109 fawns/100 does
57.5 bucks/100 does

Mule deer
60 fawns/100 does

*Summary of wildlife census conducted in 1975 and 1976 in Gas Hills, T33N, R90W (north of Beaver Divide).

TABLE 2.9-2

RARE AND ENDANGERED LIST*

Mammals

Timber Wolf (Canis lupus lycaon) - extinct
Kit Fox (Vulpes velox) - rare
Grizzly Bear (Ursus horribilis, Ursus arctos imperator) - rare
Mountain Lion (Felis concolor) - undetermined
Canada Lynx (Lynx canadensis) - rare
Blackfooted Ferret (Mustela nigripes) - endangered
Pine Marten (Martes americana) - undetermined
Fisher (Martes pennanti) - rare
Otter (Lutrus canadensis) - rare
Bison (wild) (Bison bison) - extinct
Wolverine (Gulo luscus) - rare
Ringtail (Bassariscus astutus arizonenis) - rare
Spotted Bat (Euderma maculatum) - rare
Oppossum (Didelphis marsupialis virginiana) - undetermined

Birds

Bald Eagle (Haliacetus leucocephalus) - undetermined
Goshawk (Accipiter gentelis) - undetermined
Swainson's Hawk (Butco swainsoni) - undetermined
Ferruginous Hawk (Butco regalis) - undetermined
Osprey (Pandion haliaetus carolinensis) - rare
Prairie Falcon (Falco mexicanus) - rare
Gyrfalcon (Falco obsoletus) - rare
Peregrine Falcon (Falco perigrinus) - rare
Snowy Owl (Nyctea nyctea) - undetermined
Great Grey Owl (Scatiaptex nebulosa nebulosa) - undetermined
Short-eared Owl (Asio flammeus flammeus) - undetermined
Burrowing Owl (Speotyto cunicularia hypugaea) - rare
Pygmy Owl (Glaucidium gnoma) - undetermined
Screech Owl (Otus asio) - undetermined
Hawk Owl (Surnia ulula caparaik) - undetermined
Saw-whet Owl (Cryptoglaux acadica acadica) - undetermined
Turkey Vulture (Cathartes aura) - undetermined
Trumpeter Swan (Olar buccinatur) - rare

Long Billed Curlew (Numenius americanus) - undetermined
Mountain Plover (Eupoda montana) - undetermined
Upland Plover (Bartramia longicauda) - rare
Snowy Egret (Egretta thula brewsteri) - rare
Black Crowned Night Heron (Nycticarax nycticarax hoactli) - rare
Columbian Sharptail (Pediaecetes phasianellus columbianus) - - undetermined

Reptiles

Tree Lizard (Urosaurus ornatus) - undetermined
Midget Faded Rattlesnake (Crotalus viridis concolor) - rare
Great Basin Rubber Snake (Charina bottae utahensis) - rare
Western Smooth Green Snake (Opheodrys vernalis blanchardi) - rare
Great Basin Bull Snake (Pituophis melanoleucus deserticola) - - undetermined

Amphibians

Wood Frog (Rana maslini, Rana sylvatica) - rare
Maniboba Toad (Bufo hemiphrys baxteri) - rare

Fish

Shovelnose Sturgeon (Scaphirhynchus platorynchus) - rare
Goldey (Hiodon alosoides) - undetermined
Snake River Cutthroat Trout (Salmo clarki) - rare
Colorado River Cutthroat Trout (Salmo clarki pleuriticus) - rare
Pearl Dace (Semotilus margarita nachtriebi) - rare
Finescale Dace (Phoxinus neogaeus) - rare
Hornyhead Chub (Nocomis Biguttatus) - peripheral
Sturgeon Chub (Hybopsis gelida) - rare
Bonytail (Gila elegans) - extinct
Leatherside Chub (Gila copei) - rare
Colorado Squawfish (Ptychocheilus lucius) - extinct
Kendall Warmsprings Dace (Rhinichthys osculus thermalis) - rare
Suckermouth Minnow (Phenocobius mirabilis) - peripheral
River Shines (Notropis blennius) - undetermined
Silvery Minnow (Hybognathus nuchalis) - undetermined
Stoneroller (Campostoma anomalum) - peripheral
Bluehead Sucker (Catostomus discobolus) - undetermined
June Sucker (Chasmistes liorus) - extinct
Humpback Sucker (Xyrauchen texanus) - extinct
Orangethroat Darter (Etheostoma spectabile pulchellum) - peripheral

*By the Wyoming Fish and Game Commission taken from the Wyoming Fish and Game & Fish Unnumbered Leaflet entitled "Wyoming's Rare and Endangered Wildlife".

TABLE 2.9-3

Small Mammal Trapping Summary of each Site in the Gas Hills Area

September, 1975

Site	Species	Number Per 100 Trap-Nights	Site Species Diversity Index	Percent of Maximum Biological Diversity
1 Big sagebrush	Deer Mouse	5.0	0.566	56%
	Least chipmunk	0.5		
	13-line ground squirrel	0.5		
2 Big sagebrush	Deer Mouse	3.0	0.410	75%
	13-line ground squirrel	0.5		
3 Big sagebrush	Deer Mouse	4.5	0.325	70%
	Merriam shrew	0.5		
4 Overburden	Deer Mouse	5.0	0.0	0.0
5 Big sagebrush	Deer Mouse	8.0	0.0	0.0
6 Disturbed hill	Deer Mouse	2.0	0.0	0.0
7 Big sagebrush	Deer Mouse	6.5	0.0	0.0
8 Grassland	Deer Mouse	4.0	0.0	0.0
9 Greasewood	Deer Mouse	14.0	0.371	72%
	Least chipmunk			
10 Rabbitbrush	Deer Mouse	9.0	0.325	70%
	Least chipmunk	1.0		
11 Gravel ridge	Deer Mouse	5.0	0.450	78%
	13-line ground squirrel	1.0		
12 Big sagebrush	Deer Mouse	3.5	0.610	88%
	Least chipmunk	1.5		

Table 2.9-3 continued

Site	Species	Number Per 100 Trap-Nights	Site Index Species Diversity	Percent of Maximum Biological Diversity
13 Dry reservoir bottom	Deer Mouse	9.5	0.0	0.0
14 Big sagebrush	Deer Mouse	4.5	0.0	0.0
15 Shale ridge	Deer Mouse	3.5	0.0	0.0
16 Shale ridge	Deer Mouse	1.5	0.693	93%
	Least chipmunk	1.5		
17 Limber pine	Deer Mouse	5.5	0.0	0.0
18 Limber pine	Deer Mouse	3.0	0.0	0.0
19 Big sagebrush	Deer Mouse	3.5	0.0	0.0
20 Big sagebrush	No catch			
21 Big sagebrush	Deer Mouse	1.0	0.693	93%
	13-line ground squirrel	1.0		

TABLE 2.9-4

Trapping results in the Gas Hills Area, May 1976, summarized by major vegetative type.

Site	Species	Number Per 100 Trap-Nights	Total Per 100 Trap-Nights
Big Sagebrush	Deer mouse	3.15	
	13-line ground squirrel	0.20	3.40
	Harvest mouse	0.05	
Bluebunch wheatgrass-Rough Breaks	Deer mouse	1.20	
	13-line ground squirrel	0.05	1.30
	Harvest mouse	0.05	
Pine-Juniper	Deer mouse	0.45	
	Harvest mouse	0.05	0.50

TABLE 2.9-5

Trapping results in the Gas Hills Area, May, 1976, by habitat type.

Site	Species	Number	Number per 100 trap-nights	Total number per 100 trap-nights
1 Big Sagebrush	Deer mouse	5	2.5	2.5
2 Big Sagebrush	Deer mouse	3	1.5	1.5
3 Big Sagebrush	Deer mouse	6	3.0	4.0
	13-line ground squirrel	2	1.0	
4 Overburden	Deer mouse	1	0.5	0.5
5 Big Sagebrush	Deer mouse	7	3.5	3.5
6 Disturbed hill	-	-	-	-
7 Big Sagebrush	Deer mouse	2	1.0	1.0
8 Grass	Deer mouse	8	4.0	4.0
9 Greasewood	Deer mouse	4	2.0	2.0
10 Rabbitbrush	Deer mouse	5	2.5	3.0
	13-line ground squirrel	1	0.5	
11 Gravel ridge	Deer mouse	12	6.0	6.0
12 Big sagebrush	Deer mouse	9	4.5	5.5
	13-line ground squirrel	2	1.0	
13 Reservoir bottom	Deer mouse	7	3.5	4.0
	Harvest mouse	1	0.5	
14 Big sagebrush	Deer mouse	14	7.0	7.0
15 Shale ledge	Deer mouse	14	7.0	8.0
	Harvest mouse	1	0.5	
	13-line ground squirrel	1	0.5	
16 Shale ledge	Deer mouse	10	5.0	5.0
17 Pine	Deer mouse	2	1.0	1.0
18 Pine	Deer mouse	7	3.5	4.0
	Harvest mouse	1	0.5	
19 Big sagebrush	Deer mouse	8	4.0	4.5
	Harvest mouse	1	0.5	
20 Big sagebrush	Deer mouse	4	2.0	2.0
21 Big sagebrush	Deer mouse	5	2.5	2.5

TABLE 2.9-6

Rodent species diversity arranged by vegetative type in the Gas Hills area, May, 1976.

Vegetative type	Site	Calculated Species diversity*	Expected diversity**	Percent of expected diversity
Big sagebrush	1,2,3,5 7,12,14 19,20,21	0.2994	1.2997	23.0
Shale ledge	15,16	0.3245	1.2997	24.9
Pine	17,18	0.3250	0.8113	40.0

* Lloyd, M., J. H. Zar and J. Karr. 1968. On the Calculation of Information - Theoretical Measures of Diversity. Am. Midl. Nat. (2): 257-272

** Lloyd, M. and R. J. Ghelardi. 1964. A Table for Calculating the "Equitability" Component of Species Diversity. J. Animal Ecol. 33: 217-225

TABLE 2.9-7

Species diversity of small mammals (rodents) calculated from trapping data in the Gas Hills area, May, 1976.

Site number	Species diversity	Expected diversity	Percent expected diversity
3	0.5623	0.8113	69.3
10	0.4505	0.8113	55.5
12	0.4741	0.8113	58.4
13	0.3767	0.8113	46.4
15	0.4634	1.2997	35.6
18	0.3767	0.8113	46.4
19	0.3488	0.8113	42.9

Unlisted sites showed zero species diversity.

TABLE 2.9-8

Rodent species diversity in the Gas Hills Area, May, 1976, all sites combined.

Calculated species diversity	Expected diversity	Percent of expected diversity
0.3005	1.2997	23.1

TABLE 2.9-9

MILES OF STREAM FOR EACH CLASS IN FREMONT AND ADJACENT COUNTIES

County	Class 1	Class 2	Class 3	Class 4	Class 5	Total
Fremont	3.0	131.8	893.2	699.5	46.5	1,774.0
Hot Springs	0	0	0	36.5	4.0	40.5
Natrona	0	0	0	23.7	0	23.7
Sublette	0	0	31.9	1.5	4.5	37.9
Sweetwater	0	0	0	0	4.2	4.2
Total	3.0	131.8	925.1	761.2	59.2	1,880.3

TABLE 2.9-10

FISHING PRESSURE WITHIN THE COUNTIES - BY STREAM CLASS

County	Class 1	Class 2	Class 3	Class 4	Class 5	Total
Fremont	1,404.0	2,891.2	6,197.0	1,746.2	0.5	12,238.9
Hot Springs	0	0	0	119.5	3.0	122.5
Natrona	0	0	0	32.5	0	32.5
Sublette	0	0	367.4	3.0	0	370.4
Total	1,404.0	2,891.2	6,564.4	1,901.2	3.5	12,764.3

TABLE 2.9-11

TOXICITY OF SOME METALS TO FISH

Metals	Toxic Concentration (mg/l)
Cu	0.015 - 3.0
Ni	0.08 - 1.0
Pb	0.10 - 6.3
Cd	0.01 - 10.0
NH_3	2.0

TABLE 2.9-12

AVERAGE FATAL TURBIDITY ON VARIOUS SPECIES OF FISH [REF 4]

Species	Length Exposure (days)	Turbidity (mg/l)
Largemouth bass	7.6	101,000
Pumpkinseed sunfish	13.0	69,000
Channel catfish	9.3	85,000
Black bullhead	17.0	222,000
Golden shiner	7.1	166,000

TABLE 2.9-13

Provisional maximum temperatures recommended as compatible with the well-being of various species of fish and their associated biota.

Temperature (°F)	Fish and Associated Biota
93°	Growth of catfish, white or yellow bass, carpsucker, and shad.
90°	Growth of largemouth bass, bluegill, and crappie.
84°	Growth of pike, perch, walleye, sanger, and smallmouth bass.
80°	Spawning and egg development of catfish and shad.
75°	Spawning and egg development of largemouth, white and yellow bass.
68°	Growth and migration routes of salmonids and egg development of perch and smallmouth bass.
55°	Spawning and egg development of lake salmon and trout.
48°	Spawning and egg development of lake trout, walleye, northern pike, sanger, and atlanti salmon.

TABLE 2.10-1

ANNUAL AVERAGES* OF RADIONUCLIDES IN WATER SAMPLES

FEDERAL-AMERICAN PARTNERS MONITOR WELLS

Location	1973	1974	1975	1976
		URANIUM		
Well #16	$.00005 \times 10^{-5}$	$.00005 \times 10^{-5}$	$.0002 \times 10^{-5}$	$.0002 \times 10^{-5}$
Well #13	-0-	$.0005 \times 10^{-5}$	$.00023 \times 10^{-5}$	$.00009 \times 10^{-5}$
T.P. #1 Well	-0-	$.0001 \times 10^{-5}$	$.135 \times 10^{-5}$	$.204 \times 10^{-5}$
Mimar Pond	$.0025 \times 10^{-5}$	$.004 \times 10^{-5}$	$.0032 \times 10^{-5}$	$.004 \times 10^{-5}$
		RADIUM 226		
Well #16	$.25 \times 10^{-8}$	$.095 \times 10^{-8}$	$.057 \times 10^{-8}$	$.01 \times 10^{-8}$
Well #13	-0-	1.83×10^{-8}	$.434 \times 10^{-8}$	$.06 \times 10^{-8}$
T.P. #1 Well	-0-	$.08 \times 10^{-8}$	$.24 \times 10^{-8}$	$.34 \times 10^{-8}$
Mimar Pond	$.41 \times 10^{-8}$	$.22 \times 10^{-8}$	$.83 \times 10^{-8}$	1.12×10^{-8}
		THORIUM 230		
Well #16	$.013 \times 10^{-6}$	$.0009 \times 10^{-6}$	$.002 \times 10^{-6}$	$.004 \times 10^{-6}$
Well #13	-0-	$.054 \times 10^{-6}$	$.003 \times 10^{-6}$	$.0006 \times 10^{-6}$
T.P. #1 Well	-0-	$.012 \times 10^{-6}$	$.001 \times 10^{-6}$	$.006 \times 10^{-6}$
Mimar Pond	$.027 \times 10^{-6}$	$.023 \times 10^{-6}$	$.011 \times 10^{-6}$	-0-

* Monitor Points
Sampled Quarterly

TABLE 2.10-2

ANNUAL AVERAGES* OF NATURAL URANIUM IN DUST SAMPLES

FEDERAL-AMERICAN PARTNERS MILL SITE PERIMETER

All values expressed in units of 10^{-11} uc/ml of air

Location	1973	1974	1975	1976	1977
Federal Camp	.012	.011	.036	.078	.029
Loco Road	NS	NS	NS	.023	.020
West Side Tailings	NS	NS	NS	.042	.026
North Fence	NS	NS	NS	.021	.025
Northeast Corner	NS	NS	NS	.025	.022
Near Well #13	NS	NS	NS	.020	.026
East Fence	NS	NS	NS	.021	.027
Buss Russ Road	NS	NS	NS	.015	.026

* Results of Samples
Collected Monthly

TABLE 2.10-3

ANNUAL AVERAGE GAMMA RADIATION SURVEY

FEDERAL-AMERICAN PARTNERS MILL & SITE

All values expressed in MR/Hr. less background

Areas Monitored Quarterly

Location	1973	1974	1975	1976
Main Office	.02	.02	.02	.02
Lab Office	.02	.02	.04	.03
YC Room	.02	.02	.04	.04
Flourametric Room	.02	.03	.03	.04
between Lab & Crusher Bldg.	.03	.03	.03	.03
Doghouse on Ore Pad	.03	.03	.02	.04
Portable Crusher	.02	.03	.03	.03
Conveyor Tunnel	.03	.03	.03	.04
Crusher 3rd Floor over Grizzley	.03	.03	.03	.03
Crusher 2nd Floor Jaw Crusher	.03	.04	.03	.03
Crusher Ground Floor under Crusher	.03	.03	.02	.03
Sample Prep Blending Room	.03	.03	.03	.03
Sample Prep Moisture Room	.03	.03	.03	.02
Ore Dryer Ground Floor	.03	.03	.03	.03
Above Ore Bins East End	.03	.04	.04	.04
Below Ore Bins West End	.03	.03	.04	.03
Weightometer Area	.02	.02	.03	.03
Rodmill Feed End	.03	.03	.03	.03
Mill Maintenance Shop	.04	.04	.03	.04
Leach Tank #1	.04	.05	.05	.02
Leach Tank #2	.04	.04	.03	.04
Leach Operators Desk	.02	.02	.01	.02
SWECO Tra Screens	.03	.02	.03	.03
RIP Operators Desk	.02	.02	.02	.02
SWECO Screens RIP	.03	.02	.02	.02
SWECO Screens IX	.04	.03	.03	.02
Mill Office	.02	.02	.03	.02
SX Mixer-Settler Area	.03	.03	.04	.03
SX Cone Area	.02	.02	.03	.04
Precip Tank Top	.04	.04	.03	.04
YC Roaster Bottom Floor	.03	.04	.04	.04
YC Roaster Deck Rear	.04	.04	.04	.04
Stairway to Ground Floor	.03	.03	.02	.03
YC Packaging Room North Wall	.03	.03	.03	.03
YC Packaging Room Scales	.02	.02	.03	.02
Warehouse Office	.02	.03	.02	.02
Fuel Pumps	.03	.03	.03	.03
Rubber Shop East Room	.03	.03	.03	.03
Electric Shop	.03	.03	.03	.03
Instrument Shop	.02	.03	.02	.03
Between Main Office & Mill	.02	.03	.02	.04
Along Fence Line	.03	.03	.03	.02
Southwest Corner of Fence	.03	.03	.03	.03
Southeast Corner of Fence	.03	.02	.02	.03

TABLE 2.11

HIGH VOLUME AIR SAMPLING RECORD
(Sagebrush-Tablestakes)

Date	Micrograms/Cubic Meter	Remarks (Weather Operation)
6/1/78	15.5	Not stripping, cloudy, small, or no breeze
7/1/78	29.8	
8/6/78	-	Equipment malfunction
9/5/78	43.8	
10/5/78	73.9	
11/4/78	88.5	
12/4/78	49.4	
1/3/79	51.6	High wind with equipment working upwind from sampler
2/2/79	23/0	
3/4/79	22.3	Wet conditions, short duration
4/3/79	45.5	Equipment in vicinity
5/03/79	26.1	
6/02/79	80.8	
7/02/79	119.5	Mining activity nearby, windy, and haul road construction nearby, new motor
8/01/79	195.0	

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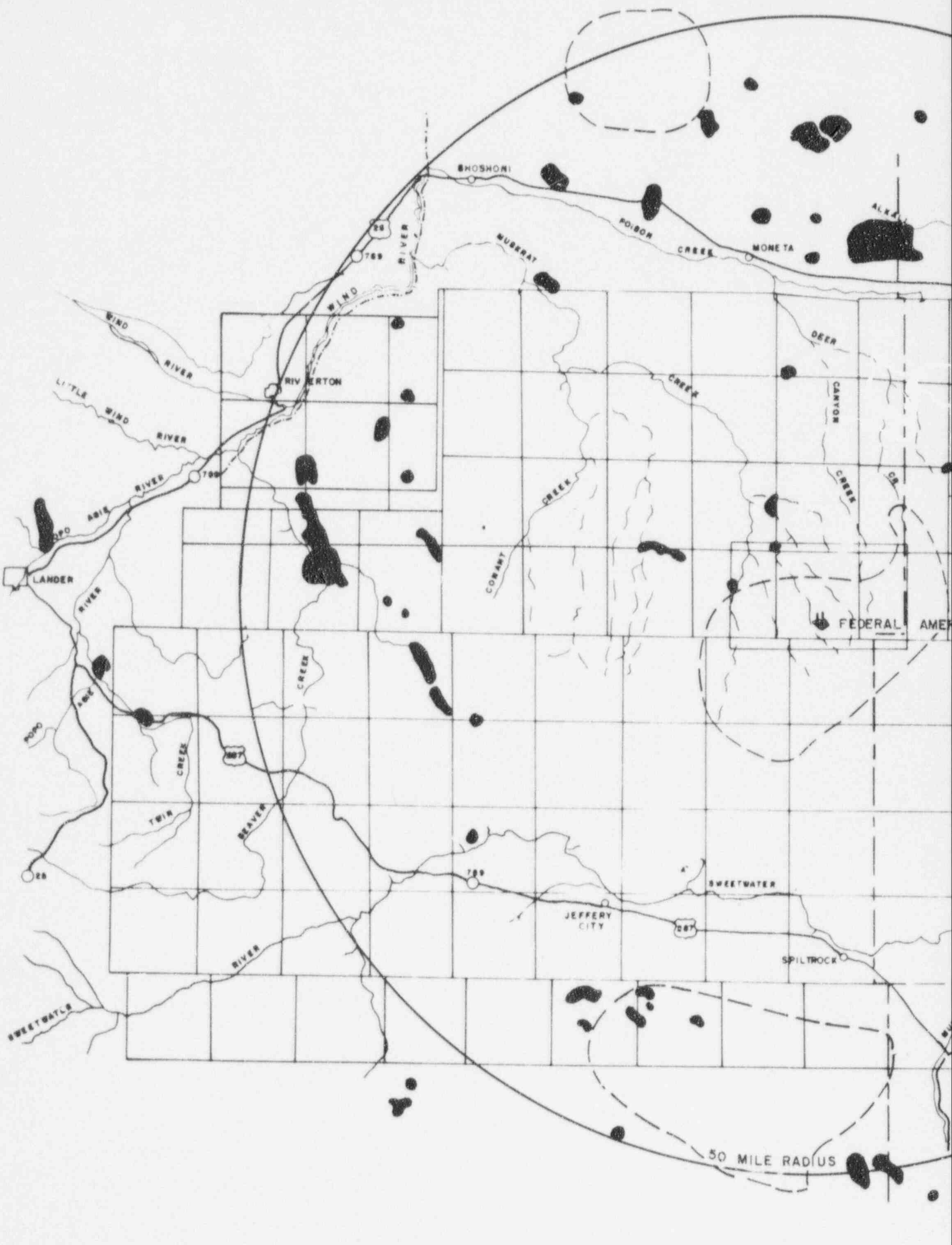
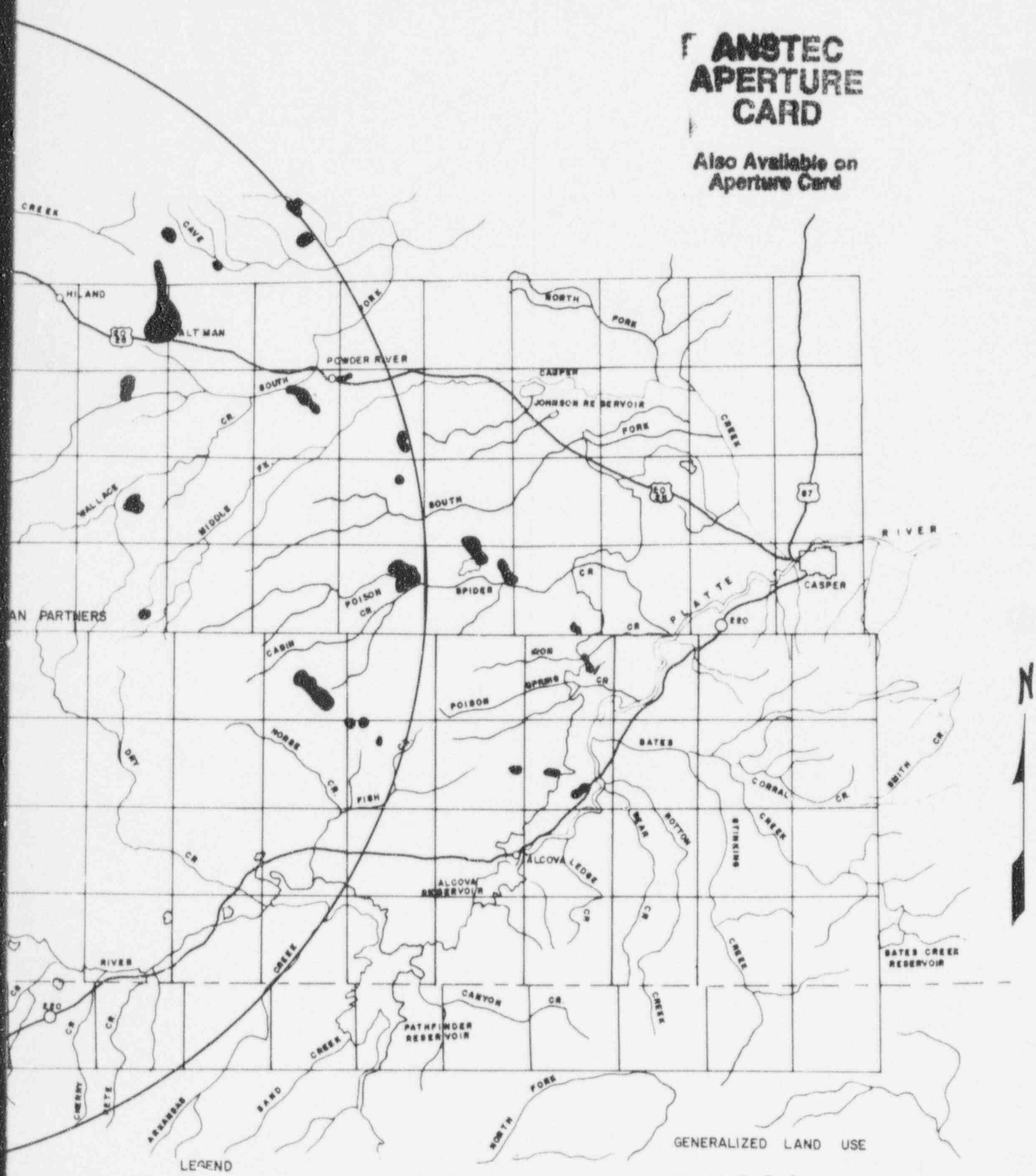


SHOSHONI
MONETA
POISON CREEK
MUSKRAT
ALKALI
WIND RIVER
LITTLE WIND RIVER
RIVERTON
DEER CREEK
CANYON CREEK
CR
LANDER
POPO AGIE RIVER
CONANT CREEK
FEDERAL AMER
CREEK
TWIN CREEK
BEAVER
SWEETWATER
JEFFERY CITY
SPLITROCK
RIVER
SWEETWATER
50 MILE RADIUS



GENERALIZED LAND USE

FIGURE 2.2-1

LEGEND

(solid black)	OIL AND GAS
— · — · —	FARM LANDS
— — — —	MINING AREAS
	GENERALIZED GRAZING

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CREEK
CARTON
CREEK
LUCKY MC
FEDERAL-AMER
WESTERN NUCLEAR CORP
SWEETWATER
JEFFERY
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SPLITROCK
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SWEETWATER
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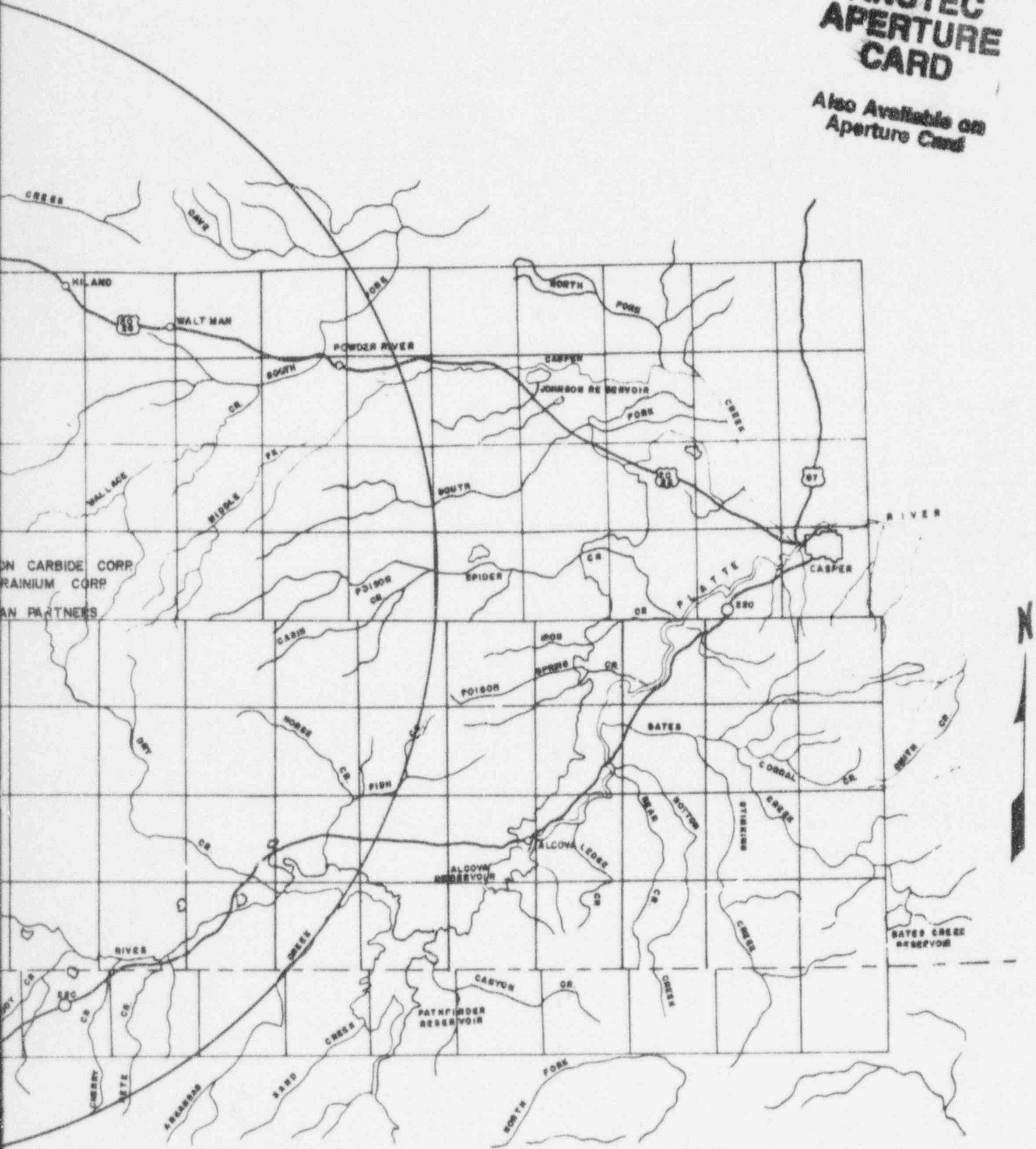
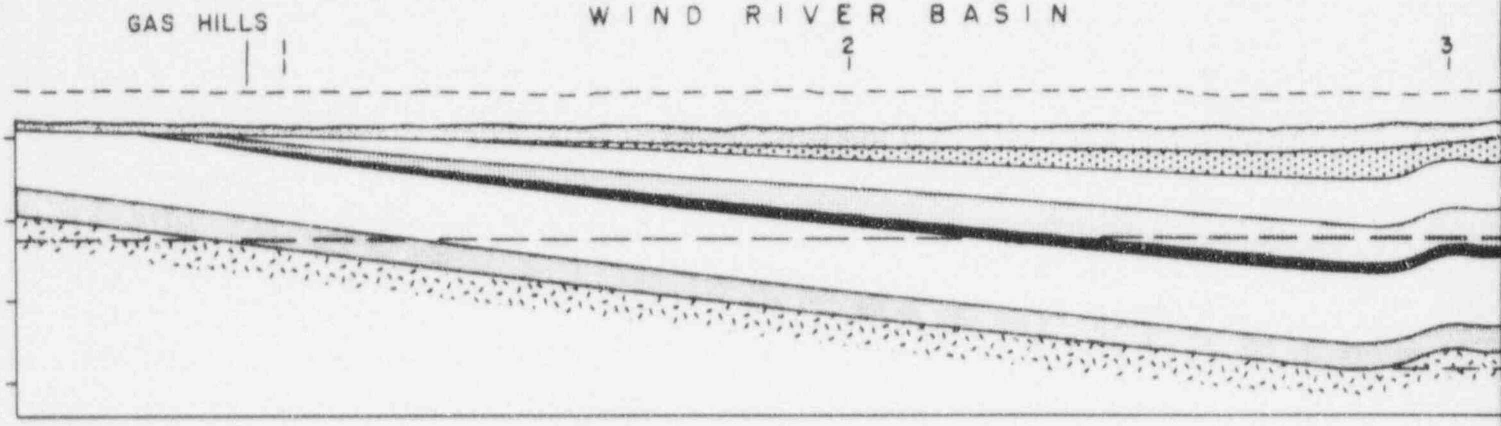
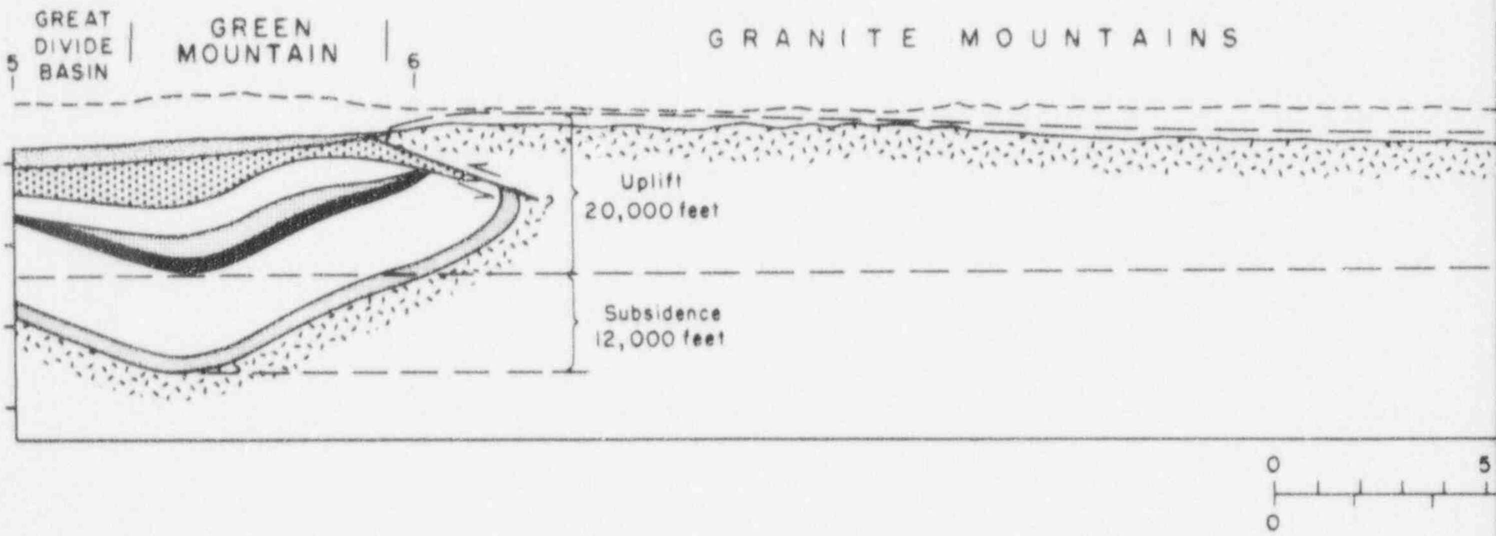


NUCLEAR FUEL FACILITIES

FIGURE 2.2-3

9706130065-04





Wind River formation. Willwood formation in Bighorn basin; conglomerate in Great Divide basin. (Eocene)

Indian Meadows formation. Battle Spring formation in Great Divide basin. (Eocene)

Fort Union formation (Paleocene)

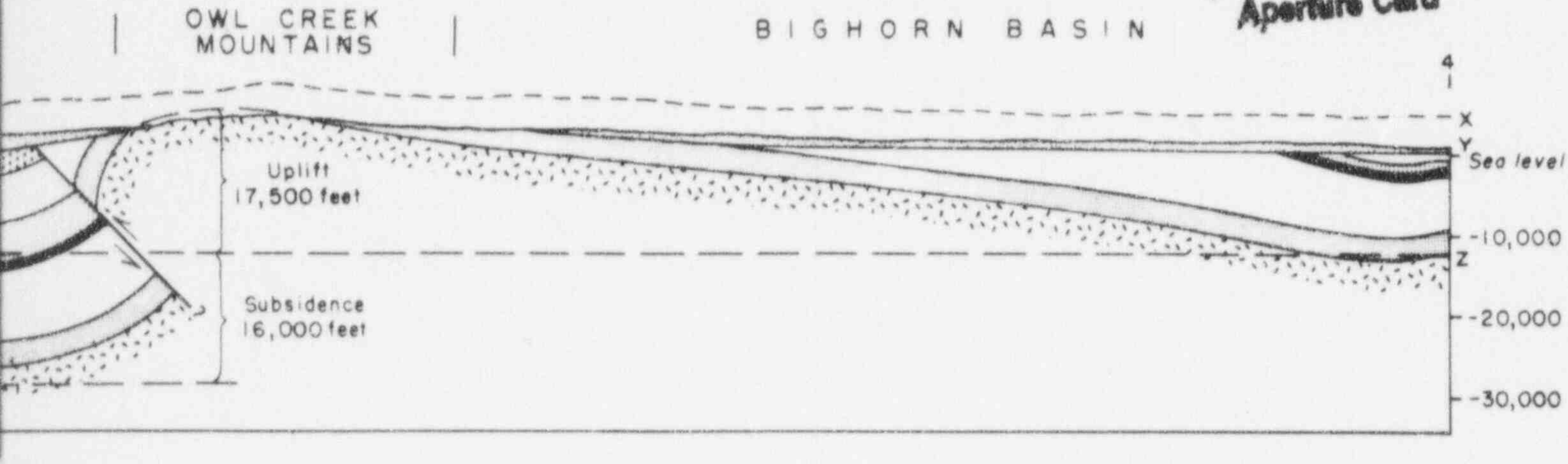
Lance formation (Upper Cretaceous)

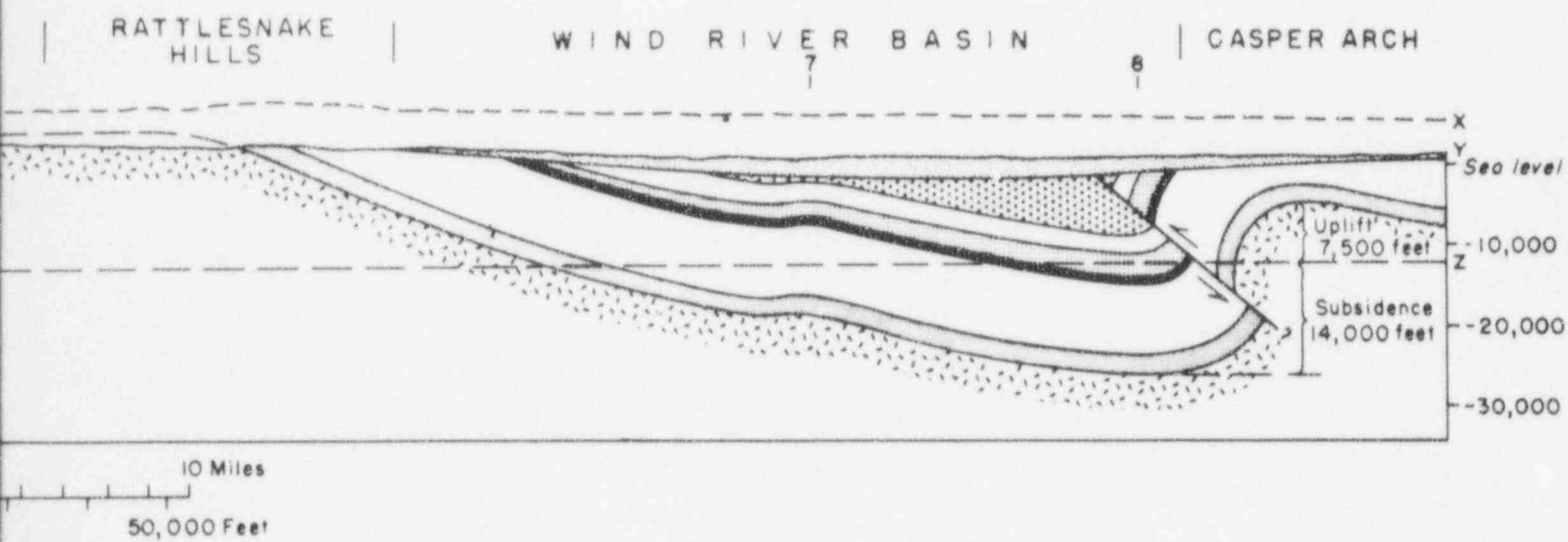
Meeteets (Upper C

Mesozoi and Lew

Well locations: 1-Seaboard Oil Co., Double Butte No. 1; 2- Humble Oil and Refining Co., Poison Creek No. 1; 3-Sh
5-British American Oil Prod. Co., Gov't. -O' Donnell No. 1; 6-Sinclair Oil and Gas Co., Cooper Cre

Restored sections depicting structure at end of early Eocene dep





formation and Lewis shale
etaceous)

Paleozoic rocks

rocks older than Meeteetse
formations

Precambrian rocks

X-Present topographic profile

Y-Postulated topographic profile at close of early Eocene time.
(On Plates 4A-D, Y is topographic profile at stages indicated).

Z-Top of Precambrian rocks at beginning of Laramide deformation

l Oil Co., Howard Ranch No. 23-15; McCulloch Oil Corp., Gov't.-Voth No. 1; 4-G and G Oil Co., Nieber Dome No. 1;
x No. 1; 7-True Oil Co., Sun Ranch No. 1; 8-British American Oil Prod. Co., J. B. Eccles No. 1

sition across parts of central Wyoming.

REF: KEEFER, LOVE, CONTRIBUTIONS to GEOLOGY, VOL. 2, 1963

FIGURE: 2.5-1

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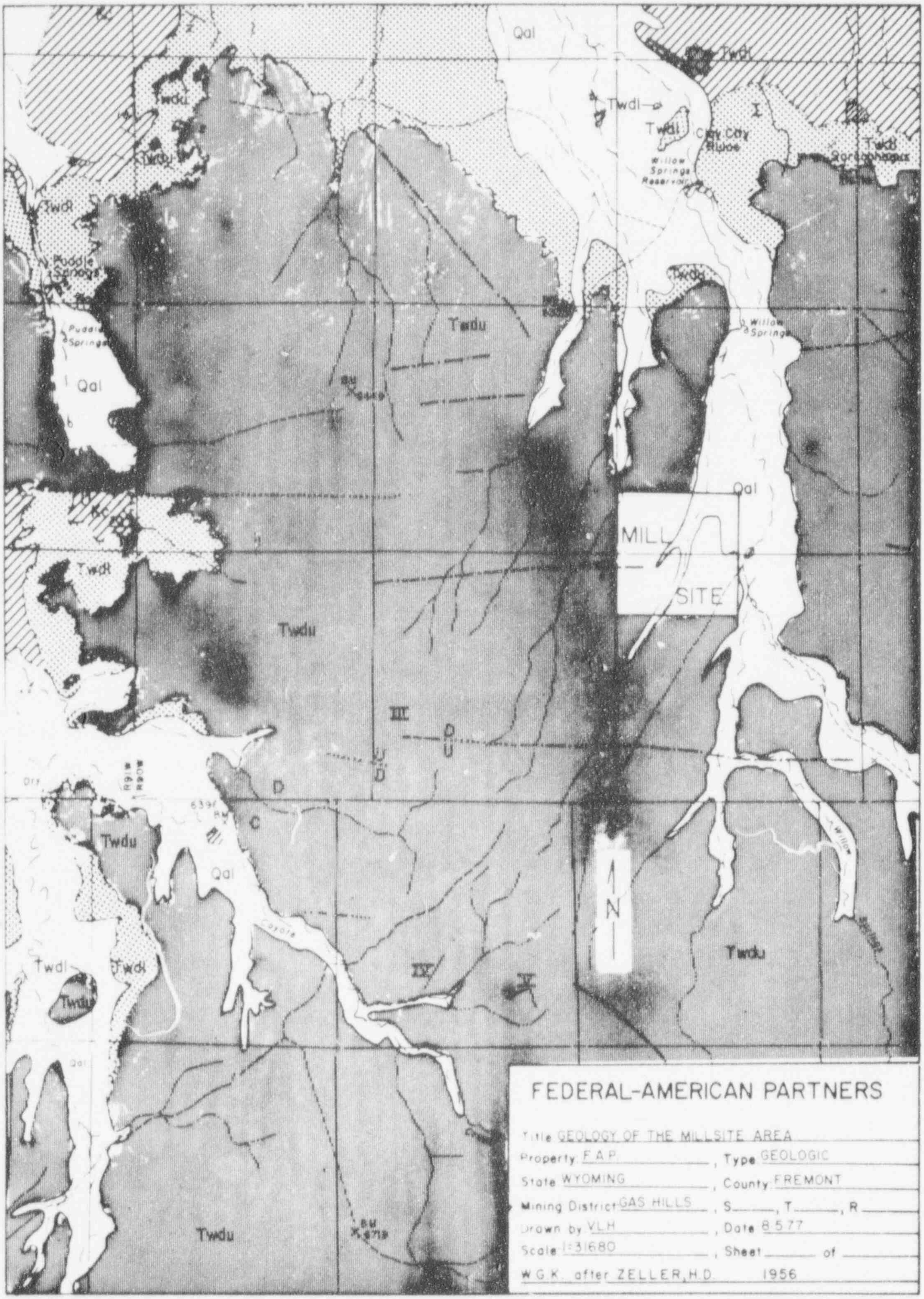


FEDERAL-AMERICAN PARTNERS

Title GEOLOGY OF THE MILLSITE AREA

Property F.A.P. , Type GEOLOGIC

State WYOMING , County FREMONT

Mining District GAS HILLS , S.____ , T.____ , R.____

Drawn by VLH , Date 8.5.77

Scale 1:31680 , Sheet ____ of ____

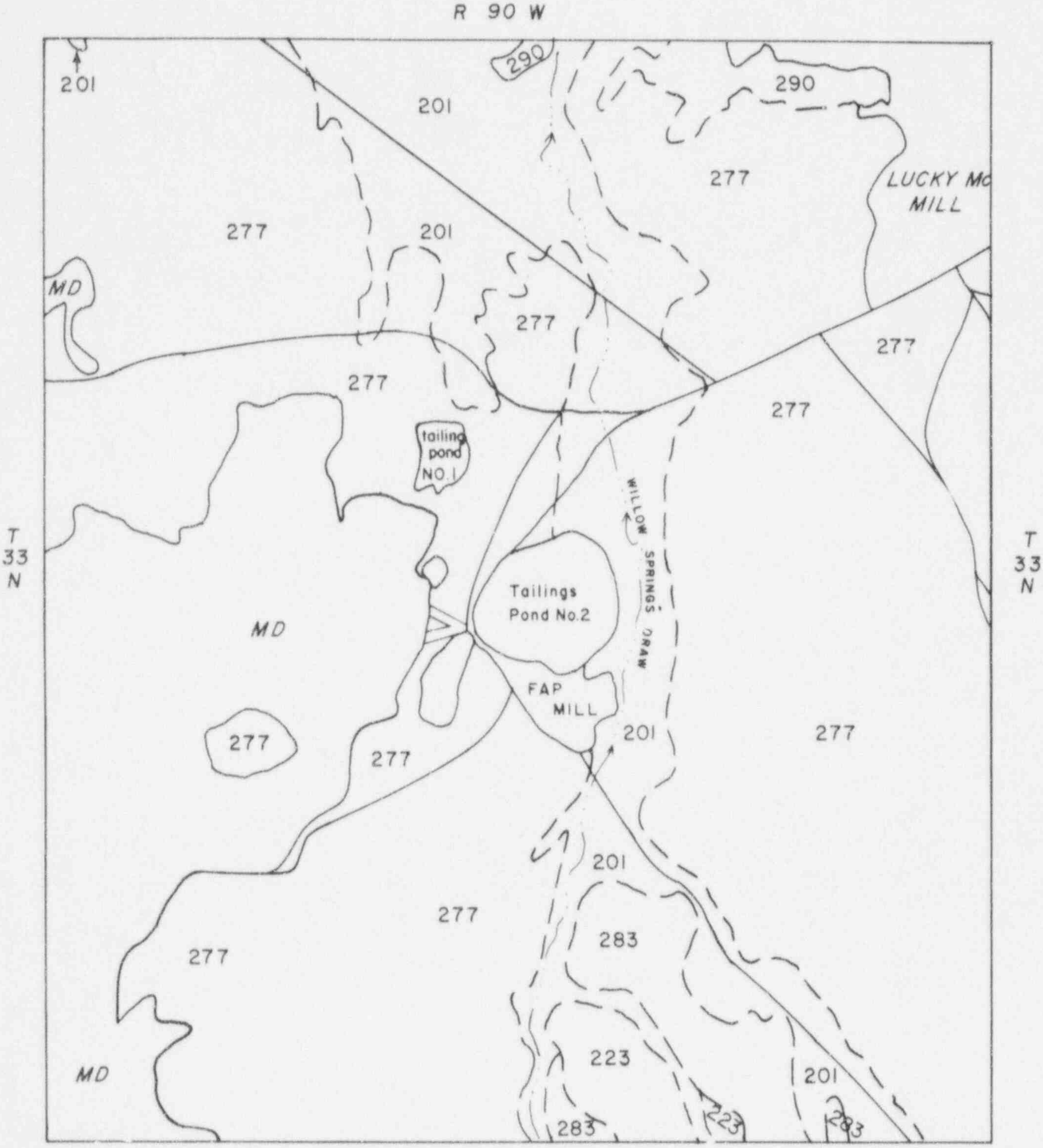
W.G.K. after ZELLER, H.D. 1956

FIGURE 2.5-2

QUATERNARY	QAL	ALLUVIUM , SLOPEWASH AND TERRACE DEPOSITS 0-20 FEET THICK
EOCENE	Twdu	ARKOSOIC SANDSTONES AND CONGLOMERATES OF THE UPPER WIND RIVER FORMATION 0-600 FEET THICK
		DISCONFORMITY - EROSIONAL
	Twdl	IMPERVIOUS VARIEGATED FINE GRAINED SILT AND MUDSTONE LOWER WINDRIVER FORMATION 0-120 FEET THICK
		UNCOMFORMITY, ANGULAR
CRETACEOUS	Kc	IMPERVIOUS BLACK MARINE SHALES OF THE CODY SHALE FORMATION 0-2000± FEET THICK

FEDERAL-AMERICAN PARTNERS

Title: STRATIGRAPHIC COLUMN
Property: MILL SITE , Type:
State: WYOMING , County: FREMONT
Mining District: GAS HILLS , S___ T___ , R___
Drawn by: WGK VH , Date: 8/4/77
Scale: ___ , Sheet ___ of ___
Figure: 2.5-3



SOIL ASSOCIATION	SYMBOL
HOVRE-FORELLE COMP. SL	201
COMP. 23-85-83	223
DIAMONDVILLE-FORELLE	277
COMP. 21-83-85	283
ROCK OUTCROP HIGHPOINT	290

R 90 W

1000 0 1000 2000 3000

SCALE

FEDERAL-AMERICAN PARTNERS

Title: SOIL MAP OF MILL AREA

Property: MILL SITE , Type:

State: WYOMING , County: FREMONT

Mining District: GAS HILLS , S. ____, T. 33 , R. 90

Drawn by: VLH , Date: 8-25-77

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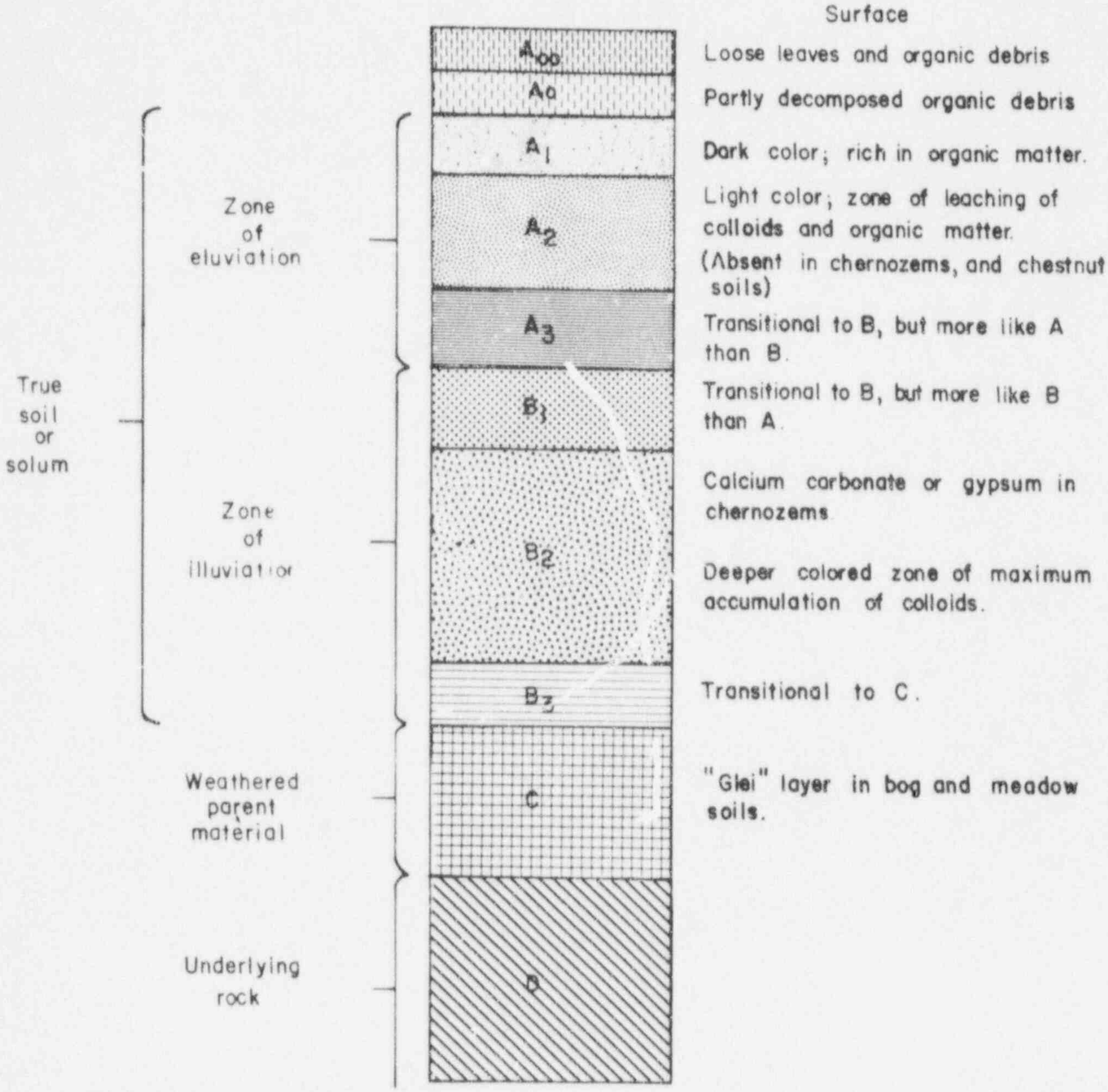
Figure: 2.5-4



An "ideal" soil profile showing all principle horizons. (From Strahler, A.N., Physical Geography, Copyright © 1969 by John Wiley and Sons. Reproduced with permission.)

FEDERAL-AMERICAN PARTNERS

Title: SOIL PROFILE

Property: ______, Type: ______

State: ______, County: ______

Mining District: ______, S____, T____, R____

Drawn by: ______, Date: ______

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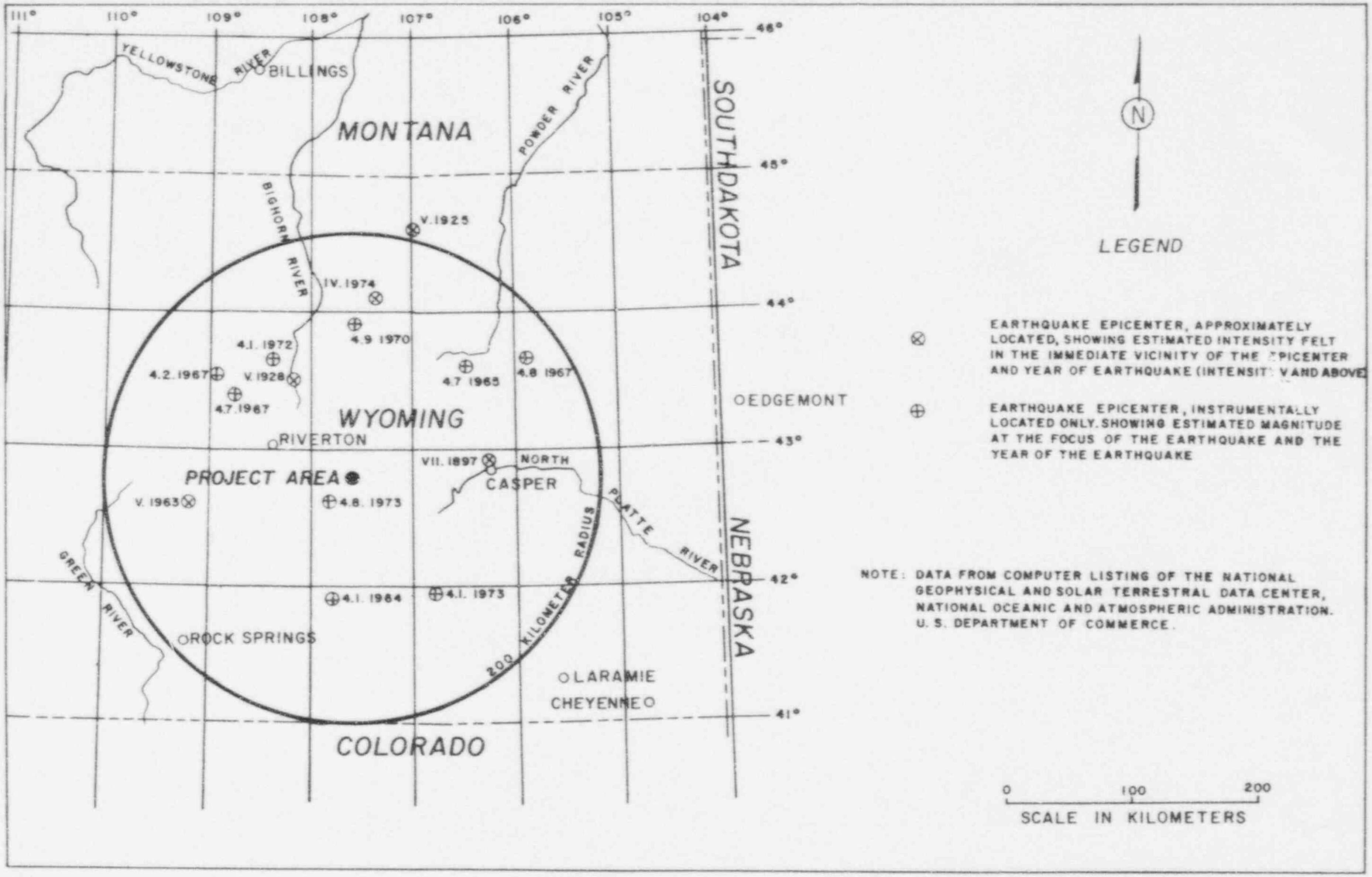
Figure: 2.5-5



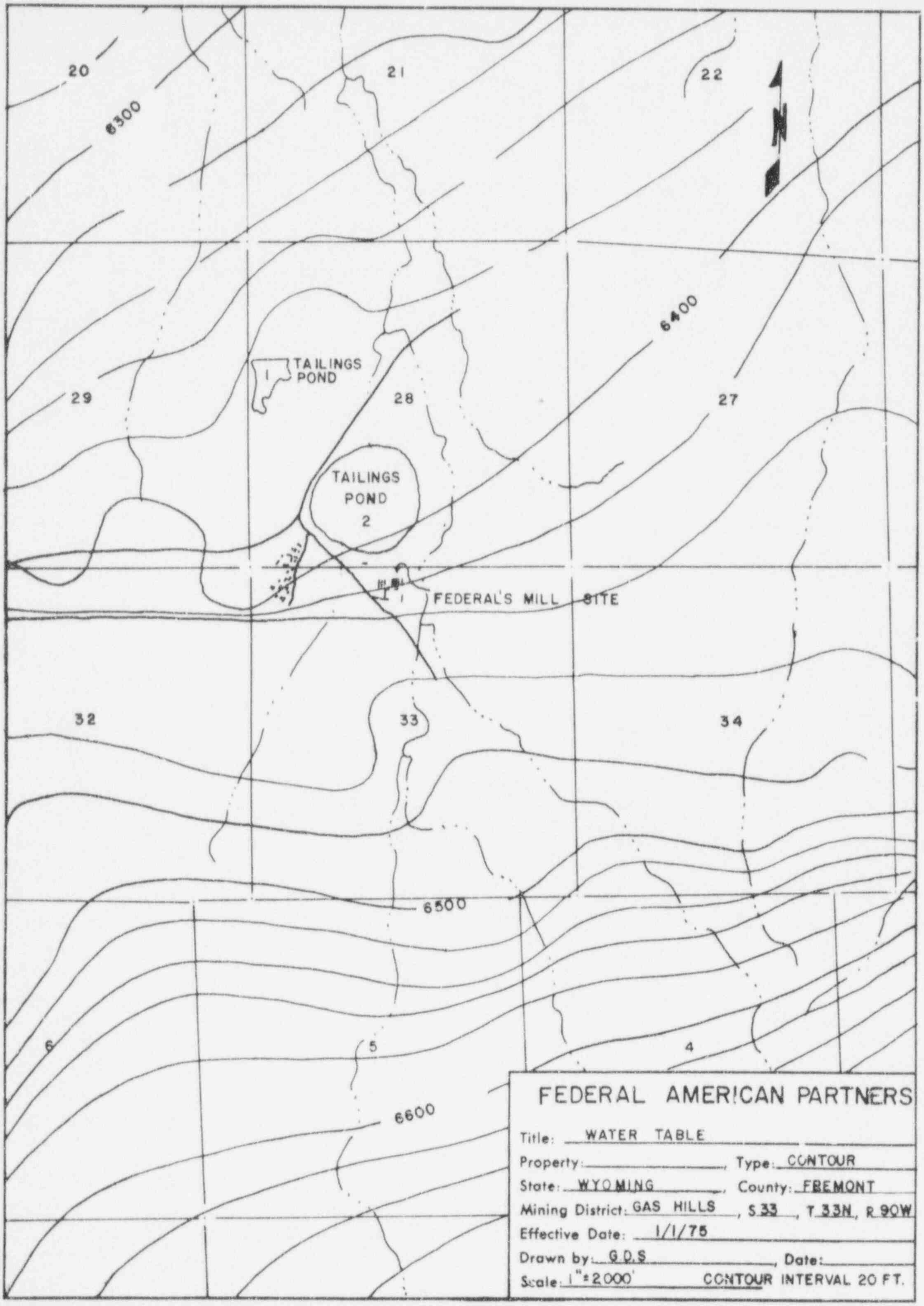
REGIONAL SEISMICITY

FIGURE 2.6-1

ROSSI-FOREL INTENSITY SCALE (1883)	MODIFIED - MERCALLI INTENSITY SCALE (1930) MM I WOOD & NEUMANN	RICHTER MAGNITUDE M	ENERGY E	GROUND ACCELERATION a	UBS SEISMIC ZONES
col. 1	col. 2	col. 1	2	3	
	1 DETECTED ONLY BY SENSITIVE INSTRUMENTS		ERGS	cm/sec a/g	
1 THE SHOCK FELT ONLY BY EXPERIENCED OBSERVER UNDER VERY FAVORABLE CONDITIONS	2 FELT ONLY BY A FEW PERSONS AT REST, USUALLY ON UPPER FLOORS; DELICATE SUSPENDED OBJECTS SWING	M 3	10^{15}	2, 3	0.0025g
2 FELT BY A FEW PEOPLE AT REST; RECORDED BY SEVERAL SEISMOGRAPHS	3 FELT NOTICEABLY INDOORS, BUT NOT ALWAYS THOUGHT OF AS BEING QUAKES; AUTOS ROCK SLIGHTLY, VIBRATIONS		10^{16}	4, 5 .005 g., 6	
3 FELT BY SEVERAL PEOPLE AT REST; STRONG ENOUGH FOR THE DURATION OR DIRECTION TO BE MEASURED	4 FELT INDOORS BY MANY, BY A FEW OUTDOORS, SOME ARE AWAKENED AT NIGHT, DOORS, DISHES, WINDOWS, DISTURBED	M 4	10^{17}	7, 8, 9, 10 .01 g.	
4 FELT BY SEVERAL PEOPLE IN MOTION; DISTURBANCE OF MOVABLE OBJECTS CRACKING OF FLOORS	5 FELT BY MOST PEOPLE, SOME BREAKAGE OF DISHES, WINDOWS, AND PLASTER; DISTURBANCE OF TALL OBJS.	M 5	10^{18}, 10^{19}	20, 30	1
5 FELT GENERALLY BY EVERYONE; DISTURBANCES OF FURNITURE, RINGING OF SOME BELLS	6 FELT BY ALL; MANY FRIGHTENED AND RUN OUTDOORS; FALLING PLASTER AND CHIMNEYS; DAMAGE SMALL			40, 50 .05 g., 60	
6 GENERAL AWAKENING OF THOSE ASLEEP, RINGING OF BELLS, SWINGING CHANDELLERS, PEOPLE RUN OUTDOORS	7 EVERYBODY RUNS OUTDOORS; DAMAGE TO BUILDINGS VARIES DEPENDING ON QUALITY OF CONSTRUCTION, CARS SHAKE	M 6	10^{20}	70, 80, 90, 100 0.1 g.	2
7 OVERTHROW OF MOVABLE OBJECTS, FALL OF PLASTER, RINGING OF BELLS, PANIC GREAT DAMAGE TO BUILDINGS	8 PANEL WALLS THROWN OUT OF FRAMES; FALL OF WALLS, MONUMENTS, CHIMNEYS; SAND AND MUD EJECTED, CARS MOVE		10^{21}	200, 300	0.25g.
8 FALL OF CHIMNEYS; CRACKS IN THE WALLS OF THE BUILDINGS	9 BUILDINGS SHIFTED OFF OF FOUNDATIONS, CRACKED, THROWN OUT OF PLUMB, GROUND CRACKS, PIPES BREAK	M 7	10^{22}	400, 500 0.5 g., 600	3
9 PARTIAL OR TOTAL DESTRUCTION OF SOME BUILDINGS	10 MOST MASONRY AND FRAME STRUCTURES DESTROYED; GROUND CRACKS RAILS BENT; LANDSLIDES			700, 800, 900, 1000 1 g.	
10 GREAT DISASTERS, RUINS, DISTURBANCE OF STRATA, FISSURES, ROCKFALLS, LANDSLIDES, ETC.	11 NEW STRUCTURES REMAIN STANDING; BRIDGES DESTROYED; FISSURES IN GROUND; PIPES BROKEN; LANDSLIDES	M 8	10^{23}	2000, 3000	
	12 DAMAGE TOTAL; WAVES SEEN ON GROUND SURFACE; LINES OF SIGHT AND LEVEL DISTORTED, OBJECTS IN AIR		10^{24}	4000 5 g.	

APPROXIMATE RELATIONSHIP BETWEEN EARTHQUAKE MAGNITUDE, INTENSITY, ACCELERATION AND ENERGY RELEASE.

FIGURE 2.6-2



FEDERAL AMERICAN PARTNERS

Title: WATER TABLE

Property: ______, Type: CONTOUR

State: WYOMING, County: FREMONT

Mining District: GAS HILLS, S 33, T 33N, R 90W

Effective Date: 1/1/75

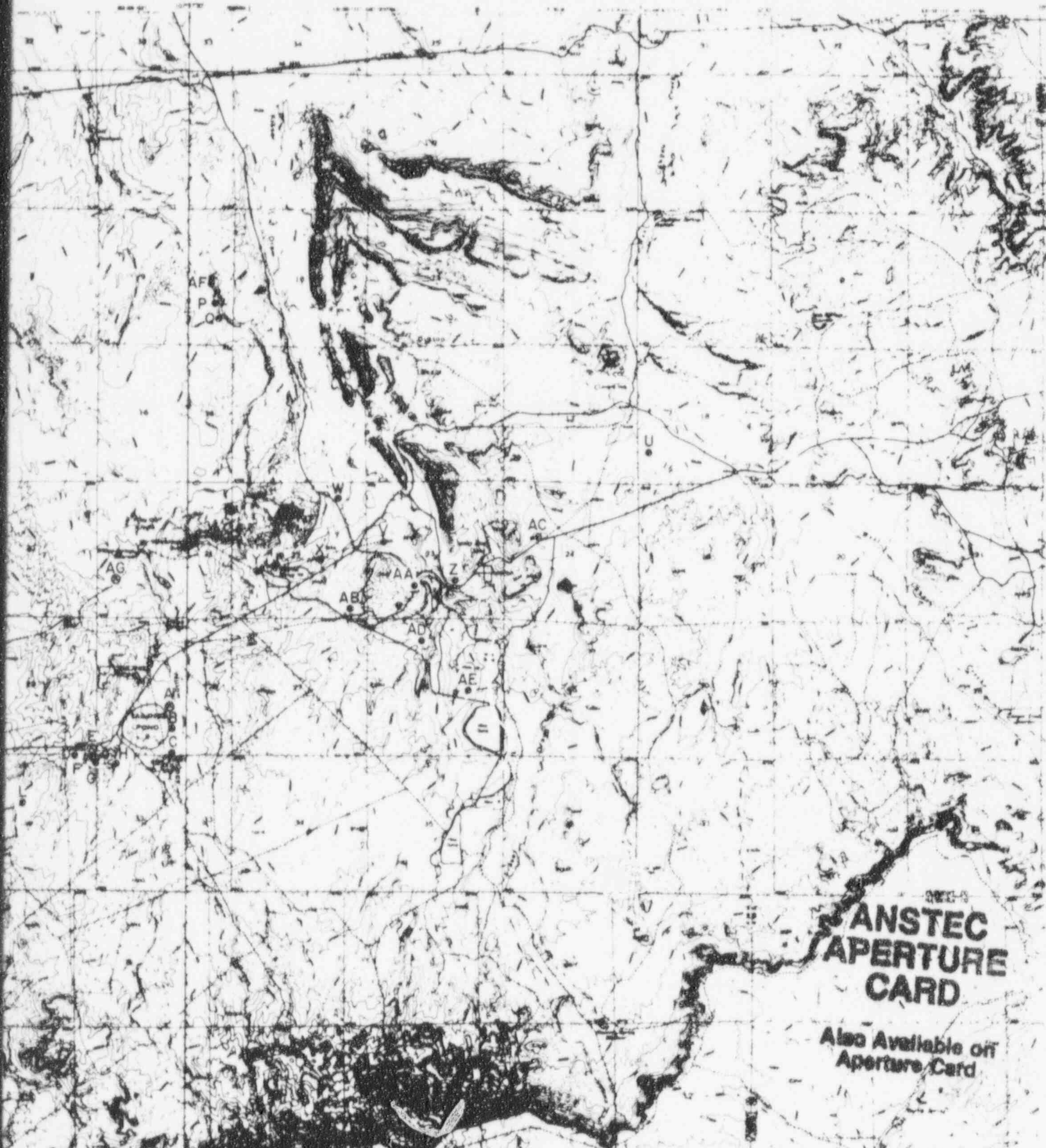
Drawn by: G.D.S, Date: ______

Scale: 1" = 2000' CONTOUR INTERVAL 20 FT.

FIGURE 2.7-1

WATER WELL IDENTIFICATION

- A FEDERAL NO 15
- B FEDERAL NO 8
- C FEDERAL NO 6
- D SAGEBRUSH NO 1-A
- E FEDERAL NO 16
- F FEDERAL NO 11
- G SAGEBRUSH NO 1
- H FEDERAL NO 1
- L TABLESTAKES NO 1
- M DICK NO 1
- N PUDDLE SPRINGS NO 17-1
- AF LUCKY MAC NO 3
- P LUCKY MAC NO 2
- Q LUCKY MAC NO 1
- S PUDDLE SPRINGS NO 17-3
- T ALJOB NO 1
- U WATER WELL NO 3
- V LUCKY Mc NO 6
- W LUCKY Mc NO 7
- X LUCKY Mc NO 8
- Y LUCKY Mc NO 11
- Z LUCKY Mc NO 1
- AA LUCKY Mc NO 5
- AB LUCKY Mc NO 4
- AC LUCKY Mc NO 9
- AD LUCKY Mc NO 2
- AE JAY NO 1
- AG TP NO 1



LEGEND

- MONITOR WELL
- USE WELL
- ROADS
- NATURAL DRAINAGE

RE USGS PUDDLE SPRINGS & GAS HILLS QUAD. MAPS - 7.5 MINUTES

9706130065-06

FEDERAL-AMERICAN PARTNERS

TITLE AREA WATER WELL LOCATIONS

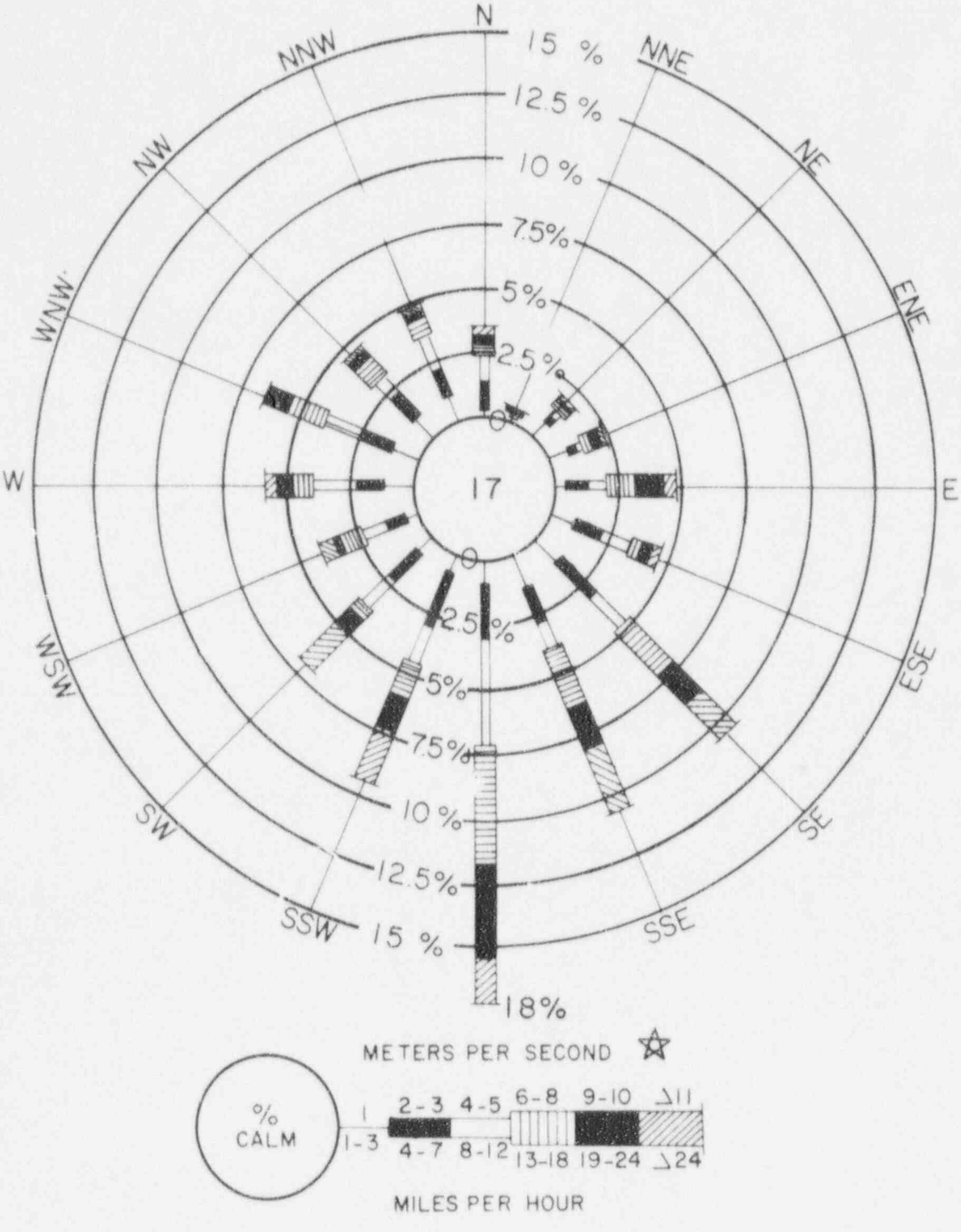
SEC. 28, 29, 32, & 33 T. 33 N. R. 90 W.

STATE WYOMING COUNTY FREMONT

DRAWN BY W.R. DATE 8/18/77

CONTOUR INTERVAL 20

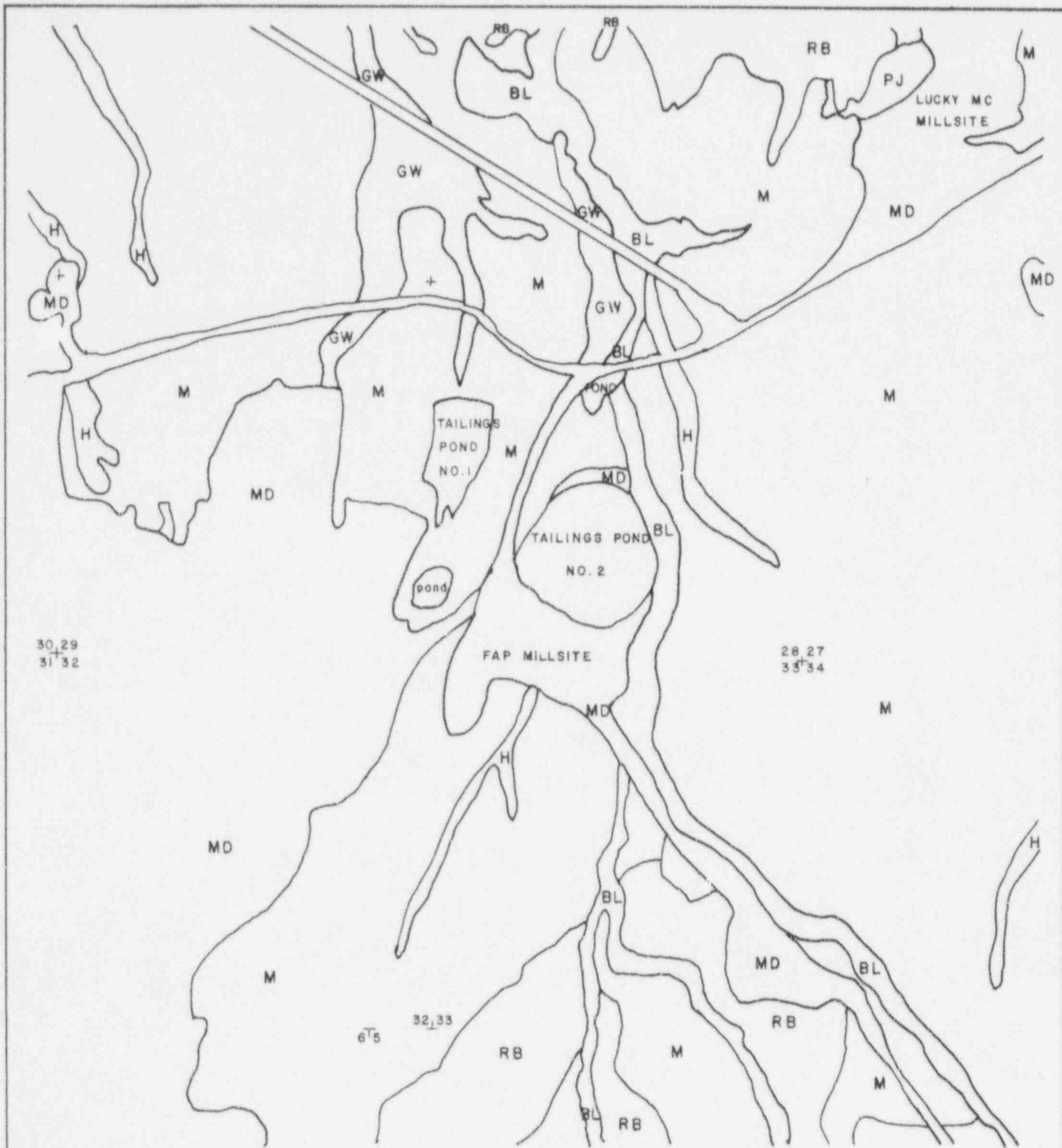
FIGURE 2.7-2



☆ THE RECORDED VALUES WERE IN MILES PER HOUR ; THE METERS-PER SECOND SCALE THUS CONSISTS OF ROUNDED VALUES.

WIND DIRECTIONAL SPEED FOR THE GAS HILLS AREA FOR THE PERIOD JUNE 1975 - JAN 1976

FIGURE 2.8



KEY

M	BIG SAGEBRUSH	MEDIUM STAND
H	BIG SAGEBRUSH	HEAVY STAND
BL	BOTTOM LAND	
GW	GREASEWOOD BOTTOM	
RB	ROUGH BREAKS	
PJ	PINE-JUNIPER	
MD	MINE DISTURBANCE	

FEDERAL-AMERICAN PARTNERS

Title: VEGETATION MAP MILL VICINITY
Property: MILLSITE, Type:
State: WYOMING, County: FREMONT
Mining District: GAS HILLS, S 32, T 33N, R 89W
Drawn by: VLH BP, Date: 6-22-78
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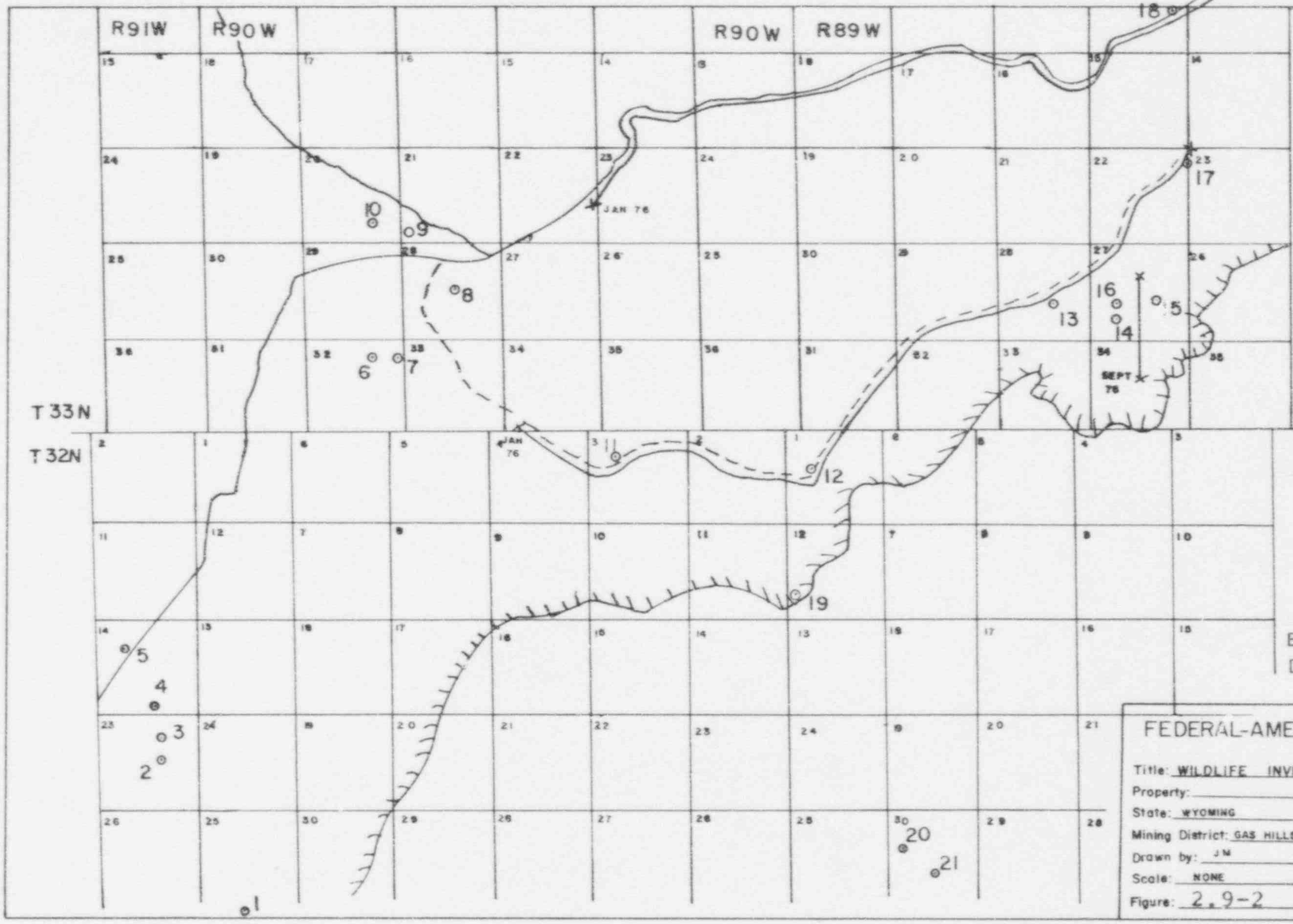
Figure: 2.9-1



LEGEND

TRAPPING SITES

TRAILS

CENSUS LINES

BEAVER DIVIDE

FEDERAL-AMERICAN PARTNERS

Title: WILDLIFE INVENTORY MAP

Property: ________, Type: ________

State: WYOMING, County: FREMONT

Mining District: GAS HILLS, S____, T____, R____

Drawn by: JM, Date: 9-20-77

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Figure: 2.9-2

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3. THE MILL

3.1 SITE AREA

The project site area, including the expanded mill, solar evaporation pond, and the below-grade tailings disposal area is shown in figure 3.1-1. This figure also shows the boundaries of the site and the boundaries of the restricted areas.

Access to the restricted areas would be through locked gates or via the mill access security station. Total acreage of the restricted areas is expected to be approximately 144 hectares (355 acres).

3.2 EXTERNAL APPEARANCE OF THE MILL

The expanded mill complex would consist of a number of existing and new buildings. Plans are currently being finalized so that the exact number, location, and dimensions of the buildings are not known at this time. However, the following paragraphs provide the information that is currently available.

The existing mill building (Ore Processing Area A) would continue to be used. This building is constructed of structural steel, covered with corrugated, galvanized sheets. A bridge plank roof is covered with roofing paper layered with hot tar and a top covering of pea gravel. Physical dimensions are 37 meters x 43 meters x 13 meters high (120 feet x 140 feet x 42 feet).

The mill expansion building (Ore Processing Area B) would be located to the south of Ore Processing Area A. It would be constructed of structural steel covered with corrugated, galvanized roofing and siding sheets. Ore processing equipment for area B along with a maintenance shop area, a warehouse area, and a changehouse area would be included in this building. Dimensions of this building are anticipated to be approximately 85 meters x 55 meters x 18 meters high (280 feet x 180 feet x 60 feet). These dimensions may vary depending on engineering studies and the availability of land to the south of area A. A covered personnel access way would be provided between the two ore processing areas. Figure 3.2-1 shows a preliminary general arrangement for the mill expansion building.

An expanded ore storage pad of approximately 18,700 square meters (4.6 acres) would provide surge capacity for more than two weeks of the expanded mill operation. A dump pocket would be provided to introduce ore to the process. A tunnel and a covered belt conveyor structure would connect the dump pocket with area B.

Rubber fabrication and carpenter shops would be located in a separate building detached from the main mill facilities. The existing cement block warehouse located to the east of area A would remain. Its dimensions are approximately 47 meters x 10 meters x 6 meters high (154 feet x 32 feet x 20 feet).

Administration offices would be consolidated into a new central structure located in the general vicinity of the project area. An enclosed security station would be located at the entrance to the restricted mill area to provide product security and an added measure of safety to the general public.

A new modern laboratory would be constructed. It would use the latest in analytical equipment for the accurate analyses of process samples, along with environmental, industrial hygiene, and bio-assay samples.

Existing structures housing the crushing plant, ore dryer, offices, rubber shop, laboratory, and carpenter and electrical shops would be dismantled or utilized for other purposes.

3.3 THE MILL CIRCUIT

3.3.1 General Process Description

The expanded mill would consist of ore preparation, ore processing, and yellow cake production operations. The ore preparation facilities would include ore receiving, stockpiling and semi-autogenous grinding (SAG) systems. These facilities would be common for both ore processing areas. The ore processing facilities would consist of acid leach, sand-slime separation, resin-in-pulp (RIP) ion exchange and solvent extraction processes. Ore Processing Area A would include the ore processing operations in the existing mill. Ore Processing Area B would include processes located in the expanded portion of the mill. Common yellow cake production facilities for both ore processing areas would be provided in the expanded portion of the mill. These facilities would consist of yellow cake precipitation, thickening, roasting, and packaging systems. Ore crushing and drying facilities and yellow cake production facilities associated with the existing mill would not be used in the expanded mill. Figure 3.3-1 is a flowsheet showing the expanded mill processes.

3.3.2 Ore Preparation Operations

Ore received from one or more of the mines would be weighed and stored on an expanded outdoor ore pad located adjacent

to the mill. The storage pad would be sized to store approximately 45,000 metric tons (50,000 short tons) of ore. This would be adequate to supply the mill for more than two weeks at the expanded processing rate.

The ore pad would consist of a circular storage area (6,570, square meters,) machinery access areas (7,270 square meters), and ore storage piles (4,850 square meters). Total ore pad area would be approximately 18,700 square meters (4.6 acres).

Ore would be stored in ten storage piles of varying ore grades. Average data for the individual storage piles is listed below:

- Base Area - 485 square meters (5,200 square feet)
- Height - 10.5 meters (34 feet)
- Volume - 2,550 cubic meters (90,000 cubic feet)
- Wet Bulk Density - 1.78 grams/cubic centimeter (110 pound/cubic foot)
- Capacity - 4,540 metric tons (5,000 short tons)

Ore grade is expected to average 0.12 percent U_3O_8 over the life of the mill. Radioactivity of a typical sample of ore would be approximately the following [ref 1]:

- Natural Uranium (U-nat.) - 720 picocuries/gram
- Radium-226 (Ra-226) - 420 picocuries/gram
- Thorium-230 (Th-230) - 150 picocuries/gram
- Lead-210 (Pb-210) - 240 picocuries/gram

This data indicates that a secular equilibrium between uranium daughter products does not exist. It should be noted that uranium daughter products in Wyoming ores are typically not in secular equilibrium [ref 2 and 3].

Ore required for the plant feed would be reclaimed by front-end loaders and dumped through a grizzly into an underground surge hopper at the truck dump station. Ore would be reclaimed from the various piles in an attempt to blend the ore so that operating conditions can be kept as constant as possible. The ore would be removed from the bottom of the surge hopper by an apron feeder that would discharge onto a conveyor belt that would transport the ore to the expanded portion of the mill.

Ore conveyed from the ore receiving area would be slurried with process water and ground in a SAG mill. Material discharged from the mill would pass through a trommel screen,

would be diluted with additional process water, and would be pumped through hydroclones for size classification. Oversize material would be returned to the SAG mill feed for further grinding. Cyclone overflow would be pumped to a series of agitated storage vessels that would provide surge capacity and ore blending capabilities.

The SAG mill would be installed in the expanded mill building. It would be located in an area that has a concrete floor that is curbed and sloped to a cleanup sump designed to catch any spills and return them to the process.

The SAG mill grinding circuit would completely replace the existing dry crushing circuit and its associated ore drying facility. In addition, the existing dry crushed ore storage capacity and ball mill grinding circuit would be eliminated.

Operating time of the ore preparation operations is expected to be approximately 20 hours per day, 340 days per year.

3.3.3 Ore Processing Area A

Ore Processing Area A is the ore processing area of the existing mill. It has been in operation since 1959.

Ore slurry would be pumped from the agitated storage vessels to Ore Processing Area A at the rate of 860 metric tons (950 short tons) per day (dry weight basis). The ore would be pumped into a 4.9 meter diameter by 5.2 meter high (16 feet x 17 feet) wood stave leach tank. Sulfuric acid (H_2SO_4) would then be added to bring the concentration of acid to 12 grams per liter. The temperature of the slurry at this point would be 48-50°C (119-122°F).

The ore slurry would pass through six leach tanks in series. Each leach tank would retain the slurry for two hours. It would be air lifted from one tank into the next. Acid would again be added in the no. 2 unit to give a terminal pH from the no. 6 unit of 10.5 grams per liter free acid. $NaClO_3$ would be added at the no. 2 or no. 3 leach tank initially and then intermittently throughout the rest of the leaching process. The amount added would be sufficient to give 425 + EMF readings in the last unit.

The acid leach slurry would be pumped into two 0.25 meter (10 inch) Krebs cyclones in which the initial split would be made. The fine fraction would report to the ion exchange circuit and the coarse material would enter the first classifier. This fraction would be washed counter currently with a 1 to 1 ratio of water through a series of 0.15 meter (6 inch) Krebs cyclones and one 0.75 meter (30 inch) and two 0.60 meter (24 inch) classifiers. The washed sand would then be pumped to the common tailings sump. The fine material would report to the ion exchange circuit. The slimes

overflowing from the last bank of 0.15 meter (6 inch) cyclones would report to the 6 meter diameter X 3 meter high (20 feet x 10 feet) RIP holding tank. In this tank, ammonia (NH_3) would be added to increase the pH, of the slurry to appro[illegible]ately 1.65. At this pH the U_3O_8 in solution would be re[illegible]ly picked up with anionic resins in the RIP ion exchange.

The solution would be pumped into the first of seven RIP loading tanks in series at 12 percent solids and at a 1,225 to 1,325 liters per minute (325 to 350 gallons per minute) flow rate. It would remain in each tank for 20 minutes before being air lifted to the next unit. Resin would be transferred into the last of these tanks and would advance in the opposite direction of the slurry flow. This would be done by the resin and solution both overflowing a given tank into an airlift, and being lifted to a Sweco screen with a 60 x 24 mesh deck. The slurry being minus 325 mesh would pass through the screen and be diverted to the tank directly below. The resin being plus 60 x 24 mesh would overflow the screen and be diverted to the tank above. When the resin has passed through all the contacts it would be loaded and ready to be stripped ~~stripped~~. It would then advance to the last elution unit. The slurry, after its seven contacts with the risin, would be barren and report to the common tailings sump where it would mix with the coarse fraction of sand from the sand-slime circuit.

The resin would be stripped with dilute sulfuric acid at approximately 125 grams per liter. This solution would be fed into the first elution unit at approximately 110 liters per minute (30 gallons per minute). It would make eleven 33 minute contacts with the resin. The counter current flow of resin to solution would be the same as on the loading side except that cones would be used instead of screens. The mechanics would be the same as the solution would overflow the cone to the downward tank and the resin would discharge from the cone apex to the upstream tank. After eleven elution contacts the resin would be washed in two tanks with a 30 minute retention time per tank. This wash water would be returned to the grinding circuit for classifier dilution water. The washed resin would then be pumped back to the last RIP loading unit to again load U_3O_8. The pregnant liquor overflowing the last cone tank would be filtered through a sparkler filter into a clarified pregnant liquor tank. The suspended solids filtered out of the pregnant solution would be returned to the RIP holding tank.

The clarified pregnant liquor would be pumped into the first of four solvent extraction loading units. The solution would then be contacted four times with an organic solution flowing countercurrent to it. This organic solution would be made up of 5 percent tertiary amine, 2.5 percent isodecanol, and 92.5 percent kerosene which would be used as a

carrier. The countercurrent flow would be obtained by the difference in weight of the two solutions. The organic solution being lighter would overflow the unit and advance from no. 4 through no. 1. The pregnant aqueous liquor being heavier would advance through a standpipe from the lower side of the tank from no. 1 through no. 4. When the aqueous liquor has been contacted four times, all of the U_3O_8 would have been removed from it. This solution now called barren raffinate would return to the elution makeup tank as it would still contain 90 percent of the acid. In the elution makeup tank acid would be added to bring the concentration back to 125 grams per liter.

The loaded organic would then be contacted four times with an ammonium sulfate solution at 19 liters per minute (5 gallons per minute). This solution would be introduced into the no. 4 unit while the organic would flow into the no. 1 unit. By using NH_3 to control the pH at 4.1, the U_3O_8 solution would be stripped from the organic. A countercurrent flow would again be used with the loaded strip solution reporting to the common precipitation circuit in the expanded area of the mill. The barren organic would go back to the extraction side of the circuit to load more uranium.

Ore Processing Area A is scheduled to operate 24 hours per day, 7 days per week.

3.3.4 Ore Processing Area B

Ore Processing Area B would be located south of the existing mill building. The process in area B would be very similar metallurgically to the process in area A. However, the instrumentation and equipment would be more modern. Because the mill expansion design has not been completed, detailed information is not available for area B; therefore, the following paragraphs discuss area B in general terms. In addition, information on the process chemistry is provided.

3.3.4.1 Leaching

Ore slurry would be pumped from the agitated storage vessels to the leach tanks in Ore Processing Area B at the rate of 1,810 metric tons (2,000 short tons) per day (dry weight basis). Sulfuric acid and sodium chlorate would be added to the slurry in the leach tanks to oxidize and dissolve the uranium from the slurry. Steam would be added to maintain the leaching temperature at 50°C (122°F). The slurry would pass through the six leach tanks in series to provide a total leaching retention time of sixteen hours. The general leaching reactions include the following:

$$3H_2SO_4 \xrightarrow{H_2O} 6H^+ + 3SO_4{-}^2$$

$$6Fe^{+2} + NaClO_3 + 6H^+ \longrightarrow 6Fe^{+3} + NaCl + 3H_2O$$

$$UO_2 + 2Fe^{+3} \longrightarrow UO_2^{+2} + Fe^{+2}$$

$$UO_2^{+2} + 3SO_4^{-2} \longrightarrow [UO_2\ (SO_4)_3]^{-4}$$

The leach system would be located indoors in an area having a concrete slab and perimeter curbing to contain any spillage from the system. The slab would be sloped into a sump where a pump would return the spills back to the leach tanks. The concrete slab and sump would be coated to give protection from the acid leaching solution.

3.3.4.2 Sand-Slime Separation

The leached pulp would be classified to separate the sands from the pregnant solution and slime by washing in a countercurrent arrangement of cyclones and classifiers. The cyclone overflow consisting of minus 325 mesh pulp would be fed to a RIP ion exchange feed tank for further processing, and the plus 325 mesh cyclone underflow would be returned to the classifier/cyclone circuit in a closed loop for washing and discharging as tailings.

The classifier circuit would be designed to wash the soluble uranium sulfate salt from the solids. The circuit would consist of four classifiers in which the solids would be washed in a countercurrent system.

The classifiers would be located adjacent to each other to allow gravity flow of solids from one to another while the overflows would be advanced by pumping through cyclones. The washed solids from classifier no. 4 would be discharged to a tailings repulper tank and pumped to the common tailings sump.

The floor in the sand-slime area would be sloped to drain into a sump equipped with a pump to recover spills and wash down liquids.

3.3.4.3 Resin-in-Pulp Ion Exchange

The uranium values would be extracted from the pregnant slime solution in a resin-in-pulp (RIP) ion exchange circuit. In this circuit, the resin would be circulated through loading and elution tanks in a countercurrent direction to the pulp and the eluant.

The pulp fed to the RIP system would be pumped from a feed tank which would provide some surge capacity with the sand-slime separation circuit. After the uranium has been extracted from the pulp in the loading tanks, the slimes would be discharged as tailings. The uranium would then be extracted from the resin in the elution tanks and the pregnant

eluant solution would be advanced to the solvent extraction system.

The RIP ion exchange circuit is discussed in more detail in the following paragraphs.

a) Loading

The loading circuit would consist of an RIP feed tank, eight RIP loading tanks, and the required screens and pumps. The pregnant pulp from the sand-slime separation circuit would be screened to remove oversize materials before being fed into the RIP feed tank where the pulp would be mechanically agitated and ammonia added to adjust the pH prior to processing in the loading tanks.

The RIP loading tanks would be equipped with mechanical agitators to gently agitate and mix the pulp and the resin. The pulp and resin mixture would be air lifted from tank to tank in the loading circuit and discharged through screens to separate the resin from the pulp. The separated resin and pulp would be discharged from the screens to flow in opposite directions through the loading tanks.

The loaded resin from the screen on the first loading tank would be washed and transferred to the resin elution circuit. The barren slimes from the last loading tank would be pumped to the common tailings sump where it would be mixed with sand discharged from the sand-slime circuit. The basic resin loading reaction can be described as follows:

$$2[(Resin)_2\ SO_4] + [UO_2\ (SO_4)_3]^{-4} \longrightarrow [Resin_4\ UO_2\ (SO_4)_3] + 2SO_4^{-2}$$

b) Resin Elution

Loaded resin with uranium values would be fed into the first of the 13 resin elution tanks. The tanks would be equipped with slow-speed agitators to gently agitate and mix the eluate (sulfuric acid) and the resin. The mixed resin and eluant solution would be air lifted from tank to tank through the elution system and discharged through settling cones to separate the resin from the eluate. The separated resin and eluate would be discharged from the cones to flow in opposite direction through the elution tanks. The barren resin from the last eluant tank would be washed and returned to the last of the loading tanks for reuse. The uranium-loaded eluant solution (unclarified pregnant solution) would be collected in a surge tank before being filtered through a pressure filter to remove undissolved particles. Filter cake would be returned to the resin loading circuit. The filtered solution would be collected in a clarified solution/surge tank before being advanced to the solvent extraction

system. The basic resin elution reaction is described as follows:

$$[Resin_4\ UO_2\ (SO_4)_3] + 2SO_4^{-2} \longrightarrow [UO_2(SO_4)_3]^{-4} + 2[(Resin)_2SO_4]$$

3.3.4.4 Solvent Extraction

The solvent extraction system would consist of four stages of extraction mixer/settler tanks, four stages of stripping mixer/settler tanks, an impurity removal tank, and a sulfating tank. The uranium would be transferred from the clarified pregnant solution to an aqueous ammoniacal solution by an ion exchange process in the solvent extraction system. This would be done to separate impurities and prepare a solution from which the uranium can be readily precipitated. An organic chelating agent (a tertiary amine) would be used as the intermediate transfer agent between aqueous solutions.

The solvent extraction equipment would be located indoors in an area having concrete floors and curbing to catch and contain process spills. The area around the extraction settlers would be separately curbed from the area around the strip system to prevent cross contamination of the spills from the extraction and strip circuits. The concrete slabs in these two areas would be sloped to drain to their respective sumps from which the spilled material would be either returned to the process or discharged with the tailings. The concrete surfaces in the solvent extraction area would be coated for protection from the acid in the process streams. The solvent extraction circuit is discussed in more detail in the following paragraphs.

a) Extraction System

The extraction system would consist of the four mixer/settler stages described above and a settler tank. The clarified pregnant solution would contact the organic in the mix tanks to transfer the uranium values to the organic solution. The aqueous/organic mixture would then be discharged into the settler tanks for phase separation. The barren aqueous solution would then be returned to the RIP elution area for reuse and the organic which contains the uranium would flow by gravity to the stripping section. The basic chemical reaction is very similar to the loading reaction of the resin extraction circuit.

b) Stripping Section

The stripping section would consist of four mixer settlers, one organic sulfating mixer settler, and an impurity removal mixer settler for soda ash treatment to remove molybdenum and other impurities. The strip solution would contact the

pregnant organic in the mix tanks to transfer the uranium values to the strip solution and would then overflow into the settler tanks for phase separation. After removal of the uranium, the organic would be pumped into a barren organic holding tank for reuse in the extraction system. The strip solution containing the uranium would be pumped into the precipitation tank for precipitation of the uranium as described in the next section. The basic stripping reaction can be characterized as follows:

$$(R_3NH)_4UO_2(SO_4)_3 + (NH_4)_2SO_4 \quad 2(R_3NH)_2SO_4 + (NH_4)_4UO_2(SO_4)_3$$

3.3.4.5 Operating Schedule

Ore Processing Area B is scheduled to operate 24 hours per day, 7 days per week.

3.3.5 Yellow Cake Production

The pregnant strip solution loaded with uranium values from both ore processing areas would be pumped to the precipitation tank where anhydrous ammonia would be injected into the solution through a submerged pipe to increase the pH of the precipitation solution to the range of 8.0 to 8.5. A chemical reaction would result between the pregnant strip solution and the ammonia to produce a precipitate salt of ammonium diuranate ($(NH_4)_2U_2O_7$).

The precipitate solution would flow by gravity into the no. 1 yellow cake wash thickener tank where the uranium precipitate would be gravity-separated from the strip solution. The thickener underflow would be pumped to no. 2 thickener tank for further washing and the thickener overflow solution would be recycled to the solvent extraction strip section. The underflow from no. 2 thickener would be pumped to a centrifuge for washing. The solution removed by the centrifuge would be returned to the no. 2 thickener and the washed ammonia diuranate precipitate would be fed into an agitated surge tank and then into a multi-hearth dryer where the ammonium diuranate would be converted to U_3O_8 and gaseous ammonia. The dried yellow cake (U_3O_8) would be discharged into a storage bin through a lump breaker.

Yellow cake would be withdrawn from the storage bin for packaging in 200-liter (55-gallon) drums for shipment. A drum scale would be provided to record the weight of the yellow cake that has been packaged.

Yellow cake production operations would take place 24 hours per day, 5 days per week.

At the expanded ore processing rate of 2,680 metric tons (2,950 short tons) per day, 340 days per year, the mill is expected to process 910,000 metric tons (1,003,000 short tons)

of ore per year. The ore grade is expected to average approximately 0.12 percent U_3O_8 over the life of the project. The uranium recovery rate is expected to be approximately 91 percent. The U_3O_8 content of the yellow cake product is expected to be approximately 96 percent. Under these conditions, annual yellow cake production would be approximately 1,035 metric tons (1,140 short tons) per year.

3.3.6 Water Supply and Recycle Systems

Potable water is currently obtained from well no. 16 on the FAP property. This source is considered to be sufficient for the expanded mill.

Process water is currently obtained from a nearby FAP mined out mining pit. This existing process water supply is considered to be sufficient for the expanded mill operation. If there is a future need for an alternative process water supply, it would be developed from mining operations wells, or existing adjudicated water rights.

The expanded mill would make use of the maximum practicable reuse of process water. Tailings from both ore processing areas would be pumped to the below grade tailings disposal area. Water would be decanted from the tailings in the below grade disposal area and pumped back to the mill for reuse. Excess process water would be bled off and pumped to the solar evaporation pond or excess process water disposal system.

Figure 3.3-2 presents a preliminary water balance for the expanded mill and below grade tailings disposal area.

3.3.7 Process Reagent and Material Usage

Expanded mill operation is expected to require the use of a number of process reagents and materials. Annual usage of these reagents is listed in Table 3.3-1 (Annual Usage of Process Reagents) and Table 3.3-2 (Annual Usage of Process Materials).

3.4 SOURCES OF MILL WASTES AND EFFLUENTS

Both radiological and non-radiological wastes and effluents would be generated by the expanded mill. These would consist of solid, liquid, and gaseous wastes and effluents. All wastes and effluents would be controlled, as necessary, and disposed in an environmentally acceptable manner. Table 3.4-1 summarizes the principal parameters for the radiological assessment. Sources of expanded mill wastes and effluents are discussed in the following paragraphs. Emission calculations for mill waste and effluents are presented in appendix A.

3.4.1 Solid and Liquid Wastes (Mill Tailings)

The mill tailings would represent the bulk of both radiological and non-radiological wastes. With the exception of the recovered uranium and some process losses, tailings would account for practically all of the ore solids and the process additives, including water. Approximately 9,060 metric tons (9,990 short tons) of tailings would be discharged from the expanded mill per day. These tailings would consist of approximately 30 percent solids by weight. Tailings solids are usually classified as the following:

- Sand - Consists of solids greater than 325 mesh
- Slimes - Consist of solids less than 325 mesh
- Liquids - Solutions of chemicals from the ore and process reagents.

In the Draft Generic Environmental Impact Statement on Uranium Milling, the NRC assumed that the slimes and liquids would constitute 35 percent and 50 percent of the tailings, respectively [ref 1]. The remaining 15 percent of the tailings would consist of sands. Therefore the slimes would consist of approximately 70 percent of the tailings solids.

In the expanded FAP mill the solids would constitute only 30 percent of the tailings by weight. If the solids were assumed to be 70 percent slimes as in the NRC case, the tailings would have the following composition:

Sand	9%
Slimes	21%
Liquid	70%
	100%

The radioactivity of a typical sample of the ore would be approximately:

U nat. - 720 picocuries/gram
Ra-226 - 420 picocuries/gram
Th-230 - 150 picocuries/gram
Pb-210 - 240 picocuries/gram

At the expanded mill processing rate of 910,000 metric tons (1,003,000 tons) per year the radioactivity entering the mill would be approximately:

U nat. - 155 curie/year
Ra-226 - 382 curie/year
Th-230 - 137 curie/year
Pb-210 - 218 curie/year

The quantity of U_3O_8 entering the tailings is expected to be approximately 11.8 kilograms/hour (26 pounds/hour) or approximately 8.8 percent of the U_3O_8 entering the mill. Therefore, approximately 8.8 percent of the natural uranium entering the mill is expected to end up in the tailings. In the *Draft Environmental Statement Related to Operation of Morton Ranch Uranium Mill*, the NRC estimated that the product yellow cake would contain 5 percent of the Th-230, 0.2 percent of the Ra-226, and 0.2 percent of the Pb-210 originally in the ore [ref 2]. If it is assumed that the remaining quantities entered the tailings, 95 percent of the Th-230, 99.8 percent of the Ra-226, and 99.8 percent of the Pb-210 originally in the ore would enter the tailings. Based on the above percentages, the radioactivity leaving the mill in the tailings would be approximately:

U nat. - 58 curie/year
Ra-226 - 381 curie/year
Th-230 - 130 curie/year
Pb-210 - 217 curie/year

At an annual tailings discharge rate of approximately 3,080,000 metric tons (3,395,000 short tons), the radioactivity of the tailings would be approximately:

U nat. - 19 picocuries/gram
Ra-226 - 124 picocuries/gram
Th-230 - 42 picocuries/gram
Pb-210 - 70 picocuries/gram

In the *Draft Generic Environmental Impact Statement on Uranium Milling*, the NRC assumed that 85 percent of the radioactivity in the tailings would be concentrated in the slimes [ref 3].

As stated above, the tailings liquids would consist of solutions of chemicals from the ore and process reagents. Process reagents used by the expanded mill are discussed in section 3.3.7

3.4.2 Dust and Gaseous Effluent Releases

Dust and gaseous effluents would be discharged to the atmosphere from various portions of the expanded mill. Sources of these effluents would include the ore storage pad, various locations in the wet processing areas of the mill, the yellow cake drying and packaging operations, and the tailings disposal and solar evaporation pond areas. Figure 3.4-1 shows the location of dust and gaseous effluent release points. Table 3.4-2 presents information on the stacks discharging effluents. Table 3.4-3 presents the average annual radioactive nuclide emissions to the atmosphere during milling operations. Sources of dust and gaseous effluents are discussed in the following paragraphs.

3.4.2.1 Ore Storage Pad

Dust and gaseous effluent emissions from the ore storage pad would consist of fugitive dust blown from the surface of ore piles and radioactive Rn-222 gas released from the ore.

Dust emissions would include radioactive U nat, Th-230, Ra-226, and Pb-110. In addition, the dust would include non-radioactive materials contained in the ore. When the mill processed ores on a toll basis with the Lucky-Mc Uranium Corporation, non-radioactive constituents of the ore included the following:

SiO_2	-	92%
Iron	-	3.5%
CaCO	-	4.5%
Phosphate	-	0.002%
Molybdenum	-	0.008%

These non-radioactive constituents of the ore would also be present in the ore dust. Total dust emissions from the ore storage pad and ore grinding operations are estimated to be approximately 3.1 metric tons (3.4 short tons) per year. Radioactive dust emissions from the ore storage and grinding operations are listed in table 3.4-3.

Radioactive radon (Rn-222) is produced by the decay of uranium daughter products. Because it is a gas, it is released from the ore during storage. Rn-222 emissions from the ore storage and grinding operations have been estimated to be approximately 160 curies per year.

3.4.2.2 Ore Grinding Operations

Because the conveyor belt feeding the SAG mill is enclosed and because the grinding operations are wet, dust emissions are considered to be negligible. It should be noted that the ore drying, crushing, screening, and sampling operations in the existing mill would be replaced with the wet SAG mill. Because of this, dust emissions from these operations would be eliminated. Radioactive emissions from the crusher stack that would be eliminated have been measured to be the following:

U nat - 4.97×10^{2} picocuries/year
Th-230 - 1×10^{5} picocuries/year
Ra-226 - 7×10^{4} picocuries/year
Pb-210 - 2×10^{4} picocuries/year

Most of the radioactive Rn-222 gas not released from the ore storage piles would be released during the grinding operations. Emissions from the ore grinding operations ore included with the ore storage pad emissions.

3.4.2.3 Ore Processing Areas

Significant dust emissions are not expected from the ore processing areas because all processing operations would be wet. Because most of the Rn-222 gas would be released during ore storage and grinding operations, Rn-222 emissions from the ore processing areas are not expected to be very significant. Small quantities of sulfuric acid (H_2SO_4) fumes would be emitted from the acid leach operations. In addition, small quantities of ammonia (NH_3) fumes would be released from the pregnant slime storage tanks in the sand-slime separation area.

3.4.2.4 Yellow Cake Precipitation, Thickening, and Drying Operations

Dust and gaseous effluents would be released from the yellow cake precipitation, thickening, and drying operations.

Dust effluents would consist of yellow cake dust emmitted from the dryer. The yellow cake emitted to the atmosphere would consist primarily of U_3O_8. Other radioactive dust materials would include Th-230, Ra-226, and Pb-210. Radioactive emissions from the yellow cake dryer and the yellow cake packaging operations are presented in table 3.4-3. Non-radioactive materials would also be included in the dusts. When the mill processed ores on a toll basis with the L[illegible]cky-Mc Uranium Corporation, non-radioactive constituents of the yellow cake included the following:

Vanadium	0.01 %
Phosphorous	0.01 %
Halides	0.01 %
Fluorides	0.01 %
Molybdenum	0.16 %
Sulphur	2.76 %
Iron	0.12 %
Arsenic	0.02 %
Carbonate	0.01 %
Calcium	0.04 %
Sodium	0.02 %
Boron	0.001%
Silica	0.05 %

These non-radioactive constituents of the yellow cake would also be present in the dust. Total dust emissions from the yellow cake dryer and packaging operations are estimated to be 1.4 metric tons (1.5 short tons) per year.

Gaseous effluents would consist of small quantities of ammonia (NH_3) fumes from the yellow cake precipitation, thickening, and centrifuge systems and natural gas combustion products and moisture from the yellow cake dryer.

Radioactive Rn-222 gas emissions from the yellow cake precipitation, thickening, and drying operations are expected to be negligible.

3.4.2.5 Yellow Cake Packaging Operations

Dust effluents from the yellow cake packaging operations would consist of yellow cake. Dust and radioactive emissions were included in the emissions from the yellow cake drying operations above.

3.4.2.6 Tailings Disposal Areas

Dust and gaseous effluent emissions from the tailings disposal areas would consist of wind-blown tailings solids and Rn-222 gas released from the disposed tailings.

Tailings solids would be disposed in a below-surface disposal area. Because of this the tailings would not be as exposed to the wind as in a conventional tailings impoundment. Therefore dust emissions from the disposed tailings are expected to be less than those from a conventional tailings impoundment. Total dust emissions from the tailings impoundment have been estimated to be approximately 146 metric tons (160 short tons) per year. This dust would contain radioactive U nat, Th-230, Ra-226, and Pb-210. Estimated radioactive emissions from the tailings disposal areas are presented in table 3.4-3. Most of the dust emitted from the tailings disposal area would consist of the sands (SiO_2) that made up more than 90 percent of the ore.

Uranium daughter products would continue to decay in the disposed tailings releasing radioactive Rn-222 gas. These emissions would be comparable to those for a conventional tailings impoundment. Radioactive emissions of Rn-222 gas from the tailings disposal area are estimated to be approximately 10,500 curies per year. This represents the largest source of radioactive emissions in the mill.

3.4.3. Comparison of Mill Wastes and Effluents with Environmental Standards and Regulations

The only direct emission standard that would apply to the expanded mill would be the State of Wyoming's process weight rate standard for new sources. This standard is the following:

$E = 3.59\ P^{0.62}$
Where E = Emission standard in pounds per hour
P = Process Weight Rate in tons per hour

For a process weight rate of 418 pounds per hour (0.21 short tons per hour), the yellow cake dryer and yellow cake packaging

operations would be allowed to emit 635 grams (1.4 pounds) of particulate per hour. Particulate emissions from these operations are estimated to be approximately 225 grams (0.5 pounds) per hour.

The State of Wyoming also has a visible emission standard of 20 percent opacity. This standard would apply to the acid leach, pregnant slime storage, and yellow cake dryer stacks. Because of the control systems employed, visible emissions should be significantly less than 20 percent opacity.

State of Wyoming regulations pertaining to fugitive dust emissions require that water or suitable chemicals be applied to dirt roads, materials stockpiles, and other surfaces. These controls must be applied as necessary to maintain compliance with ambient air quality standards. would apply water where necessary to comply with this FAP regulation.

Because liquid wastes would be recycled or stored in the below-surface tailings disposal area and the solar evaporation pond, no discharges to surface waters are anticipated. In addition any process spills would be collected and returned to the process or discharged with the tailings. Therefore the mill would comply with liquid discharge regulations.

Because the tailings would be disposed in an environmentally acceptable manner, compliance with solid waste regulations would be maintained.

Control methods discussed in section 3.5 are expected to reduce radioactive emissions from the ore storage pad, mill, and tailings disposal areas to comply with NRC regulations on radioactivity in restricted and non-restricted areas.

3.5 CONTROLS OF MILL WASTES AND EFFLUENTS

3.5.1 Tailings Disposal System

3.5.1.1 General Tailings Management Plan

The release point for the tailings is shown schematically on figure 3.4-1. The tailings from the expanded mill would be disposed in a subsurface program utilizing a mined-out pit (Sagebrush - Tablestakes).

This subsurface impoundment would provide approximately 10 years of capacity for expanded mill tailings.

This entire program is addressed in detail in the January 1979 submittal to the NRC entitled "Baseline Geotechnical Investigation for the Subsurface Disposal of Millwaste".

The basic program outline consists of using the Sagebrush-Tablestakes pit (see figure 3.5-1) with its underlying continuous, impervious mudstone layer and some type of sealed sidewalls (either with differential sand-slime discharge or some type of clay emplacement) for the impoundment of all tailings. The disposal area would allow for the decant of solutions for recycle back to the mill or into the solar evaporation pond (no. 1 in the general layout diagrams).

Several different methods of delivery of tailings to the disposal area would be examined during the current engineering study. A few possible alternatives include:

- A tailings thickener inside the mill complex for primary solution removal and subsequent pumping of the underflow to the subsurface site.

- A movable thickener located at the subsurface site for more complete control and easier, more reliable slurry transport to the site.

- A hydrocyclone at the site for differential separation and flexibility in sanding and sliming the walls of the pit.

- A direct and moveable discharge of the mill tailings directly into the pit.

As efficiencies, costs and practicalities are developed in the engineering study, a final selection would be made.

In any case, the tailings slurry line and any solution return lines would be placed in a trench with moderate embankments to contain any leaks that may result from line failure or wear. A continuous tailings discharge monitor would be located at the discharge point on the tailings line to provide a continuous warning against any interruption in tailings flow which may indicate a failure.

In addition, these lines would be fenced off to prevent public or animal access.

This tailings impoundment area would serve as an ancillary evaporation area in the summer months with the solar evaporation pond supporting most of the evaporation requirements.

Seepage from these ponds should be contained to approximately 50 liters per minute (13 gallons per minute) or less from each pond. This would be verified by monitor wells placed in the appropriate locations around the containment areas.

A complete monitoring program of surface emissions and the surrounding environment would be carried out on a continuous basis during the operation of the proposed tailings site with regular and appropriate reports submitted to the NRC.

Liquid samples would be monitored for natural uranium, thorium-230 and radium-226. Volumes of liquid discharges would be measured for monitoring any occurrance of ground-water seepage.

Following the filling of the below surface disposal area, a program of reclamation would commence. The tailings would be covered to a level that would provide erosion integrity and control radioactivity from radon gas to a level approaching background. The surface cover would be revegetated in order to minimize erosion. A post operational monitoring program would be developed in order to maintain proper surveillance of radionuclides in the general vicinity.

3.5.1.2 Field Investigation

The field investigation for the alternative disposal areas consisted of 21 exploration borings. Borings were advanced with two CME drill rigs, capable of auger drilling and sampling, in situ permeability testing, and core drilling. The borings were drilled into corable bedrock with 10.2 centimeter (4 inch diameter solid augers. The soils, fill, and/or bedrock above core point were sampled with either a 5.1 centimeter (2 inch) diameter California Sampler or a Split Spoon Standard Sampler. Standard Penetration tests were conducted at each sample location. When corable bed-rock was encountered, continuous core was retrieved with an NX wire line core barrel. In situ packer-type permeability tests were conducted in most of the borings. The tests were conducted at different depths and in different lithological zones, to determine horizontal permeabilities for each lithology. The tests were conducted by using a 7.6 or 10.2 centimeter (3 or 4 inch) diameter rubber packer, set in a 10.2 centimeter (4 inch) diameter auger hole or a "NX" size core hole. In most cases the packer tests were conducted at more than one hydraulic head to verify the permeability test results. Upon completion of each boring, the hole was geophysically logged by logging equipment. Upon completion of drilling and logging, each boring was cased with 5.1 centimeter (2 inch) diameter slotted PVC for water level monitoring.

In addition to the drilling program, representative tailings samples were obtained from the mill discharge line. These samples were obtained for use in subsequent laboratory investigations.

3.5.1.3 Laboratory Investigation

The laboratory testing program was divided into two sections. The first section was composed of material classification tests, including sieve analysis and Atterberg Limit determinations, on undisturbed samples from each lithology and on samples of mill

tailing. The second section consisted of engineering property tests, including standard Proctor determinations, one-dimensional time-rate consolidation tests, and falling-head permeability tests. Time-rate consolidation tests were conducted on undisturbed foundation soils and remolded samples of mill tailings and overburden material. Falling-head permeability tests were conducted on undisturbed samples from each lithology and on remolded samples of mill tailings and overburden material. All of the laboratory tests were conducted in accordance with appropriate ASTM specifications.

3.5.1.4 <u>Area Geology</u>

Subsoil conditions are similar across both the Sagebrush-Tablestakes area but vary with depth.

Typically 0 to 27 meters (0 to 90 feet) of pit backfill or stockpiled overburden overlies a residual sand (weathered bedrock materials) that varies in thickness from 0 to 15 meters (0 to 50 feet). The bedrock encountered consists of a homogeneous white to yellow brown, fine to coarse grained sandstone over light to dark green, fine to medium grained silty sandstone. This sandstone unit is generally interbedded with mudstone lenses varying from 0 to 12 meters (0 to 40 feet) in thickness. A 9 meter (30 feet) thick, continuous mudstone lens was encountered in the Sagebrush-Tablestakes area. The bedrock units in the Sagebrush-Tablestakes area are capped with a silty sandstone conglomerate bedrock varying in thickness from 0 to 8 meters (0 to 25 feet). It should be noted that the subsurface conditions are greatly affected by the presence of a high angle normal fault striking approximately east-west and having an average displacement of approximately 34 meters (110 feet), down to the north. This fault roughly divides the Sagebrush-Tablestakes and Bullrush areas.

Existing fill permeabilities average 5×10^{4} centimeters per second in both the vertical and horizontal directions. Conglomerate permeabilities could not accurately be determined due to poor sample recovery and hole caving. Conglomerate permeabilities are estimated to be approximately 10^{3} centimeters per second in both the vertical and horizontal directions. The homogeneous fine to coarse grained sandstone has an average permeability of 2×10^{4} centimeters per second in both directions. The interbedded fine to medium grained sandstone and mudstone has an average horizontal permeability of 4×10^{5} centimeters per second and an average vertical permeability controlled by the mudstone lenses, of 3×10^{7} centimeters per second.

Excavation at the alternative disposal site area is exposing lenses of clay soil. At present, it is estimated that the site contains at least 5,660 cubic meters (200,000 cubic

yards) of a montmorillonite and sand mixture with a permeability of 10^{7} centermeters per second and 2,830 cubic meters (100,000 cubic yards) of bentonite. It is anticipated that more of these clay soils would be exposed as pit excavation continues. An economic analysis would also be prepared to determine the relative costs of alternative lining materials such as synthetic rubber versus clay or combinations of these materials.

3.5.1.5 Area Hydrology

The drainage area that would contribute to the subsurface pit area is approximately 518,000 square meters (0.2 square miles). This is a preliminary number because of the continual topographic changes in the mining area. It assumes that the adjacent Union Carbide K-1 mining pit would be backfilled and that drainage from that area would be redirected to drainages located east of the pit. In addition, it assumes that drainage in the area of a pit under excavation immediately northwest of the Sagebrush-Tablestakes pit would also be redirected away from the site.

The retention volume for the Sagebrush-Tablestakes pit was determined using volumes that could be expected from the Probable Maximum Flood series. The probable maximum flood series is made up of two floods: the Probable Maximum Flood (PMF) and a flood equivalent to 40 percent of the PMF occurring a few days prior to the main flood.

The water volume generated by the PMF would be approximately 118,000 cubic meters (96 acre-feet) for the drainage area. The total volume to be retained (above the normal pool elevation) would be 96 + .40 (96) = 134.4 acre-feet (116,000 cubic meters). This assumed negligible evaporation during the time between the two flood events.

The volume of the PMF was determined by adjusting the probable maximum one-hour thunderstorm value of 24.9 centimeters (9.8 inches) to a runoff value of 22.4 centimeters (8.83 inches) (curve number=92; Antecedent Moisture Condition III). These values were obtained from rainfall maps and charts presented in the Bureau of Reclamation publication "Design of Small Dams" and from charts presented in the Soil Conservation Service Technical Release No. 55 "Urban Hydrology for Small Watersheds". The runoff value of 22.4 centimeters (8.83 inches) was used for 90 percent of the drainage area. Since the retention pond in the disposal area would cover approximately 10 percent of the total area, the total 24.9 centimeters (9.8 inch) value was used for this water surface. The runoff curve number was obtained by adjusting the normal curve number of 81, which has been found to be satisfactory for the area, to 92 for the saturated antecedent moisture condition (AMC-III).

3.5.1.6 Groundwater

Groundwater flow is from north to south at gradients corresponding to lithologic dips. Within the project area, groundwater flow is being controlled by the east-west fault, and by pumping withdrawals from the Union Carbide K-1 mining pit and the Federal-American Partners existing Bullrush pit.

It is estimated that upon termination of pumping in the Sagebrush-Tablestakes area the groundwater surface would recharge to approximately 9 meters (30 feet) above the top of the continuous mudstone lens (elevation 6,425). Flow in this area would be generally from north to south with a gradient of approximately 0.015 feet per foot.

3.5.2 Dust and Gaseous Effluent Controls

Control systems and methods would be employed in the expanded mill to reduce dust and gaseous emissions to as low as is reasonably achievable. These control systems and methods generally represent the state-of-the-art in the uranium milling industry. The following paragraphs discuss the dust and gaseous effluent control systems and methods.

3.5.2.1 Ore Storage Pad

Because of the limited amount of ore stored on the pad and because the ore comes from the mine with an average moisture content of 10 percent, fugitive dust emissions from the existing ore pad has not been a problem. During expanded mill operation, the ore is expected to average 8-10 percent moisture. Therefore, future fugitive dust emission problems are not anticipated. Should fugitive dust emissions become a problem, water sprays would be utilized to reduce the amount of dust as far as practicable. According to the "EPA Region VIII Policy Paper on the Air Quality Review of Surface Mining Operations," wetting represents the "Best Available Control Technology" (BACT) for fugitive dust emissions from uranium ore storage piles, and that wetting would result in a control efficiency of approximately 50 percent [ref 1]. Haul roads would be wetted with mobile equipment designed for fugitive dust control whenever necessary.

3.5.2.2 Ore Grinding Operations

Ore would be reclaimed by front-end loaders and dumped through a grizzley into an underground surge hopper. This hopper would then discharge through an apron feeder to the mill feed conveyor belt. The underground apron feeder and conveyor belt loading point would be enclosed to reduce dusting. General ventilation would be provided in the underground conveyor feed areas to reduce any buildup of Rn-222 gas that may be released from the ore. This ventilation would be approximately 2.4 cubic meters per second

(5,000 cubic feet per minute). Because of the enclosures on the apron feeder and conveyor belt load point and the relatively high ore moisture content, dust controls are not considered necessary at this point.

The conveyor belt and the SAG mill feed operation would be enclosed to reduce fugitive dust emissions. Dust emissions from the mill would be negligible because of the wet milling process.

3.5.2.3 Ore Processing Areas

Significant dust emissions are not expected from the ore processing areas because the processing operations are wet. However, control systems would be provided to control H_2SO_4 fumes from the acid leach operations and NH_3 fumes from the pregnant slime storage tanks in the expanded mill building. These control systems would consist of packed bed water scrubbers. Water from the scrubbers would be returned to the process. These scrubbers are expected to have a control efficiency of 90 percent or better.

3.5.2.4 Yellow Cake Precipitation, Thickening, and Drying Operations

Yellow cake precipitation tanks, thickeners, the centrifuge, and the dryer would be enclosed and ventilated to the yellow cake dryer control system. This control system would be a high efficiency venturi scrubber designed to remove 99.5 percent or more of the particulate matter released from the dryer. It would also remove most of the NH_3 fumes from the yellow cake precipitation and thickening operations. Scrubber water would be returned to the process to recover the U_3O_8 collected by the scrubber.

3.5.2.5 Yellow Cake Packaging Operations

Ventilation air from various operations in the yellow cake packaging area would be ducted to a medium energy venturi scrubber. This scrubber would be designed to remove approximately 99.5 percent of the particulate matter emitted from these operations. This scrubber is a lower energy scrubber than the one on the yellow cake dryer because the particulate matter is expected to be larger in size making it easier to scrub. Scrubber water would be returned to the process to recover the U_3O_8 collected by the scrubber.

3.5.2.6 Effluent Stacks

Effluent stacks would be provided for the scrubber effluents from the acid leach operations, the pregnant slime storage tank and the yellow cake processing operations. These stacks would extend approximately 3 meters (10 feet) above

the height of the mill expansion building. The stacks would be equipped with monitoring ports so that sampling could be conducted when necessary.

3.5.2.7 Tailings Disposal Areas

Dust emissions from the solar evaporation pond are not expected to be significant because the disposed materials would be kept wet. Portions of the disposed tailings in the below surface tailings disposal area would also be kept wet. In addition, the tailings disposal area would not be exposed to the wind as much as a conventional tailings impoundment would be because it is located below the ground surface. Should fugitive dust emissions from the tailings disposal areas become a problem, water sprays or other measures would be utilized to reduce dusting as much as practicable.

3.6 SANITARY AND OTHER MILL WASTE SYSTEMS

The following paragraphs describe the other mill waste systems. They all would be operated in compliance with Wyoming State Department of Environmental Quality and other applicable regulations.

3.6.1 Sanitary Sewer

The expanded mill would continue to utilize the existing sanitary sewer system as sufficient capacity is available in this system. The existing sanitary sewer system consists of a conventional septic tank and leach field.

3.6.2 Laboratory Wastes

Liquid wastes from the new laboratory would be pumped to the tailings disposal sump for disposal with the tailings. The laboratory would be equipped with ventilation hoods designed for safe chemical laboratory operations. Effluents from these laboratory hoods would be controlled as necessary.

3.6.3 Sanitary Land Fill

All solid wastes such as garbage, paper, etc. would be disposed in the existing company controlled sanitary land fill.

3.6.4 Gas-Fired Steam Generator

An existing natural gas-fired steam generator would be utilized for space heating and the heating of process liquids. It has a capacity of 600 boiler horsepower and requires a heat input of 2.6×10^{10} joules per hour (25×10^{6} BTU/hour). No effluent controls would be provided for this steam generator

because emissions are considered to be low and in compliance with standards. Emissions from the steam generator are estimated to be the following:

Particulate Matter	-	0.9 metric ton/year (1.0 short ton/year)
Sulfur Oxides (as SO_2)	-	0.05 metric ton/year (0.06 short ton/year)
Carbon Monoxide	-	1.6 metric ton/year (1.7 short ton/year)
Hydrocarbons	-	0.3 metric ton/year (0.3 short ton/year)
Nitrogen Oxides (as NO_2)	-	16.2 metric ton/year (17.9 short ton/year)

3.6.5 Vehicular Emissions

Vehicles such as ore haulage trucks, the ore front-end loader, personnel vehicles, etc. would emit particulate matter, carbon monoxide, nitrogen oxides, and hydrocarbons. Vehicles controlled by FAP would be maintained in compliance with vehicle emission standards. Air quality impacts resulting from vehicle operation are expected to be minor because of the limited number of vehicles operating in the area.

3.7 MINING ACTIVITIES

The expanded mill would process ores from FAP/TVA surface and underground mines operated by FAP in the Gas Hills area. All of these ore reserves are leased by the TVA and would be milled under agreements with the TVA.

REFERENCES: SECTION 3.3.2

1. Sample ore radioactivity data provided by FAP. Data was based on analyses performed by Ecology Audits, Inc. of Houston, Texas. Data was modified as explained in appendix A.

2. Rosholt, John, Jr., "Natural Radioactive Disenquilibrium of the Uranium Series," U.S. Geological Survey, Bulletin 1084-A.

3. Personal Communication from Phillip Dodd, Project Officer - Technical Applications, U.S. Department of Energy, Grand Junction, Colorado.

REFERENCES: SECTION 3.4.1

1. "Draft Generic Environmental Impact Statement on Uranium Milling," U.S. Nuclear Regulatory Commission, NUREG-0511, P-5-1 and 5-4, April 1979.

2. U.S. Nuclear Regulatory Commission, "Draft Environmental Impact Statement Related to Operation of Morton Ranch Uranium Mill," NUREG-0439, P. 3-9, April 1978.

3. Ibid, NUREG-0511, p. 5-4.

REFERENCES: SECTION 3.4.2

1. U.S. Nuclear Regulatory Commission, "Draft Generic Environmental Impact Statement on Uranium Milling," NUREG-0511, P. 5-7 and 5-8, April 1979.

REFERENCES: SECTION 3.5.2

1. U.S. Environmental Protection Agency, "EPA Region VIII Interim Policy Paper on the Air Quality Review of Surface Mining Operations," p.8.

TABLE 3.3-1

ANNUAL USAGE OF PROCESS REAGENTS

Reagent	Annual Usage
Ammonia	2,050 metric tons (2,260 short tons)
Sulfuric Acid	29,600 metric tons (32,600 short tons)
Sodium Chlorate	1,650 metric tons (1,810 short tons)
Ferrous Sulfate	N/A*
Soda Ash	1,110 metric tons (1,220 short tons)
Caustic Soda	65 metric tons (72 short tons)
Kerosene	39,800 One (10,500 gallon)
Tertiary Amine	2,025 kilograms (4,460 pounds)
Isodecanol	3,205 kilograms (7,070 pounds)

*Ferrous sulfate would only be used occasionally when the iron content of the ore is insufficient for proper process operation.

TABLE 3.3-2

ANNUAL USAGE OF PROCESS MATERIALS

Material	Annual Usage
Resin	30 cubic meters (1,050 cubic feet)
Celetom (Filter Aid)	10 metric tons (11 short tons)
Activated Carbon	4,130 kilograms (9,100 pounds)

TABLE 3.4-1

PRINCIPAL PARAMETERS FOR RADIOLOGICAL ASSESSMENT

Parameter	Value
Ore Quality, U_3O_8	0.12 percent
Ore Activity	
U nat	720 picocuries/gram
Th-230	150 picocuries/gram
Ra-226	420 picocuries/gram
Pb-210	240 picocuries/gram
Operating Days Per Year	340 days
Ore Process Rate	910,000 metric tons/year (1,003,000 short ton/year)
Extraction Efficiency	91 percent
Yellow Cake Yield	1,035 metric tons/year (1,140 short ton/year)
Yellow Cake Quality, U_3O_8	96 percent
Yellow Cake Drying Stack Effluent, U_3O_8	1,430 kilograms/year) (3,150 pounds/year)
Yellow Cake Drying Stack Control Efficiency	99.5 percent
Total Below Surface Tailings Area	243,000 square miles (60 acres)
Total Solar Evaporation Pond Area	93,100 square miles (23 acres)
Projected Specific Gravity of Dry Tailings	2.6
Measured Dry Density of Tailings Taken from Existing Impoundment	1.42 - 1.63 grams/cubic centimeter (88.6 - 101.5 pounds/cubic foot)

TABLE 3.4-1 (Cont)

Parameter	Value
Seepage Rate from Solar Evaporation Pond	0.8 liters/second (13 gallons/minute)
Seepage Rate from Below Surface Tailings Area	Negligible
Tailings Activity	
U nat	19 picocuries/gram
Th-230	42 picocuries/gram
Ra-226	124 picocuries/gram
Pb-210	70 picocuries/gram
Fresh Process Water Requirement	8.1 x 105 cubic meters/year (661 acre-feet)
Ore Pad Area	18,700 square meters (4.6 acres)
Storage Pile Height	10.5 meters (34 feet)
Average Ore Storage Time	17 days

TABLE 3.4-2

STACKS DISCHARGING EFFLUENTS

No.	Location	Control Equipment	Control Efficiency	Stack Height (Meters (Feet))	Flow Rate (Cubic Meters/ Second) (Cubic Feet/ Minute)	Effluent
1	Acid Leach	Demister Pad	90% +	21 (70)	2.36 (5,000)	H_2SO_4 Fumes
2	Pregnant Slime Storage	Demister Pad	90% +	21 (70)	0.47 (1,000)	NH_3 Fumes
3a	Yellow Cake Precipitation, Thickening, and Drying	High Energy Venturi Scrubber	99.5% +	21 (70)	3.30 (7,000)	NH_3 Fumes U_3O_8
3b	Yellow Cake Packaging	Medium Energy Venturi Scrubber	99.5%	--	Included in 3a above	U_3O_8

NOTE: A common stack is provided to discharge effluents from yellow cake precipitation, thickening and drying operations and the yellow cake packaging operations.

"Stack Height" is height above grade; stacks would extend approximately 3 meters (10 feet) above the roof of the building.

TABLE 3.4-3

AVERAGE ANNUAL RADIOACTIVE NUCLIDE EMISSIONS TO THE ATMOSPHERE DURING ACTIVE MILLING OPERATIONS (CURIE PER YEAR)

Source	Nuclide				
	U nat.	Th-230	Ra-226	Pb-210	Rn-222
Ore Storage and Grinding Operations	2.2×10^{3}	4.7×10^{4}	1.3×10^{3}	7.4×10^{4}	160
Uranium Drying and Packaging Operations	8.0×10^{1}	9.6×10^{3}	1.1×10^{3}	5.6×10^{4}	Negligible
Tailings	9.2×10^{3}	2.0×10^{2}	6.0×10^{2}	3.4×10^{2}	10,500

NOTE: Emission calculations were based on the following radioactivity for a typical sample of ore:

U nat - 720 picocuries/gram
Th-230 - 150 picocuries/gram
Ra-226 - 420 picocuries/gram
Pb-210 - 240 picocuries/gram

Emission calculations were also based on emission factors presented in the Draft Generic Environmental Impact Statement prepared by the NRC [ref 1].

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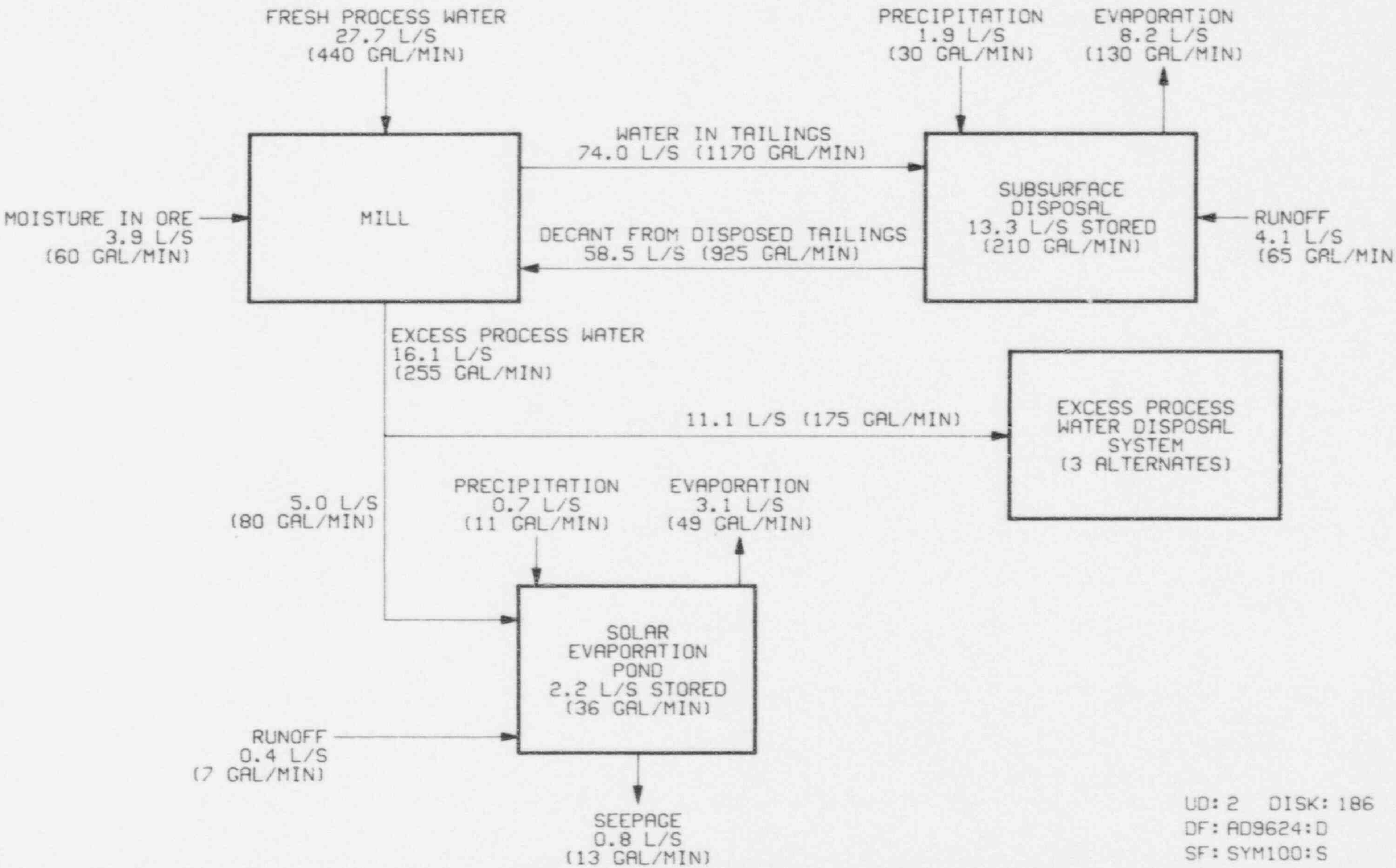
FIGURE 3.3-2

PRELIMINARY PROCESS WATER BALANCE FOR EXPANDED MILL OPERATION



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D. PINCKNEY
FC/NMSS T5C7

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3-20-96			

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LATRAVETTA LEE	415-5879	3/19/96

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4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND CONSTRUCTION FOR THE MILL EXPANSION

4.1 EXPANSION DESCRIPTION

4.1.1 Area

Expansion would occur 15 meters (50 feet) south of the existing mill and would cover approximately two hectares (five acres) of previously disturbed land.

4.1.2 Construction Schedule and Workforce

Construction is scheduled to start around June 1980, and be completed around November 1981. This would be roughly a 17 month construction period.

There would be an average of 100 construction personnel at the site at any one time. As certain components of the expansion are completed, the construction force would change in number and composition.

4.2 EXISTING CONDITIONS IN THE MILL EXPANSION AREA

The entire mill expansion would be in an active operational area, the present mill yard. The site is therefore presently disturbed in terms of vegetation and wildlife.

4.3 LAND USE ENVIRONMENTAL IMPACT

Mill expansion construction is not expected to create significant land use environmental impacts. Wherever possible, however, land disturbance would be minimized and construction activities would be followed by a cleanup program.

4.3.1 Vegetative Impacts

The mill expansion would result in the use of approximately two hectares (five acres) of land. Prior to disturbance for past mill activities, this land had grassland-sagebrush vegetation types. Since most of the vegetation is now absent in the expansion area, there would be little additional vegetative impact.

4.3.2 Wildlife and Livestock Impacts

Large mammals and livestock do not presently use the area involved in the expansion. Therefore, there would be no reduction in large mammal use. Mobile species of small mammals, insects, birds, etc. can migrate out of the construction area. Only slight reduction in wildlife numbers could

be expected of a few small animals present such as mice and some larger animals killed because of increased vehicle traffic. Control of traffic speed would help to minimize this possibility.

None of the rare or endangered species listed on state lists [ref 3] or Federal lists [ref 4] are expected on the mill expansion site.

4.3.3 Archaeological Impacts

Mill expansion would not affect any historical or archaeological site listed in the National Register of Historic Places [ref 2]. The site has been previously inspected for archaeological resources and none were found. If a find occurs during construction, activities would be stopped until the proper archaeological officials are notified.

4.3.4 Soil Impacts

Construction activities usually result in a small loss of soil resources. This loss should be insignificant due to the small area and would be minimized by removing, stockpiling, and protecting the topsoil.

4.3.5 Air Impacts

Air quality impacts which may result from construction would include particulates and engine exhaust emissions. Both of these emission types are not expected to be significant.

Earthwork and travel on unpaved areas commonly results in particulate or fugitive dust emission. For many construction activities this is roughly equal to 3.1 metric ton per hectare (1.4 tons per acre) per month [ref 1]. Even undisturbed surrounding areas without heavy vegetative cover contribute particulates during windy periods. Most of the construction dust would settle before reaching operational boundaries and therefore would not impact vegetation and animal life. Water sprays used when dry, windy conditions occur along with construction activities, would help reduce particulate emissions. This would also help to minimize soil loss.

Heavy-duty equipment engine exhaust would probably result in insignificant emissions of carbon monoxide, sulfur dioxide, and other normal internal combustion engine emissions. Air standards are not expected to be exceeded; however, equipment would be properly maintained to minimize release of pollutants. This maintenance could include routine inspections, tuneups, replacement of fuel and oil filters, etc.

4.3.6 Socioeconomic Impacts

The most pronounced impacts of the mill expansion construction would probably be felt in the area of socioeconomics. Several of these impacts would possibly be temporarily negative. Other impacts of equal if not greater importance should be beneficial and a stimulant to the economy.

During the 17-month construction period, the proposed project would directly create an average of 100 jobs. Twenty-five percent of the work force would be made up of local residents. The remaining 75 percent would be made up of individuals coming from other areas. Some of these individuals may temporarily relocate their families, even if they would not be present for the entire 17 month period because of driving distance. Most construction workers would come from sources over 60-70 kilometers (37-43 miles) away. This would temporarily increase the number of new people in the area and may impact the area's schools, health service, law enforcement, and housing. It is expected that the increased temporary population could be absorbed into the community without significant problems based on past community experience with other construction projects. These negative effects on the socioeconomic structure should be far outweighed by several positive effects.

One very important positive socioeconomic impact of mill expansion construction would be a decrease in the area's unemployment rate. Approximately 25 percent, or 25 construction positions, would be filled by local residents in the Riverton and Indian Reservation area. Following construction some of these positions may be phased into the 15 to 20 new long term operational positions required to operate the expanded mill. Thirty or so additional secondary support employees in the community would also help reduce unemployment. These secondary support employees would include employees in restaurants, stores, and filling stations.

The entire construction work force, whether permanent or temporary should have an overall positive impact on area businesses and stimulate the economy in general.

4.4 WATER USE ENVIRONMENTAL IMPACTS

Site preparation and construction are not expected to impact surface or ground water sources. This would mean negligible impact in terms of quantity, quality, and drainage.

4.4.1 Water Quantity

The volume of water required for construction and by the construction workers is small so that other area water users should not be affected, both wildlife and human.

Construction of the mill expansion is not expected to alter overall surface drainage because of the flat topography at the expansion site, low regional precipitation, and absorptive capacity of the soils. The small area of disturbance relative to the drainage basin also makes an effect from construction on surface drainage unlikely.

4.4.2 Water Quality

Construction activities would not be in close proximity to any active surface water body. Also, due to the low amount of precipitation, low stream gradients, and general scarcity of surface water, construction should not add suspended solids, sewage, or other construction pollutants to surface or ground water. This is important not only to humans, but fish and wildlife also. Even if impacts are not expected, drainage ditches would be constructed to divert storm flow away from the construction area. Chemical toilets would be used to prevent water pollution by sewage.

4.5 RESOURCES COMMITTED

Site preparation and mill expansion construction would require the commitment of a variety of building materials and process equipment, as well as commitments of labor, energy, and capital. The dollars invested would be recovered through the sale of yellow cake produced in the mill. At the end of the project, most of the process equipment and some of the building materials would be salvaged. However, the other resources should be considered irretrievable commitments.

No irreversible or irretrievable commitment of surface land resources would be made due to site preparation or mill expansion construction. Although activities would require approximately five acres of land, this area would be returned to a grazing condition at project termination.

REFERENCES: SECTION 4

1. PEDCo - Environmental Specialists, Inc., 1973.

2. Federal Register (42FR6198), "National Register of Historic Places," February 1, 1977 and subsequent weekly supplements.

3. Wyoming Game and Fish, "Current Status on Inventory of Wildlife in Wyoming," July 1977.

4. Federal Register (43FR238), "List of Endangered and Threatened Wildlife and Plant," December 11, 1978.

5. ENVIRONMENTAL EFFECT OF MILL OPERATION

5.1 RADIOLOGICAL IMPACT ON BIOTA OTHER THAN MAN

5.1.1 Exposure Pathways

The most likely pathways for exposure to radionuclides at the site, would be by direct radiation and atmospheric dispersion of radioactive dust and gases inside the restricted area, or by subsurface seepage of radioactive liquids and atmospheric dispersion of radioactive dust outside the restricted area.

The tailings disposal areas would be the principal sources from which non-human biota may be exposed to radionuclides. Less significant sources of exposures would emanate from ore stock piles and effluents from milling operations released to the atmosphere.

The tailings disposal areas would contain natural uranium thorium-230, radium-226, and lead-210. Small amounts of these radionuclides could enter natural food chains by inhalation of windblown dust carried into the surrounding areas. However, this source would be held to very low levels, principally by the crusting effect of the tailings. Once overburden has been placed over these tailings, plants growing directly on top in the mine overburden should not be damaged by direct radiation. The low level gamma radiation would also not be accumulated in the plant tissues.

A security fence would enclose the tailings disposal areas impoundment to restrict entry, which in turn would reduce the possiblity of external whole-body gamma exposure and ingestion of radioactive material by large animals. Arthropods, reptiles, and small mammals would be able to gain access to the areas through the fence. It also would be possible for birds, including migratory waterfowl, to land on the tailings disposal areas.

Since the tailings water would be acidic (pH about 1.5 to 2.0), it would be distinctly unpalatable and would discourage consumption by small animals and waterfowl. It is therefore unlikely that appreciable quantities of radionuclides would enter the food chain through this exposure pathway (see figure 5.1).

Seepage would be retarded from the tailings disposal areas by the action of deposited tailings slimes which would affect a partial sealing of the areas. Previous laboratory studies by our consultants indicate that the tailings slimes would have permeabilities, orders of magnitude lower than soils, and stockpiled overburden in the area [ref 1]. In

the event that some minor amount of seepage does occur, it is unlikely that radionuclides would migrate to the groundwater since most soils would have the ability to remove contaminants from liquids by chemical reactions, ion-exchange, and absorption.

Assuming that the seepage was not retained as soil moisture, it would percolate through soil and rock according to layering and attendant variations in permeability. Most of the effluent would be intercepted by relatively impermeable layers and retained as perched groundwater, or would flow down-gradient to a point of egress at the ground surface. Above the regional groundwater table, seepage would move down gradient at less than 5 degrees to the north. If seepage reached the regional water table, it would move with the groundwater to the northwest. The gradient of the main water table is estimated to be 13.2 to 16.5 meters per kilometer (80 to 100 feet per mile) to the northwest. Dispersion and soil absorption would be expected to reduce the constituents to extremely low levels. Studies done by others concerning the effect of mill tailings on groundwater resources have shown that in general, radium and thorium could be expected to reach background levels less than 2 kilometers (1.1 miles) down gradient [ref. 2]. However, as discussed previously, only minimal seepage would be expected to percolate to natural soils or the groundwater table.

5.1.2 Radioactivity in the Environment

The mill would generate some effluents that could distribute modest amounts of natural radioactivity (uranium and daughters) to the project area. The solid and liquid effluents would be closely controlled and contained. The airborne radioactive effluents would be emitted at low concentrations and would be diluted to even lower concentrations by natural diffusion and dispersion processes within a short distance from the points of emission.

The liquid and solid process wastes which would contain the bulk of the radioactivity would be retained in the tailings disposal areas which would be located in the restricted areas. Approximately 9,060 metric tons (9,990 short tons) of tailings would be discharged to the tailings disposal areas. The radioactive levels were discussed in section 3.4.1. Since approximately 85 percent of the radioactivity would be concentrated in the slimes, which would be covered with overburden, radioactive emissions should not result in damage to plant and animal populations.

There is no surface water on the site, and there would be no surface discharge of fluids from the tailings disposal areas. Consequently, there would be no buildup of radionuclides in water bodies. Additonal monitor wells would be

drilled around the tailings disposal aras. Water would be analyzed periodically for radioactivity to determine if the buildup of radionuclides occurs.

Any possible seepage would travel via the exposure pathways described in section 5.1.1. A quantitative assessment of radionuclides above and below the groundwater table relative to distance from the facility, is discussed in section 6.1. This indicates a very low concentration of radionuclides. The low concentrations of radioactive constituents in possible seepage and the small quantity of seepage, if any, plus the historical data presented in section 6.1 indicate that essentially no impact has occurred from the present tailings disposal operations. There would be no other releases of radioactive wastes of effluents to land areas or bodies of water under normal operations.

Once operations are concluded and overburden has been layered over the tailings disposal areas, release of radioactive wastes would not be expected to exceed standards. This would apply not only to seepage but to vegetative uptake as well. The topic of vegetative uptake of radioactive compounds, along with heavy metals and other toxic materials from or through the tailings cover material is an important issue. This topic has been studied in great detail and is discussed below.

The conclusion that there is very little potential for contamination of vegetation by radioactive compounds and other toxic materials in the cover material or through the cover material is based on test results. The cover material expected to be used in reclaiming the tailings disposal areas would have a composition similar to the overburden data presented in table 5.1-1. These data and the discussion of overburden characteristics were taken from the Wyoming State Mining Permit No. 438 A1 for the Sagebrush-Tablestakes Mine. Current plans call for overburden from the Bullrush Mine (0.46 kilometer (0.25 mile) northwest of the Sagebrush-Tablestakes Mine) to be used in covering the tailings. Three samples of overburden were taken from exposed pitwalls at the mine site. An analysis of the samples was performed by the Colorado School of Mines Research Institute.

The test results show that Samples Nos. 5886, 5887, and 5900 were similar for most of the test parameters. The ph was mildly basic and soluble salts were below levels that would restrict plant growth. None of the toxic elements included in the analyses were found to be in amounts sufficient enough to be absorbed and concentrated by plants to toxic levels. Background radioactivity levels were not high enough to present a danger to humans or animals. It is not anticipated that overburden samples Nos. 5886, 5887, and

5900 would present any hazardous or plant growth retarding characteristics. It is assumed that the characteristics of theunoxidized sands and sandstone would be similar in many parameters to the material represented by Samples Nos. 5886, 5887, and 5900.

5.1.3 Dose Rate Estimates

Release of airborne radionuclides is expected to be low, as discussed in section 3.4. However, of the possible pathways that could expose the local vegetation to radioactivity, physical disposition of particles on plants would be the most significant. Since radon-222 is gaseous, it would not deposit on vegetation. Deposition of particles would therefore apply primarily to thorium-230, radium-226, and lead-210.

The principal biota of concern in the area would be cattle pronghorn antelope, blackfooted ferret, praire falcon, and the plant Artemisia porteri. Radiation doses directly to animal tissues and plant leaves or to the digestive tract, through ingestion of deposited uranium dust on vegetation, is expected to be minimal based on preliminary studies. Impact from this avenue of exposure would be reduced even further with the mill expansion. Due to the proposed wet grind of ore particulate, emission would be reduced from present rates.

The distrubution of radioactivity to the subsurface environment would not impact either surface or ground burrowing biota unless such effluents reach the surface along perched water seeps or as a constituent of the main groundwater system where it recharges surface bodies of water. As discussed previously, no subsurface effluents are expected to be released from the site. Moreover, considering the dips of possible perching layers in relation to the topography and the depth of the groundwater table, potential seepage travel paths are of substantial length. The main groundwater table does not reach the ground surface within 9.3 kilometers (5 miles) of the site, as indicated by available information on groundwater levels.

Release of airborne radionuclides would be extremely low as discussed in section 3.4.

5.2 RADIOLOGICAL IMPACT ON MAN

5.2.1 Exposure Pathways

Exposure pathways applicable to radiological impact on man would include subsurface and airborne routes discussed in Section 5.1.1. Less significant pathways would include ingestion of dust containing radioactive materials and

ground "shine" from deposited particulates. The consumption of local animals (cattle and antelope) which may have ingested or inhaled effluent radionuclides, would present a slight potential for the contamination of man's food chain. Ingestion of a significant concentration of radionuclides through this pathway would be unlikely because the animals are exposed to very low levels of contaminants (see Table 6.1-1 and 6.1-2). The cattle normally would spend less than half the year in the vicinity of the project site. Pronghorns would use the area as a range in the summer, as a migratory route during the fall months, and as a wintering ground in mild years. Hence, the radiological impact to man would be insignificant even if he consumed large quantities of meat. Figure 5.2 presents a flow chart of the possible pathways of exposure to man.

5.2.2 Liquid Effluents

Possible seepage from the tailings disposal areas would constitute the only liquid effluent emanating from the operation. Surface discharge of water is not anticipated.

There normally is no surface water within 9.3 kilometers (5 miles). Groundwater containing some seepage could conceivably be consumed by stock or wildlife, which contribute products to the human food chains. The radionuclide concentrations which could possibly reach these consumption sites would be minute fractions of the amounts entering the environment at the source. This is based on the fact that the levels of radionuclides found in the groundwater samples presented in table 6.1-1 are so low that it is assumed that either the tailings slimes prevent most seepage or the soil absorbs the radionuclides. Measurable radioactive exposure, resulting from consumption of liquid effluents migrating to the locations of receiving waters, would not occur under normal operations.

5.2.3 Gaseous and Dust Effluents

Radon-222 is the only radioactive gas released from the operation as an emission from the ore stock pile and the tailings disposal areas. As discussed in Section 3.4, the quantity of radon released to the atmosphere would be small.

Small amounts of other radionuclides, such as thorium-230, radium-226 and lead-210, could be released in dust from ore stock piles or from the solar evaporation and below surface tailings disposal areas. The possible dose from such releases would be small. It has been established that less than 1 percent of the maximum permissible concentration (MPC) of these radionuclides are released to the unrestricted area on an annual average from current operations.

Airborne solid radionuclides and radon gas released from the mill and tailings disposal areas would be subject to atmospheric dispersal by winds which generally blow from the southwest to south-southwest at an estimated mean hourly speed of 18.5 kilometer per hour (miles per hours). The prevailing wind direction is especially important in terms of the below surface tailings disposal area. The main operational areas are downwind of the below surface disposal area. The "crusting over" and wetting acton of tailings should control dust emissions. Again the estimated emissions are very low and there are no cultivated food crops in the general area on which airborne radioactive material could be deposited.

5.3 EFFECTS OF CHEMICAL DISCHARGES

The reagents used in the mill which could also be present in the tailings are presented in Table 3.3-1. Possible seepage from the tailings disposal areas could carry these compounds into subsurface soils at the site along the same paths described in section 5.1.1.

Seepage would not occur to a significant degree and probably would not exceed 50 liters per minute (13 gallons per minute) for the entire tailings disposal system. Slimes would be used to seal the bottom of the tailings disposal areas and essentially stop seepage. Test well results support this conclusion.

In the unlikely event of seepage, some of the materials such as iron and sodium chlorate would be carried into the groundwater system. Groundwater is usually naturally high in these constituents. The other chemicals, such as sulfuric acid would either be diluted or neutralized as they travel through the subsoil [ref 1]. Aquatic or terrestrial plants or animals should not be significantly affected if seepage occured [ref 2].

5.4 IMPACT OF SANITARY AND OTHER NON-RADIOLOGICAL WASTES

5.4.1 Sanitary Sewer

As discussed in section 3.6, sanitary wastewater would be discharged to a septic tank and then to a leach field. No significant environmental impacts are expected to result from the discharge of sanitary wastes through this system.

5.4.2 Chemical Waste

Chemical waste from the laboratory would be discharged to the tailings sump.

5.4.3 Sanitary Land Fill

Garbage, paper, etc., disposed of in the company controlled land fill would be in compliance with Wyoming State Department of Environmental Quality Regulations. There should be no impact to the environment.

5.5 OTHER EFFECTS

5.5.1 Air Quality

5.5.1.1 Particulates

The main impact of continued mill operation on air quality would be fugitive dust or particulates [ref 1]. These radioactive and non-radioactive particles would be blown by winds from disturbed areas around the mill, tailing disposal areas, and unpaved roads. The winds would suspend these dust particles for a period of time in the air until they would eventually settle at certain distances from the source. Some of the operational stacks also contribute particulates, such as from the packaging and drying operations. The impact of these particulates on vegetation could be a slight shift in the biotic community wherever considerable amounts of the dust falls. This would mean some dust tolerant plants may increase in number while other dust sensitive plants may decrease. This biotic shift is not expected to be significant due to the planned dust control systems.

5.5.1.2 Other Air Pollutants

Air emissions such as SO_2, NO_x, kerosene vapors sulfuric acid mist, NH_3, nitrogen, carbon dioxide, and carbon monoxide may be produced by various components of the operation. Some of these emissions would be from a small natural gas-fired drying furnace. These emissions are not expected to be detrimental due to their small volume and the scrubbing controls.

5.5.2 Topography, Soils, and Land Use Impacts

The topography and site drainage of the mill and associated areas would not be altered by the operation to any degree. Approximately 54 hectares (134 acres) of land soils have already been disturbed by existing construction and milling operations. The majority of this disturbance was due to earthwork activities and wind erosion. Table 5.5 presents estimates of disturbed areas. These estimates reflect proposed future operations. Almost all of the disturbance has already occurrred.

In terms of land use, the area mentioned above originally was grazing land. By the end of the mill life the operation would have impacted 144 hectares(355 acres) by changing the land use to industrial.

The area devoted to the mill itself would be reclaimed after operations close for a return to grazing. The tailings disposal areas would however be considered restricted.

5.5.3 Wildlife Impacts - Non-Radiological

Original construction had some impact on wildlife; however, continued operation should have little additional significant impact. This applies to the normal populations and to the species of concern in the general area such as the blackfooted ferret [ref 2], paririe falcon [ref 3] and economically important game species, pronghorn antelope and sagegrouse.

5.5.4 Vegetative Impacts

As with wildlife, most vegetative disturbance occurred during original construction. Very little additional impact should occur due to continued operation.

There should not be any impact to the threatened plant Artemisia postire which is known to exist in the general Gas Hills area. This is due to the facts that this plant has not been observed in the immediate area and that future operation should not disturb new areas.

A possible minor impact to several vegetative species which may be occuring due to continued operation is secondary succession or biotic shift. Dust generated by the construction and operation may result in an increase in numbers of certain species and reduction in numbers of others. Examples of some of the species that commonly increase in number after many construction operations and overgrazing situations are: plains pricklypear (Opuntia polycantha); hoods phlox (Phlox hoodii); bottlebrush squirreltail (sitanion hystrix); inland saltgrass (Aistichlis spicata stricta); rubber rabbitbrush (Chrysothamnus nauseosios); and Douglas rabbitbrush (Chrysothamnus viscidiflorus).

Increase in numbers of the above is again very common and not necessarily bad. With continued use of controls such as water sprays for dust, changes may be hardly noticeable.

5.5.5 Groundwater Withdrawal

Water for the operation has in the past and would continue in the future to come from groundwater sources. The daily makeup requirements for the future operation would be approximately 28 liters/second (440 gallons/minute). This would be approximately 2,420 cubic meters per day (634,000 gallons/day).

5.5.6 Socioeconomic Impacts

Operation of this project has and would continue to have a very positive impact on the socioeconomic structure of the area. Approximately 20 additional people may be required for future expanded operation. These individuals would probably come from the present labor market in Riverton and the Indian Reservation area. The 20 direct labor and 20 or more secondary support indivduals would amplify the positive socioeconomic impacts already occurring.

The projected population distribution around the mill operation is presented in figure 5.5 for 1989. Future mill expansion and operation would not change the present population numbers and distribution to any significant degree. As figure 5.5 illustrates most people would live either 40 to 50 kilometers (22 to 27 miles) SSN or 60 to 70 (32 to 38 miles) kilometers west of the operation as they now do.

The milling operation has and would greatly benefit the community ··pecially in terms of property taxes, state and local sales tax and jobs.

No additional impacts on the areas health, education, political and law enforcement facilities are anticipated since mill expansion and operation would directly add only approximately 20 additional mill employees.

5.6 RESOURCES COMMITTED

The estimated mineral inventory now dedicated to the project is approximately 9.5 million kilograms (21 million pounds) of uranium oxide. Milling operations, at present capacity, would consume process reagents and materials as discussed in section 3.3.7.

In addition, energy in the form of electricity, gasoline, natural gas, and diesel fuel would be expended.

Much of the process water used would pump from abandoned open pits. Approximately 2,420 cubic meters per day (634,000 gallons per day) of makeup water would be required for the expanded operation. Process water would be recycled to the maximum extent practicable.

Wildlife habitants of consequence should not be destroyed as a result of the mill operation and endangered species should not be affected.

The tailings disposal areas would represent a land resource that would be committed or restricted for use for a period of time in the future. The remaining disturbed land would, however, be returned to it's former land use by implementing the decommissioning and reclamation plan presented in section 9.

REFERENCES: SECTION 5.1.1

1. F. M. Fox and Associates, Inc., "Baseline Geotechnical Investigation for the Subsurface Disposal of Millwaste," January 1979.

2. U.S. Nuclear Regulatory Commission, "Draft Generic Environmental Impact Statement on Uranium Milling," NUREG - 0511, April 1979.

REFERENCES: SECTION 5.3

1. U.S. Nuclear Regulatory Commission, "Draft Generic Environmental Impact Statement on Uranium Milling," NUREG -0511, April 1979.

2. Mc Kee, Jack and Harold Wolf, "Water Quality Criteria," California State Water Resources Control Board, 1963.

REFERENCES: SECTION 5.5

1. PEDCO - Environmental Specialists, Inc., 1973.

2. Game and Fish Department, Wyoming "Current Status on Inventory of Wildlife in Wyoming," July 1977.

3. Federal Register (43 FR 238), "List of Endangered and Threatened Wildlife and Plants," December 11, 1978.

TABLE 5.1-1

CHEMICAL AND PHYSICAL ANALYSES OF OVERBURDEN SAMPLES

Sample No.	ph in Water	Soluble Salt Electrical Conductivity millimhos/cm.	Sodium Water Soluble (milliequivalents/100 g)	Sodium NH4 Acetate Soluble (milliequivalents/100 g)	Cation Exchage Capacity (milliequivalents/100 g)	Exchangeable Sodium Percentage
5886	8.1 (1:2 Dilution)	0.33 (1:2 Dilution)	0.31	0.32	7.2	<1.0
5887	7.6 (1:2 Dilution)	0.27 (1:2 Dilution)	0.28	0.40	5.8	2.1
5900	8.2 (1:1 Dilution) 7.7 (1:5 Dilution)	0.4 (1:2 Dilution)	0.13	.43	6.25	4.8

Sample No.	Boron Water Soluble ppm	Molybdenum Anion Exchangeable ppm	DTPA EXTRACTABLE Iron ppm	Copper ppm	Manganese ppm	Zinc ppm	Nickel ppm	Lead ppm	Cadmium ppm
5586	0.7	0.11	192	0.6	3.4	<0.5	<1.0	<1.0	<0.2
5887	0.6	0.04	86	<0.5	7.0	<0.5	<1.0	<1.0	<0.2
5900	1.9	0.09	41	0.6	.9	1.0	.3	.8	<0.05

Sample No.	Fluoride Total ppm	Aresnic Total ppm	Selenium Available ppm	Mercury Total ppm	Background Radioactivity Equivalent Uranium ppm	Equivalent Thorium ppm	Radium 226 Picocuries per g	Water-Holding Capaicty, % (Dry-Sample Wt. Basis) 1/3-Bar Suction
5886	274	2.0	<0.03	0.010	10	13	3.5	8.9
5887	232	7.6	<0.03	<0.010	12	13	4.0	9.5
5900			0.025		10	17	3.5	

TABLE 5.5

DISTURBED ACRES

Area Description	Hectares	Acres
Mill Area - Existing and Expansion Areas	101.2	250
Tailings Disposal System		
Below Surface Tailings Disposal Area, Subsurface Pit	24.2	60
Solar Evaporation Pond	9.3	23
Sewage Lagoon	0.4	1
Roads	6.1	15
Tailings Disposal Line	2.4	6
	143.6	355

FIGURE 5.1

POSSIBLE EXPOSURE PATHWAYS TO NONHUMAN BIOTA

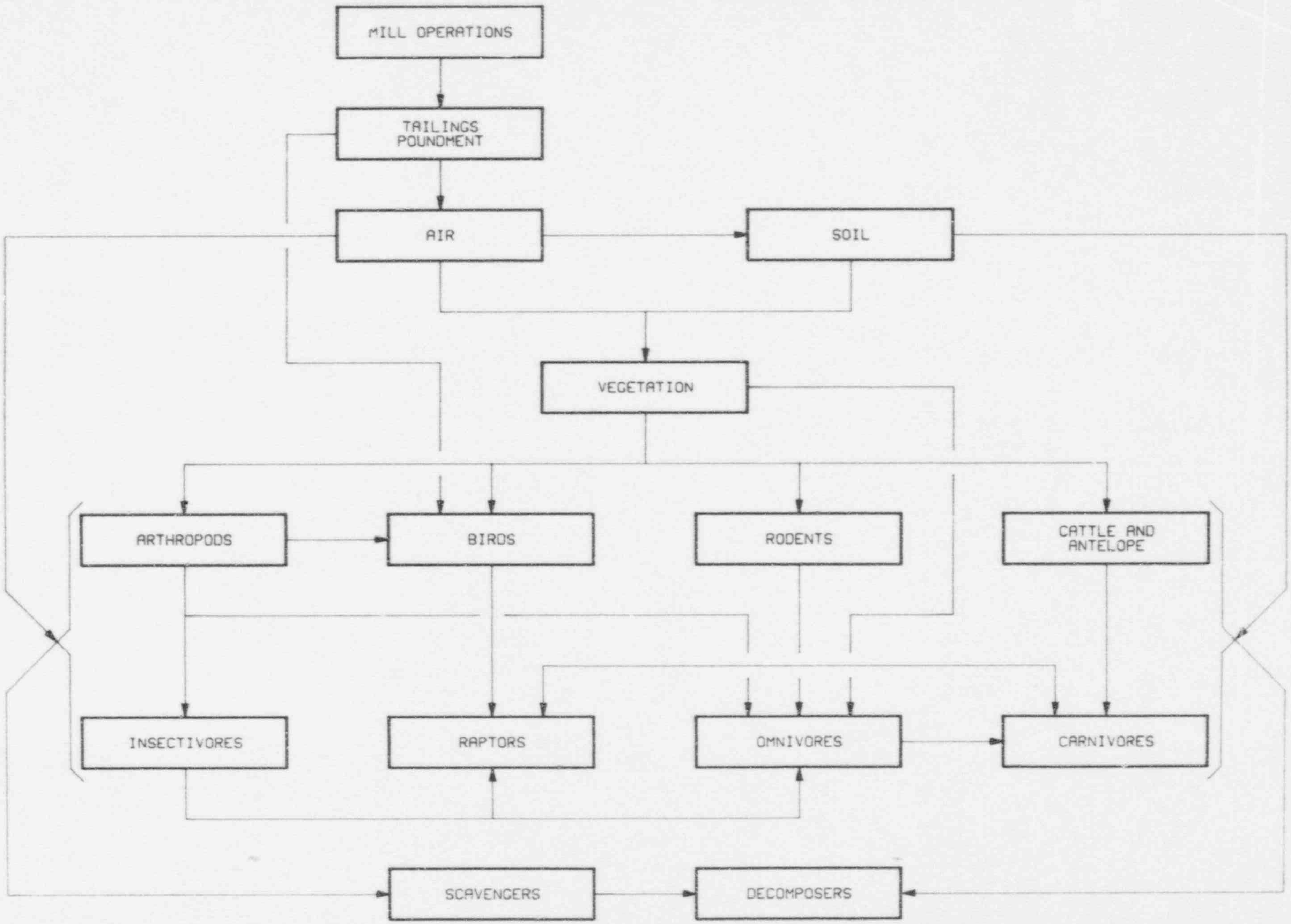

FIGURE 5.2

POSSIBLE EXPOSURE PATHWAYS TO MAN

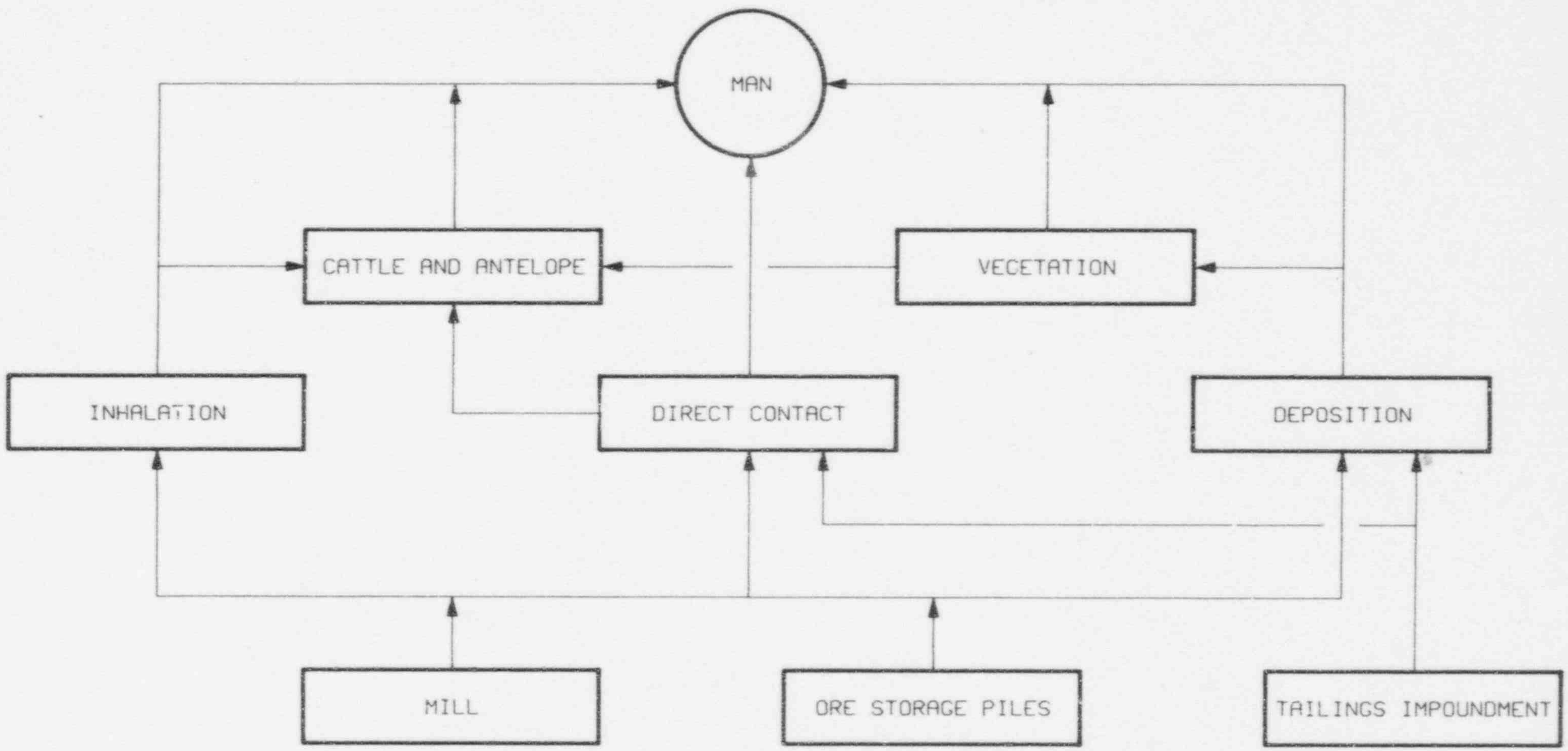

FIGURE 5.5

POPULATION DISTRIBUTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Kilometers	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0:0- .1																
:1- .5																
:5- 1.0													350			
1:0- 2.0																
2:0- 3.0																
3:0- 4.0																
4:0- 5.0			188													
5:0-10.0														2		
10:0-20.0				30												
20:0-30.0				10												
30:0-40.0																
40:0-50.0		15	10							5737		40				
50:0-60.0		12		160				15								250
60:0-70.0			6					200					13180		2017	
70:0-80.0																

Sources: Natrona County Planner,
Fremont County Planner, and
Sweetwater County Planner.

Note: Projected population figures for 1989.
Population projection sources indicate Federal American Partners expansion will have no significant effect on overall population growth.

6. EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PRE-OPERATIONAL MONITORING PROGRAM-MILL EXPANSION PROJECT

6.1.1 Mill Site

The major modification and expansion to the current FAP mill would take place entirely in an area currently disturbed and active in milling operations. As parts of the current complex are dismantled and decommissioned (the office, drying and crushing plant, and rubber shop), the expansion would be constructed in their place. This activity and replacement function makes pre-operational monitoring in this area uninformative and subsequently unwarranted (by mutual agreement between the U.S. Nuclear Regulatory Commission (NRC) and FAP-10/9/79 Silver Spring, Maryland).

FAP maintains a continuous monitoring program of air and water quality around the site. These program results are reported in a comprehensive manner to the NRC every six months. The data serves as an ongoing record of site conditions and quality which will provide an excellent basis for comparison with the expanded complex.

Tables 6.1-1 and -2 illustrate representative monitoring data from FAP's most recent semi-annual report. These data must be considered as a worst case situation as the current operation employs the ore drying and dry crushing methodology which is responsible for comparatively higher air quality emissions. The modified milling complex would employ the semi-autogenous wet grinding method which in itself would significantly protect air quality and provide a significant improvement over that which currently exists. The elimination of fine ore storage in the expanded complex would also contribute to improved air quality.

6.1.2 Subsurface Disposal Site

The proposal by FAP for its subsurface disposal site consists of the Sagebrush-Tablestakes pit which is currently in the stripping and mining stages. Additionally, the Union Carbide Minerals Corporation is actively involved in the development and mining of an adjacent pit. Further upwind from these operations lie several active mining areas, all of which are open pit, and these contribute their proportional share to the air quality degradation of the proposed subsurface site.

In view of these ongoing and constantly changing conditions, any pre-operational monitoring progress would be severely compromised as to its credibility in assessing true background values. In fact, the values recorded would be expected to be out of line with average Wyoming data acquired to date and would most probably be rejected.

FAP has maintained an ongoing program of monitoring for air quality, surface soil, vegetation, and groundwater to develop values during mining operations. The results and procedures are illustrated in tables 6.1-1 to -3.

These results reflect the status of the environment as it is today, after several years of mining and milling operations in the area. No environmental data are available for the period preceding the construction and operation of the existing mill.

These values reflect an environment in which there is some already existing industry and activity therefore do not represent pristine environmental background values. It is intended that the data presented would serve as a guide to generate baseline data for comparison at some future time.

6.2 FAP OPERATIONAL MONITORING PROGRAMS

Operational monitoring programs at FAP are designed to collect sufficient data for determining air and water quality on and around the project site.

6.2.1 Radiological Monitoring

Radiological monitoring would include measurements of the effluents from the mill, and measurements in the environs of the plant site.

6.2.1.1 Mill Effluent Monitoring

The primary source of airborne radioactive particulates is the stack from the yellow cake dryer. At monthly intervals the operator would measure the flow rate and isokinetically sample through filters the exhaust air as outlined in table 6.2-1. Other airborne radionuclides released to the environment by the mill would also be evaluated in the environmental sampling program.

These minimum detection levels are well below the MPC values specified in Appendix 6 of 10 CFR 20:

Radionuclide	MPC_a, Restricted Area (microcurie/milliliter	MPC_a, Unrestricted Area (microcurie/milliliter)
Natural uranium	1×10^{-2}	5×10^{-12}
TH-230	2×10^{-12}	8×10^{-14}
Ra-226	5×10^{-11}	2×10^{-12}
Rn-222	1×10^{-7}	3×10^{-9}

All particulate samples will be individually analyzed for gross alpha, beta, and gamma radiation, as well as for total uranium, thorium-230, and radium-226. Volumetric concentrations of gross radiation and of each radionuclide will be calculated from the analytical results. Monitoring results will be filed in accordance with 10 CFR 20 and NRC Regulatory Guide 4.14.

Should the concentration of radionuclides in air or water effluents exceed federal MPC regulations, corrective action would be taken by the operator to bring the effluent concentrations back within prescribed limits. The corrective actions would involve determining the cause of the excess concentration, halting the process in question, and repairing or modifying the equipment causing the problem.

All liquid effluents from the proposed mill would be discharged to the tailings disposal areas. Numerous samples of process liquids would be taken in the mill for process control as well as to establish the inventory of radionuclides discharged to the tailings pond. The tailings pond would be sampled on a regular basis, as a result there would be no potential effluents which are unmonitored.

6.2.1.2 Environmental Radiological Monitoring

a) Air

Air particulate samples will be collected at the points, as indicated in table 6.2-2, to measure radionuclides that may have been released from the plant. Samples would be analyzed by a certified laboratory to determine the radionuclide release rate for the particulates and reported in conformance with NRC Regulatory Guide 4.14. The detection thresholds for the particulate (lower limit of detection) is defined below in accordance to the Branch Position paper for operational radiological monitoring programs for uranium mills.

Radionuclide	Lower Limit of Detection
Natural Uranium	1×10^{-4} picocuries/cubic meter
TH-230	1×10^{-4} picocuries/cubic meter
Ra-226	1×10^{-4} picocuries/cubic meter
Pb-210	1×10^{-3} picocuries/cubic meter
Rn-222	2×10^{-1} picocuries/liter

b) Water

Water samples would be collected at the points indicated in table 6.2-1 and analyzed by a certified laboratory for natural uranium, thorium-230, and radium-226. The results would be reported in conformance with NRC Regulatory Guide 4.14. The detection threshold (lower limit of detection) for the liquid samples is as defined in the proposed Branch Position paper on radiological environmental monitoring programs for uranium mills:

Radionuclide	Lower Limit of Detection
Natural Uranium	2×10^{-1} picocurie/liter
TH-230	2×10^{-1} picocurie/liter
Ra-226	2×10^{-1} picocurie/liter
Po-210	2×10^{-1} picocurie/liter
Pb-210	5×10^{-1} picocurie/liter

c) Direct Radiation

Monthly measurement of gamma dose rates will be taken at the same five locations for the air particulates. In addition, five more locations will be sampled on a monthly basis utilizing TLD's. All reporting will be in conformance with NRC Regulatory Guide 4.14.

d) Soil

An annual collection of soil samples would be taken (at least 5 centimeters deep) at the same five locations as the air particulates. The sample would be analyzed by a certified laboratory to determine the amount of radionuclides present. The lower limit of detection for natural uranium, Ra-226, and Pb-210 in the soil sample is 2×10^{-1} picocuries per gram.

e) Vegetation

Collection of vegetation samples would be made from three locations that are near the mill and downwind of the site and would be performed three times during the grazing season. The lower limit of detection for Ra-226 in the vegetation is

5×10^{-1} picocuries per kilogram (wet weight) and 1 picocurie per kilogram (wet weight) for Pb-210. All reporting would be in conformance with NRC Regulatory Guide 4.14.

6.2.2 Chemical Effluent Monitoring

Chemical monitoring is conducted on the samples collected for radiological monitoring of selected wells on the property. These samples are collected on a quarterly basis and sent to Hazen Research, Inc., Golden, Colorado. Analysis is performed for As, Cu, Pb, N, SO_4, Zn, and Fe.

The results of analysis of representative samples are found in table 6.2-3.

There is no chemical monitoring program of gaseous effluents.

6.2.3 Meteorological Monitoring

Meteorological monitoring is accomplished by utilizing those stations presently established in the Gas Hills area. Lucky Mc Uranium Corporation located two miles northeast, and Union Carbide Corporation located six miles east, are contacted whenever there is a need. Recorded information is readily available.

Also at the mill site there would be continuous monitoring of wind speed, wind direction, and ambient temperature.

6.3 POST-OPERATIONAL MONITORING PROGRAM

There would be two distinct phases of monitoring following termination of mill operation: the first would involve monitoring to determine compliance with decommissioning requirements before termination of license, and the second would involve potential on-going, long term site monitoring.

6.3.1 Monitoring to Determine Compliance

The compliance monitoring program would be defined in detail near the end of operation of the mill. However, in general, it would involve making direct and indirect measurements of surface contamination on mill structures that may be decontaminated for further use at the site. Surface and subsurface soil profile sampling would be required in combination with gamma dose-rate measurements of the site to determine compliance with land cleanup requirements applicable to portions of the site away from the tailings disposal area.

With regards to the tailings disposal and reclamation program, a combination of earth surface flux measurements,

ambient measurements, and visual observations would be performed to determine compliance.

Radon concentrations in air are extremely variable because of the large number of factors that influence the rate at which the radon is released, (temperature, pressure, wind speed, etc.). Because of this, determination of compliance with tailings disposal requirements would be accomplished by measurement of cover thickness, supplemented by surface flux and air concentration measurements.

Radon emanation would be measured to verify that attenuation was reasonably close to that predicted in the initial establishment of thickness requirements.

The groundwater portion of the operational monitoring program delineated in table 6.2-1 should be continued until applicable licenses are terminated. Also, because one of the major aspects of the tailings disposal program would be surface reclamation (for example, vegetation) to ensure long-term stability of the tailings cover, the period of monitoring to determine compliance would extend for a considerable period of time (5-20 years). An extended monitoring period would be required, because it would take about five years for vegetation to become firmly established. Furthermore, it would take several years to experience a sufficiently varied set of climatic conditions to make judgements about the potential long-term performance of such covering.

6.3.2 Long Term Monitoring

The purposes of any long-term post-operational monitoring effort would be:

- Confirm that the tailings disposal program was providing the degree of isolation expected under natural weathering and erosional forces.

- Ensure that human activities at the site were not compromising the tailings isolation.

The primary means of isolating the tailings would continue to be physical barriers, such as earthen cover. Continued monitoring would provide additional measure that could detect breaches of isolation in time to allow appropriate repair.

REFERENCES: SECTION 6.2

1. NRC, "Preparation of Environmental Reports for Uranium Mills," Regulatory Article 3.8, Rev. 1, September 1978.

2. NRC, "Concentrations in Air and Water above Natural Background," 10 CFR 20, Appendix B, November 1975.

3. NRC, "Measuring, Evaluating, and Reporting Radioactive Materials in Liquid and Airborne Effluents from Uranium Mills," Regulatory Guide 4.14, June 1977.

4. NRC, "Proposed Branch Position for Operational Radiological Environmental Monitoring Programs for Uranium Mills," January 1978.

5. NRC, "Draft Generic Environmental Impact Statement on Uranium Milling," NUREG - 0511, Project M-25, April 1979.

TABLE 6.1-1

MILL SITE - PRE-OPERATION RADIOLOGICAL MONITORING DATA - FAP PROJECT

Sample Type	Number	Location	Type	Frequency	Results
Particulates	6	Station 1 (Camp Park West of Mill)		One Week/Month First Half 1979	Ra-226 - $.003 \times 10^{-12}$ microcuries/milliliter Th-230 - 3.60×10^{-14} microcuries/milliliter Pb-210 - $.03 \times 10^{-12}$ microcuries/milliliter U - $.01 \times 10^{-12}$ microcuries/milliliter Rn - 4.75 picocuries/liter Solids - .033 micrograms/liter
	6	Station 2 (Camp Cor- rals South of Mill)		One Week/Month First Half 1979	Ra-226 - 0.000×10^{-12} microcuries/milliliter Tb-230 - N.A. Pb-210 - $.01 \times 10^{-12}$ microcuries/milliliter U - $.01 \times 10^{-12}$ microcuries/milliliter Rn - 4.04 picocuries/liter Solids - .025 micrograms/liter
	6	Station 3 (Puddle Springs)		One Week/Month First Half 1979	Ra-226 - $.003 \times 10^{-12}$ microcuries/milliliter Tb-230 - 1.60×10^{-14} microcuries/milliliter Pb-210 - $.02 \times 10^{-12}$ microcuries/milliliter U - $.01 \times 10^{-12}$ microcuries/milliliter Rn - 3.34 picocuries/liter Solids - .009 micrograms/liter
	6	Station 4 (Well No. 13 Area)		One Week/Month First Half 1979	Ra-226 - 0.000×10^{-12} microcuries/milliliter Tb-230 - 3.40×10^{-14} microcuries/milliliter Pb-210 - 0.35×10^{-12} microcuries/milliliter U - $.01 \times 10^{-12}$ microcuries/milliliter Rn - 11.87 picocuries/liter Solids - .033 micrograms/liter
	6	Station 5 Northeast Corner		One Week/Month First Half 1979	Ra-226 - 0.10×10^{-12} microcuries/milliliter Tb-230 - 2.00×10^{-14} microcuries/milliliter Pb-210 - $.043 \times 10^{-12}$ microcuries/milliliter U - $.01 \times 10^{-12}$ microcuries/milliliter Rn - 3.31 picocuries/liter Solids - .015 micrograms/liter
Surface Water	1	Willow Springs (North of Mill)	Grab	Once (March 1979)	pH - 5.98 U - $.03 \times 10^{-5}$ microcuries/liter Ra-226 - 0.57×10^{-8} microcuries/liter Tb-230 - 0.10×10^{-6} microcuries/liter Pb-210 - 0.04×10^{-7} microcuries/liter Fe - <0.02 milligram/liter Mo - .008 milligram/liter U - 48.8 milligram/liter SO_4 - 1113 miligram/liter
Well Water	2	Well No. 16	Monthly Grab	First Quarter 1979	pH - 6.05 U - 0.01×10^{-5} microcuries/liter Ra-226 - 0.65×10^{-8} microcuries/liter Tb-230 - 0.00×10^{-6} microcuries/liter Pb-210 - 0.02×10^{-7} microcuries/liter Fe - <0.02 milligram/liter Mo - 0.352 milligram/liter U - 12.5 milligram/liter SO_4 - 503 milligram/liter N - 2.80 milligram/liter Mn - <0.02 milligram/liter As - .006 milligram/liter Pb - .008 milligram/liter TDS - 896 milligram/liter

TABLE 6.1-1 (Cont)

MILL SITE - OPERATION RADIOLOGICAL MONITORING DATA - FAP PROJECT

Sample Type	Number	Location	Type	Frequency	Results
Monitor Water	2	Monitor Well TPI - DI below Solar Evaparation Pond near Dam Face	Monthly Grab	First Quarter 1979	pH - 5.35 U - 0.22×10^{-5} microcuries/liter Ra-226 - 11.55×10^{-8} microcuries/liter Tb-230 - 0.09×10^{-6} microcuries/liter Pb-210 - 0.06×10^{-7} microcuries/liter Fe - <0.02 milligram/liter Mo - 0.036 milligram/liter U - 164 milligram/liter SO_4 - 1577 milligram/liter N - 5.93 milligram/liter Mn - 1.58 milligram/liter As - 0.010 milligram/liter Pb - 0.012 milligram/liter TDS - 3331 milligram/liter
Monitor Water	2	Monitor Well TPI - DI below Solar Evaparation Pond near Dam Face	Monthly Grab		pH - 6.06 U - 0.01×10^{-5} microcuries/liter Ra-226 - 9.39×10^{-8} microcuries/liter Tb-230 - 0.15×10^{-6} microcuries/liter Pb-210 - 0.10×10^{-7} microcuries/liter Fe - <0.02 milligram/liter Mo - 0.012 milligram/liter U - 12.1 milligram/liter SO_4 - 550 milligram/liter N - 1.62 milligram/liter Mn - 0.07 milligram/liter As - 0.004 milligram/liter Pb - 0.007 milligram/liter TDS - 945 milligram/liter

TABLE 6.1-2

SUBSURFACE TAILINGS SITE - PRE-OP RADIOLOGICAL MONITORING DATA - FAP PROJECT

Sample Type	Number	Location	Type	Frequency	Results
Particulates	5	All around site at Park, Corrals, Puddle Springs, Well #13 and N.E. Corner.			.043 μg/l Jul. 79 Rn - 8.83 pCi/l .017 μg/l Aug. 79 Rn - 15.70 pCi/l .049 μg/l Sept. 79 Rn - 22.14 pCi/l
Particulates	1	At Subsurface Site	High - Volume	24 hours Every 6th Day	Unat - .0079 μg/m³ Th^{230} - .0000 pCi/m³ Apr. 79 Ra^{226} - .0001 pCi/m³ Pb^{210} - .0020 pCi/m³ Unat - .0055 μg/m³ Th^{230} - .0001 pCi/m³ May 79 Ra^{226} - .0001 pCi/m³ Pb^{210} - .0020 pCi/m³ Unat - .0022 μg/m³ Th^{230} - .0002 pCi/m³ June 79 Ra^{226} - .0000 pCi/m³ Pb^{210} - .0060 pCi/m³
Soil Sample	2	Sagebrush Ext. (Sub-surface Site Area)	Grab	Once	Ra^{226} - 1.02 pCi/l #1 Ra^{226} - 2.28 pCi/l #2 U - 0.168 mg/g #1 U - 0.350 mg/g #2
Soil Sample	2	Bullrush Pit (Similar Type Area to Sub-surface Site)	Grab	Once	Ra^{226} - 11.74 pCi/l #1 Ra^{226} - 34.5 pCi/l #2 U - 0.016 mg/g #1 U - 0.028 mg/g #2

TABLE 6.1-2 (Cont.)

SUBSURFACE TAILINGS SITE - PRE-OP RADIOLOGICAL MONITORING DATA - FAP PROJECT

Sample Type	Number	Location	Type	Frequency	Results	
Overburden Sample	3	Sub-surface Site	Grab	Once	Sample #1 -	
					pH - 8.1	Cd - <0.2 ppm
					Mo - 0.11 ppm	F - 274 ppm
					Fe - 192 ppm	As - 2.0 ppm
					Cu - 0.6 ppm	Se - <0.03 ppm
					Mn - 3.4 ppm	Hg - 0.010 ppm
					Zn - <0.5 ppm	U - 10 ppm
					Ni - <1.0 ppm	Th^{230} - 13 ppm
					Pb - <1.0 ppm	Ra^{226} - 3.5 pCi/g
					Sample #2 -	
					pH - 7.6	Cd - <0.2 ppm
					Mo - 0.04 ppm	F - 232 ppm
					Fe - 86 ppm	As - 7.6 ppm
					Cu - <0.5 ppm	Se - <0.03 ppm
					Mn - 7.0 ppm	Hg - <0.01 ppm
					Zn - <0.5 ppm	U - 12 ppm
					Ni - <1.0 ppm	Th^{230} - 17 ppm
					Pb - <1.0 ppm	Ra^{226} - 4.0 pCi/g
					Sample #3 -	
					pH - 8.2	Pb - .8 ppm
					Mo - 0.09 ppm	Cd - <0.05 ppm
					Fe - 41 ppm	Se - 0.025 ppm
					Cu - 0.6 ppm	U - 10 ppm
					Mn - 0.9 ppm	Th^{230} - 17 ppm
					Zn - 1.0 ppm	Ra^{226} - 3.5 pCi/g
					Ni - 0.3 ppm	

TABLE 6.1-3

WATER MONITORING

Hole Identity	Depth of Water (Feet)	May 1979 (pH)	June 1979 (pH)
M-1	40	4.01	4.38
M-2	48	2.55	2.72
M-3	25	5.58	5.69
M-4	14	4.05	3.63
TP1-1	7	4.80	5.23
TP1-10	38	5.00	6.20
TP1-20	62	5.60	6.09
TP1-24	3	3.46	3.94
TP2-1	41	5.92	5.88
TP2-2	38	5.97	5.93
TP1-D1	141	N/A	N/A
TP1-D2	57	5.98	5.73
WELL-6	13	6.12	5.75
WELL-13	61	5.50	6.27
WELL-16	160	5.58	6.10

TABLE 6.2-1

OPERATIONAL EFFLUENT MONITORING PROGRAM FOR FAP URANIUM MILL

Type of Sample	Sample Collection: Number	Sample Collection: Location	Sample Collection: Type	Sample Collection: Frequency	Sample Measurement: Frequency	Sample Measurement: Type of Measurement
AIR						
Particulates	One	Crusher dust collector stack	Isokinetic or equivalent	Monthly (for 1 week period)	Monthly	Natural Uranium, Ra-226, Th-230
	One	Yellow cake roaster stacks	Isokinetic or equivalent	Monthly (for 1 week period)	Monthly	Natural Uranium
	One	Ore dryer stack	Isokinetic or equivalent	Monthly (for 1 week period)	Monthly	Natural Uranium, Ra-226, Th-230
Radon Gas	Three	Same locations as for air particulates (above)	Continuous for two days/month representing about the same period each month	Samples collected for 48-hr intervals	Each 48-hr sample	Rn-222
WATER						
Drain water	One	Discharge to tailings pond	Grab	Weekly	Weekly	Natural Uranium, Th-230, Ra-226
Groundwater	One	Well located hydrologically upgradient from tailings disposal area to serve as control or background location	Grab	Quarterly	Quarterly	Natural Uranium, Ra-226, Th-230, Pb-210, Po-210, chemicals*
Surface Water	One	Drainage system downstream of mill and tailings area	Grab	Quarterly following precipitation event	Quarterly following precipitation event	Total natural Uranium, Ra-226, Th-230, Pb-210, Po-210, suspended solids

*Chemical parameters to be analyzed will be determined from an analysis of samples taken from the tailings pond once mill operations have begun.

TABLE 6.2-2

OPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM FOR FAP URANIUM MILL

Type Sample	Number	Location	Method (Duration)	Frequency	Frequency	Nuclide or Radiation
AIR Particulates	Three	Locations near the site boundaries; 1 upwind - 1 downwind 1 near FAP	Continuous	Weekly filter change, or more frequently as required by dust loading	Quarterly composite, by location, of weekly samples	Natural Uranium, Ra-226, Th-230, and Pb-210
	One	At the nearest residence in FAP Camp	Continuous	Weekly filter change, or more frequently as required by dust loading	Quarterly composite, by location, of weekly samples	Natural Uranium, Ra-226, Th-230 and Pb-210
	One	Control Location at Puddle Springs Ranch	Continuous	Weekly filter change, or more frequently as required by dust loading	Quarterly composite, by location, of weekly samples	Natural Uranium, Ra-226, Th-230, and Pb-210
Radon Gas	Four	Same Locations as for air particulates except upwind on site	Continuous for one week	One week per calendar month representing approximately the same period each month	Monthly	Rn-222
WATER Groundwater	Three	Well #13, WS 12, and Ft. 22	Grab	Monthly (1st yr) Quarterly (after 1st yr)	Monthly (1st yr) Quarterly (after 1st yr)	Dissolved natural Uranium, Ra-226, and Th-230
	One Control Sample	Well #16 used for drinking water	Grab	Quarterly	Quarterly	Total natural Uranium, Ra-226, Th-230, and Po-210
WATER Surface water	Two	Willow Springs	Grab	During runoff		Total natural Uranium, Ra-226, Th-230 and Po-210
DIRECT RADIATION	Ten	Same as for air particulate samples +5	TLD's	Monthly	Monthly	Monthly measurements of X- + gamma-ray exposure rates
SOIL	Five	Same as for air particulate samples	Grab (5 cm deep)	Annually	Annually	Natural Uranium, Ra-226, and Pb-210
VEGETATION OR FORAGE	Three	From animal grazing areas near the mill site and downwind	Grab	Three times during grazing season (June-September)	Each sample	Ra-226 and Pb-210

TABLE 6.2-3

REPORT OF ANALYSIS
(October 28, 1977)

Analysis No.	Sample Designation	As (mg/l)	Cu (mg/l)	Pb (mg/l)	Nitrate, as N mg/l	SO_4 (g/l)	Zn (mg/l)	U (mg/l)
12313-1	Tailings Pond #1 Well	<0.01	0.03	0.13	40	4.06	0.02	4.3
-2	Tailings Pond #2	10.1	2.06	1.45	0.39	13.2	4.99	8.8
-3	Well #13	<0.01	0.01	<0.05	0.06	0.41	0.01	0.010
-4	Well #16	<0.01	0.10	<0.05	0.22	0.50	0.06	0.003
-5	Mimar Pond	0.07	0.01	<0.05	0.85	0.12	0.01	0.09
-6	Tailings Pond #1	12.1	1.61	1.76	0.55	18.8	10.3	18.6
	(December 9, 1977)							
12540-3	T. P. Well #1A	<0.01	0.03	0.13	0.24	4.00	0.02	

Note: Pb^{210}, Ra^{226}, and Th^{230} were not run due to insufficient sample.

7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The occurrence of accidents related to operation of the expanded mill would be minimized through the proper design, manufacture, and operation of process components and through a quality assurance program designed to establish and maintain safe operations. In accordance with the procedures set forth in the appropriate regulations, FAP has submitted applications containing descriptions of the facility design, the organization of the operation, and the quality assurance program. These documents, together with the Environmental Report and supplements, would be reviewed by various agencies to ensure that there is a basis for safe operations at the site. Moreover, those agencies would maintain surveillance over the plant and its individual safety systems by conducting periodic inspections of the facility and its records and by requiring reports of effluent releases and deviations from normal operations.

Despite the above precautions, accidents involving the release of radioactive materials or harmful chemicals have occurred in operations similar to those proposed by FAP. In this assessment, therefore, accidents that might occur during milling operations have been postulated and their potential environmental impacts evaluated. The probabilities of occurrence and the nominal consequences are assessed, using the available estimates of probabilities and realistic assumptions regarding release and transport of radioactive materials. Where information adequate for a realistic evaluation was unavailable, conservative assumptions were used to compute environmental impacts. Thus, the actual environmental impacts of the postulated accidents would be less, in some cases, than the effects predicted by this assessment.

Exposure pathways considered in estimating dose commitments resulting from accidental releases were inhalation and immersion in contaminated air. It was assumed that exposure through the ingestion and surface pathways could be controlled if necessary.

7.1 MILL ACCIDENTS INVOLVING RADIOACTIVITY

The specific activities of the radioactive materials handled at the mill are extremely low: $\approx 10^{-9}$ curies per gram for the ore and tailings and $\approx 10^{-6}$ curies per gram for the refined yellow cake product.* The quantities of materials handled,

*In contrast to the relatively high specific activities of a number of prominent radionuclides (i.e., $\approx 10^{-1}$ curies per gram for plutonium-239 and $\approx 10^{-9}$ curies per gram for cobalt-60).

on the other hand, are relatively large: 1035 metric tons (1,140 short tons) of yellow cake per year, representing ≈ 600 curies of radioactivity per year. These very low specific activities require the release of exceedingly large quantities of material to be of concern; driving forces for such releases would not exist at the mill site.

For this assessment, the postulated plant accidents involving radioactivity are considered in the following three categories:

- Trivial incidents (i.e., those not resulting in a release to the environment).
- Small releases to the environment (relative to the annual release from normal operation).
- Large releases to the environment (relative to the annual release from normal operations).

Trivial incidents would include spills, ruptures in tanks or plant piping containing solutions or slurries, and rupture of a tailings disposal system pipe in which the tailings slurry would be released into the tailings disposal area. Small releases would result from failure of the air cleaning system serving the concentrate drying and packaging area, a fire or explosion in the solvent extraction circuit, or an explosion in the yellow cake dryer. Large releases would result from a major tornado strike or earthquake.

During the three decades of nuclear facility operations, the frequency and severity of accidents have been markedly lower than in related industrial operations. The experience gained from the few accidents that have occurred has resulted in improved engineering safety features and operating procedures, and the probability that similar accidents might occur in the future is very low. Based on analysis, it is believed that even if major accidents did occur, there would probably not be a significant release of contamination offsite, and radiological exposures would be too small to cause any observable effect on the environment or any deleterious effect on the health of the human population.

7.1.1 Trivial Incidents Involving Radioactivity

The following accidents at the mill caused by human error or equipment failure would not result in the release of radioactive material to the environment.

7.1.1.1 Minor Leaks

A minor leak in a pipeline inside the mill would result in the release of a few gallons of chemically contaminated solution. Since a leak of this type would be visible inside the mill, quick detection and corrective action, such as isolation of the leaking line, would be taken. All spilled liquids would be returned to mill process streams, and spilled tailings would be pumped to the tailings disposal areas.

Oil and chemical spills too small to efficiently route into mill circuits would be cleaned up using the most efficient and environmentally acceptable techniques available.

7.1.1.2 Major Tank or Piping Failure

Because of FAP's detection and correction procedures, major leaks or tank ruptures occurring inside the buildings should not cause any impact to the external environment. The contained liquids would be confined within the building perimeter, reclaimed for recycle to process systems or disposal to the tailings disposal area.

7.1.1.3 Release of Uranium-Bearing Material to Tailings Disposal Area

Since all milling processes would be closely monitored a significant release is unlikely. No offsite environmental releases would be expected, and the increase in radioactive material deposited in the tailings disposal area would neither significantly increase dose rates offsite nor complicate final restoration of the site.

7.1.2 Small Releases Involving Radioactivity

The following accidents, due to human error or equipment failure, would release small quantities of radioactive materials to the environment. The estimated releases, however, are expected to be small in comparison with the annual release from normal operations.

7.1.2.1 Scrubber Failure

Partial failure of the wet scrubbers on the yellow cake dryer or the packaging operations could result from a water pump failure, a clogged water line, or a loss of water supply. Even with a complete loss of water to the scrubber, partial removal of yellow cake would occur by impingement within the scrubber. However, maximum permissible concentrations of yellow cake in the stack exhaust would probably be exceeded for a short time. Detection of the failure

would be by direct observation of the appropriate instrument and control systems during the shift, or by the routine monitoring discussed in section 6. Corrective actions would involve an immediate shutdown of the dryer and/or packaging operations until the necessary repairs or alterations were completed.

The environmental impact of a scrubber failure and subsequent yellow cake release would require evaluation of conditions prevalent at the time of the accident. Monitoring of yellow cake contamination and cleanup following such an incident might be necessary. However, measurable effects are expected to be limited to the vicinity of the site.

7.1.2.2 Fire

The greatest potential in the plant for a fire with offsite effects is in the solvent extraction area where kerosene would be used in the chelating process. Special precautions would be taken to reduce the possibility of a fire in the area. These include: prohibiting smoking and requiring a written permit signed by the maintenance supervisor and plant superintendent to perform any maintenance, welding or cutting, or use of portable power equipment in an empty tank that contains or contained organic solution.

Should a fire occur in the SX area, a number of separate and concurrent actions would be taken to prevent the spread of the fire, and to minimize its severity, including:

- All mixers and pumps would be de-energized to prevent the advance of the organic and the spread of the fire.
- All electric power to that area of the mill, would be disconnected.
- An overhead automatic extinguisher system would be activated to control any kerosene fire in the tanks.
- Conventional fire fighting techniques would be employed by the company fire department.

In the solvent extraction circuit which contains approximately 37,850 liters (10,000 gallons) of kerosene, the uranium held in acid aqueous solution would be extracted into an organic phase. This organic phase would be approximately 92 percent kerosene by volume. The pregnant organic phase would be separated from the aqueous phase, and then stripped of uranium.

In either of these steps, it would be possible for the kerosene in the organic phase to catch fire and release a heavy black smoke containing carbon soot and some natural uranium. The solvent extraction area would be equipped with an automatic extinguisher system capable of containing the fire. Portable fire extinguishers would be placed at intervals around the area as necessary. In addition, the solvent extraction operations would be segregated from other operations in the mill building. With these safety precautions, a fire in one of the process tanks would be contained before other tanks were ignited. The smoke generated by the fire would be released to the atmosphere through the air vents in the top of the building.

Since the project is located in a remote area, such a fire is not expected to cause significant environmental impacts. The short-term release of smoke, soot, and unburned hydrocarbons would decrease air quality and might cause some damage to vegetation within the immediate vicinity of the plant, but these effects would be of a very short-term nature. The release of uranium in the smoke would be most serious if the fire happened at a time when all the uranium was in the organic phase. The uranium carried in the soot would be dispersed over the same area as the smoke. However, this uranium would have very low levels of radioactivity. In a documented case of an actual fire in a uranium solvent extraction unit, the area around the burned building was sampled at distances of 30 meters (100 feet) and 400 meters (0.25 mile). No detectable uranium was found [ref 1].

As far as can be determined, any fire in the solvent extraction system would most likely be caused by human carelessness rather than by spontaneous or process-related incidents. In 1968, two solvent extraction fires occurred in uranium mills. Between 900 and 1,360 kilograms (2,000 and 3,000 pounds of uranium were involved in each fire. Damages from the fires totaled $1 million. However, neither fire resulted in appreciable releases of uranium to the unrestricted environment, and essentially complete recovery of the uranium was predicted. Consequently, the impact from such an event at the FAP facility would be limited to the cleanup of contaminated soil, replacement of destroyed mill components, and a short duration release of non-radioactive combustion products to the atmosphere.

On the basis of these facts, a maximum probability of one such fire per 200 years of operation is estimated. The probability that a fire would produce a significant environmental impact is negligible.

7.1.3 Large Release Involving Radioactivity

The following incidents might release large quantities of radioactive materials to the environment compared with annual releases from normal operations. By virture of complex and highly variable dispersion characteristics, however, the individual impacts would not necessarily be proportional to the total amount of radioactivity released to the environment.

7.1.3.1 Failure of Tailings Retention System

Because the tailings would be disposed in a subsurface area, a failure of the retention system would not be possible. The following discussion would pertain to the solar evaporation pond.

In considering conditions that might lead to a breaching of the solar evaporation pond retention system, and therefore an accidental release of waste, it should be noted that the solar evaporation pond area does not encompass a natural drainage area, so flash floods from this source can be eliminated. It is, therefore, only necessary to consider the precipitation falling directly on the solar evaporation pond area as a potential flood-causing mechanism. Analysis has shown that 1.5 meters (5 feet) of embankment freeboard, which would be maintained, is quite sufficient to accommodate the maximum precipitation for the area which is in the order of 33 centimeters (13 inches).

The other potential condition for releasing waste from the solar evaporation pond would be a failure of the dam. A failure is considered to be extremely unlikely because:

- Analysis of the slope stability of the 1977 construction data under a wide range of rather severe conditions indicate that the dam should be stable under all conditions.

- The site is in the Zone One seismic risk category where damage from earthquake is defined as "minor" and would not be sufficiently severe to cause failure of the system.

- The solar evaporation pond area is inspected each shift for incipient damage and to ensure that no release of waste would occurr as a result of equipment failure or operator error.

- Open check well monitoring would be used to monitor the condition of the dam on a quarterly basis.

- Annual bank stability evaluations consisting of the onsite inspection by an engineer, review of open check well records, and subsequent evaluation would be performed.

Nevertheless, an analysis was performed for a postulated dam failure considering maximum impounding behind the solar evaporation pond dam. The conclusion of the analysis was that 90 percent of the solid tailings lost during such a failure would be contained behind a roadway fill immediately below the plant and the remainder would go no farther than 3.2 kilometers (two miles) because of high infiltration rates in the area. The closest continuously flowing body of water is the Boysen Reservoir, 85 kilometers (53 miles) from the mill. The consequences of such a failure would therefore be relatively minor.

In the unlikely event that a dam failure occurs, efforts would be made to immediately close the break to reduce the loss of liquid effluent. The solar evaporation pond dam has been designed to withstand all predictable meteorological and seismological conditions which are probable at the site. In spite of these precautions, a probability exists that some natural event or unforeseen accident might cause a break in the dam.

Tailings dam failures have been reported. Of six tailings dam failures that occurred between 1959 and 1971, one was attributed to flooding conditions, one was the result of erosion from a break in a tailings pond slurry line, and the other four were apparently due to poor structural design. None of these failures resulted in measurable releases of radionuclides to natural waterways in excess of the federal regulations.

In the event of a major release, the pond liquid might flow into Willow Springs Draw before the spilled liquid was absorbed in the soil or evaporated. Both Willow Springs Draw and Muskrat Creek, which Willow Springs Draw feeds, are dry most of the year, which would reduce the risk of contamination.

The environmental effects of such an accident would likely be small. As soon after the flood as possible, contaminated areas would be surveyed for radiation. Affected soil and vegetation, above limits, would be removed and livestock would be kept out of the area until cleanup operations were completed. Since no one lives in this portion of the Gas Hills area, it is unlikely that people would come into direct contact with any radionuclides released in the accident. There is a possibility that radionuclides deposited on vegetation could enter the natural food web, but it is not expected that the amounts would be large enough to create a significant impact.

7.1.3.2 Tornado

Although the occurrence of a tornado in the Gas Hills area is highly remote, the most significant environmental impact from such a phenomenon would be picking up liquid and dispersing it to the environment from the tailings disposal area. The dispersed liquid would have a pH between 1.5 and 2.0 and contain some uranium, radium, and/or thorium. The liquid deposited in this manner should not harm plant or animal life. A slight increase in background radiation could result, but the increase would not exceed a few percent of natural background in the dispersal area.

7.1.3.3 Earthquake

The facility has been designed to withstand all severe environmental conditions remotely possible in the area. If an earthquake of sufficient magnitude were to occur, the effects would be the same as a major break in the solar evaporation pond dam. Destruction of mill equipment might also result.

7.2 TRANSPORTATION ACCIDENTS

The accidents whose potential effect on the offsite environment that need to be evaluated are those involving the vehicle moving the yellow cake concentrates.

The product would be packed into steel drums to a net weight of approximately 408 kilograms (900 pounds) and then shipped to the uranium enrichment facility. The drums would be sealed and properly marked for low specific activity radioactive material. The vehicles transporting the product would also be properly marked for the shipment of radioactive material. The product would be shipped by an interstate trucking company.

The amount of yellow cake that would be released by breaching the drums would depend on the severity of the accident. During the course of operation of the Gas Hills mill since 1959, there has been one vehicular accident resulting in release of concentrate, produced by another mill in the area and the probability of another such occurrence is considered to be extremely small. Should such an accident occur, no severe radiological hazard would result to people at the accident scene or in the vicinity because of the low specific activity level of the yellow cake. Under the regulations of the U.S. Department of Transportation, uranium oxide is classified as low specific activity material (49 CFR Part 173, Section 173, 389C and 173.392).

The extent of the environmental impact of a transportation accident involving the product would be very small. Even in the case of a severe accident, only a few drums are likely to be breached. Furthermore, the dispersion of the material would be limited because of its density. Standard decontamination procedures would be applied and the spill removed and returned to the plant. Any contaminated soils in the vicinity of the vehicle would also be removed for burial or recovery of uranium. The responsibility for handling a yellow cake spill during transportation would be with the shipper under Department of Transportation regulations.

The probability that a transportation accident will occur is about 10^{-6} per vehicle mile; it decreases to about 10^{-13} per vehicle mile for very severe accidents (AEC, 1972). Procedures require shipments of low level radioactive materials to be in compliance with applicable state and federal regulations.

7.3 OTHER ACCIDENTS

Other mishaps such as overflows from process tanks, chemical explosions, fires, or large spills of reagents such as sulfuric acid or kerosene are credible accidents that may occur in uranium mill operations. Spillage in the mill would be washed down and pumped back into the mill circuit.

Several non-radioactive chemicals would be used and stored within the mill area. Table 7.3 lists chemical storage, daily use rates, and environmental or toxicological data. In general, non-radiological accidents are similar to those of any other facility using similar quantities and types of chemicals. The probability of serious environmental effects from any of these accidents is low.

7.3.1 Chemical Spills

Quantities of ammonia, kerosene, sulfuric acid, and diesel oil would be stored within the restricted area. With the exception of ammonia, all spills of stored chemicals would be absorbed in the soils or contained in the immediate vicinity of the storage tank. Most of the spilled liquid could be pumped to the process or the tailings pond. However, a portion of the chemicals absorbed in the soil would have to be cleaned up by FAP.

An ammonia spill would result in ammonia vapor dispersed to the environment; however, the resultant concentrations would be quite low and offsite consequences would be negligible.

7.3.2 Strong Winds

Strong winds are common in the plant area. In the 20 years for which data has been accumulated for the Casper, Wyoming area, the highest record wind was 130 kilometers (81 miles) per hour. Winds of this magnitude are not expected to damage plant facilities. These winds would create waves in the solar evaporation pond, but the impact on the environment would be slight because the impoundment would have sufficient freeboard to prevent any spillage.

High winds would blow dust from unprocessed ore piles. However, this dust is of low specific activity, and causes very little measurable increase in environmental background levels.

7.3.3 Minor Flood

During the summer months, the area occasionally experiences short periods of heavy rainfall. Rainfall within the solar evaporation pond area would be contained.

Storm runoff from the mill site follows the natural gravity drainage system. Radioactive release from flooding is remote. During periods of heavy rainfall, the only flood damage at the mill site is surface. Erosion damage is repaired by bulldozing, and no long-term damage is anticipated. Embankments are landscaped to minimize stormwater erosion.

7.3.4 Major Flood

A major flood of such a magnitude as to break the solar evaporation pond dam or wash out portions of the below surface tailings disposal area is considered highly improbable. This type of flood would result in dispersion of tailings and ore over an area of land in the immediate vicinity of the mill. Due to the isolation of the location, it is unlikely that background levels of radioactivity would measurably increase in populated areas. Once the flooding had subsided, the area would have to be surveyed to establish the impact of the presence of tailings and ore on plant and animal life. If adverse impacts on important biota were identified, the area would be cleaned up.

REFERENCES: SECTION 7.1

1. Personal communication to Humble Oil Refining Co. from Petrotomics Mill Superintendent, 1971.

TABLE 7.3

CHEMICAL STORAGE

Chemical and Form	Storage Capacity	Daily Use Rate	Environmental or Toxicological Data
Ammonia (Liquefied)	24,000 gallons	8.75 short tons	TLV (threshold limit value); 25 parts per million in air (1).
Kerosene (Li[illegible]	5,000 gallons	30 gallons	LD50 rabbits (lethal dose to 50% of rabbit population) 28.350 milligrams/kilogram (3). Moderate fire hazard.
Sodium [illegible]ate (Solut[illegible]	20,000 gallons	5.3 short tons	Local irritation (4) may form highly flammable compounds with organic materials.
Sulfuri[illegible] (Liquid)	1,000 short tons	96 short tons	TLV 1 milligram/cubic meter (2).
Natural gas	NA	7.0×10^5 cubic feet	Moderate fire and/or explosion hazard.
Chlorine, for water treatment (Gas)	200 pounds	0.4 pounds	TLV 1 part per million air; 3 milligrams/cubic meter air (2).
Diesel oil, stored in underground tanks	13,000 gallons (2 tanks)	200 gallons (a)	LD50 rabbits 28.350 milligrams/kilogram (3). Moderate fire hazard (4).

(1) Manufacturing Chemist Data Sheet SD3.
(2) American Conference of Governmental and Industrial Hygienists, 1975.
(3) Merck Index, 1968.
(4) Sax, 1968.
(a) Diesel oil is intended for heavy equipment.

8. ECONOMIC AND SOCIAL EFFECTS OF MILL OPERATION

8.1 BENEFITS

The plans are to expand the plant from 950 to 2,950 short tons (862 to 2,680 metric tons) per day. This is in line with the U.S. goals to expand uranium production to meet the increased needs of nuclear-powered facilities. Currently the U.S. is searching for alternate forms of energy other than petroleum. Various coal, synthetic fuels, and nuclear processes are under research to meet the U.S. energy requirements for the remainder of the twentieth century. The facility would produce approximately 2,188,800 pounds of U_3O_8 from low grade uranium ore per year. The equivalent electrical energy which could be produced by fission of the product would be approximately 185,000 megawatt hours, assuming 50 percent efficiency in recovery of U_{235} and a generating efficiency of 33 percent. Therefore, this expansion of the mill helps to meet this national goal.

The mill expansion would create jobs for twenty additional personnel. These additional jobs would create additional sources of revenue for state, local and Federal governments through taxes, additional markets for the local merchants, and of course jobs for twenty additional persons. The infusion of money, as wages and in purchases of goods and services, into the local area exerts a multiplier effect to the economy. The real meaning of the payments for wages, goods, and services is that these monies will provide support to the worker and the worker's family, and to the supporting industry in the community.

The expansion of the mill, because of the new equipment being installed and the new processing methods being used would improve the quality of the surrounding environment while increasing production. The mill expansion would also provide an opportunity for making improvements to the current operations in a timely and economic fashion.

The use of uranium for the generation of electrical power may reduce the use of fossil fuels which can in turn improve the average air quality in the communities near the source of electrical power generation.

The absolute economic value or financial benefits derived from the mill expansion are difficult to quantify.

8.2 ESTIMATED COSTS

As specified in the NRC Regulatory Guide 3.8 "Preparation of Environmental Reports for Uranium Mills", September 1978, costs for decommissioning and reclamation have been estimated. These 1979 costs will help in the establishment of a bond.

8.2.1 Decommissioning Costs

Decommissioning costs for the FAP uranium mill are shown in table 8.2-1. These direct costs include decontamination and removal of the existing direct mill and proposed mill expansion, associated buildings, and foundations, equipment, and roads.

The decommissioning is based on cost data for a similar uranium facility. Quantities for building areas, fencing, and roads were taken from a plot plan; all other quantities were factored from a similar facility.

These cost figures may change depending on conditions at the time of final decommissioning. The assumptions made in terms of cost estimating are as follows:

a) Private Access Roads and Fencing

Costs are estimated to remove fencing and remove the top portion of the roadway, and haulage to the disposal area for burial.

b) Ore Pads

Costs include labor and equipment to remove concrete ore pads and haul them to the disposal area for burial.

c) Buildings Except Mill Buildings A and B

Skin and other architectural components would be dismantled and hauled to the disposal area for burial. The steel would then be dismantled, decontaminated, and sold for scrap. All foundations would be broken up and hauled to the disposal area for burial.

d) Mill Buildings A and B

It is assumed, as far as cost, that the mills would be demolished and hauled to the disposal area for burial. Foundations would then be broken up and hauled to the disposal area for burial.

e) Equipment

All mill building and SX equipment would be cut up into manageable sizes and hauled to the disposal area for burial. Other equipment would be cleaned and sold for scrap. Brick work from the furnaces would be removed and passed through another uranium mill crushing and processing facility. Mobil equipment would be cleaned and sold as used equipment, or scrapped.

f) Miscellaneous Steel, Electrical, etc.

Cost figures were included to cut up and haul miscellaneous material to the disposal area for burial.

8.2.2 Reclamation Costs

The costs of reclaiming the land once decommissioning has been completed are presented in table 8.2.2. This table includes costs for reclaiming the mill site, solar evaporation ponds, mill tailings, subsurface disposal site, and tailings disposal line, sewage lagoon and roads. These 1979 costs for materials and labor are based on the assumptions given below. The assumptions have been made for costing only and may change depending on conditions at the time of final reclamation.

8.2.2.1 Tailings Coverage

Tailings would be covered with the necessary material to reduce radon emanation to 2 picocuries per square meter per second above background of overburden. The principal cost for tailings coverage would be truck haulage.

8.2.2.2 Slope Recontouring and Scarification

The majority of grading and recontouring would be of the banks of the solar evaporation system. A few other areas, such as where foundations are removed, would also require grading. Scarification would be done during grading operations also.

Ripping or scarification is done to reduce compaction in areas such as roads, to prevent slippage of topsoil, and to allow a good overburden-topsoil interface. This ripping would promote better vegetative growth.

It is assumed that approximately 134 acres will be involved in recontouring, scarification, and all remaining tasks.

8.2.2.3 Topsoil Redistribution

The majority of the topsoil costs would be due to haulage and/or upgrading inferior material to a suitable topsoil quality.

8.2.2.4 Fertilization, Neutralization, Seeding, and Mulching

Revegetation costs are estimated at 600 dollars per acre. It is assumed that nitrogen and phosphorus fertilization would be required along with possible neutralization to adjust soil pH. Species discussed in section 9 have been considered for seeding. Mulching costs were also added to the estimate and are based on the probable application of approximately two tons of straw mulch per acre.

8.2.2.5 Maintenance and Monitoring

Approximately 20 dollars per acre for 5 years or a total of 100 dollars per acre is assigned for revegetation maintenance. This may vary greatly during actual reclamation depending on droughts, etc. Maintenance costs would include regrading, reseeding and fertilization, weed and animal control, and fencing expenses.

TABLE 8.2.-1

ESTIMATE OF COST FOR DECOMMISSIONING OF FACILITIES TO BE DEACTIVATED AFTER PROCESSING OPERATIONS CEASE

Description	Amount
Strip Ore Pad Area	$ 58,800
Strip All Roads	37,400
Remove Plant Fencing	18,000
Remove Structures	
Excavation & Backfill	54,000
Remove Slabs	138,300
Remove Foundations	216,200
Remove Structural Steel	66,000
Remove Miscellaneous Steel	36,000
Remove Building Exterior	81,900
Remove Building Interior	12,600
Equipment Removal	600,000
Furnace Brick Disposal	15,000
Electrical	285,000
Piping	338,000
Scrap Value	
Equipment	(450,000)
Structural & Miscellaneous Steel	(24,600)
Total Direct Cost (Excluding Escalation)	$ 1,482,600

TABLE 8.2-2

ESTIMATE OF COST FOR RECLAMATION OF FACILITIES TO BE DEACTIVATED AFTER PROCESSING OPERATIONS CEASE

Description	Amount
Cover Tailings With Overburden	
Solar Evaporation System	$ 482,000
Subsurface Tailings Disposal Area	965,000
Recontour Slopes and Scarification	240,000
Topsoil Redistribution	175,000
Fertilization, Neutralization, Seeding, and Mulching	80,000
Maintenance and Monitoring	225,000
Total Estimate Cost (Excluding Escalation)	$2,167,000

9.0 INTERIM STABILIZATION, DECOMMISSIONING, AND RECLAMATION

9.1 INTRODUCTION

Interim stabilization, decommissioning, and reclamation are all related as they are oriented toward protecting the workers and the environment in general. Interim stabilization would accomplish this during the operation period. By taking certain special measures in the interim period, safer conditions would exist and final decommissioning would be less expensive.

The purpose of the mill decommissioning and site reclamation program is to restore the area disturbed by milling activities to essentially its original state. The program would include the survey and cleanup of the contaminated mill site, private access roads, building, and equipment, followed by removal of salvageable items and disposal of unsalvageable items by burial in the tailings disposal area.

The tailings disposal reclamation program would provide conditions meeting a "restricted area" classification. This plan would prevent tailings from adversely affecting the environment by specifying measures such as overburden placement, topsoil layering, and revegetation.

9.2 INTERIM STABILIZATION

Measures would be taken during operations to prevent the dispersion of particles by wind and water outside the operational area. The control measures would be checked routinely to determine effectiveness.

These design and operational measures or considerations would directly provide interim stabilization and also reduce the site decommissioning work and cost. For example, the principal of maintaining employee exposure and radioactive effluent release as low as reasonably achievable (ALARA) would be considered in the course of the facility and equipment design.

The following design features would be employed to assure satisfactory operation of the facility with respect to maintaining radiation exposure ALARA, and to provide interim stabilization in general:

- Provisions for ore dust suppression.
- Provisions for yellow cake dust entrainment.

- Provisions for decontamination of tools and components that are removed for repair or maintenance.

- Provisions for maintaining negative pressure differential in potentially contaminated areas of building.

- Design of mill floors and sump such that if liquid leaks from tanks, vessels, and other equipment, it does not leak out on to the site.

9.3 DECOMMISSIONING AND RECLAMATION

9.3.1 Schedule

Final decommissioning and reclamation would occur roughly over a ten year period. Initiation of these activities would probably start sometime after 10 years or longer, dependent on economics. Since the exact year when processing would conclude is not known, initiation of decommissioning is arbitrarily assigned:

Activity	Year
Decommission mill and transport of non-salvageable mill equipment and materials to tailings disposal area.	1
Contaminated soil removal in mill area.	1
Tailings disposal area drying period.	2 & 3
Addition of overburden to tailings disposal areas and mill site.	4
Slope recontouring - tailings.	4
Topsoil replacement - tailings.	4
Revegetation - tailings.	4
Revegetation maintenance - tailings.	5-10

9.3.2 Decommissioning Criteria

9.3.2.1 Land Cleanup Criteria

The objective of the decommissioning program at the uranium mill site would be to reduce the radon flux and gamma-dose rate above background to below the following target criteria [ref 1]:

- The radon-222 flux (above background) at the soil-air interface should not exceed a flux equivalent to that which would result from a soil concentration of 3 pCi/g of radium 226 at infinite thickness.

- The gamma dose-rate in air one meter above the ground should not exceed five (5) microroentgens per hour above background.

The primary sources of land contamination at the uranium mill site are ore and tailings. It has been shown that radium 226 is the critical nucleide with respect to potential radiation exposure associated with future land use.

9.3.2.2 Tailings Cleanup Criteria

Considerations have been given to the following post-reclamation performance objectives as defined in NRC Regulatory Guide 3.8 [ref 2] and 10 CFR 40 [ref 3].

- Reduce direct gamma radiation from the tailings disposal area to essentially background.

- Reduce the radon emanation rate from the tailings disposal area to about twice the emanation rate in the surrounding environs.

- Reduce radon from wastes to less than 2 picocuries per square meter per second above natural background level.

- Meet the criteria so as to be able to eliminate the ongoing monitoring and maintenance program following successful reclamation.

9.3.2.3 Facility and Equipment Decontamination Criteria

To accomplish the decontamination of equipment prior to abandonment or release for unrestricted use, the acceptable surface contamination levels, shown on table 9.3-1 of NRC Guidelines for Decontamination of Facility and Equipment [ref 4] would be followed.

9.3.3 Contamination Survey

Prior to initiating the decommissioning plan a contamination survey would be made to assess the extent of decontamination required for ore pad, roads, mill building, associated equipment located within the mill site fence, and the tailings disposal area.

9.3.3.1 Soil Survey

Potential soil contamination is expected at the ore pad and to a lesser degree on roads used to haul ore within the mill site. It is expected that the soil nearest the surface would contain the highest concentration of contamination and that the solid concentration would decrease with depth. To adequately assess the extent of contamination, soil pro le sampling or in situ gamma ray measurements of boreholes would be made at selected locations on the mill site to define the profile and depth of contamination and to determine if any unsuspected subsurface contamination exists.

Soil profiles usually show that soil contamination is highest near the surface. Also, compliance with the gamma dose-rate criteria indicates compliance with the radon-222 flux target criteria. Therefore, in these cases a simple gamma screening measurement technique could be used to identify contaminated areas greater than 5 microrems per hour requiring cleanup [ref 5].

9.3.3.2 Building and Equipment Survey

To protect personnel engaged in decommissioning of the mill building and equipment, and to also meet the NRC Guideline stated above, contamination surveys would be performed both before and after decontamination operation so that no unexpected radiation exposure would result.

9.3.3.3 Radiation Safety during Survey and Decontamination

During contamination surveys and decontamination operations, strict adherence to the plant radiation safety procedure would be maintained, including the use of respiratory protection and protective clothing, as required.

9.3.4 Building Areas (Except Mill Building and SX Building)

Most outer architectural components would be hauled to the tailings disposal area for burial. Steel would be dismantled and hauled to the mill building, decontaminated, and sold for scrap. Liquid waste would be sent to the evaporation pond. All foundations would be broken up and hauled to the tailings disposal area for burial.

9.3.5 SX and Mill Area

Removal of heavy accumulations of dust in inaccessible areas would occur first [ref 5]. All components would then be demolished, along with foundations, and hauled to the tailings disposal area for burial.

9.3.6 Equipment in the Mill Area

9.3.6.1 Non-Salvageable Equipment

Non-salvageable equipment would be cut up into manageable sizes or broken up (ore pads) and hauled to the tailings disposal area for burial. This includes for example, highly contaminated, soft, and porous material.

9.3.6.2 Salvageable Equipment

Salvageable equipment would be cleaned and sold for scrap. Cleaning could be accomplished by scrubbing with water or detergent as required. For troublesome surfaces sandblasting, steam, scraping, or utilization of special cleaning products such as Turco may be necessary.

9.3.7 Contaminated Ground in the Mill and Associated Areas

Contaminated ground under areas such as the roads, ore pad, and buildings would be stripped and this earth hauled to the tailings disposal area for burial. The amount of stripping would be determined at the time of the final decommission, based on surveys, and would allow compliance with the decommissioning criteria.

9.3.8 Tailings Disposal Areas

Decommissioning of the tailings disposal system would apply to both the solar evaporation area and to the subsurface tailings disposal area.

9.3.8.1 Drying

Drying of the tailings would be allowed to a condition where heavy equipment can operate without getting stuck. Several years would probably be required for drying of the solar evaporation pond tailings.

Due to the chemical and physical properties of the tailings, a hard crust is formed on the surface when it is left to dry undisturbed. The crust is effective in reducing wind and water erosion, blowing of tailings, and the emanation of radon gas and gamma radiation. A detailed report on the crust conditions is contained in section 5.0 of FAP's "Tailings Dams... Application to Construct."

9.3.8.2 Overburden Cover

Overburden coverage would begin when the tailings are sufficiently dry for heavy equipment traffic, and after deposit of non-salvageable equipment, building material, and contaminated ground. The overburden thickness would have to be

sufficient to reduce the radon gas emanation rate to twice the natural background rate. This overburden cover would be of sufficient thickness to safely isolate the tailings from the biosphere. The overburden would be hauled from an open pit to be mined in the 1980's, located southwest. Analysis of the overburden has shown the clay content to be approximately 20 percent, silt content 18 percent, and sand content 62 percent.

9.3.9 All Areas

9.3.9.1 Grading and Scarification

Following backfilling of overburden, grading would be carried out so that the final slope gradient is 3:1 horizontal to vertical.

The final contour design (see final contour map no. 5) would allow for surface runoff water to drain freely without depressions where water would collect. Grading would be done on the banks of the solar evaporation system. A few other areas, such as where foundations are removed, would also be graded.

Scarification or ripping would be done during the grading operation.

The ripping would reduce compaction and prevent slippage of topsoil. This also would allow for a better subsoil-topsoil interface [ref 6].

9.3.9.2 Topsoil Redistribution

Topsoil stockpiled during construction of the expanded mill and original facilities would be applied during reclamation. The amount may vary from area to area as little topsoil was stockpiled during original construction.

9.3.9.3 Seed Bed Preparation

After the topsoil has been spread, it may require disking, addition of straw mulch, and fertilization. If possible, these operations would be conducted along the contour of the slopes. On slopes with a gradient less than 10 percent, tilling operations would be conducted in a direction perpendicular to the predominant south-southwest winds. Fertilization and neutralization would be carried out if determined to be necessary by analysis of the composite soil [ref 7].

9.3.9.4 Seeding

Areas which are not suited to drill seeding would be broadcast or hydroseeded and lightly harrowed prior to drilling where the slopes are too steep for the equipment to be safely operated.

The seed mixture given in table 9.3-2 would be drilled at a rate of 15 pounds per acre. If it becomes necessary to use broadcast seeding techniques, the application rate would be 23 pounds per acre. The plant species mixture would be effective for erosion control and slope stabilization. It would also be suitable forage for wildlife and livestock in the unrestricted grazing areas.

9.3.9.5 Revegetation Maintenance and Monitoring

Maintenance may be necessary in terms of regrading and reseeding in certain areas. In addition, the fence on the perimeter of the restricted area would be maintained during all phases of reclamation and would help assist in the establishment of vegetation. The fence would be approximately 128 centimeters (50 inches) high constructed with woven wire sheep fence and one strand of barbed wire. Encroachment of natural vegetation from surrounding areas is anticipated to occur over a period of several years and should survive unaided.

Operational monitoring of vegetation, water, and air quality will continue into the post operational period until bond release. In terms of vegetation, the monitoring would establish whether revegetation has been at least 70 percent effective. Air monitoring would assess the effectiveness of the decommissioning by measuring particulates. Ground water would be monitored utilizing wells to assure that the radioactive criteria for ground water is not exceeded.

9.4 FINAL DECOMMISSIONING PLAN

A final decommissioning plan would be established and presented at a later date. The assumption made is that all buildings and structures would be dismantled and removed at the completion of milling operations, that all foundations would be broken up, removed and buried in the tailings disposal area, and the site, including the tailings disposal area, would be regraded and replanted with native vegetation.

After decommissioning and reclamation, land use activities would be divided into the classifications of restricted and unrestricted. The restricted area would consist of the stabilized tailings areas, surrounded by permanent fences. The

mill site and some of the roads would be reclaimed to sagebrush and grassland allowing unrestricted use for wildlife and livestock. Boundaries of the two land use classifications are illustrated on the Final Contour after Reclamation Map no. 5.

REFERENCES: SECTION 9

1. NRC, "Staff Technical Position, Fuel Processing and Fabrication Branch, Interim Land Cleanup Criteria for Decommissioning Uranium Mill Sites", May 1978.

2. NRC, "Regulatory Guide 3.8", Revision 1, preparation of Environmental Reports for Uranium Mills, September 1978.

3. NRC, "Uranium Mill Tailings Licensing", 10 CFR 40, Appendix A, Technical Criteria 6, August 24, 1979.

4. NRC, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material", November 1976.

5. NRC, "Draft Generic Environmental Impact Statement on Uranium Milling", Project m-25, April 1979.

6. Thames, John L., "Reclamation and Use of Disturbed Land in the Southwest", 1977.

7. Vories, Kimery, "Reclamation of Western Surface Mined Lands", March 1976.

TABLE 9.3-1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

Radionuclide	Acceptable Levels
U-238	5,000 d/m* over 100 cm^2
	200 d/m removable**
Th-230, Ra-226	100 d/m over 100 cm^2
	20 d/m removable

* "d/m" means disintegrations per minute.

** Activity on filter or soft absorbent material obtained on wiping surface.

TABLE 9.3-2

PLANT SPECIES FOR THE TAILINGS PONDS AND MILL SITE

Species	Kilograms/ Hectare	(Pounds/ Acre)	Seeds/ Square Meter	(Seeds/ Square Feet)
Thickspike Wheatgrass (Agropyron dasystachyum)	3	3	120	11
Western Wheatgrass (Agropyron smithii) Rosana Var.	3	3	87	8
Beardless Bluebunch Wheatgrass (Agropyron spicatun inerme) Whitmar Var.	3	3	109	10
Small Burnet (Sanguisorba minor)	2	2	33	3
Antelope Bitterbrush (Purshia tridentata)	1	1	5	1
Four-Wing Saltbush (Atriplex canescens)	2	2	11	1
Common Winterfat (Eurotia lanata)	1	1	22	2
Douglas Rabbitbrush (Chrysothamnus viscidiflorus)	0.6	0.5	76	7
Total	15.6	15.5	463	43

10. ALTERNATIVES TO THE PROPOSED ACTION

10.1 ALTERNATIVE SITE

FAP's facility site, including the mill and existing tailings improvements has been in continuous operation since 1959. The use of any alternative site would require the construction of a complete new mill at a "greenfield" site. This would be extremely costly and would create additional environmental impacts at a new site. Total environmental impacts would clearly exceed those from expansion at the present site.

The present plan to dispose tailings from the expanded mill in a mined-out pit close to the mill is considered to be the best alternative. This alternative would locate the disposed tailings in an area in which they would have an extremely low probability of being disrupted or dispersed by natural forces. In addition, this tailings disposal alternative would result in the least amount of disturbance to undisturbed areas. Other alternatives, such as providing additional surface disposal areas or digging new pits to dispose tailings, would result in significantly greater environmental impacts because of increased disturbance of surface areas.

10.2 ALTERNATIVE PROCESS

The expanded mill would use an acid leach, resin-in-pulp, solvent extraction process to extract U_3O_8 from the uranium ore. This process is a long established technique of present-day operation in the uranium milling industry and will probably continue.

10.3 ALTERNATIVE METHODS OF EXPANDED MILL TAILINGS MANAGEMENT

Several alternative methods of subsurface tailing disposal are under study at present. The studies are aimed at maximum utilization of local materials and site conditions. In particular, the site of the Sagebrush-Tablestakes Mine Pit is underlain by a layer of mudstone with a thickness believed to be 7.6 to 9.1 meters (25 to 30 feet). This mudstone layer is presently being investigated by additional exploratory borings to verify the thickness, low permeability characteristics and continuity.

The top of the mudstone layer is at an elevation of approximately 1,950 meters (6,400 feet) above mean sea level. At present, it is anticipated that excavation for removal of ore would stop at an elevation of 1,958 meters (6,425 feet). This is the approximate level of the groundwater table. It would be possible, therefore, to establish the pit bottom at an elevation of 1,958 meters (6,425 feet) and prepare the bottom to accept tailings at this elevation. The alternative

would be to continue excavation to the mudstone layer and utilize it as a bottom liner. If the mudstone layer were used as a bottom liner, it would be inspected after exposure and remedial construction work would be done if required. An economic analysis is underway to determine which of these two alternatives is more cost effective.

The excavation at the Sagebrush-Tablestakes Mine Pit is exposing lenses of clay soil. At present, it is estimated that the site contains approximately 153,000 cubic meters (200,000 cubic yards) of a montmorillonite and sand mixture with a permeability of 10^{-7} centimeters per second and 76,500 cubic meters (100,000 cubic yards) of bentonite. It is anticipated that more of these clay soils would be exposed as pit excavation continues.

Other alternatives which are under study, deal with internal pit operations. This includes methods of handling tailings solids and liquids. The alternatives for handling liquids would deal with the use of surface decanting of recycled liquids combined with some evaporation and the possibility of using an underdrain system or a combination of both if the economics favor such an alternative. The methods of handling solids would involve the distribution of coarse material and slimes within the pit and the use of hydrocyclones or other appropriate devices for separation of coarse material from slimes.

10.4 ALTERNATIVE METHODS FOR MANAGEMENT OF EXISTING TAILINGS

The existing mill is discharging tailings into a conventional tailings impoundment. This practice would be discontinued when the below surface tailings disposal becomes operational. There are two main alternatives being studied by FAP for management of the tailings in the existing impoundment. These include reclaiming the tailings in place or moving them to the below grade tailings disposal area. These alternatives are discussed in the following paragraphs.

10.4.1 Reclamation of Existing Impoundment

In the first alternative, the tailings would be left in place. They would be allowed to dry sufficiently to support earth moving equipment. The disposed tailings would be covered with overburden and other soil materials to a depth that would reduce radioactive emissions to an acceptable level. The surface would then be revegetated. Fencing would be used to isolate the area from people, livestock, and wildlife.

Advantages of this method are that costs would be lower than the alternative, energy requirements would be less, environmental impacts caused by moving the tailings would not occur, and the tailings would be reasonably safe from disruption or dispersal by natural forces. The Gas Hills area experiences little rainfall, the seismicity is low, revegetation activities would reduce wind erosion, and there are no major active water courses nearby. Therefore, it is unlikely that natural forces would disrupt or disperse the tailings.

An unavoidable impact of this method is that the topography of the land has been altered for the last twenty years and would remain in this configuration permanently. However, its proximity to the Beaver Rim and surrounding hills (of the high plains desert ecotype) have virtually mitigated any objectionable views to the casual observer.

10.4.2 Relocation of Tailings to Below Surface Disposal

In the second alternative, the disposed tailings would be reclaimed from the existing surface impoundment and transported to the below surface tailings disposal area. Tailings would be transported by slurrying and pumping them or by trucking them to the below surface tailings disposal area. After all tailings and contaminated soil had been removed, the area would be reclaimed and revegetated. The area would then be fenced to isolate it from people, livestock, and wildlife.

Advantages of this method are that the disposed tailings would be safe from dislocation or disturbance from natural forces, and the land could be returned approximately to its original contour. However, its current topography prevents access by grazing and game animals that would be most affected by tailings intrusions.

Disadvantages of this method are that it would cost considerably more than the first alternative and would use considerably more energy. In addition, environmental impacts such as a leak in a tailings slurry line, windblown dust from a truck, a truck accident, windblown dust during tailings reclaiming operations, etc., could occur while the tailings are being reclaimed and transported to the below surface tailings disposal area. This method would also result in filling the below surface tailings disposal area faster so that more areas would be required than with the first alternative, resulting in substantially increased environmental impacts in other areas.

10.5 ALTERNATIVE METHODS FOR DISPOSING EXCESS PROCESS WATER

A portion of the process water decanted from disposed tailings would be pumped back to the mill and reused to the maximum

extent possible. However, some excess process water would have to be disposed of. Some of this water, 3.1 liters per second (49 gallons per minute) would be evaporated at the existing solar evaporation pond. The remaining water, 11 liters per second (175 gallons per minute) would exceed the capacity of the solar evaporation pond. Three alternatives that FAP is studying to handle this water include treatment to neutralize the water and recycle it to the mill, evaporation by sprinkle evaporators in the solar evaporation pond, or additional solar evaporation pond areas.

10.6 FAP TOWNSITE

At the present time, a significant number of the mill employees and their families live at the FAP townsite. This townsite could remain at its present location, be relocated to an alternative location, or be closed. These alternatives are discussed in the following paragraphs.

10.6.1 Leave Townsite at its Present Location

Positive aspects of this alternative include low cost, company subsidized, and conveniently located housing for the FAP employees. A potentially unavoidable impact is that the employees and their families would be voluntarily residing in an area of potential exposure to radioactivity theoretically above natural background levels. However, in twenty years of village existence, there have been no documented cases of any health or genetic defects resulting from this theoretical exposure.

10.6.2 Relocate the Townsite

Advantages of this alternative are that the employees could still have access to housing relatively close to work and that the theoretical potential for exposure to milling activity radioactivity would be less. Relocation would not mitigate the effects of continuous and increased cosmic radiation levels (significantly greater than sea level - where the major population center and gene pools are located) of the high altitude location of the village or surrounding towns.

A significant negative impact of relocation would be the sudden and unexpected financial impact on the employees affected. Although firm costs are not available, a new village for ninety-seven families would cost several million dollars. The unavoidable costs that would have to be passed on to the employees would cause economic hardships particularly during the adjustment period. In addition, acreage required for a new village would result in totally new disturbance to what is presently virgin surface at the new village site, wherever that would be.

10.6.3 Close the Townsite

This alternative would close the townsite thereby forcing ninety-seven families to seek alternative housing in the Riverton areas.

This option presents severe disadvantages. First, the Riverton area is incapable of absorbing ninety-seven families in any reasonably short time frame. Area growth has currently resulted in artificially high real estate prices due to local inability to meet demand. Housing prices on a square foot basis are now in the same range as those in Orange County, California, the San Francisco Bay Area, and Washington, D.C. A large additional impact of this type coupled with currently high interest rates, would force the average employee to pay in excess of 10 times what he/she currently pays for housing in the FAP village. Additionally, this loss of population could conceivably force the closure of the Gas Hills Elementary School and require the construction of a new facility in Riverton. Numerous additional commuters would also be added to the daily traffic on Wyoming Route 136 significantly increasing the risk of auto accident deaths.

The only tangible advantage is that closure would reduce the theoretical exposure to radioactivity by employees' families.

11. BENEFIT COST ANALYSIS

11.1 GENERAL

The availability of uranium to fuel a reactor is implicit in the decision of a utility to construct a nuclear power plant. The uranium to be produced by the FAP mill is among the resources considered to be available to the commercial market for reactor fuel; thus, the uranium from this mill and the expansion of the mill is needed to meet the demands of the nuclear power industry. Table 11.1 shows the projected U.S. requirements for U_3O_8 from 1979 to 2000. In this environmental report the amount of electrical energy produced, one of the benefits of the mill expansion, was discussed along with the economic and environmental costs. Since the benefits and the costs of the proposed expansion are not just localized and difficult to identify, it is appropriate to review only the specific site related benefits and costs for the FAP mill expansion.

11.2 ECONOMIC IMPACTS

Section 8 of this Environmental Report discusses the economic impacts for the FAP mill expansion. On the one hand, many monetary benefits accrue to the community from the presence of the mill such as local expenditures of construction and operating funds, and the state and local taxes paid by the mill. Against these monetary benefits are the monetary costs to the different communities involved, such as costs for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between the benefits and costs for any one community unit or for the mill, because the distribution of revenues to support services may not be timely or completely consistent with those geographical locations where impacts occur.

However, since there is already an existing facility, the costs to the community would be only slightly more than is currently being experienced. The construction phase of the expansion is limited, thereby not necessarily increasing the costs to the community even on a short-term or temporary basis. The addition of twenty workers to the work force should have little or no additional monetary impact on the use of community services.

11.3 THE BENEFIT-COST SUMMARY

As stated section in 11.1, the benefit-cost summary for a fuel-cycle facility such as the FAP mill rests on a comparison between the societal benefit of an assured U_3O_8 supply (ultimately providing electrical energy) and local environmental costs

for which there are no directly related compensations. For the FAP mill these uncompensated environmental costs are basically two: any additional radiological impact and any additional disturbance of the land. As shown in sections 4 and 5, the radiological impact of the FAP mill is acceptable by current standards and the disturbances of the land are judged to be small in comparison to alternative uses the land may support in the future.

TABLE 11.1

PROJECTED U.S. REQUIREMENTS FOR U_3O_8, 1976-2000*

Year	Generating Capacity (Gigawatt)	Annual U_3O_8 Requirements (Metric Ton)	Cumulative U_3O_8 Requirements (Metric Ton)
1979	57	11,000	40,200
1980	61	11,000	52,000
1981	74	17,500	69,400
1982	87	18,000	87,600
1983	100	20,500	108,000
1984	112	22,500	130,000
1985	127	26,500	157,000
1986	141	28,000	185,000
1987	154	30,000	215,000
1988	167	32,500	248,000
1989	181	35,500	283,000
1990	195	38,000	321,000
1991	210	41,000	362,000
1992	225	43,500	406,000
1993	240	46,500	452,000
1994	260	51,500	504,000
1995	280	54,500	558,000
1996	300	58,000	616,000
1997	320	61,500	678,000
1998	340	65,500	743,000
1999	360	68,500	811,000
2000	380	71,500	883,000

*The annual U_3O_8 requirements were calculated on the basis of annual discharges of 28 metric tons/gigawatt (0.7 plant factor) of spent fuel and replacement of that spent fuel with a 3% enriched fuel with tails assay of 0.25% in enrichment.

To convert to short tons, multiply by 1.1.

Fuel replacement only. Does not include initial reactor loading.

12.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

The permits, licenses, and approval of construction and operations, as required by federal and state authorities for the protection of the environment for the mill, are listed in table 12.1.

The table shows application and granted dates for those permits already in force and to those that are still pending.

Permits for utility rights-of-way, sanitary sewage disposal, and construction will be addressed in writing as they are formulated and submitted.

TABLE 12.1

STATUS OF REGULATORY APPROVALS AND PERMITS

Permit	Authority	Application Date	Granting Date
Mill Permit (Existing)	DEQ-LQD[a]	7/59	6/30/75
Air Permit - Mill (Existing)	DEQ-AQD[b]	1/7/77	2/28/77
Water Wells:			
FAP-5 151	SE[c]	6/11/59	6/22/59
FAP-6 152	SE	6/11/69	6/22/59
FAP-8 154	SE	6/11/59	6/22/59
FAP-13 984	SE	4/26/62	4/27/62
FAP-17 42420	SE	N/A	3/6/68
GEORGE-1 46768	SE	12/21/77	3/6/79
Sanitary Sewage Disposal	DEQ-WQD	N/A	In Force
Potable Water Wells:			
FAP-1 182	SE	2/26/58	2/26/58
FAP-16 984	SE	N/A	2/16/63
Utility - Rights of Way	Fremont County	N/A	In Force
By Product Material License			In Review
Tailings Impoundment	NRC-SE-DEQ-LQD[d]	Pending	In Review
Source Materials License: SUA-667	NRC	11/21/79	In Review
PSD	DEQ-AQD	Pending	

(a) Wyoming Department of Environmental Quality - Land Quality Division
(b) Wyoming Department of Environmental Quality - Air Quality Division
(c) Wyoming State Engineer
(d) U. S. Nuclear Regulatory Commission

APPENDIX

EMISSION CALCULATIONS

I. RADIOACTIVITY OF A TYPICAL SAMPLE OF FAP ORE

Source: FAP - Based on analytical results obtained by an independent laboratory (Ecology Audits).

Unat. - 263 picocurie/gram ore
Ra-226 - 155 picocurie/gram ore ± 5
Th-230 - 55 picocurie/gram ore ± 17
Pb-210 - 88.8 picocurie/gram ore ± 3.2
U_3O_8 Content - 0.044 percent

These results do not indicate a secular equilibrium between uranium daughter products. It should be noted that uranium daughter products in Wyoming ores are typically not in secular equilibrium.

Ore processed in the expanded mill would have an average U_3O_8 concentration of 0.12 percent. If it is assumed that the uranium daughter products would be in the same proportions in the 0.12 percent ore, the radioactivity of each would be 0.12/0.044 times the values stated above.

Therefore a typical sample of the average ore would have the following radioactivity:

Unat. - 720 picocurie/gram ore
Ra-226 - 420 picocurie/gram ore
Th-230 - 150 picocurie/gram ore
Pb-210 - 240 picocurie/gram ore
U_3O_8 Content - 0.12 percent

II. RADIOACTIVITY ENTERING THE MILL

Expanded mill processing rate: 910,000 metric tons per year.
Source: FAP.

Unat. entering mill equals:

Unat. = (720 picocurie/gram) (10^{-12} picocurie/gram) (10^6 gram/metric ton) x (910,000 metric ton/year)

Unat. = 655 curie/year

In the same manner:

Ra-226 = 382 curie/year
Th-230 = 137 curie/year
Pb-210 = 218 curie/year

III. RADIOACTIVITY OF YELLOW CAKE PRODUCT

U_3O_8 recovery rate: 91 percent. Source: FAP.

Therefore 91 percent of the Unat. radioactivity entering the mill would end up in the product yellow cake.

$$\text{Unat.} = (0.91)(655) = 596 \text{ curie/year}$$

The NRC has estimated that the yellow cake product from a typical uranium mill would contain 5 percent of the Th-230, 0.2 percent of the Ra-226, and 0.2 percent of the Pb-210 originally in the ore. Based on this, the FAP yellow cake would have the following radioactivity:

$$\begin{aligned} \text{Ra-226} &= (0.002)(382) = 0.8 \text{ curie/year} \\ \text{Th-230} &= (0.05)(137) = 6.9 \text{ curie/year} \\ \text{Pb-210} &= (0.002)(218) = 0.4 \text{ curie/year} \end{aligned}$$

At the expanded mill yellow cake production rate of 1,035 metric tons per year, the concentration of radioactivity in the yellow cake would be the following:

$$\text{Unat.} = \frac{(596 \text{ curie/year})(10^{12} \text{ picocurie/curie})}{(1{,}035 \text{ metric ton/year})(10^{6} \text{ gram/metric ton})}$$

$$\text{Unat.} = 5.8 \times 10^{5} \text{ picocurie/gram yellow cake}$$

In the same manner:

$$\begin{aligned} \text{Ra-226} &= 7.7 \times 10^{2} \text{ picocurie/gram yellow cake} \\ \text{Th-230} &= 6.7 \times 10^{3} \text{ picocurie/gram yellow cake} \\ \text{Pb-210} &= 3.9 \times 10^{2} \text{ picocurie/gram yellow cake} \end{aligned}$$

IV. RADIOACTIVITY OF YELLOW CAKE DRYER AND PACKAGING OPERATIONS EFFLUENT

Yellow cake emissions from dryer and packaging operations = 0.009 pounds per minute. Source: Kaiser Engineers process flow sheet (figure 3.3-1).

$$\begin{aligned} \text{Yellow cake emissions} &= (0.009 \text{ pound/minute})(453.6 \text{ gram/pound}) \\ &\quad \times (1{,}440 \text{ minute/day}) \\ &= 5{,}880 \text{ gram/day} \end{aligned}$$

Yellow cake drying and packaging operations take place 24 hours per day, 5 days per week. Source: Kaiser Engineers process flow sheet (figure 3.3-1).

$$\begin{aligned} \text{Operating days} &= (340)(5/7) = 243 \text{ days/year} \\ \text{Annual emissions} &= (5{,}880 \text{ gram/day})(243 \text{ days/year}) \\ &= 1.43 \times 10^{6} \text{ grams } U_3O_8\text{/year} \end{aligned}$$

Radioactivity of effluent equals:

$$\text{Unat.} = (5.8 \times 10^5 \text{ picocurie/gram})(1.43 \times 10^6 \text{ gram/year}) \times (10^{-12} \text{ curie/picocurie})$$

$$\text{Unat.} = 0.8 \text{ curie/year}$$

In the same manner:

$$\text{Ra-226} = 1.1 \times 10^{-3} \text{ curie/year}$$
$$\text{Th-230} = 9.6 \times 10^{-3} \text{ curie/year}$$
$$\text{Pb-210} = 5.6 \times 10^{-4} \text{ curie/year}$$

V. RADIOACTIVITY OF TAILINGS

It is assumed that the tailings would account for the remaining radioactivity. Therefore:

$$R_{Tail} = R_{In} - R_{yellow\ cake} - R_{Effluent}$$

Unat.	= 655	- 596	- 0.8	≅ 58	curie/year
Ra-226	= 382	- 0.8	- 0.0011	≅ 381	curie/year
Th-230	= 137	- 6.9	- 0.0096	≅ 130	curie/year
Pb-210	= 218	- 0.4	- 0.00056	≅ 217	curie/year

Tailings discharge rate = 9,984 tons per day. Source: Kaiser Engineers process flow sheet (figure 3.3-1).

$$\begin{aligned}\text{Tailings discharge rate} &= (9{,}984 \text{ ton/day})(340 \text{ day/year}) \times (0.907 \text{ metric ton/ton}) \\ &= 3.08 \times 10^6 \text{ metric ton/year}\end{aligned}$$

At this discharge rate, the average radioactivity of the tailings would be the following:

$$\text{Unat.} = \frac{(58 \text{ curie/year})(10^{12} \text{ picocurie/curie})}{(3.08 \times 10^6 \text{ metric ton/year})(10^6 \text{ gram/metric ton})}$$

Unat. = 19 picocurie/gram tailings solution

In the same manner:

Ra-226 = 124 picocurie/gram tailings solution
Th-230 = 42 picocurie/gram tailings solution
Pb-210 = 70 picocurie/gram tailings solution

VI. EMISSIONS FROM TAILINGS

The NRC has estimated that 1,080 kilograms per day of tailings dust would be blown from the conventional tailings impoundment of a 1,800 metric ton per day mill [ref 2]. This would be equivalent to approximately 1,600 kilograms per day for the 2,680 metric ton per day FAP mill. However,

because the solar evaporation pond would be kept wet at all times and because the tailings would be disposed below grade where exposure to the wind would not be as great, emissions from the FAP mill tailings systems are assumed to be 25 percent of the stated values or less. Therefore, dust emissions from the tailings systems are estimated to be the following:

Dust = (0.25)(1,600 kilogram/day) = 400 kilogram/day
Dust = 146 metric ton/year

The tailings solids are expected to comprise approximately 30 percent of the tailings solution by weight.

$$\text{Tailings solids} = (0.30)(3.08 \times 10^6 \text{ metric ton/year}) = 9.24 \times 10^5 \text{ metric ton/year}$$

If it is conservatively assumed that all of the radioactivity is concentrated in the tailings solids, the average radioactivity of the solids would be the following:

$$\text{Unat.} = \frac{58 \text{ curie/year}}{9.24 \times 10^5 \text{ metric ton/year}} = 6.3 \times 10^{-5} \text{ curie/metric ton tailings solids}$$

In the same manner:

Ra-226 = 4.1×10^{-4} curie/metric ton tailings solids
Th-230 = 1.4×10^{-4} curie/metric ton tailings solids
Pb-210 = 2.3×10^{-4} curie/metric ton tailings solids

Based on a dust emission rate of 146 metric tons per year, the radioactive emissions from the tailings are estimated to be the following:

Unat. = (6.3×10^{-5} curie/metric ton)(146 metric ton/year)
Unat. = 9.2×10^{-3} curie/year

In the same manner:

Ra-226 - 6.0×10^{-2} curie/year
Th-230 - 2.0×10^{-2} curie/year
Pb-210 - 3.4×10^{-2} curie/year

The NRC has estimated that Rn-222 emissions from the tailings of a 1,800 metric ton per day mill would be approximately 7,000 curies per year [ref 3]. For a 2,680 metric ton per day mill such as the FAP mill, this would be equivalent to approximately 10,500 curies per year.

VII. EMISSIONS FROM ORE STORAGE PAD

The NRC has estimated that dust emissions from the ore storage pad and ore crushing and grinding operations would be approximately 3.4 kilograms per day for a 1,800 metric ton

per day mill with an average ore storage of 18,000 metric tons [ref 4]. Most of these emissions would be from the ore storage pad. For a 2,680 metric ton per day mill that provided 45,000 metric tons of storage, this would be equivalent to the following:

$$\text{Dust} = \left(\frac{45,000}{18,000}\right) (3.4) = 8.5 \text{ kilogram/day}$$

$$\begin{aligned}\text{Dust} &= 3.1 \text{ metric ton/year} \\ &= 3.1 \times 10^6 \text{ gram/year}\end{aligned}$$

Radioactive dust emissions would be the following:

$$\text{Unat.} = (720 \text{ picocurie/gram})(3.1 \times 10^6 \text{ gram/year}) (10^{-12} \text{ curie/picocurie})$$

$$\text{Unat.} = 2.2 \times 10^{-3} \text{ curie/year}$$

In the same manner:

Ra-226 - 1.3×10^{-3} curie/year
Th-230 - 4.7×10^{-4} curie/year
Pb-210 - 7.4×10^{-4} curie/year

The NRC has estimated that Rn-222 emissions from a 1,800 metric ton per day mill would be 107 curies per year. This would be equivalent to approximately 160 curies per year for a 2,680 metric ton per day mill for ore storage, crushing, and grinding operations [ref 5].

VIII. EMISSIONS FROM GAS-FIRED STEAM GENERATOR

Steam generator capacity = 600 Boiler Horsepower
Heat Input = 25×10^6 Btu/hour
Fuel Heat Content = 1,000 Btu/cubic foot

$$\text{Fuel Usage} = \frac{25 \times 10^6 \text{ Btu/hour}}{1,000 \text{ Btu/cubic foot}} = 2.5 \times 10^4 \text{ cubic feet/hour}$$

Emission Factors:

	Pound/10^6 Cubic Feet
Particulates	10
Sulfur Oxides (as SO_2)	0.6
Carbon Monoxide	17
Hydrocarbons	3
Nitrogen Oxides (as NO_2)	175

$$\text{Particulates} = \left(\frac{10 \text{ pounds}}{10^6 \text{ cubic feet}}\right) (2.5 \times 10^4 \text{ cubic feet/hour})$$

$$= 0.25 \text{ pound/hour}$$

$$\begin{aligned}\text{Particulates} &= (0.25 \text{ pound/hour})(24 \text{ hour/day})(340 \text{ day/year}) \\ &= 2,040 \text{ pound/year} = 0.9 \text{ metric ton/year}\end{aligned}$$

In the same manner:

Sulfur Oxides	= 0.015 pound/hour = 122 pound/year = 0.05 metric ton/year
Carbon Monoxide	= 0.43 pound/hour = 3,470 pound/year = 1.6 metric ton/year
Hydrocarbons	= 0.075 pound/hour = 612 pound/year = 0.3 metric ton/year
Nitrogen Oxides	= 4.38 pound/hour = 35,700 pound/year = 16.2 metric ton/year

REFERENCES: APPENDIX

1. "Draft Environmental Impact Statement Related to Operation of Morton Ranch Uranium Mill," U.S. Nuclear Regulatory Commission, NUREG - 0439, April 1978, pp. 3-11.

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3. Ibid, pp. 5-8.

4. Ibid, pp. 5-7.

5. Ibid, pp. 5-8.

6. "Compilation of Air Pollutant Emission Factors," U.S. Environmental Protection Agency, AP-42, Third Edition, pp. 1.4-2.