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HERMIT MINE
GROUND-WATER CONDITIONS
MOHAVE COUNTY, ARIZONA
FOR
ENERGY FUELS NUCLEAR, INC.
DENVER, COLORADO

Dames & Moore

Prepared By:

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March 20, 1987

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March 20, 1987

Energy Fuels Nuclear, Inc.
One Tabor Center, Suite 2500
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Denver, Colorado 80202

Attention: Mr. William J. Almas

Re: Hermit Mine
Ground-Water Conditions
Mohave County, Arizona

Gentlemen:

We are pleased to submit our report on Ground-Water Conditions at the Hermit Mine.

We would be pleased to discuss the report with you and to respond to any questions or comments you may have.

Very truly yours,

DAMES & MOORE

Richard L. Harlan djb

Richard L. Harlan
Associate/Senior Hydrogeologist

RLH:djb

Enclosures

HERMIT MINE

GROUND-WATER CONDITIONS

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SUMMARY AND CONCLUSIONS

The Hermit Mine is a proposed underground uranium mine, located approximately 22 miles south-southwest of the town of Fredonia in Mohave County, Arizona. The mineralized zone to be mined is within a collapse breccia pipe which will be accessed by a 1,100 foot vertical shaft to be located outside the ore body, and by extending horizontal drifts into the ore body.

The mine site is located on the Kanab Plateau which is part of the Grand Canyon section of the Colorado Plateau physiographic province. This section of the Colorado Plateau is characterized by flat to gently-sloping plateaus and mesas abruptly dissected by deep canyons. Geologically, the region as a whole is characterized by a thick sequence of flat to gently-dipping sedimentary rocks. In the Grand Canyon area, the sedimentary sequence ranges from about 3,500 to 4,500 feet thick and overlies highly-deformed Precambrian sedimentary, metamorphic, and igneous rocks.

Throughout much of the Colorado Plateau, the regional ground-water table is deep and controlled largely by the elevation of the Colorado River and its major tributaries which are deeply incised. In the vicinity of the Hermit Mine, the regional water table is at a depth greater than 2,000 feet and approximately 1,000 feet below the proposed depth of mining.

Perched ground-water conditions occur locally within the sedimentary sequence above the regional water table. These perched aquifers, however, are typically discontinuous and frequently not capable of being produced on a sustained-yield basis due to the low rates of natural ground-water recharge and their limited lateral extent.

At the Hermit Mine site, perched ground-water conditions have been identified during exploratory drilling within the Coconino sandstone immediately above its contact with the underlying Hermit shale and within the Toroweap limestone. Other perched ground-water zones also may be anticipated to occur as isolated or discontinuous lenses within the Toroweap and Kaibab limestones. These perched zones may yield small quantities of water to the mine workings as they are penetrated. The experience at the Hack Canyon and Pigeon Mines, which are located in the same general area, has been that rates of ground-water inflow to the mine workings decrease with time and generally cease within a period of several months. Parametric studies have further shown that based on the observed rates of ground-water inflow at the Hack Canyon and Pigeon Mines, the "effective" radius of influence as a result of drainage into the mine workings will be small and is typically less than a few thousand feet.

The mine plan for the Hermit Mine calls for extraction of uranium ore from an approximate 600-foot vertical zone within the breccia pipe. The final depth of mining, however, will be nearly 1,000 feet above the regional ground-water table which is within the Redwall-Muav limestone aquifer. The Redwall-Muav aquifer is the upper-most aquifer of regional importance capable of providing a continuous water supply of even a few gallons per minute. Following cessation of mining, the rate of ground-water inflow to the mine workings will depend on the hydraulic transmission and storage characteristics of the overlying strata and the rate of natural ground-water recharge. As the mine working will be above the regional ground-water table, continued inflow and partial filling of the mine would result in a potential for downward percolation and recharge to the underlying strata and the Redwall-Muav aquifer system. Although a potential exists for downward water migration, the likelihood of significant downward flow is extremely small due to the extensive and complete recementation of the breccia pipe during and following mineralization. Visual observations within both the Hack Canyon and Pigeon Mines have shown the absence of open fractures or joints within the pipe and that essentially all of the voids within the rubblized collapse zone have been filled with a fine-grained matrix comprised mainly of carbon-aceous materials. As a result, the breccia pipe and the area immediately surrounding the pipe are effectively impermeable. This has been confirmed by laboratory tests on core samples from the Canyon Mine prospect. Laboratory tests on rock core samples from the breccia pipe at the Canyon Mine prospect, which is located on the South Rim of the Grand Canyon, indicates that the hydraulic conductivities of the rock mass within and adjacent to the pipe is less than 1×10^{-8} cm/sec. This is consistent with observed conditions in operating mines on the North Rim, specifically the Hack Canyon and Pigeon Mines.

Because of the physical separation between the bottom of the mine and the regional water-table and the potential ameliorating effects of the intervening argillaceous strata, no measurable effects on ground-water quality or quantity are expected to occur as a result of the mining activities.

1.0 INTRODUCTION

The Hermit Mine is a proposed underground uranium mine. The ore deposit is located within a breccia pipe which was located in 1985 and confirmed by exploratory drilling by Energy Fuels Nuclear, Inc. (EFN) . The site is located on unpatented lode mining claims, approximately 22 miles south-southwest of the town of Fredonia in Mohave County, Arizona (Section 17, Township 39 North, Range 4 West, Gila and Salt River Meridian).

In this report, existing geologic and ground-water conditions in the Hermit Mine area are addressed. A discussion is also presented on the hydrogeological characteristics of other breccia pipe mines in the general vicinity and the potential hydrogeological impacts as a result of the proposed mining activities.

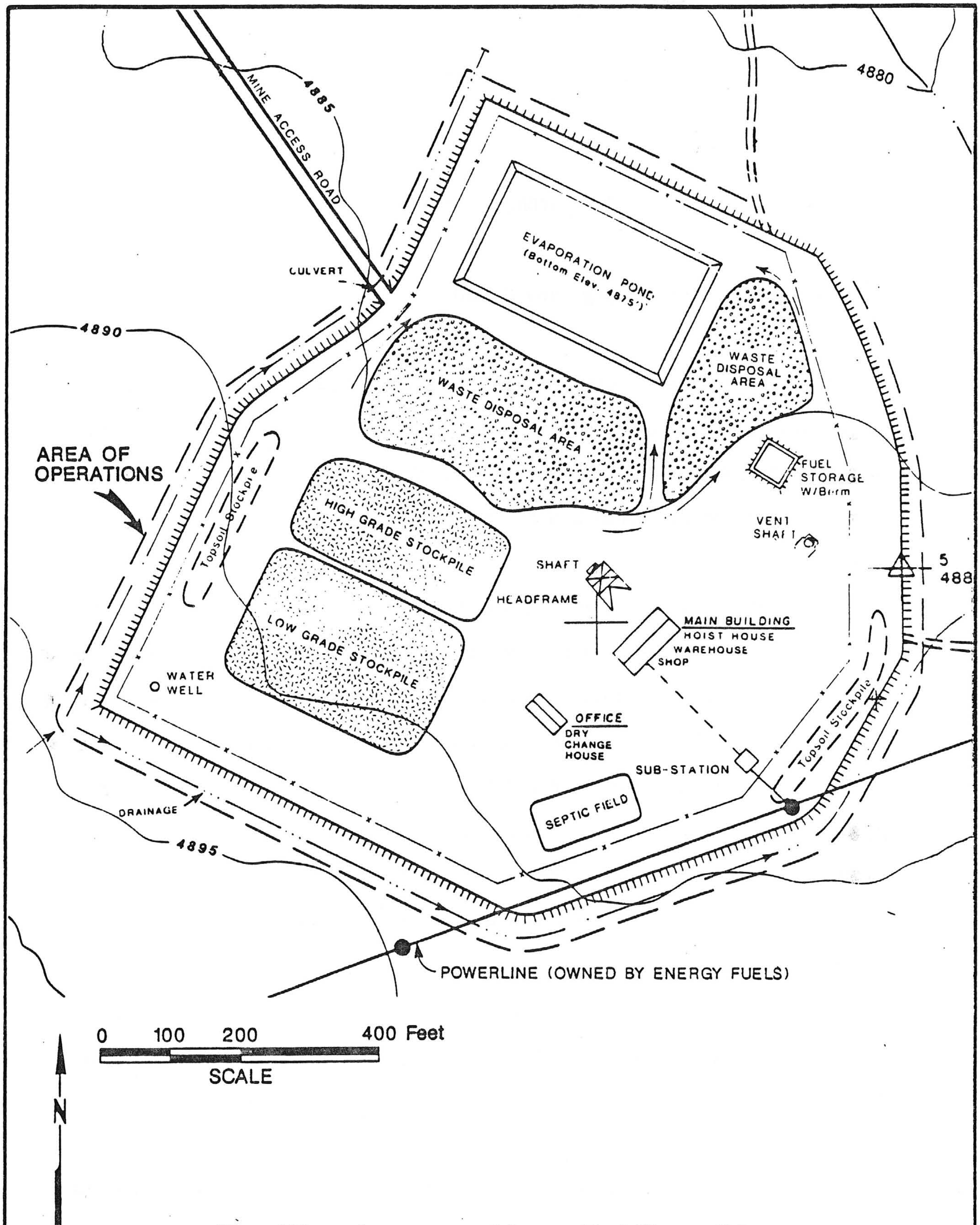
2.0 PROJECT DESCRIPTION

The Hermit Deposit is a uranium ore deposit located within and immediately adjacent to a collapse breccia pipe. The deposit will be mined by sinking a vertical shaft approximately 1,100 feet below the existing ground surface. The shaft will be located adjacent to but outside of the zone of mineralization. The deposit will be mined by extending horizontal drifts into the ore body and mining out the mineralized core of the breccia pipe.

Surface facilities at the mine site will include the headframe, combined hoist, compressor, warehouse and maintenance building and office/mine dry facility. A one-and-a-half mile access road will be constructed to connect the mine site with the existing Mount Trumbull Road. The proposed physical layout of the surface facilities at the Hermit Mine site is shown on Figure 1.

The uranium ore produced by the mine will be temporarily stored in a lined area at the mine site and trucked to an existing mill at Blanding, Utah. No ore processing will be carried out at the mine site.

Plans call for the completion of a water well into the Redwall-Muav aquifer to supply the water requirements for both mining operations and sanitary purposes. The proposed depth of the water-supply well to be located onsite is 2,800 to 3,000 feet.



Facility Layout Hermit Mine Site

Dames & Moore

Figure 1

3.0 HYDROGEOLOGICAL SETTING

3.1 Location, Physiography, and Climate

The Hermit Mine is situated on the Kanab Plateau which is part of the so-called "Arizona Strip". The Arizona Strip includes that portion of northwestern Arizona north and west of the Grand Canyon and the Colorado River, including the North Rim of the Grand Canyon.

The Grand Canyon of the Colorado River lies within the Colorado Plateau physiographic province. The Colorado Plateau extends over an area of some 130,000 square miles including all of the Arizona Strip. The Grand Canyon section of the Colorado Plateau is characterized by flat to gently-sloping plateaus and mesas abruptly dissected by deep canyons. Geologically, the region as a whole is characterized by a thick sequence of flat to gently-dipping sedimentary rocks. The mine site itself is flat to gently sloping with maximum relief in the area on the order of 80 feet.

The Hermit Mine site is located near the headwaters of Bulrush Canyon. Bulrush Canyon is a tributary to Kanab Creek which in turn is a tributary to the Colorado River. Kanab Creek has the lowest yield per unit area of the tributaries to the Colorado River in the Grand Canyon area with no measurable flow for several months of each year at its confluence with Bulrush Creek.

Vegetation within the Hermit Mine area consists mainly of grasses and sagebrush. Typically the density of the vegetative cover is less than about 50 percent.

The regional climate is semi-arid to arid and is continental, typified by cool winters and warm summers, and light precipitation (less than 15 inches per year).

Precipitation in the Grand Canyon area is dependent on elevation and geographic location. Elevational effects can be illustrated by comparing the mean annual precipitation on the South Rim, at Phantom Ranch, and on the North Rim (Table 1). These three locations lie roughly on a straight line, approximately 13 miles long. For the period 1951 to 1980, the South Rim at elevation 6,970 feet received an average annual rainfall of 14.6 inches; Phantom Ranch at 2,570 feet received an average of only 8.7 inches, and the North Rim at 8,400 feet received 25.5 inches. The importance of geographic location is illustrated by comparing average annual precipitation on the South Rim and at Desert View, 18 miles to the east. For the 21-year period 1961 to 1982, the South Rim averaged 15.5 inches annually compared to Desert View which is on the same plateau, which received an average of 13.0 inches.

TABLE 1

AVERAGE MONTHLY PRECIPITATION AT GRAND CANYON AREA LOCATIONS

	Elevation (ft)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
South Rim[1]	6,785	1.49	1.26	1.61	0.92	0.62	0.58	1.49	1.96	1.07	1.20	1.01	1.45	14.65
Desert View[2]	7,400	1.16	1.08	1.54	0.75	0.71	0.28	1.29	1.53	1.04	1.43	0.97	1.54	13.32
Phantom Ranch[1]	2,570	0.85	0.65	0.92	0.46	0.36	0.35	0.82	1.20	0.76	0.82	0.74	0.78	8.69
North Rim[1]	8,400	4.43	2.82	3.69	1.57	1.00	0.68	1.95	2.37	1.33	1.61	1.48	2.55	25.47
Mt. Trumbull[3]	5.600	0.78	0.62	0.81	0.56	0.52	0.48	1.72	1.89	0.98	0.74	0.72	0.83	10.63
Lees Ferry[1]	3,210	0.43	0.34	0.51	0.38	0.33	0.23	0.83	0.86	0.50	0.60	0.53	0.46	5.99
Supai[4]	3,205	0.65	0.69	0.85	0.38	0.42	0.28	1.10	1.41	0.63	0.64	0.77	0.67	8.48
Pierce Ferry[5]	3,860	0.90	1.00	1.37	0.79	0.53	0.35	0.88	1.52	0.78	0.61	1.06	0.95	10.73
Tuweep[1]	4,775	1.23	0.99	1.26	0.67	0.56	0.47	1.39	1.71	0.85	0.86	0.87	1.24	12.08

1. Period of Record 1951-1980
2. Period of Record 1960-1982
3. Period of Record 1948-1977, station now closed
4. Period of Record 1956-1982
5. Period of Record 1963-1982

Notes: Station title of north rim is Bright Angel RS. There are many gaps in the record for the north rim. Station title at south rim is Grand Canyon NP 2. Complete title for Pierce Ferry 17 SSW.

Practically all of the winter precipitation on the North and South Rims of the Grand Canyon occurs as snow. On the Coconino Plateau, south of the Grand Canyon, snow usually melts shortly after it falls, while on the Kaibab Plateau on the north side, much of the snow accumulates until spring when melting snow and rainfall recharge the underlying ground-water system and contribute to high seasonal runoff. The high seasonal runoff in combination with the rapid runoff during summer high-intensity, short-duration rainfall events effectively limits the amount of precipitation available for ground-water recharge within Kaibab Plateau.

3.2 Regional Geology

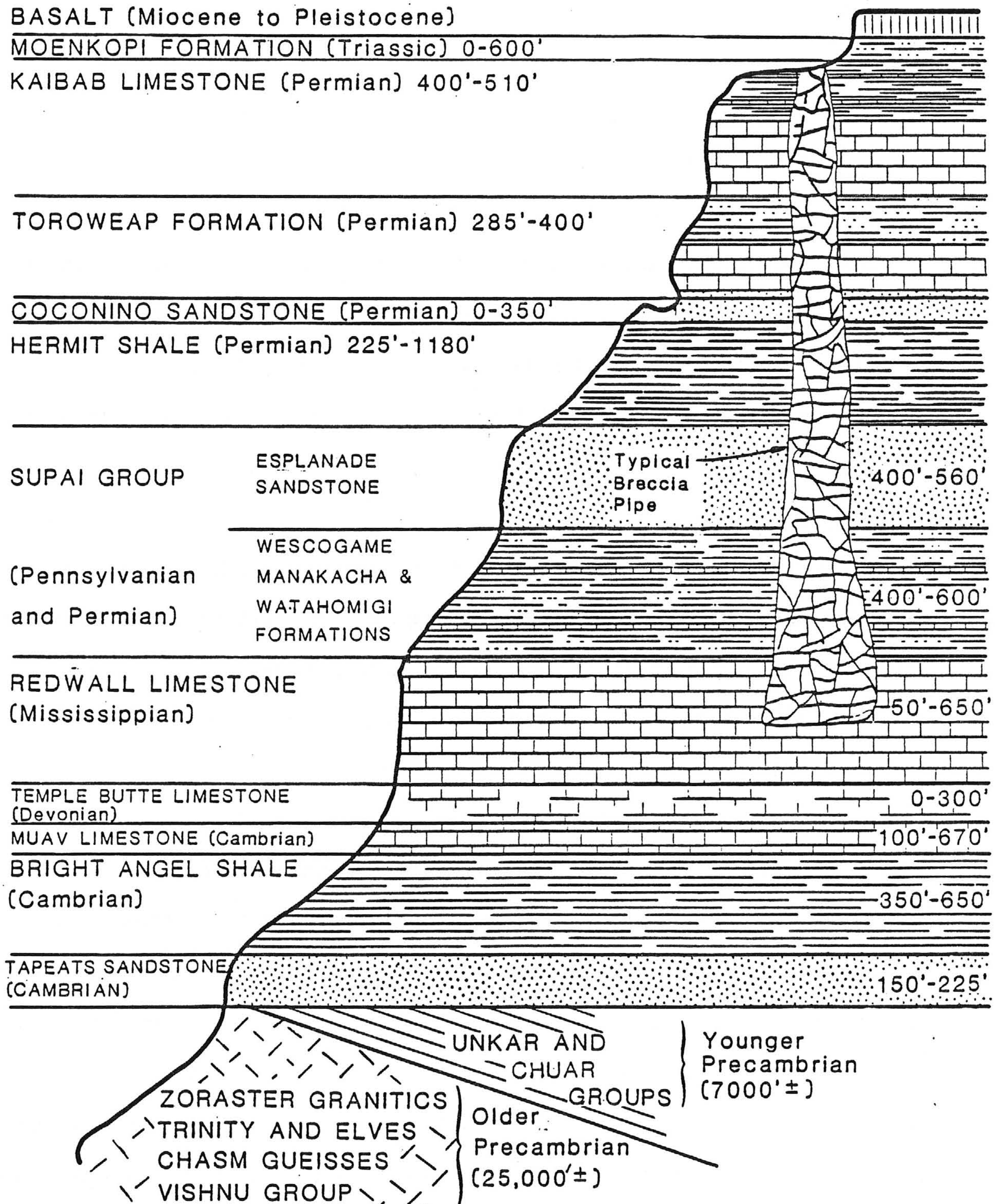
The Kaibab Plateau, on which the Hermit Mine prospect is located, is underlain by a thick sequence of horizontal to gently dipping Paleozoic rocks (570 to 225 million years before present). The sedimentary sequence, which is exposed in the walls of the Grand Canyon, ranges from about 3,500 to 4,500 feet thick and overlies highly-deformed Precambrian (older than 570 million years before present) sedimentary, metamorphic, and igneous rocks. The Precambrian rocks form the basement complex which for practical purposes constitute the lower limit of ground-water occurrence and movement (National Park Service, 1984). While some ground water undoubtedly occurs within the Precambrian, the quantities and its significance are small compared to those within the overlying sedimentary strata.

3.2.1 Stratigraphy

The generalized stratigraphy in the Hermit Mine site area is shown on Figure 2 and discussed below. Section 3.2.2 addresses the structural geology; Section 3.2.3 describes the occurrence and nature of breccia pipes, within the Colorado Plateau and their hydrogeological characterization.

In the Hermit Mine site area, the uppermost formation is the Moenkopi of Triassic age. The Moenkopi consists of red siltstone and claystone which outcrop directly at the surface or underlie the surface at a shallow depth. The formation in the mine site area ranges from about 100 to 500 feet in thickness.

The Moenkopi is underlain by the Kaibab and Toroweap limestones. These formations dip gently to the north and are exposed in the walls of the Grand Canyon. In the Hermit Mine area, the aggregate thickness of the Kaibab and Toroweap Formations is 600 to 800 feet. In the vicinity of the Hack Canyon and Pigeon Mines, the Toroweap Formation consists of a basal unit of sandstone and shale approximately 30 feet thick (Seligman Member), a 210-foot thick middle unit of fossiliferous grey limestone (Brady Canyon Member), and an upper, slope-forming unit of about 160 feet of gypsiferous shale and siltstone (Woods Ranch Member).



SOURCES:

- DEPT. OF INTERIOR, 1976, DRAFT ENVIRONMENTAL STATEMENT, GRAND CANYON
- NUEXCO, REPORT 176, APRIL, 1983

Arizona Strip District
Generalized Stratigraphy

Dames & Moore

Figure 2

The Kaibab Formation consists of a lower member of fossiliferous, cherty, limestone (Fossil Mountain Member) and an overlying sequence of thinly-bedded limestone, shale and gypsiferous siltstone (Harrisburg Gypsiferous Member).

The Coconino sandstone directly underlies the Toroweap limestone at a depth of 900 to 1,000 feet within the mine area. The Coconino ranges in thickness in the mine area from about 30 to 50 feet. In the canyon rim north of the visitor center at the Grand Canyon National Park, the Coconino sandstone is approximately 300 feet thick. The Coconino sandstone is a white, cross-bedded eolian deposit of Permian age.

The Coconino sandstone is underlain within the mine area at depths of 930 to 1,050 feet by the Hermit shale. The Hermit shale is a dense, clay-cemented siltstone and behaves as a confining bed under the coarser and more permeable Coconino sandstone. As a result of the permeability contrast between these units, perched ground-water conditions may exist locally above the contact. Also springs and seeps occur locally along the contact between those units in the canyon walls (Metzer, 1961).

The Hermit shale, in turn, is underlain by the Supai Formation which extends from about 1,050 to 2,300 feet below the surface. The upper few hundred feet of the Supai Formation is the resistant sandstone that resulted in the formation of the inner gorge of the Grand Canyon. The upper Supai Formation and the overlying Hermit shale are the main host rocks for the ore deposit at the Hermit prospect. The lower portion of the

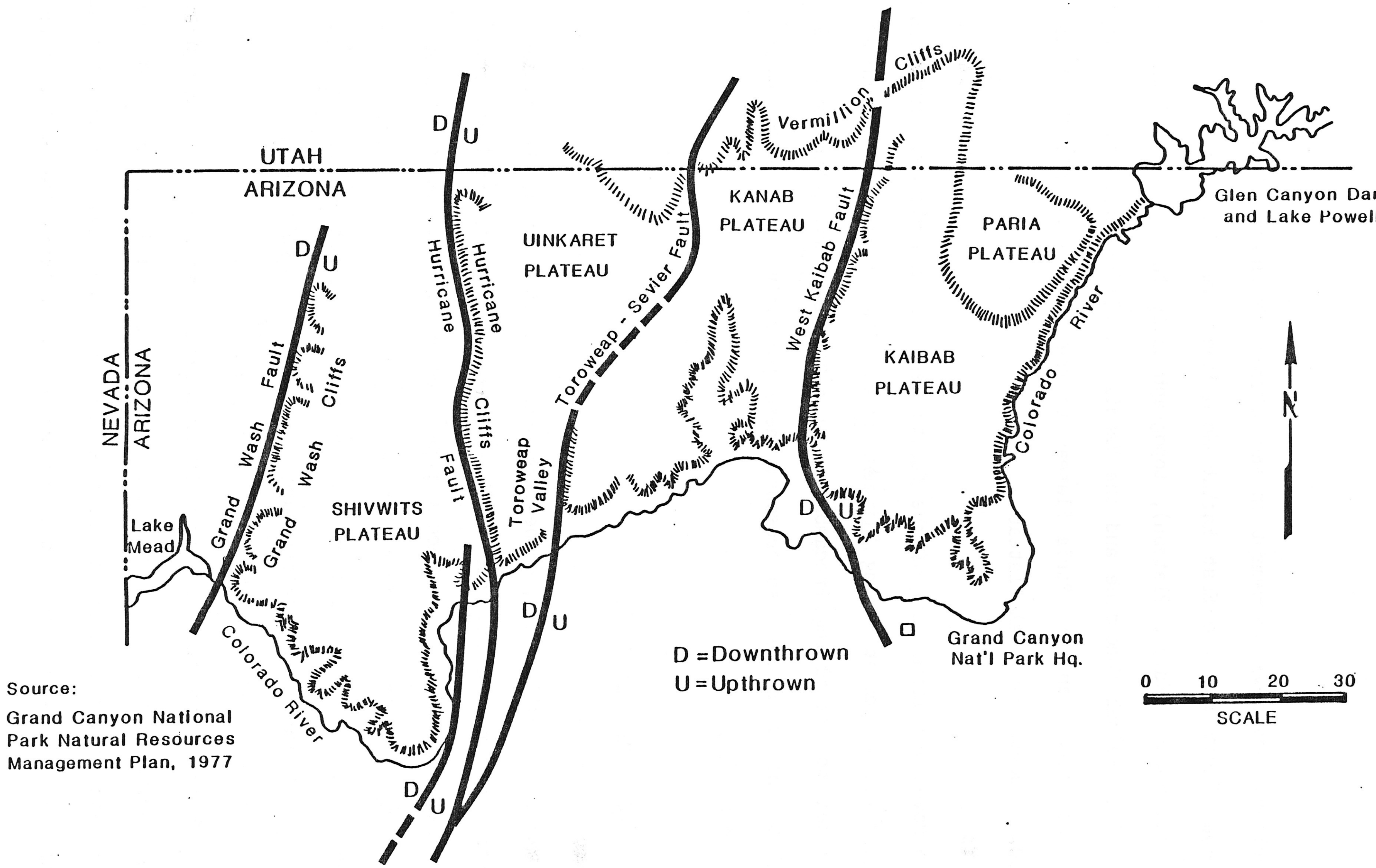
Supai grades from a sandstone to a limestone which overlie the older limestones of the Redwall Formation (U.S. Forest Service, 1985).

The Redwall and underlying Temple Butte and Muav limestones collectively comprise the Redwall-Muav aquifer of Northern Arizona. The Redwall limestone is a thickly-bedded, fine-grained limestone that typically is a cliff former where exposed along the walls of the Grand Canyon. In the area of interest, the Redwall is approximately 450 feet thick. The upper karstic member of the Redwall limestone is the source of the existing water supply for on-going operations at the Pigeon Mine, Kanab North, Pinenut, and the Canyon Mines. It is also the proposed source of water for the Hermit Mine.

The Temple Butte limestone, which underlies the Redwall, consists of interbedded dolomite, dolomitic sandstone, sandy limestone, siltstone and sandstone. It crops out as thin ledges and occupies small channels cut into the underlying Muav limestone. The Muav limestone consists chiefly of dolomitic limestone and is gradational with the underlying Bright Angel shale.

3.2.2 Structural Geology

Major north-south trending faults provide geologic and topographic boundaries to many of the plateaus (Figure 3). The Kanab Plateau on which the Hermit Mine is located, lies between the Toroweap-Sevier Fault on the west and the West Kaibab Fault on the east. Both of these faults trend



Arizona Strip District

Major Structural and Physiographic Features Map

Dames & Moore

Figure 3

north-northeast with movement on the order of hundreds of feet. The West Kaibab Fault and the East Kaibab Monocline form the boundaries of the Kaibab upwarp (Kaibab Plateau), topographically the highest of the area. The East Kaibab Monocline and the Vermillion Cliffs intervene between the Kaibab Plateau and the Paria Plateau to the northeast. The Kanab Valley Fault bisects the Kanab Plateau.

Movements along many of the faults began in the Miocene, but much of the activity peaked during Pliocene time. The faults are thought to be related to underlying Precambrian zones of weakness. Numerous smaller faults and folds are also present; these generally trend north, northwest, or northeast.

3.2.3 Breccia Pipes

Roughly cylindrical, pipe-like collapse structures, termed breccia pipes, are common geologic features across the southern portion of the Colorado Plateau. The breccia pipes are relatively small in diameter, generally less than 500 feet, but may be thousands of feet deep. The pipes contain broken, rubbled rock from surrounding formations encircled by a series of concentric ring fractures. The more-permeable annular fault ring and the rock debris within the center of the pipe provided a vertical conduit for ascending and/or descending mineralizing fluids. When mineable ore occurs in a pipe, it typically is located in both the annualar fault ring and the central breccia matrix, principally in the Hermit and Supai Formations. Because the pipes are not known to extend below the Redwall limestone, it is generally held that the pipes resulted from successive chimney collapse of the overlying formations into solution caverns developed within the Redwall limestone:

> "Geologists believe that cavities formed millions of years ago by dissolution of portions of the Redwall limestone [which] created space into which the overlying rock collapsed. The collapse zone propagated its way up hundreds, and in some instances, several thousands of feet in the form of a narrow cylinder or cone. This broken rock or pipe created a favorable environment for mineral deposition" (U.S. Forest Service, 1985).

Subsequent to the formation of the breccia pipes and mineralization, the materials within the pipe and in surrounding areas have been recemented and the void spaces filled with a fine-grained matrix consisting mainly of carbonaceous materials. As a result, the breccia pipe and the area around the pipe is effectively impermeable. Laboratory tests, for example, on rock core from the breccia pipe and surrounding areas at the Canyon Mine, (located south of the Grand Canyon), have shown the rock-mass hydraulic conductivities generally to be less than 1×10^{-9} cm/sec.

3.3 Ground-Water Occurrence and Movement

3.3.1 Colorado Plateau Region

The regional geology of the Colorado Plateau has been studied extensively by the U.S. Geological Survey, Energy Fuels, and others. The occurrence and movement of ground water within the plateau, however, have not been studied in the same level of detail, largely because of the depth of occurrence throughout much of the region. The regional ground-water table throughout much of the plateau is controlled by the elevation of the Colorado River and its major tributaries which are deeply incised. Throughout much of the area, the depth to the regional water table is several thousands of feet beneath the tops of the plateaus.

Because of the depth of incisement of the Colorado River through the Colorado Plateau, the principal water-bearing zones of interest are exposed in the canyon wall. As a result, ground-water occurrence and ground-water chemistry within the Grand Canyon and its major tributary valleys have been studied in detail. These studies, which are based largely on direct surface observations and measurements, in combination with limited borehole and water-quality information for the plateau region, provide a comprehensive and coherent understanding of the regional hydrogeology both on the North and South Rims of the Grand Canyon.

Metzer (1961) describes the relationship between the geology and ground-water resources along the South Rim of the Grand Canyon and provides preliminary conclusions for quality and rates of recharge and discharge. Because of the similarities in the geology between the North and South Rims of the Grand Canyon, Metzer's conclusions also have direct relevance to the assessment of ground-water conditions and the prediction of the potential effects of mining on the Colorado Plateau, in general, and in the Hermit Mine area, in particular.

Huntoon (1982) reports on the results of investigations on ground-water circulation in the plateau regions adjacent to the Grand Canyon. Based on his studies, Huntoon concludes that the ground-water discharge from these regions occurs mainly to springs in the Grand Canyon. Specifically the major springs issue from the Redwall-Muav aquifer system, which is, as previously noted, the major aquifer system in Northern Arizona. Johnson and Sanderson (1968) also provides a compilation of data on ground-water discharge at springs along the Colorado River within the Grand Canyon.

Loughlin (1983) provides interpretations and conclusions on hydrodynamic conditions at the time of formation of breccia pipes in the Grand Canyon area and for ground-water circulation near important springs. The Grand Canyon National Park Water Resources Management Plan (National Park Service, 1984) provides a summary of hydrogeological and hydrochemical data for the park and adjacent areas.

The geology in combination with the low precipitation/high evapotranspiration losses leads to little water actually infiltrating and percolating downward to the regional water table. Although exact rates of natural ground-water recharge are not known, it is suggested that the rates of natural recharge are probably on the order of several hundredths to a few tenths of an inch per year, at best (Metzer, 1961).

Within the thick unsaturated zone above the regional water table, the sedimentary deposits are generally fine-grained and well cemented, although zones containing coarser sands do exist. A potential exists for perched ground-water conditions to occur above the regional water table wherever a permeability contrast exists, for example immediately above the contact of the permeable Coconino sandstone with the underlying low permeability Hermit shale. Perched ground water may also be anticipated to occur as isolated or discontinuous lenses within the overlying Toroweap and Kaibab limestones. The existence of localized perched ground-water zones above the regional water table is manifested in isolated springs and seeps along the walls of the Grand Canyon and tributary canyons. The discharge from these perched zones is typically small, that is less than a few gallons per minute, and frequently intermittent.

The experience has been regionally that these isolated perched ground-water zones are not capable of being produced at a sustained rate for any length of time because of their limited areal extent and the slow rates of natural ground-water recharge. Consequently, it can be anticipated that if perched ground-water zones are encountered during mining, they may produce small quantities of water initially, but the yield can be expected to decrease with time and frequently to cease altogether within a period of several weeks or months. This is consistent with observed conditions during mining at the Hack Canyon and Pigeon Mines where aggregate inflow to the mine workings has decreased from about 10 to less than 5 gallons per minute.

3.3.2 Site-Specific Conditions

The proposed mine plan for the Hermit Mine calls for the extraction of uranium ore from an approximate 600 foot interval within the breccia pipe. The ore body would be accessed by construction of a 1,100-foot vertical shaft located outside of the mineralized zone and by extending horizontal drifts into the mineralized zones within the breccia pipe. The final depth of mining will be nearly 1,000 feet above the regional ground-water table which is within the Redwall-Muav limestone aquifer. Consequently, it is not expected that significant ground-water inflow to the mine itself will occur. Isolated zones and some fractures above and in the area of the planned mine workings are known to contain perched ground water. Specifically, perched ground water has been encountered in the Toroweap limestone and within the Coconino sandstone immediately above the top of the Hermit shale. During mine development, these perched ground-water zones may cause water to collect in the mine workings, requiring pumping to the ground surface. It is further expected that as mining progresses the inflow to the mine from any perched zones that are encountered will decrease; resulting in the expectation that the Hermit Mine will be essentially dry in the latter phases as have been the cases in the Hack Canyon and the Pigeon Mines.

The perched ground-water zone within the Toroweap limestone at the location of the proposed Hermit Mine has been developed to provide water for livestock. The well at this location can be produced at about 2 gpm on an intermittent basis only. The potential yield from the perched ground-water zone at the base of the Coconino sandstone is believed to be very small.

3.4 Ground-Water Quality

Existing data on the quality of ground-water inflow to existing mines within the Colorado Plateau are limited primarily because of its infrequent occurrence. The analytical results for a sample collected from the Pigeon Mine in August, 1986 by Energy Fuels together with the results of ground-water samples from wells in the area are summarized in Table 2. A description of the wells listed in Table 2 is given in Table 3.

The Pigeon Mine water sample was collected from the discharge to the main sump at the lowest working level in the mine and represents water that has percolated downward through the workings. The sample, therefore, should be representative of mine water. The water is a strongly bicarbonate type indicating neutral to basic pH conditions within the mine. The sample, however, except for radiochemistry, meets all Primary Drinking Water Standards and exceeds the Secondary Drinking Water Standards only for sulfate (851 mg/l) and total dissolved solids (1,920 mg/l). The radiochemistry for the Pigeon Mine sample is summarized in Table 4.

TABLE 2

SUMMARY OF RESULTS FOR CHEMICAL ANALYSIS FOR GROUND-WATER SAMPLES
FROM WELLS WITHIN THE ARIZONA STRIP
(Constituent Levels Exposed In Mg/L)

Well Name/Ref. No.	Pigeon Mine	Pigeon #4	Hack #10	Hunt #5	Kanab #6	Maximum Allowable	Contaminated Level
Well Reg. No.	Main Sump	503711	640855(1)	503919	509198		
Aquifer	---	RW	BP	K/T	RW	(MCL)	(MCL)
Date Sampled	8/22/86	10/4/82	10/4/82	8/4/83	12/6/85	(2)	(3)
Constituent							
Arsenic	<0.01	<0.02	<0.02	0.028	<0.01	(0.05)	(0.05)
Barium	<0.1	<0.50	0.05	<0.5	<0.05	(1.0)	(1.0)
Cadmium	<0.0001	<0.01	-0.013	<0.005	<0.005	(0.01)	(0.01)
Chromium	<0.001	<0.05	<0.05	<0.01	<0.01	(0.05)	(0.05)
Fluoride	0.07	1.6	1.1	1.2	1.0	(1.4-2.0)	(1.4-2.4)
Lead	<0.001	<0.02	0.21	0.024	<0.02	(0.05)	(0.05
Mercury	<0.00006	<0.002	<0.002	<0.001	<0.001	(0.002)	(0.002)
Nitrates	---	0.086	0.055	0.2	<0.20	(10.0)	(45.0)
Selenium	<0.01	0.0050	<0.01	0.005	<0.005	(0.01)	(0.01)
Silver	<0.0001	<0.02	<0.02	0.02	<0.02	(0.05)	(0.05)
Alkalinity	337.0	245.0	186.5	260.0	204.0	N/A	N/A
Calcium	179.0	142.0	131.0	570.0	435.0	N/A	N/A
Chloride	---	31.3	26.3	18.0	72.0	N/A	500.0
Copper	<0.001	0.01	0.01	<0.05	<0.05	N/A	1.0
Iron	0.05	2.0	<0.05	2.2	<0.1	N/A	0.3
Magnesium	202.0	40.0	59.0	175.0	170.0	N/A	N/A
Manganese	0.05	0.0	0.02	<0.05	<0.05	N/A	0.05
Sodium	99.0	104.0	717.0	25.0	128.0	N/A	N/A
Sulfate	851.0	890.0	3,560.0	2,020.0	1,535.0	N/A	500.0
TDS	1,920.0	---	---	2,980.0	2,570.0	N/A	1,000.0
Zinc	2.5	<0.05	1.11	5.4	<0.05	N/A	5.0
Uranium	0.17						

Aquifer: RW = Redwall/Muav
BP = Breccia Pipe
K/T = Kaibab/Toroweap

(1) Sample was taken after passing through a water softener.
(2) Arizona Department of Health Services.
(3) Federal drinking water standards.

TABLE 3

WATER WELL STATISTICS

WELL NAME/ REF. NO.	REGISTRATION NUMBER	WELL DEPT.	STATIC WATER LEV.	YIELD (GPM)	PRINCIPAL AQUIFER
Pigeon Well/ #4	503711	2,350	1,736	10	Redwall Ls.
Hunt Well+/ #5	503919	660	370	2	Toroweap Fm.
Kanab North Well/#6	509198	2,700	1,470	10	Redwall Ls.
Hack Canyon/ #10	640855	1,475	1,096	5	Breccia Pipe

Note: N/A - Not Available.

\+ - Hunt Well #5 is located at the Hermit Mine Site.

TABLE 4

RADIOCHEMISTRY, PIGEON MINE WATER

Gross Alpha (pCi/l), Total	331 ± 36
Gross Beta (pCi/l), Total	99 ± 17
Radium 226 (pCi/l), Total	39 ± 1.6
Radium 228 (pCi/l), Total	1.4 ± 1.6

4.0 HYDROGEOLOGICAL CHARACTERISTICS OF BRECCIA PIPES

As discussed previously in Section 3.2.3, mineralization in the Hermit Mine area occurs in or near a breccia-pipe structure that cuts vertically through the flat-lying sedimentary strata. Cavities formed millions of years ago by dissolution of portions of the deeper Redwall limestone created cavities which resulted over time in the collapse of the overlying strata. The collapse zone propagated upward through the overlying strata several hundreds of feet forming a cylinder or narrow cone filled with breccia or rock fragments.

Geochemical changes within the breccia zone resulted in cementation of the breccia or broken rock infilling the voids with a fine-grained matrix, and depositing uranium and other minerals including silver and copper. As a result of the primary and secondary mineralization, the breccia zone is denser and less permeable than the surrounding rocks. Laboratory tests on rock core from the Canyon Mine prospect, which is located on the South Rim of the Grand Canyon, confirm the dense nature and low hydraulic conductivity of the material both within the breccia pipe and in the natural materials immediately surrounding the pipe. The results of the laboratory measurements which are summarized in Table 5 indicate that the geologic materials immediately surrounding the pipe are effectively impermeable with measured hydraulic conductivities less than 1×10^{-9} cm/sec. In comparison, the measured hydraulic conductivities for the material from inside the breccia pipe but not within the uranium ore zone range from 2.0

x 10^{-7} to 1.4×10^{-6} cm/sec. Measured hydraulic conductivities for three samples taken within the pipe but below the proposed depth of mine were less than 1×10^{-8} cm/sec.

TABLE 5

LABORATORY HYDRAULIC CONDUCTIVITY
OF ROCK CORE SAMPLES, CANYON MINE

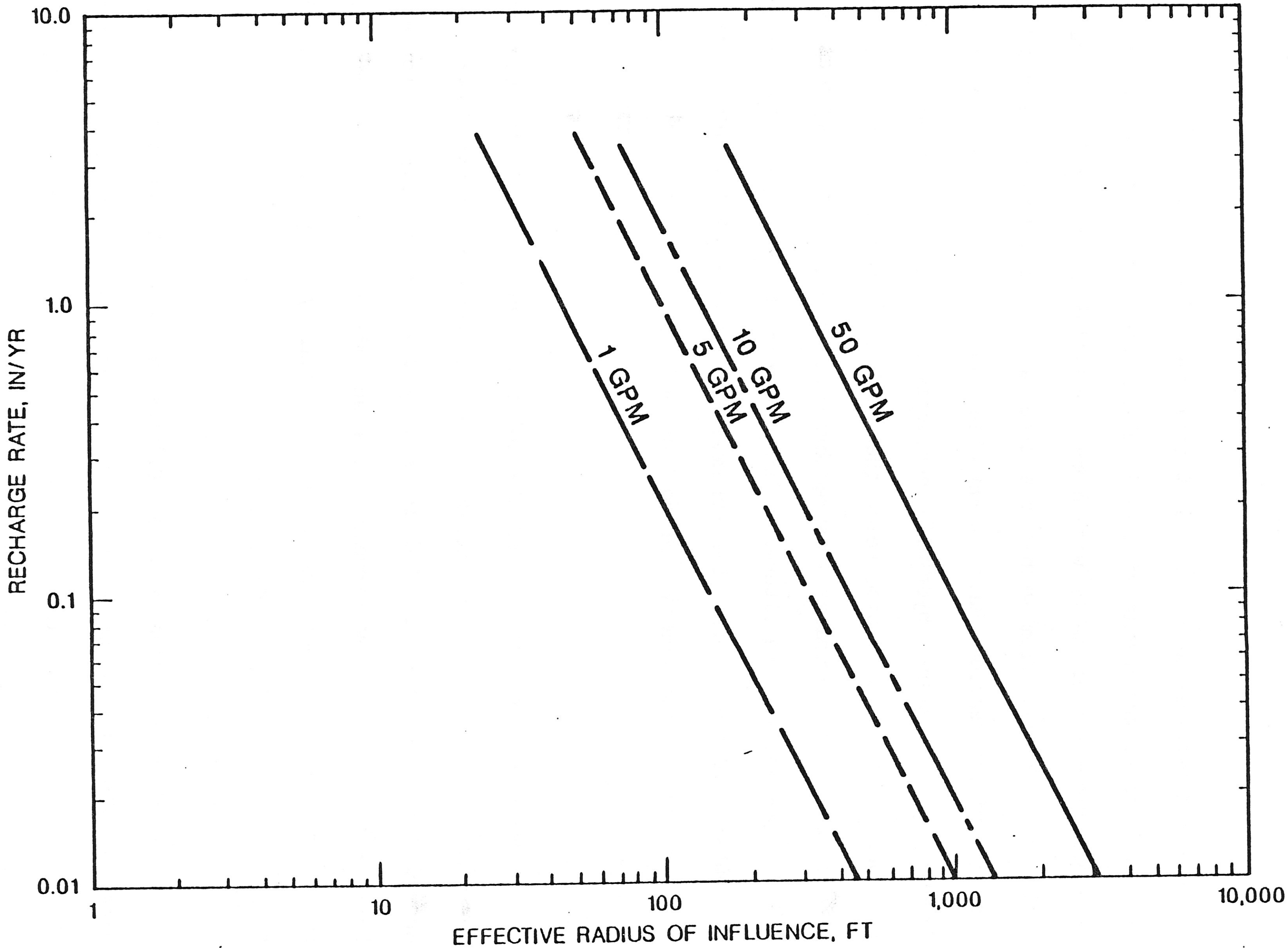
Sample	Sample Description	Depth Below Ground Surface -Feet-	Hydraulic Conductivity -cm/sec-
1	Sandstone/siltstone-outside pipe	2,020	2.2×10^{-10}
2	Sandstone/siltstone-outside pipe	2,303	1.3×10^{-11}
3	Sandstone/siltstone-outside pipe	2,045	9.4×10^{-11}
4	Sandstone/siltstone-outside pipe	2,059	$<3.4 \times 10^{-13}$
5	Sandstone/siltstone-outside pipe	- SAMPLE FAILED -	
6	Sandstone/siltstone-outside pipe	2,285	1.2×10^{-11}
7	In pipe, but not in uranium ore zone	2,299.25	2.0×10^{-7}
8	In pipe, but not in uranium ore zone	1,381.50	6.1×10^{-7}
9	In pipe, but not in uranium ore zone	1,188.50	1.4×10^{-6}
10	In pipe below 2,000 foot level	2,012	1.6×10^{-9}
11	In pipe below 2,000 foot level	2,073	7.0×10^{-9}
12	In pipe below 2,000 foot level	2,133	4.7×10^{-9}

5.0 POTENTIAL IMPACT OF MINING OPERATIONS

Experience to date has shown that the rates of ground-water inflow to the existing mines in the Kanab Plateau decrease with time and are small, that is less than 5 gallons per minute. Following cessation of mining, it can be expected that ground-water inflow to the mine workings will continue and that with time a potential exists for the mine workings to partially fill with water. In that the mine workings are above the regional water table which is believed to be some 1,000 feet below the depth of mining, a potential will exist for downward seepage from the mine to the regional water table. The rates of filling of the mine workings and the rates of downward seepage will depend on the hydraulic transmission and storage characteristics of the overlying, underlying and adjacent strata. The low rates of natural ground-water recharge is evidenced by the limited and localized occurrence of perched ground-water conditions above the regional water table and the fact that the yield from their perched zones generally is not sustainable, even at low pumping rates.

The experience at the Hack Canyon and Pigeon Mines has been that perched ground-water conditions can be expected to be encountered during sinking of the shaft and mining. The aggregate rates of inflow to the workings at both the Hack Canyon and Pigeon Mines, however, have been small, that is less than about 5 gallons per minute. The inflow, which is largely associated with localized perched zones at or near the top of the Hermit shale, has decreased with time and is currently less than a few gallons per minute. Also of importance is that the quality of the inflow to the mine workings as indicated by analysis of water samples from the Pigeon Mine is very good. The quality of the water in the main sump in the bottom of the Pigeon Mine meets all Primary Drinking Water Standards, except for radiochemistry, and exceeds the Secondary Standards only for sulfate and total dissolved solids.

The effect of intercepting "perched" ground-water conditions during mining will be localized due to the discontinuous nature of ground-water occurrence above the regional water table. Parametric analyses based on observed conditions during mining at the Hack Canyon and Pigeon Mines further supports the localized nature of the potential impacts. Given low, but reasonable rates, of natural ground-water recharge and actual rates of ground-water inflow to the mine workings at the existing mines, it can be shown that the effective radius of influence as a result of intercepting perched conditions will be small and typically less than a few thousand feet. This relationship between rate of ground-water inflow to the mine workings, rate of natural ground-water recharge, and the "effective" radius of influence is shown on Figure 4. As can be seen from Figure 4, the effective radius of influence is not highly sensitive to the assumed rate of natural recharge for a given aggregate mine inflow rate and in the worst case less than several thousands of feet.



Effective Radius of Influence as a Function of Aggregate Mine Inflow and Rate of Ground-water Recharge

Dames & Moore

Figure 4

The proposed depth of mining within the mineralized portion of the breccia pipe at the Hermit site will be approximately 1,000 feet above the regional ground-water table within the Redwall-Muav aquifer. Laboratory tests on rock core from within the breccia pipe but below the depth of uranium mineralization have shown the rock mass to be effectively impermeable. Measured hydraulic conductivities for the non-mineralized portions of the breccia pipe below the depth of mining were less than 1×10^{-8} cm/sec. This compares measured hydraulic conductivities of less than 1×10^{-9} cm/sec for the altered sandstone and siltstone units adjacent to, but outside of the breccia pipe and measured values of 2.0×10^{-7} to 1.4×10^{-6} cm/sec for non-mineralized portions of the pipe within the zone of mining.

In summary, recementation of the collapse breccia within the pipe and the alternation and recementation of the sedimentary units immediately around the pipe have resulted in a very low permeability environment. Because of the very low permeabilities and the physical separation, the potential for any direct impact on water quality or quantity within the Redwall-Muav limestone aquifer is negligible.

In addition to these physical factors which limit the potential for water quality or quantity impacts with the Redwall-Muav aquifer, adsorption of heavy metals and radioactive constituents on the surfaces of clays as well as chemical reactions with the rock strata will tend to minimize or eliminate any short-term or long-term potential water-quality impacts.

Thick sequences of argillaceous mudstones and limestones with high adsorptive capacities physically separate the uppermost aquifer within the Redwall-Muav limestones and the proposed depth of mining.

Although regionally, breccia pipes are a common geologic feature within the Colorado Plateau, only a relatively few contain sufficient uranium mineralization to be commercially mineable. These breccia pipes, as discussed, are typically small in diameter - that is less than 300 to 500 feet. Given the existing geologic and hydrogeologic conditions in and in the immediate area of mineralized breccia pipes in the Colorado Plateau, it is highly improbable that the development, and mining of selected breccia pipes such as at the proposed Hermit Mine site will have a measurable or quantifiable impact on ground-water quality or quantity within the Redwall-Muav aquifer. It can be expected that mine development may locally dewater perched ground-water systems which exist within the thick unsaturated zone above the regional water table. Any effect on these perched systems, however, will be limited to the immediate mine area.

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Wildlife Resource Survey
Hermit Mine Site
Mohave County, Arizona

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September 1986

Executive Summary

The Hermit Mine Site, at 4900 ± 30 feet elevation in Mohave County, Arizona, was surveyed on 24 and 25 September, 1986. No big game animals and very minimal big game sign were observed. One jackrabbit, one raven, and several flocks of mountain bluebirds were observed.

No significant irreversible impacts to the local environment or long-term impacts on wildlife use of the site are anticipated.

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Hermit Mine Site

1.0 INTRODUCTION

Energy Fuels Nuclear, Inc. (EFN), Denver, Colorado, retained John W. Sigler of Spectrum Sciences and Software, Inc. and W.F. Sigler of Sigler & Associates Inc. (WFSAI) of Logan, Utah, to conduct a wildlife survey in the area of the proposed Hermit Mine Site. The site is located in the SW 1/4 of Section 17, Township 38 N Range 4 West, Mohave County, Arizona.

Both detailed ground and limited aerial surveys were completed in the vicinity of the proposed Mine Site. Aerial reconnaissance by helicopter included the site, surrounding area and the upper portion of Grama Canyon, located 1.5 to 2.0 miles southeast of the proposed Mine Site. The ground reconnaissance entailed an intensive transect search for wildlife or wildlife sign within approximately a 0.5 mile radius, inclusive of the proposed Mine Site.

2.0. SURVEY OBJECTIVES

This survey was designed to develop baseline wildlife resource data and to determine the extent and intensity of wildlife utilization in the vicinity of the proposed Mine Site.

3.0 DESCRIPTION OF .HE STUDY AREA

The proposed Mine Site has a generally north-northwest aspect although very little relief (estimate less than 30 feet total horizontal elevation change across the site) exists across either the proposed Mine Site itself or the drainage within which it is located.

The drainage area is approximately 200 acres and the proposed Mine Site will occupy 30 acres within it. The site is about 1/3 to 1/2 of the way down the small watershed in which it is located. The drainage above the site has no significant or notable features (e.g., large rock outcrops, tree lines, etc.).

Road access to the proposed Mine Site is presently by approximately three miles of unimproved dirt road off of the Mt. Trumball Road. The proposed access haulage road location would be 1.5 miles long to connect with the Mt. Trumball Road. The proposed new access road would connect to the Mt. Trumball Road, traveling west/northwest from the proposed Mine Site.

4.0 RESULTS

Transects established for wildlife ground reconnaissance are shown on Plate 1, attached.

4.1 Aquatic Resources

A small (approximately 20 feet in diameter) earthen berm pond is located in the northeast portion of the proposed Mine Site. This pond is filled by catchment/containment dikes and a windmill attached to one of the exploration drill holes drilled by EFN. No aquatic species were observed and none would be expected due to the fluctuating levels and temporary nature of the pond. A second, larger pond (approximately 75 feet in diameter) exists approximately 1/2 mile north of the proposed Mine Site. No aquatic species were observed or are expected in this pond.

4.2 Avian Species

Several flocks of mountain bluebirds *Sialia currucoides* were observed as well as one common raven *Corvs corax* in the general area of the proposed Mine Site. It is unlikely that activity at the site will significantly displace either of these species.

Lack of displacement for either of these species is based on the presence of essentially the same habitat in the surrounding area. Additionally, both of these species are commonly found in association with human activity.

During the aerial survey, not only was the area of the proposed Mine Site examined but also the large drainage area and the upper three miles of Grama Canyon including its westerly arm. In the area surveyed, no suitable raptor nesting sites were observed. In general the walls of Grama Canyon in the upper reaches are of insufficient (less than 100 feet) height to attract nesting raptors.

4.3 MAMMALIAN SPECIES

4.3.1 Small Animal

Only one black-tailed jackrabbit (*Lepus californicies*) was observed near the proposed Mine Site, approximately 300 yards northwest of the windmill. No other small animals were observed on the site during ground or aerial observation.

4.3.2 Big Game Animals

No big game animals of any species were observed on or near the proposed Mine Site during ground or aerial surveys. No tracks (possibly due to the recent rain storm) were observed on the site or in the surrounding drainage area. One small mule deer *Odocoileus hemionus* pellet group was noted some 200 yards north of the windmill. One mule deer was observed in Grama Canyon approximately 3.5 miles from the proposed Mine Site.

5.0 CONCLUSION

Due to the non-unique topography, general botanical characteristics and total lack of vegetative cover, it is our opinion that the wildlife resources in the vicinity of the proposed Mine Site will not suffer any long-term irreversible or significant short-term impact as a result of mining activities at the proposed Mine Site.

Although some displacement of wildlife species may occur in the immediate vicinity of the proposed Mine Site as a result of the removal of the temporary stock pond, the additional water source located approximately 1/2 mile away, as well as the two additional water ponds located within approximately a 3-mile radius, should be more than adequate to provide for wildlife needs.

Limited wildlife utilization of the area is based on the lack of cover in the area surrounding the proposed Mine Site and the lack of animal tracks, sign and sighting. Some potential for displacement of wildlife species exists if utilization of the stock pond on the site is critical. However, an additional water site exists at a distance of approximately 1/2 mile and two additional water ponds are located within a 3 mile radius. (One in the drainage to the south of the site at the head of Grama Canyon and one at the head of the west arm of Grama Canyon.)

AIR QUALITY IMPACT ANALYSIS
OF THE
HERMIT PROJECT

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February 2, 1987

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1.0 PROJECT OVERVIEW

Energy Fuels Nuclear, Inc. (Energy Fuels) is proposing to develop an underground uranium mine on unpatented mining claims on the Kanab Plateau approximately 22 miles south-southwest of Fredonia, Arizona and, at its closest point, approximately seventeen miles north of the boundary of the Grand Canyon National Park. The Project Area is situated at an elevation of 4,885 feet MSL and the relief in the immediate vicinity of the Project Area is relatively flat. The actual location of the proposed mining project, known as the Hermit Project, is shown in Figure 1.

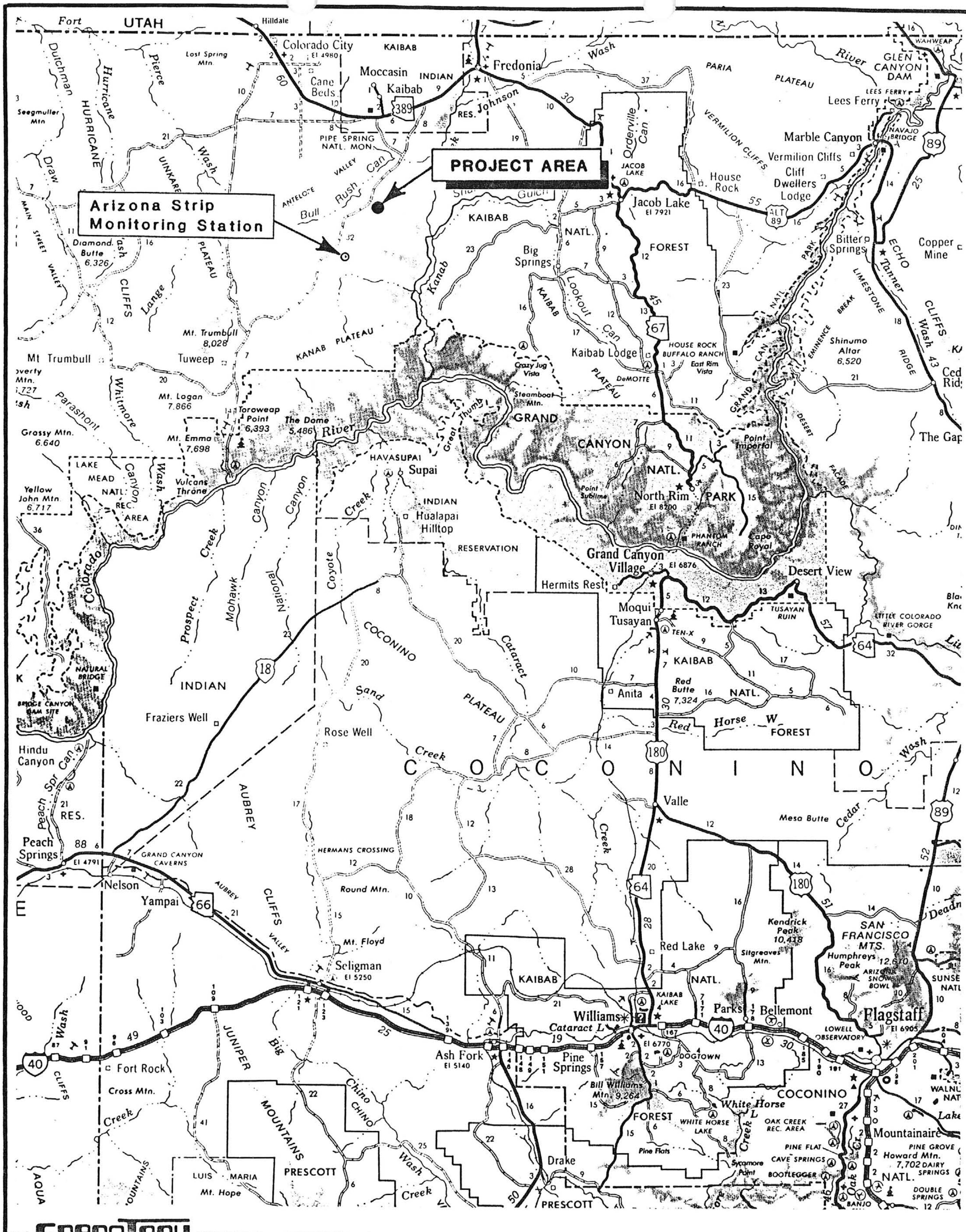
The proposed mining schedule calls for two shifts per day (from 7:00 a.m. to 11:00 p.m.) working five days per week, 52 weeks per year. Over the life of the mine, the Hermit Project is expected to support the removal of an average of 300 tons per day of uranium ore. Because the pertinent air quality standards address pollutant concentrations averaged on an annual, or more frequent basis, a longer or shorter project life does not affect this air quality analysis. Therefore, if maximum pollutant concentrations are assessed during "worst-case" operating conditions, as has been done in this study, it can be realistically assumed that pollutant concentrations in other operating years will be less.

Access to the ore body will be by a 1100 foot vertical shaft. To provide mine ventilation and an escape route, a second shaft, eight feet in diameter, will be drilled approximately 300 feet east of the mine portal. Figure 2 shows the surface locations of the shafts. The mine ventilation shaft will be capped with a 200,000 CFM fan to exhaust air, thereby ensuring adequate air flow throughout the mine workings.

While actual mining occurs underground, certain surface structures and activities will be required to support the mining project. A total of 23.6 acres will be disturbed to support these surface activities. Figure 2 presents the configuration of surface facilities within the Project Area.

Several of these surface facilities and/or activities could result in the release of pollutants into the atmosphere. These facilities and activities include:

- Mine vent;
- Wind erosion from ore, waste and top soil stockpiles and disturbed areas;



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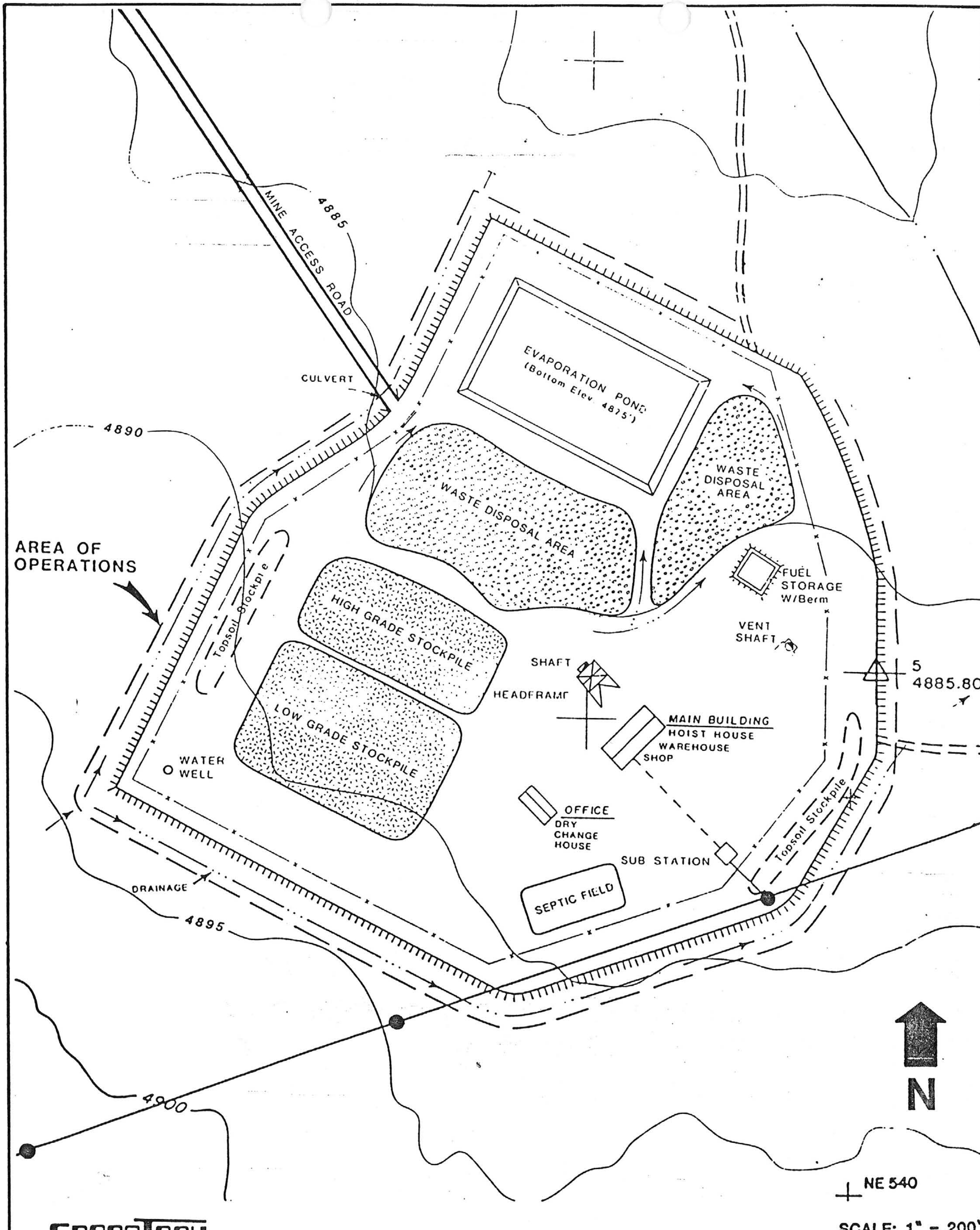
PROJECT **Hermit**

Location Map

FILE NO. ______ DATE 12/86 FIGURE NO. 1



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PROJECT Hermit

Project Area Emission Sources

FILE NO. ______ DATE 2/87 FIGURE NO. 2

- o Loading and unloading of stockpiles;
- o Ore and waste handling; and
- o Ore transport.

By far, dust (particulates or TSP) will be the primary pollutant released as a result of the Project. (This analysis is not intended to analyze the potential radiological impacts resulting from the Project and, thus, they are excluded from further discussion). Other pollutants, specifically carbon monoxide (CO), oxides of nitrogen (NO_x) and sulfur dioxide (SO_2) will be emitted in very small amounts. These pollutants will result exclusively from vehicles involved in the Project activities. Since Energy Fuels will provide and encourage bus transportation for its employees to and from the Project Area, employee vehicle emissions will be below the diminimus levels. An average of only twelve haul trucks per day are proposed for ore transport, and therefore, haul truck exhaust emissions will also be below the diminimus level.

Since emissions of CO, NO_x and SO_2 resulting from the Project will be well below the diminimus levels, an attempt to quantify their potential impact on the local air quality would not be justified. Consequently, the contribution of the proposed Project with respect to these emissions will not be further analyzed in this study.

One of the larger sources of on-site particulate emissions will be stockpile loading and unloading and the resultant potential wind erosion. Ore and waste rock will be brought to the surface and dumped in their respective stockpiles. It is anticipated that 150,000 tons of barren waste rock will be generated through the course of the Project. This barren waste rock will be stored on the surface in two waste rock disposal areas. Top soil removed during construction activities will be stored in inactive stockpiles for use in subsequent reclamation activities. Location of the respective stockpiles is also shown on Figure 2.

No ore processing or milling is planned on-site. Instead, ore will be transported by haul truck to an uranium processing mill near Blanding, Utah. To accommodate the planned mining rate of 300 tons per day, up to twelve haul trucks will be employed daily (five days per week) to transport ore. Ore haulage from the Project Area will be via unpaved roads for approximately the first twelve miles (approximately 1.2 miles will be along the new project access road and approximately eleven miles will be on Mt. Trumbull Road), after which travel will be on paved roads. The haul trucks will be covered with tarpaulins to reduce the possibility of ore spillage and to minimize windblown emissions.

2.0 SITE CHARACTERISTICS

2.1 Climatology

The general Project region is classified as a semi-arid continental climate. As such, it is typified by cool winters, warm summers and light precipitation. Winter temperatures in the area commonly drop below freezing at night, while temperatures in the summer months routinely rise above 90°F. Annual precipitation in the area averages less than fifteen inches and the summer and winter months are typically the wettest. Winter precipitation is primarily in the form of snow; summer precipitation is the result of thunderstorm activity which at times can be heavy. Specifics of the area's precipitation, temperatures and wind patterns are presented below.

2.1.1 Precipitation

Twenty-three years of meteorological data have been collected and summarized at the Fredonia, Arizona weather observation station located approximately 22 miles northeast of the Project Area. Data from this station is representative of the Project Area. A summary of these data is presented in Table 1.

The data collected at the Fredonia station show that the annual average precipitation for the area is approximately 10.1 inches. Spring is usually the driest season, while the winter is usually the wettest. Winter precipitation, which usually occurs as snow, results primarily from Pacific storms passing over the area. Snowfall from year to year is quite variable in both frequency and amount, but averages 23.3 inches annually. At least a trace of frozen precipitation can be expected in every month from October through April with January normally the snowiest.

While the winter season is typically the wettest season, August is usually the wettest month, averaging 1.27 inches of precipitation. Summer and fall precipitation in the area is most commonly the result of locally induced thunderstorm activity.

The maximum recorded daily rainfall recorded in the area was just over two inches in a 24 hour period. Daily precipitation amounts of 0.10 inches or more should occur on the average of 28 days a year.

TABLE 1

CLIMATOLOGICAL SUMMARY FOR FREDONIA, ARIZONA[1]

Month	Temperature (°F) Mean Monthly	Mean Daily Maximum	Mean Daily Minimum	Extremes High	Low	Precipitation (in.) Totals Mean	Maximum	Snowfall Mean	Maximum[2]	Mean # Days Precipitation[2] ≥ .1"
JAN	32.7	46.0	19.4	66	-18	1.17	3.28	8.1	13.6	4
FEB	36.2	50.6	21.7	71	-15	.89	1.65	4.2	11.0	3
MAR	42.4	58.6	26.2	79	5	1.09	3.56	4.2	14.5	2
APR	50.7	68.7	32.7	86	10	.68	1.87	.7	2.0	1
MAY	58.0	77.0	39.0	94	20	.44	1.33	0	0	2
JUN	66.5	86.7	46.2	104	26	.32	.96	0	0	1
JUL	73.8	92.8	54.7	105	37	.69	1.88	0	0	2
AUG	72.1	90.1	54.1	104	33	1.27	2.68	0	0	4
SEPT	65.1	84.6	45.6	99	26	1.04	2.82	0	0	2
OCT	53.8	72.4	35.4	96	17	.88	3.08	T	T	2
NOV	41.6	58.3	24.9	76	0	.62	1.39	.3	1.5	3
DEC	34.6	48.5	20.7	70	-15	1.00	2.30	1.2	6.0	2
ANN	52.3	69.5	35.1	105	-18	10.09	3.56	22.3	14.5	28

Source: Climatography of the United States NO. 86-2 Arizona.
1. Unless otherwise specified, based upon period of record 1937 - 1960.
2. Period of record 1951 - 1960.

2.1.2 Temperature

Table 1 also presents a summary of temperature data from the Fredonia station. These data show that the average monthly maximum temperatures range from 46.0 °F in January to 92.8 °F in July. Average monthly minimums range from 19.4 °F to 54.7 °F also occurring in January and July, respectively. The mean annual temperature is 52.3 °F.

The Table 1 data show that the daily maximum is normally above 90 °F in July and August and daily minimum temperatures are normally below freezing from November through March. Temperature extremes recorded at Fredonia show a maximum of 105 °F and a minimum of -18 °F.

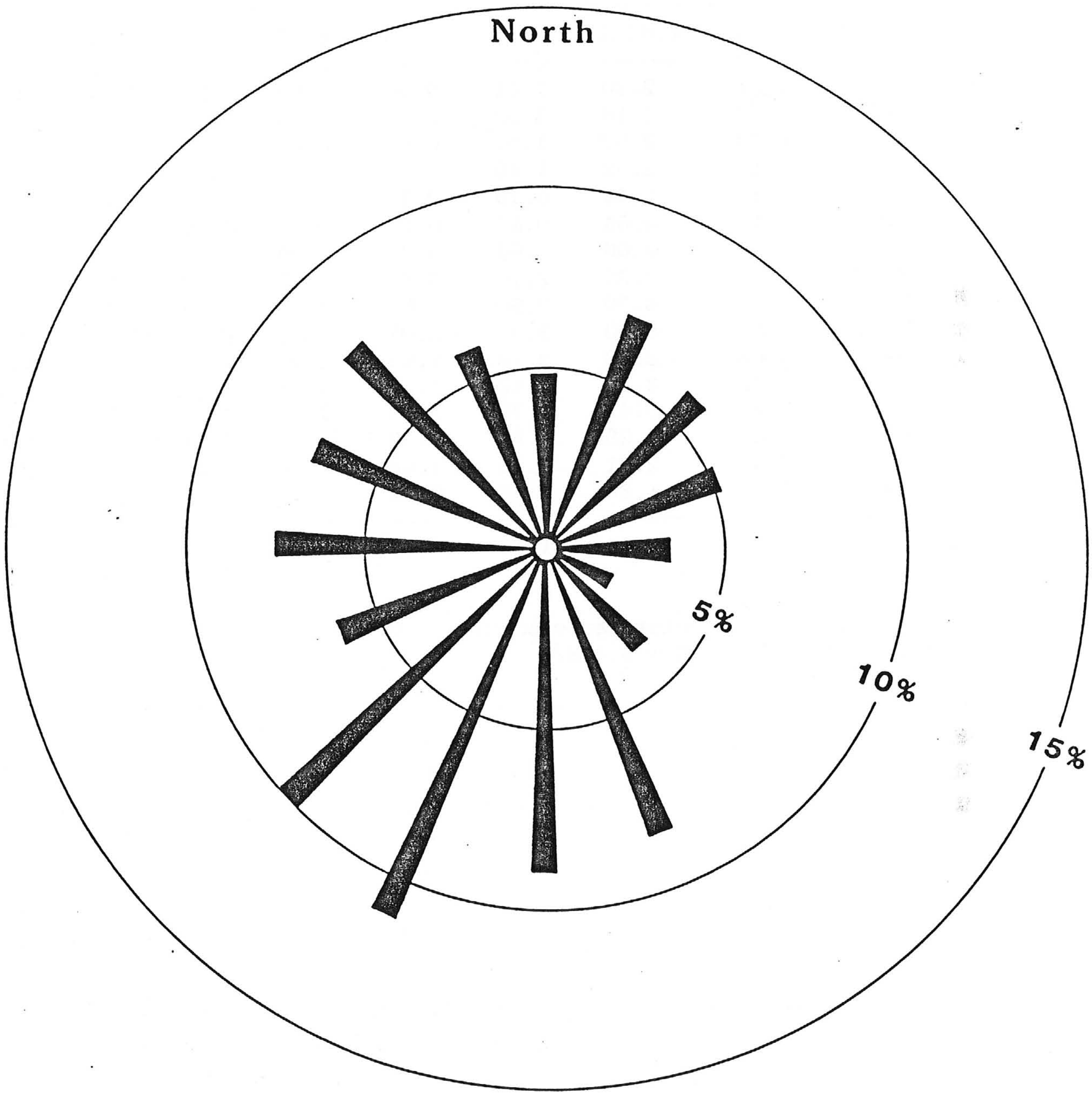
2.1.3 Winds

Long-term wind data are limited in the vicinity of the Project. However, to better define the wind patterns of the Arizona Strip Area, in 1983, Energy Fuels contracted with Fox Consultants Inc., an independent consultant, to measure wind patterns of the area. As a result, a one year data set was collected from a meteorological station located near Sunshine Point approximately seven miles south of the Project Area. Figure 1 shows the location of this meteorological station.

Wind data at this station were collected from March 1983 to March 1984 and, because of the similarities in terrain and the close proximity of the meteorological station to the Project Area, the resultant meteorological data are very representative of the Project Area. Figure 3 presents the graphical annual wind rose from the station and Table 2 presents the tabular wind rose which also presents wind speed data. These data show that the prevailing wind direction at the Project Area is from the south-southwest, with south-southeast through southwest winds clearly dominating the wind patterns of the Area. (Nearly 40 percent of all winds blew from the south-southeast through southwest sectors). On the other hand, easterly component winds are the least frequently occurring at the Project Area, with east-southeast occurring less than 1.0 percent of the time.

As shown in Table 2, wind speeds averaged 3.4 m/sec (7.6 mph) throughout the one year monitoring period, with higher average wind speeds more often associated with southerly component winds. However, high wind speeds were not common as wind speeds in excess of 11 m/sec (24.6 mph) occurred only 0.32 percent of the time.

Percent Occurrence Of Winds By Direction
March 1983-March 1984
Arizona Strip Station



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PROJECT Hermit	Wind Rose

FILE NO. ________ DATE 2/87 FIGURE NO. 3

TABLE 2

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR
MARCH 1983 THROUGH MARCH 1984
ENERGY FUELS - ARIZONA STRIP AIR STATION MONITORING

DIRECTION	SPEED CLASS INTERVALS (M/S) 1<1.5	1.5< 3	3< 5	5< 8	8<11	>11	ALL	MEAN SPEED
N	0.31	2.10	1.41	0.35	0.04	0.00	4.21	3.0
NNE	0.29	2.18	2.89	1.05	0.15	0.00	6.56	3.6
NE	0.39	2.89	1.61	0.47	0.09	0.01	5.46	3.0
ENE	0.19	1.53	1.46	1.10	0.19	0.04	4.51	4.0
E	0.31	1.45	0.75	0.19	0.00	0.00	2.69	2.7
ESE	0.17	0.64	0.16	0.00	0.00	0.00	0.97	2.2
SE	0.44	2.06	0.63	0.09	0.00	0.00	3.22	2.3
SSE	0.32	4.26	2.76	0.87	0.07	0.00	8.27	3.0
S	0.79	4.30	2.90	1.85	0.04	0.00	9.88	3.3
SSW	0.56	5.00	3.22	2.09	0.56	0.05	11.49	3.6
SW	0.63	3.30	2.78	2.61	0.49	0.07	9.8	4.0
WSW	0.23	2.70	1.42	1.32	0.19	0.04	5.90	3.7
W	0.49	3.41	1.76	1.10	0.21	0.04	7.01	3.4
WNW	0.45	2.28	2.20	1.30	0.09	0.03	6.35	3.6
NW	0.32	2.81	2.73	1.08	0.12	0.04	7.09	3.5
NNW	0.20	1.66	2.49	0.96	0.20	0.00	5.51	3.8
ALL	6.07	42.58	31.16	16.42	2.44	0.32	98.99	34

CALM (less than one meter per second) = 1.0
PERIOD MEAN WIND SPEED = 3.4 M/S

EnecoTech Inc.
WIND4 12/03/85

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2.2 Air Quality

Associated with the Arizona Strip meteorological monitoring program, a Total Suspended Particulate (TSP) monitoring program was also conducted to establish the background TSP concentrations in the relatively remote and undisturbed Arizona Strip region.

Figure 1 shows the location of the Arizona Strip Air Quality Station. Data from this station were collected from March 1983 through March 1984 in accordance with EPA monitoring and quality assurance guidelines. As part of the QA procedures employed on this monitoring program, colocated samplers were operated to assess the precision of the TSP measurements.

Summaries of the 1983-1984 TSP data collected at the Arizona Strip Air Quality Station are presented in Table 3 and a listing of the individual sample results is included for reference in Appendix C. These data show that the annual geometric mean at this location was 13.7 $\mu g/m^3$. The highest 24-hour concentration measured in the sampling period was 59 $\mu g/m^3$. Because of the close proximity of the Arizona Strip monitoring station to the Project Area, the similarities in climatology and the absence of nearby major industrial sources, these data represent the baseline conditions at the Project Area.

TABLE 3

TSP SUMMARY FROM THE ARIZONA STRIP AIR MONITORING STATION*
March 1983 - March 1984

Concentration (μg/m^3)

	Spring	Summer	Fall	Winter	Annual
Arithmetic Mean	19.3	27.3	12.0	8.1	16.6
Geometric Mean	17.4	25.5	11.2	6.3	13.7
First 24-hr Max	32	59	23	16	59
Second 24-hr Max	30	46	20	14	46

* Data collected on EPA one day in six schedule.

3.0 EMISSIONS INVENTORY

For use in the assessment of the potential "worst-case" air quality impacts from the Project, an emissions inventory for the Project was developed by quantifying all operations and activities to be conducted in the Project Area, during maximum production, that could potentially result in the atmospheric release of pollutants. Further, as part of this "worst-case" assessment, with the exception of covered haul trucks, no emission controls nor mitigation techniques were assumed to be in effect on any potential source.

The only pollutant to be released in any measurable amount into the atmosphere, as a result of the Project, will be particulates (TSP). Further, these TSP emissions are almost exclusively comprised of dust. While the EPA distinguishes between process related particulates (fugitive emissions) and non-process dust (fugitive dust emissions) in its delineation of major emission sources, these emissions have not been segregated in this study to provide a basis for the analysis of "worst-case" impacts.

A summary of the expected TSP emission sources and the calculated emission rate in tons per year (based upon maximum activity) for the Hermit Project is presented in Table 4. While haul road activities, in reality, are off-site emissions (occurring miles from the Project Area), they have been included in the Project emissions inventory so that their potential impact on the local air quality can also be assessed. The individual emission rate calculations for each source, identified in Table 4, are presented in Appendix B of this report.

Table 5 presents a summary of the emission factors used in generating the emissions inventory. The emission factors presented in Table 5, and used in the emissions calculations, are those recommended by the EPA for this type of Project. In cases where the EPA has not recommended a specific emission factor for an individual emission source, currently accepted emission factors are used. With respect to haul road emissions, there have been a number of studies conducted to attempt to quantify dust emissions generated from various sized haul trucks traveling at various speeds on different types of unpaved road surfaces (soil, gravel, etc.). These studies show a wide variance in the predicted emission rates from haul road traffic. Upon discussion with EPA and in keeping with the desire to evaluate the potential "worst-case" impacts under the most restrictive conditions, the emission factor presented in Table 5 was used

TABLE 4

EMISSIONS INVENTORY SUMMARY
HERMIT PROJECT

SOURCE	ANNUAL EMISSIONS (TPY)	
Project Area:		
Ore loadout to stockpile	1.56	
Ore loading from stockpile to haul trucks	1.95	
Waste rock disposal area	0.20	
Wind erosion, disturbed area and stockpile	25.60	
Mine vent	15.00	

Project Area Total		**44.31**
Product Transport:		
Haulroad Emission (per mile) (assuming 16.0 lbs/VMT @ 12 round trips per day)	49.92	

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TABLE 5

EMISSION FACTOR
HERMIT PROJECT

Source Type	Emission Factor	Reference
Haul road, unpaved	k*5.9(s/12)(S/30)(W/3)**0.7* (w/4)**0.5[(365-p)/365]	EPA
Ore, rock, loadout	0.04 lbs/ton	EPA
Ore, rock load to truck	0.05 lbs/ton	EPA
Wind erosion	a*I*C*K*L*V	EPA
Mine vent	0.002 grains/SCFM	AMAX 1980*

where: s is the silt content (12%)
S is the vehicle speed (25 mph)
p is the number of days with 0.01 inches or more of precipitation (95)
a is the fraction of material that remains suspended (0.025)
k is the fraction of material below 30 microns (0.80)
I is the soil erodibility (38 ton/acre)
C is the climatic factor (1.0)
K is the roughness factor (1.0)
L is the field width factor (1.0)
V is the vegetative cover factor (1.0)
W is the average vehicle weight (15 tons)
w is the number of wheels (10)

* AMAX 1980 - State of Colorado air permit for Mount Emmons.

Factor derived from stack tests on AMAX's Henderson underground Molybdeum mine vent in Henderson, Colorado. During testing this mine's annual production was a factor of 10 higher than the proposed Hermit Project's annual production. Consequently, this factor is believed to be much higher than what would be expected at this Project, but is used here for lack of better data.

to calculate haul road emission rates. Knowingly using this factor results in higher emission rates than are currently cited by other federal and state agencies; it was used to approximate "worst-case" conditions.

As shown in Table 4, during a maximum production year a total of 44.31 tons per year of TSP emissions could potentially be released from the Project Area. The primary source of TSP emissions within the Project Area will be wind erosion of disturbed areas and stockpiles. These emissions account for over one-half of all the Project Area's TSP emissions.

Also from Table 4, it is shown that haul road traffic has, as a maximum, the potential to release 16.0 pounds per vehicle of TSP for each mile traveled on unpaved haul roads. Since haul trucks will be tightly covered with tarpaulins, haul road emissions will result exclusively from natural dust from the road surface.

As shown in Table 5 and Appendix Table B-1, TSP emissions from haul roads are dependent upon the number of haul trucks, vehicle speed, number of wheels, vehicle weight, the silt content of the road surface and the number of natural precipitation occurrences. Based on the factors expected for the Project, the resultant dust emissions from each one mile section of unpaved haul road is calculated to be 49.92 tons per year.

With the exception of the mine vent, all Project Area and haul road emissions will be surface released. Emissions from the mine vent will be an elevated release due to the mechanical buoyancy caused by the ventilation fan.

4.0 MODELING PARAMETERS

4.1 Model Selection

To assess the air quality impacts resulting from the Project Area sources, the Industrial Source Complex (ISC) dispersion model was used. The long-Term version (ISCLT) and the Short-Term version (ISCST) of ISC were used to calculate the annual average and 24-hour "worst-case" concentrations, respectively.

The ISC dispersion model is a state-of-the-art, EPA generated and approved air quality dispersion model. Because the model can accommodate a large number of point (elevated or stack) and area emission sources, and the resultant concentrations can be computed at selected distances from the emission sources, it is routinely utilized in impact analyses such as this one.

The ISC model contains particulate deposition and settling algorithms which more closely approximate particle dispersion by allowing the larger particles to settle out (fall to the surface). This is done by dividing the emissions into particle size classes, each with its own settling velocity, mass fraction and reflection coefficient. The three particle size classes used in the ISC model runs are presented in Table 6 immediately following.

TABLE 6

ISC PARTICLE SIZE CLASSES

Particle Diameter*	Mass Mean Diameter	Mass Fraction	Settling Velocity**	Reflection Coefficient***
4 - 10 µm	7.4 µm	0.22	0.004	0.80
10 - 20 µm	15.5 µm	0.44	0.018	0.74
20 - 30 µm	25.3 µm	0.34	0.048	0.62

* Particle size in microns (µm).
** Settling velocity in meters per second.
*** Reflection coefficient taken from ISC User's Manual.

The same method described in the ISC User's Manual was used to calculate the various parameters. The particle size distributions were obtained from the report entitled "Survey of Fugitive Dust From Coal Mines" (EPA 1978). The report presents particle size distributions for most mining activities. From this report particle size distributions were examined for the various mining activities present at the Project Area and a composite particle size distribution was used for all sources.

4.2 Input Meteorology

ISCLT utilizes, as input, meteorological data (specifically wind speed, wind direction and atmospheric stability) in the standard Joint Frequency Distribution (JFD) format. The input JFD was obtained from the hourly meteorological data collected at the Arizona Strip Air Monitoring Station from March 1983 through March 1984 (see Section 2.0).

The observations taken at the Arizona Strip Station consisted of wind speed and wind direction. Concurrent hourly sigma theta (a stability indicator) values were abstracted from the continuous wind direction strip chart trace. These hourly values, in turn, were converted to standard atmospheric stability classes using the Mitchell-Timbre technique. From the hourly wind speed, wind direction and atmospheric stability, a Joint Frequency Distribution was generated for the one year data set. The JFD used for the modeling analyses is presented in Appendix A.

ISCST requires as input sequential hourly meteorological data consisting of wind speed, wind direction and stability values. For the ISCST model runs, the sequential hourly data collected from the Arizona Strip Air Monitoring Station were used for the ISCST modeling analysis.

4.3 Emissions Input

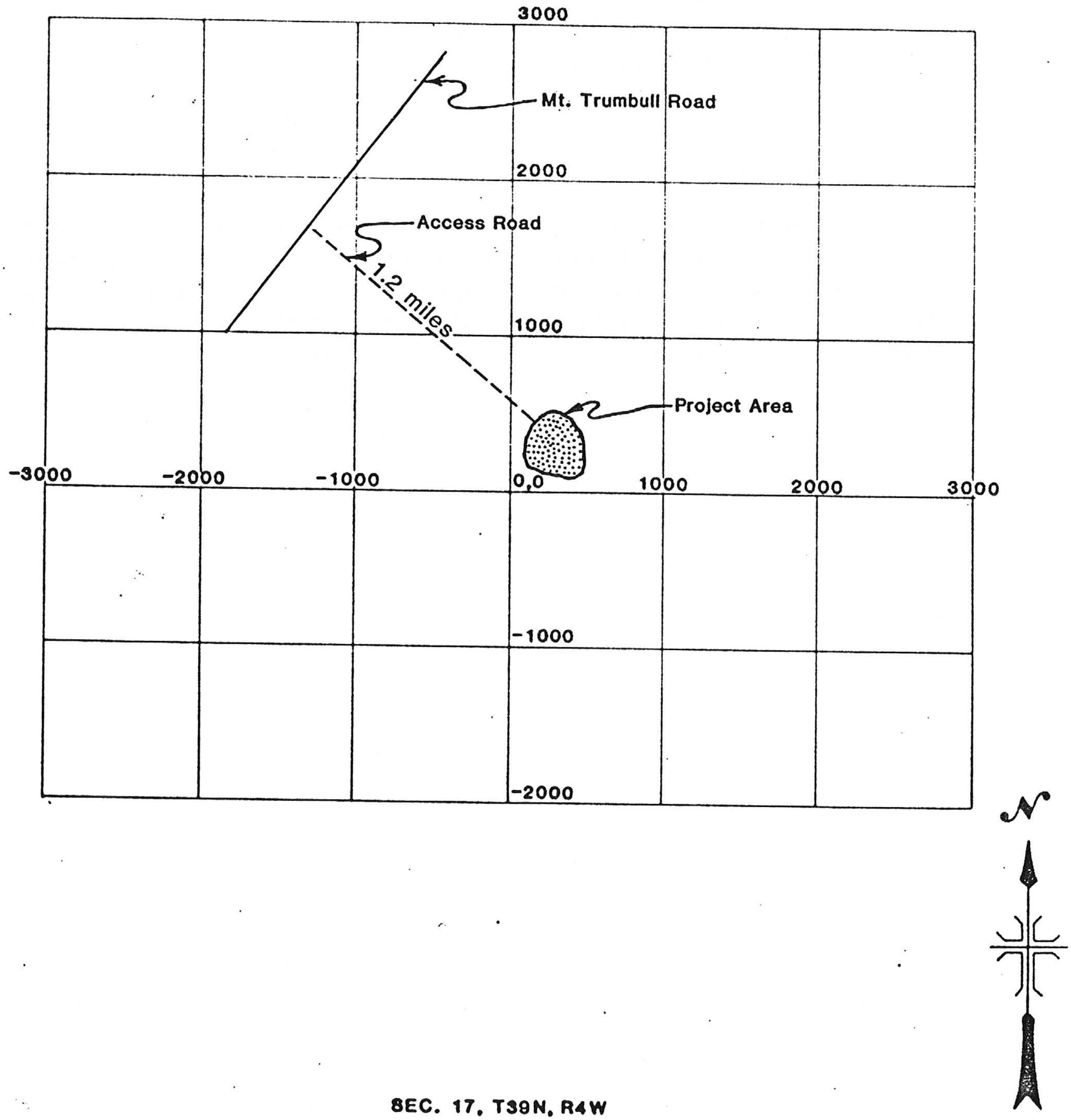
Emission source locations and emission rates are required input to the ISC model. Figure 2 shows the expected locations of each emission source within the Project Area. The emission rates were calculated using the emission factors described in the previous section. All emissions, except the mine vent and the off-site hauling of the ore, are represented by area sources.

The mine vent is located to the east of the main shaft (see Figure 2) and, in the modeling analyses, is represented by a point source. While the mine vent is shown to be approximately 300 feet to the east of the main shaft, relocating the mine vent would only minimally affect the modeling results presented in Section 5.0. The vent's exit velocity was calculated given the ventilation rate and the mine vent size (Table B-1, Appendix B). The temperature was assumed to be ambient and, as a result, the plume was assumed to have no thermal buoyancy.

For modeling, the haul roads were considered to be a line source with an emission rate of 49.92 tons per mile.

4.4 Modeling Grid

The ISC modeling or receptor grid is presented in Figure 4. The receptor grid is basically a 1000 meter rectangular grid around the Project Area. To allow assessment of concentrations at the property boundary, the origin of the receptor grid has been situated just southeast of the southern point of the Project Area. (See 0,0 point in Figure 4.)



SEC. 17, T39N, R4W
Mohave Co., Arizona

SCALE: 1" = 1000 METERS

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Denver, Colorado

PROJECT Hermit

Emission/Modeling Grid

FILE NO. ______ DATE 2/87 FIGURE NO. 4

5.0 DISPERSION MODELING RESULTS

5.1 Air Quality Standards

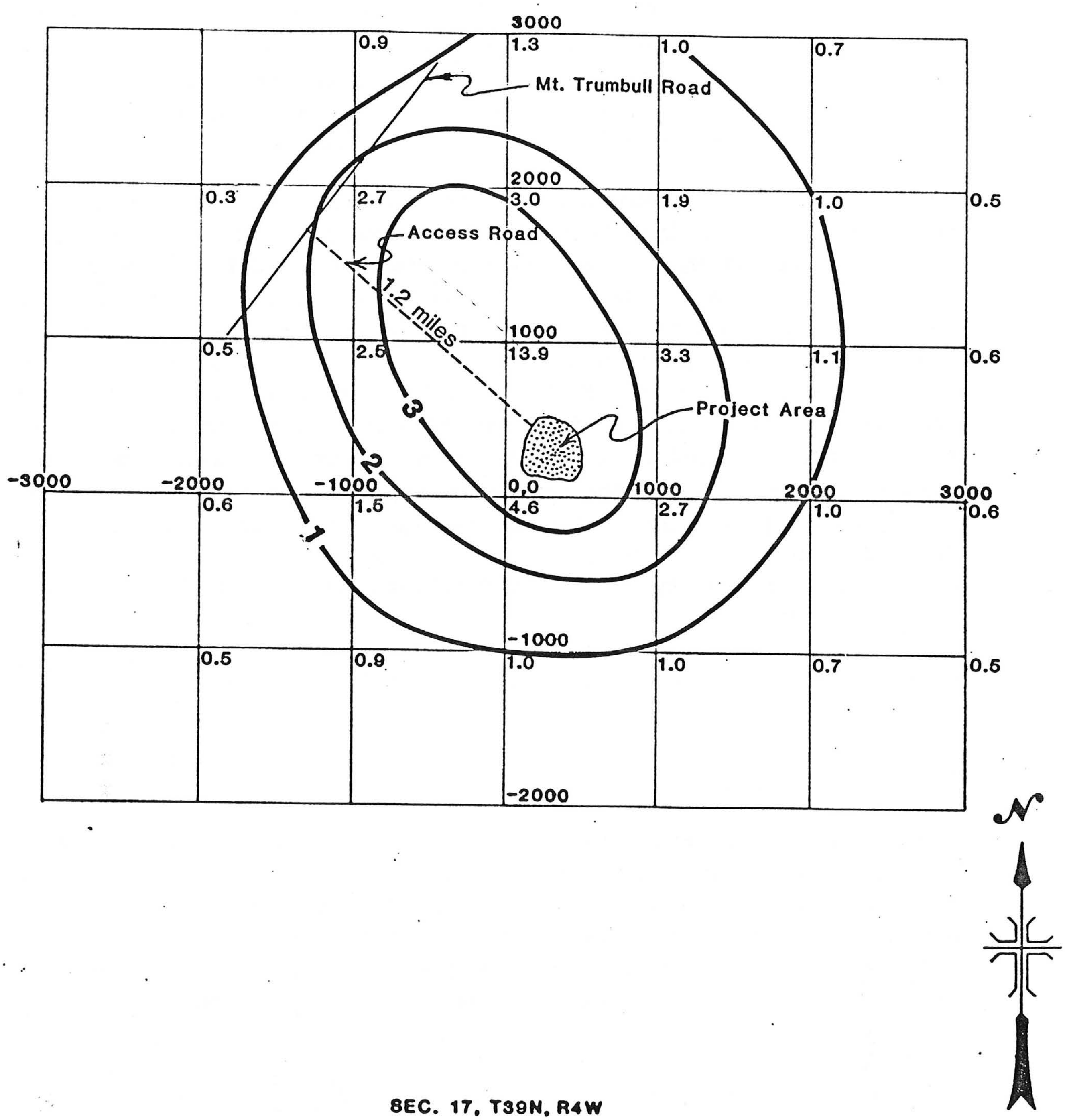
As stated earlier, only particulates are expected to be emitted from the proposed Project in noticeable enough quantities to result in an air quality impact. The National Ambient Air Quality Standards (NAAQS) for particulates are 260 $\mu g/m^3$ for the 24-hour average and 75 $\mu g/m^3$ for the annual geometric mean; and since the State of Arizona has adopted these same standards, modeling was conducted to address these standards.

Because the proposed Project is located approximately seventeen miles north of the closest boundary to the Grand Canyon National Park, it is extremely doubtful that Project related emissions could impact the Park, a mandatory Class 1 area. However, to confirm this contention an analysis was performed to assess whether or not emissions from the Project potentially could result in a significant air quality impact in the Park. For use in this assessment the EPA's designated levels or concentrations of significance, as established for Prevention of Significance Deterioration evaluations, were used to define the are of impact. The levels of significance, as established for particulates, are 1 $\mu g/m^3$ for an annual average and 5 $\mu g/m^3$ for a 24-hour average. Modeling was conducted to determine the location of these levels, and thus, to determine if any significant air quality impact could potentially occur within the Grand Canyon National Park.

Computer printouts of each model run are presented in Appendix A.

5.2 Annual Results

The Project emissions as presented in Table 4, including the haul road emissions from proposed new access (haul) road, and the one year Arizona Strip meteorological data (see Section 2.0) were input into the ISCLT model. The results of the annual ISCLT computer model run are presented graphically in Figure 5. The predicted particulate concentrations resulting from the Project Area are shown as lines of equal concentration or isopleths. The maximum concentration is predicted to be north of the Project Area with a concentration of 13.9 $\mu g/m^3$. This concentration is due primarily to the proposed new haul road which runs to the northwest of



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Denver, Colorado

SCALE: 1" = 1000 METERS

PROJECT **Hermit**

Annual Average Concentration

Units in Micrograms Per Cubic Meter

FILE NO. ______ DATE 2/87 FIGURE NO. 5

the Project area to the Mt. Trumbull Road. As can be seen from Figure 5, the concentration decreases very rapidly dropping off to less than 1 $\mu g/m^3$ within 3000 meters (1.9 miles).

As discussed in Section 2.0, the annual particulate background in the vicinity of the Project is, at a maximum, approximately 14 $\mu g/m^3$. Even adding the background concentration to the modeled impact, the resulting concentrations are predicted to be quite low, with a maximum impact of no more than 28 $\mu g/m^3$. This is well below the applicable state and federal standards.

Figure 5 also shows that the 1 $\mu g/m^3$ significance level isopleth, at its furthest distance in the direction of the Grand Canyon National Park, extends about 1000 meters from the Project Area. Thus, there should be no impact from the Project on the air quality of Grand Canyon National Park which is more than seventeen miles away.

5.3 24-Hour Results - "Worst-Case" Analysis

5.3.1 Project Area

To assess the short-term, or 24-hour, air quality impacts which might result from operations at the Project Area, potential maximum emission releases, including emissions from the proposed new haul road, were input into the ISCST (short-term) version of the ISC model and resultant pollutant concentrations were computed for each day (24-hour period) contained in the 1983 - 1984 Arizona Strip meteorological data set. That is, the ISCST modeling analysis used actual meteorological data and computed the individual daily particulate concentrations that would result if the proposed Hermit Project were in full operation during each day of the 1983 - 1984 data set. By using actual meteorological data in conjunction with the expected emission releases from the various project emission sources, a realistic assessment of the potential air quality impacts from the project can be made. These impacts, in turn, can be compared to the applicable state and federal standards to determine if the proposed Project may pose a threat to air quality of the area.

In addition, in the modeling analysis project emissions were conservatively assumed to be continuous throughout the one year meteorological data set, notwithstanding the fact that actual mining activities are scheduled for only two eight hour shifts per day, five days per week. Thus, concentrations computed by the ISCST model will be higher than would realistically occur. The purpose of allowing emissions to be released continuously in the modeling analysis was to establish the outside limits or "worst-case" of any air quality impact potentially resulting from the Project.

The "worst-case" day (24-hour period) particulate concentrations computed in the ISCST modeling analysis are presented graphically in Figure 6. In this Figure, the predicted 24-hour particulate concentrations resulting from the Project Area are shown for each receptor point and are plotted as isopleths.

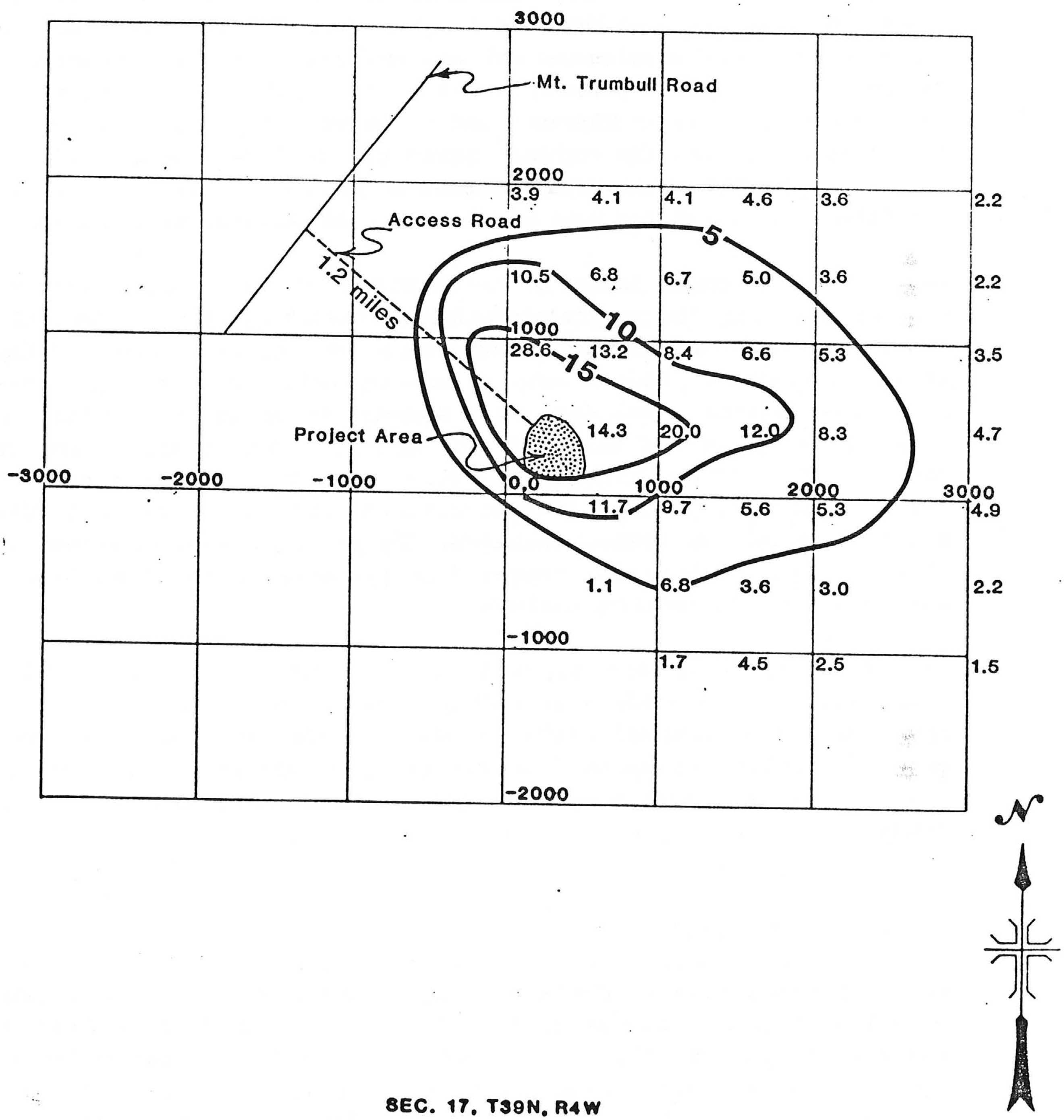
From Figure 6 it can be seen that the maximum off-site particulate concentration occurring on the actual "worst-case" day was 29 $\mu g/m^3$ and the 5 $\mu g/m^3$ level of significance extended, at its furthest point, to just over 2500 meters (1.5 miles) east of the Project Area. The predicted "worst-case" maximum of 29 $\mu g/m^3$ is well below the state and federal particulate standard of 260 $\mu g/m^3$ even when the highest 24-hour background concentration of 58 $\mu g/m^3$, as presented in Section 2.0, is added. Thus, this modeling study which employed actual meteorological data and highly conservative Project emissions assumptions show that there will be no significant air quality impact resulting from the Project.

Again, the 5 $\mu g/m^3$ level of insignificant is reached within 1.5 miles of the Project Area, well short of the Grand Canyon National Park. Thus, operation of the Project should not result in any measurable impact on the Park.

5.3.2 Haul Roads

While the haul roads and, consequently, haul road emissions will primarily be outside of the Project Area, it is useful to determine what impact, if any, the haul road emissions would have on the area's air quality. To do this, haul road emissions were modeled using actual "worst-case" meteorological conditions as obtained from the one year meteorological monitoring program (see Section 2.0).

Ore haulage from the Project will involve traveling over about twelve miles of unpaved road. Immediately from the Project Area, haul trucks will traverse the approximate 1.2 miles of proposed new project road running to the northwest from the site and connecting to Mt. Trumbull Road. Haul truck traffic will then travel north on Mt. Trumbull Road for



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Mohave Co., Arizona

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Denver, Colorado

PROJECT Hermit	"Worst-Case" 24-Hour Impact Units in Micrograms Per Cubic Meter

FILE NO. ______ DATE 2/87 FIGURE NO. 6

about eleven miles to State Route 389. From this point on, ore haulage will be via paved roads. Figure 7 shows the proposed haul road route from the Project Area.

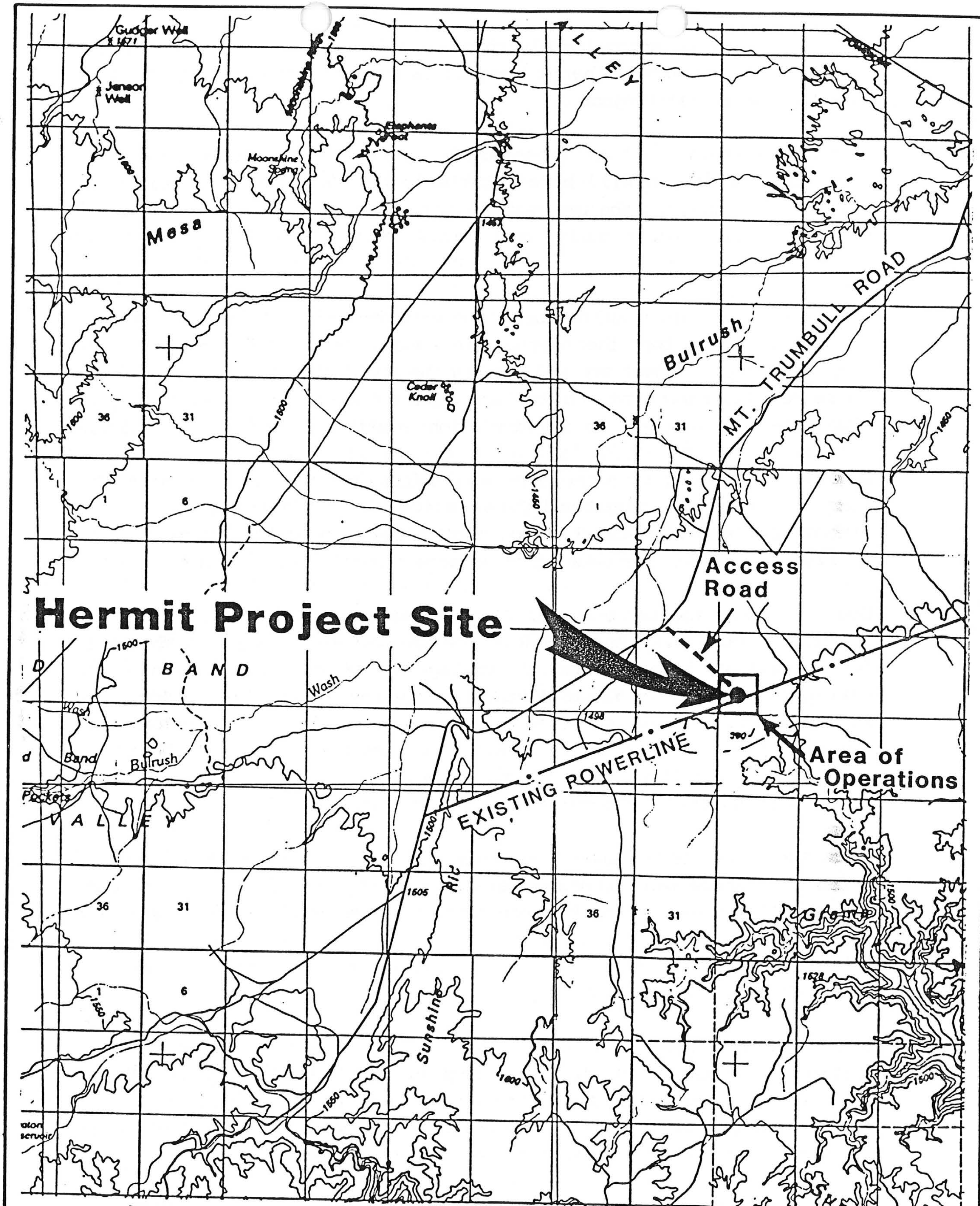
The particulate emissions resulting from haul traffic on the proposed access road were modeled as part of the Project Area impact analyses (Section 5.2 and 5.3.1). These emissions were included as part of the Project Area analyses so that the combined "worst-case" effect of the direct Project-related emissions and haul road activity could be computed. Results of the long-term (annual) and short-term (24-hour) analyses are presented graphically in Figures 5 and 6, respectively. As discussed in the previous sections the combined impact of the direct Project-related emissions and the access road emissions are so low that it can be concluded that they do not pose any threat to the particulate standards.

To assess the maximum impact of the Hermit mine's haul road traffic on Mt. Trumbull road, the particulate emissions resulting from this approximate eleven mile haul road segment were input into the ISCST model and the 24-hour particulate concentrations were computed for each day in the 1983 - 1984 meteorological data set. However, to be consistent with the conservative approach of this analysis, haul road traffic was assumed to continue from 7:00 a.m. until 11:00 p.m., seven days a week, at a rate of twelve round trips per day. In other words, no adjustment was made in the modeling analysis for weekend shutdowns. The particulate emission rate of 16.0 pounds per vehicle mile traveled (as presented in Section 3.0) was used throughout the modeling analysis.

The maximum or "worst-case" day particulate concentrations computed by ISCST show that the maximum 24-hour particulate concentration resulting from actual meteorological conditions and full haul road activities was 20 $\mu g/m^3$. This value is well below the allowable state and federal standards of 260 $\mu g/m^3$ and, thus, poses no threat to the local air quality.

5.4 Cumulative Impacts

At the time activities at the Hermit Project begin, in either May or June of 1987, mining activities at the Hack Canyon Mines (Hack 1, 2 and 3) will have ceased. Consequently, once activities at the Hermit Project begin, there will be only three other operating mining projects in the Arizona Strip District. The closest operation to the Hermit Project is the Kanab North Project located approximately six miles to the east. The Pigeon



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Denver, Colorado

PROJECT **Hermit**

Haul Road Configuration

FILE NO. ______ DATE 2/87 FIGURE NO. 7

Project is located approximately thirteen miles to the east-northeast and the recently approved Pinenut Project is approximately thirteen miles south of the Hermit Project.

Each of the operational and proposed mining projects are approximately the same size and have or will have relatively the same production rates and emissions. Further, the ore haulage rates and schedules are or will be similar - namely ten to twelve haul trucks per day (five days per week) on the average.

The impact analysis results for the Hermit Project presented in Sections 5.2 and 5.3.1 show that the particulate concentrations resulting from the proposed Hermit Project are well below the applicable standards. Further, these results show that the Project Impact Area does not extend beyond 3000 meters (1.9 miles) in any direction around the Project. (Resultant particulate concentrations fall below the level of significance within 3000 meters). Thus, with the extremely small impact area associated with the proposed Hermit Project and the relatively great distances between the other existing and planned mining operations in the area, there is virtually no potential for overlap of impacts from the Hermit Project Area.

However, since the Kanab North, Pinenut and Hermit Project will utilize common segments of Mt. Trumbull Road for ore haulage, there is a potential for cumulative impacts from ore haulage on these common segments. As currently planned the Kanab North, the Pinenut and the Hermit Projects will utilize a common seven mile section of Mt. Trumbull Road for ore haulage. Ore haulage from the Pigeon Mine does not involve Mt. Trumbull Road and the Hack Mines will be shut down prior to initiating ore haulage from the Kanab North, Pinenut and Hermit Projects.

Since the Kanab North, Pinenut and Hermit Projects each expect ore haulage rates to average ten to twelve haul truck trips (round trips) per day, five days per week, during the period when all three mines will be in the ore production phase of operations (1990 - 1993), there is a potential for a total of 72 haul trucks (36 round trips) to traverse the common segment of Mt. Trumbull Road each day.

To assess the potential cumulative air quality impact resulting from the concurrent ore haulage on the common segment of Mt. Trumbull Road, dispersion modeling was conducted using ISCST. A haul road emission rate of 16.0 pounds per vehicle mile traveled (this emission rate assumes no emission controls) was input into the model and the 24-hour particulate concentrations were computed for each day in the 1983 - 1984 meteorological data set. Again to be consistent with the conservative approach used throughout this impact analysis, haul road traffic was assumed to continue from 7:00 a.m. until 11:00 p.m., seven days a week, at a rate of 36 round trips per day, even though current plans do not anticipate a seven day per week hauling schedule.

The maximum or "worst-case" day particulate concentrations computed by ISCST show that the maximum 24-hour particulate concentration resulting from actual meteorological conditions and 36 round trips was 60 $\mu g/m^3$. This value is well below the allowable 24-hour standard. In fact, when carrying the analysis further the modeling shows that even doubling the haul road traffic on the common road segment to 72 round trips per day would only result in a maximum 24-hour concentration of 120 $\mu g/m^3$. This value is still well below the allowable 24-hour standard of 260 $\mu g/m^3$.

Thus, it can be concluded that the cumulative impacts resulting from the concurrent utilization of Mt. Trumbull Road poses no threat to the local air quality even if haulage is substantially increased.

6.0 IMPACTS ON SENSITIVE RECEPTORS

The closest sensitive receptor to the proposed Hermit Project is the Grand Canyon National Park - a mandatory Class 1 area. At its closest point, the proposed Hermit Project is approximately seventeen miles north of the Park boundary.

The "worst-case" impact analyses presented in Section 5.0 show that the maximum area of impact, as defined by the EPA concentrations or levels of significance, affected by the Hermit Project is at a maximum 3000 meters (1.9 miles) surrounding the Project Area. This is over fifteen miles short of the nearest Park boundary. Further, since all associated haul roads run northerly away from the Project Area, their impact areas will even be further away from the Park.

With such a small area of impact and with such a great distance to the Park boundary, it can be concluded with a great degree of certainty that the proposed Hermit Project will have a negligible air quality impact on the Grand Canyon National Park and no detectable impact on the visibility within the Park.

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
B	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
C	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00
D	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00
E	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00
F	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** X-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

-200.0, -130.0, 130.0, 200.0, 500.0, 1000.0, 1500.0, 2000.0, 3000.0, 4000.0,

*** Y-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

-400.0, -200.0, .0, 200.0, 400.0,

APPENDIX A

COMPUTER LISTINGS

ANNUAL AVERAGE CONCENTRATIONS FROM THE PROJECT AREA - ISCLT

MAXIMUM PROJECT AREA IMPACT - ISCST

MAXIMUM 24-HOUR HAUL ROAD IMPACT - ISCST

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

CALCULATE (CONCENTRATION=1,DEPOSITION=2)	ISW(1) = 1
RECEPTOR GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)	ISW(2) = 1
DISCRETE RECEPTOR SYSTEM (RECTANGULAR=1,POLAR=2)	ISW(3) = 1
TERRAIN ELEVATIONS ARE READ (YES=1,NO=0)	ISW(4) = 0
CALCULATIONS ARE WRITTEN TO TAPE (YES=1,NO=0)	ISW(5) = 0
LIST ALL INPUT DATA (NO=0,YES=1,MET DATA ALSO=2)	ISW(6) = 1
COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION) WITH THE FOLLOWING TIME PERIODS:	
HOURLY (YES=1,NO=0)	ISW(7) = 0
2-HOUR (YES=1,NO=0)	ISW(8) = 0
3-HOUR (YES=1,NO=0)	ISW(9) = 0
4-HOUR (YES=1,NO=0)	ISW(10) = 0
6-HOUR (YES=1,NO=0)	ISW(11) = 0
8-HOUR (YES=1,NO=0)	ISW(12) = 0
12-HOUR (YES=1,NO=0)	ISW(13) = 0
24-HOUR (YES=1,NO=0)	ISW(14) = 1
PRINT 'N'-DAY TABLE(S) (YES=1,NO=0)	ISW(15) = 0
PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE SPECIFIED BY ISW(7) THROUGH ISW(14):	
DAILY TABLES (YES=1,NO=0)	ISW(16) = 1
HIGHEST & SECOND HIGHEST TABLES (YES=1,NO=0)	ISW(17) = 1
MAXIMUM 50 TABLES (YES=1,NO=0)	ISW(18) = 1
METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1,CARD=2)	ISW(19) = 2
RURAL-URBAN OPTION (RURAL=0,URBAN MODE 1=1,URBAN MODE 2=2)	ISW(20) = 0
WIND PROFILE EXPONENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(21) = 1
VERTICAL POT. TEMP. GRADIENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(22) = 1
SCALE EMISSION RATES FOR ALL SOURCES (NO=0,YES>0)	ISW(23) = 0
PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1,NO=2)	ISW(24) = 1
PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWASH (YES=2,NO=1)	ISW(25) = 1
NUMBER OF INPUT SOURCES	NSOURC = 21
NUMBER OF SOURCE GROUPS (=0,ALL SOURCES)	NGROUP = 0
TIME PERIOD INTERVAL TO BE PRINTED (=0,ALL INTERVALS)	IPERD = 0
NUMBER OF X (RANGE) GRID VALUES	NXPNTS = 10
NUMBER OF Y (THETA) GRID VALUES	NYPNTS = 5
NUMBER OF DISCRETE RECEPTORS	NXWYPT = 0
NUMBER OF HOURS PER DAY IN METEOROLOGICAL DATA	NHOURS = 16
NUMBER OF DAYS OF METEOROLOGICAL DATA	NDAYS = 3
SOURCE EMISSION RATE UNITS CONVERSION FACTOR	TK =.10000E+07
ENTRAINMENT COEFFICIENT FOR UNSTABLE ATMOSPHERE	BETA1 = .600
ENTRAINMENT COEFFICIENT FOR STABLE ATMOSPHERE	BETA2 = .600
HEIGHT ABOVE GROUND AT WHICH WIND SPEED WAS MEASURED	ZR = 10.00 METERS
LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA	IMET = 2
ALLOCATED DATA STORAGE	LIMIT = 10000 WORDS
REQUIRED DATA STORAGE FOR THIS PROBLEM RUN	MIMIT = 5081 WORDS

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY	WIND SPEED CATEGORY					
CATEGORY	1	2	3	4	5	6
A	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
B	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
C	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00
D	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00
E	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00
F	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY	WIND SPEED CATEGORY					
CATEGORY	1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** X-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

-200.0, -130.0, 130.0, 200.0, 500.0, 1000.0, 1500.0, 2000.0, 3000.0, 4000.0,

*** Y-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

-400.0, -200.0, .0, 200.0, 400.0,

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

*** SOURCE DATA ***

SOURCE NUMBER	TYPE	WAKE	NUMBER PART. CATS.	EMISSION RATE TYPE=0,1 (GRAMS/SEC) TYPE=2 (GRAMS/SEC) *PER METER**2	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	HEIGHT (METERS)	TEMP. TYPE=0 (DEG.K); VERT.DIM TYPE=1 (METERS)	EXIT VEL. TYPE=0 (M/SEC); HORZ.DIM TYPE=1,2 (METERS)	DIAMETER TYPE=0 (METERS)	BLDG. HEIGHT TYPE=0 (METERS)	BLDG. LENGTH TYPE=0 (METERS)	BLDG. WIDTH TYPE=0 (METERS)
1	1	0	3	.37800E+00	.0	-1000.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
2	1	0	3	.37800E+00	.0	-900.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
3	1	0	3	.37800E+00	.0	-800.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
4	1	0	3	.37800E+00	.0	-700.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
5	1	0	3	.37800E+00	.0	-600.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
6	1	0	3	.37800E+00	.0	-500.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
7	1	0	3	.37800E+00	.0	-400.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
8	1	0	3	.37800E+00	.0	-300.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
9	1	0	3	.37800E+00	.0	-200.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
10	1	0	3	.37800E+00	.0	-100.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
11	1	0	3	.37800E+00	.0	.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
12	1	0	3	.37800E+00	.0	100.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
13	1	0	3	.37800E+00	.0	200.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
14	1	0	3	.37800E+00	.0	300.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
15	1	0	3	.37800E+00	.0	400.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
16	1	0	3	.37800E+00	.0	500.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
17	1	0	3	.37800E+00	.0	600.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
18	1	0	3	.37800E+00	.0	700.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
19	1	0	3	.37800E+00	.0	800.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
20	1	0	3	.37800E+00	.0	900.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00
21	1	0	3	.37800E+00	.0	1000.0	1.0	3.00	3.00	46.00	.00	.00	.00	.00

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

* SOURCE-RECEPTOR COMBINATIONS LESS THAN 100 METERS OR THREE BUILDING HEIGHTS IN DISTANCE. NO AVERAGE CONCENTRATION IS CALCULATED *

SOURCE NUMBER	- - RECEPTOR LOCATION - - X OR RANGE (METERS)	Y (METERS) OR DIRECTION (DEGREES)	DISTANCE BETWEEN (METERS)
6	-130.0	-400.0	65.11
6	130.0	-400.0	65.11
7	-130.0	-400.0	31.10
7	130.0	-400.0	31.10
8	-130.0	-400.0	65.11
8	130.0	-400.0	65.11
8	-130.0	-200.0	65.11
8	130.0	-200.0	65.11
9	-130.0	-200.0	31.10
9	130.0	-200.0	31.10
10	-130.0	-200.0	65.11
10	130.0	-200.0	65.11
10	-130.0	.0	65.11
10	130.0	.0	65.11
11	-130.0	.0	31.10
11	130.0	.0	31.10
12	-130.0	.0	65.11
12	130.0	.0	65.11
12	-130.0	200.0	65.11
12	130.0	200.0	65.11
13	-130.0	200.0	31.10
13	130.0	200.0	31.10
14	-130.0	200.0	65.11
14	130.0	200.0	65.11
14	-130.0	400.0	65.11
14	130.0	400.0	65.11
15	-130.0	400.0	31.10
15	130.0	400.0	31.10
16	-130.0	400.0	65.11
16	130.0	400.0	65.11

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

* DAILY 16-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* ENDING WITH HOUR 16 FOR DAY 103 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 60.44895 AND OCCURRED AT (200.0, 200.0) *

Y-AXIS / (METERS) /	X-AXIS (METERS) -200.0	-130.0	130.0	200.0	500.0	1000.0	1500.0	2000.0	3000.0
400.0 /	.00000	.00000	5.34414	60.44890	31.95974	15.44940	9.71071	7.46860	4.84705
200.0 /	.00000	.00000	5.34414	60.44895	32.12696	17.81814	10.74590	7.72844	5.17612
.0 /	.00000	.00000	5.34414	60.44895	32.13263	18.98085	12.10262	8.13743	5.27139
-200.0 /	.00000	.00000	5.34414	60.44895	32.13272	19.27472	13.12567	8.79609	5.38404
-400.0 /	.00000	.00000	5.34414	60.44895	32.13033	19.10911	13.57481	9.57818	5.46073

!!!!! ALL CONCENTRATION MUST BE MULTIPLIED BY 16/24 TO OBTAIN 24 HOUR AVERAGE !!!!!

*** Energy Fuels - Mt. Trumbull Road - Hermit MAX E Road - 16 hou ***

* DAILY 16-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* ENDING WITH HOUR 16 FOR DAY 103 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 60.44895 AND OCCURRED AT (200.0, 200.0) *

Y-AXIS / (METERS) /	X-AXIS (METERS) 4000.0
400.0 /	3.29566
200.0 /	3.83119
.0 /	4.09320
-200.0 /	4.09058
-400.0 /	3.87519

!!!!! ALL CONCENTRATION MUST BE MULTIPLIED BY 16/24 TO OBTAIN 24 HOUR AVERAGE !!!!!

- ISCLT INPUT DATA -

NUMBER OF SOURCES = 15
NUMBER OF X AXIS GRID SYSTEM POINTS = 11
NUMBER OF Y AXIS GRID SYSTEM POINTS = 11
NUMBER OF SPECIAL POINTS = 0
NUMBER OF SEASONS = 1
NUMBER OF WIND SPEED CLASSES = 6
NUMBER OF STABILITY CLASSES = 6
NUMBER OF WIND DIRECTION CLASSES = 16
FILE NUMBER OF DATA FILE USED FOR REPORTS = 1
THE PROGRAM IS RUN IN RURAL MODE
CONCENTRATION (DEPOSITION) UNITS CONVERSION FACTOR = .10000000E+07
ACCELERATION OF GRAVITY (METERS/SEC**2) = 9.800
HEIGHT OF MEASUREMENT OF WIND SPEED (METERS) = 10.000
ENTRAINMENT PARAMETER FOR UNSTABLE CONDITIONS = .600
ENTRAINMENT PARAMETER FOR STABLE CONDITIONS = .600
CORRECTION ANGLE FOR GRID SYSTEM VERSUS DIRECTION DATA NORTH (DEGREES) = .000
DECAY COEFFICIENT = .00000000E+00
PROGRAM OPTION SWITCHES = 1, 1, 1, 0, 0, 3, 2, 2, 3, 2, 2, 0, 0, 0, 0, 0, 0, 1, 1, 0,
ALL SOURCES ARE USED TO FORM SOURCE COMBINATION 1
DISTANCE X AXIS GRID SYSTEM POINTS (METERS)= -3000.00, -2000.00, -1500.00, -1000.00, -500.00, .00, 500.00, 1000.00, 1500.00, 2000.00, 3000.00,
DISTANCE Y AXIS GRID SYSTEM POINTS (METERS)= -3000.00, -2000.00, -1500.00, -1000.00, -500.00, .00, 500.00, 1000.00, 1500.00, 2000.00, 3000.00,

- AMBIENT AIR TEMPERATURE (DEGREES KELVIN) -

	STABILITY CATEGORY 1	STABILITY CATEGORY 2	STABILITY CATEGORY 3	STABILITY CATEGORY 4	STABILITY CATEGORY 5	STABILITY CATEGORY 6
SEASON 1	283.0000	283.0000	283.0000	283.0000	283.0000	283.0000

- MIXING LAYER HEIGHT (METERS) -

SEASON 1

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04
STABILITY CATEGORY 2	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04
STABILITY CATEGORY 3	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04	.100000E+04
STABILITY CATEGORY 4	.500000E+03	.500000E+03	.750000E+03	.100000E+04	.100000E+04	.100000E+04
STABILITY CATEGORY 5	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05
STABILITY CATEGORY 6	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05

- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 1

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00013000	.00279994	.00172996	.00000000	.00000000	.00000000
22.500	.00026999	.00319993	.00132997	.00000000	.00000000	.00000000
45.000	.00039999	.00332993	.00079998	.00000000	.00000000	.00000000
67.500	.00000000	.00106998	.00026999	.00000000	.00000000	.00000000
90.000	.00013000	.00212996	.00106998	.00000000	.00000000	.00000000
112.500	.00026999	.00079998	.00000000	.00000000	.00000000	.00000000
135.000	.00079998	.00399992	.00199996	.00013000	.00000000	.00000000
157.500	.00106998	.00612987	.00159997	.00000000	.00000000	.00000000
180.000	.00066999	.00652986	.00345993	.00052999	.00000000	.00000000
202.500	.00092998	.00585988	.00172996	.00013000	.00000000	.00000000
225.000	.00092998	.00385992	.00332993	.00000000	.00000000	.00000000
247.500	.00000000	.00212996	.00132997	.00000000	.00000000	.00000000
270.000	.00079998	.00439991	.00212996	.00026999	.00000000	.00000000
292.500	.00039999	.00172996	.00305994	.00000000	.00000000	.00000000
315.000	.00013000	.00478990	.00292994	.00013000	.00000000	.00000000
337.500	.00039999	.00185996	.00159997	.00013000	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 2

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00066999	.00132997	.00106998	.00026999	.00000000	.00000000
22.500	.00052999	.00146997	.00159997	.00026999	.00000000	.00000000
45.000	.00106998	.00252995	.00052999	.00039999	.00000000	.00000000
67.500	.00052999	.00132997	.00066999	.00000000	.00000000	.00000000
90.000	.00000000	.00199996	.00079998	.00000000	.00000000	.00000000
112.500	.00026999	.00132997	.00052999	.00000000	.00000000	.00000000
135.000	.00079998	.00319993	.00146997	.00013000	.00000000	.00000000
157.500	.00039999	.00692986	.00359993	.00013000	.00000000	.00000000
180.000	.00092998	.00319993	.00345993	.00106998	.00000000	.00000000
202.500	.00106998	.00439991	.00225995	.00159997	.00000000	.00000000
225.000	.00066999	.00132997	.00212996	.00079998	.00000000	.00000000
247.500	.00052999	.00132997	.00092998	.00000000	.00000000	.00000000
270.000	.00000000	.00092998	.00225995	.00092998	.00000000	.00000000
292.500	.00052999	.00039999	.00212996	.00106998	.00000000	.00000000
315.000	.00013000	.00199996	.00279994	.00119998	.00000000	.00000000
337.500	.00000000	.00119998	.00106998	.00000000	.00000000	.00000000

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- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 3

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
..000	.00039999	.00185996	.00079998	.00026999	.00000000	.00000000
22.500	.00052999	.00185996	.00199996	.00092998	.00000000	.00000000
45.000	.00066999	.00305994	.00172996	.00026999	.00013000	.00000000
67.500	.00039999	.00332993	.00119998	.00026999	.00000000	.00000000
90.000	.00052999	.00172996	.00106998	.00000000	.00000000	.00000000
112.500	.00079998	.00106998	.00013000	.00000000	.00000000	.00000000
135.000	.00146997	.00385992	.00079998	.00039999	.00000000	.00000000
157.500	.00146997	.00798983	.00518989	.00146997	.00000000	.00000000
180.000	.00079998	.00518989	.00492990	.00305994	.00000000	.00000000
202.500	.00066999	.00452991	.00412991	.00252995	.00000000	.00000000
225.000	.00052999	.00185996	.00305994	.00252995	.00013000	.00000000
247.500	.00026999	.00146997	.00159997	.00146997	.00000000	.00000000
270.000	.00079998	.00052999	.00199996	.00159997	.00000000	.00000000
292.500	.00052999	.00106998	.00252995	.00225995	.00000000	.00000000
315.000	.00052999	.00132997	.00252995	.00239995	.00000000	.00000000
337.500	.00000000	.00119998	.00252995	.00079998	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 4

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00199996	.00825983	.00478990	.00252995	.00039999	.00000000
22.500	.00146997	.00518989	.00785984	.00758984	.00119998	.00000000
45.000	.00199996	.00518989	.00385992	.00399992	.00052999	.00013000
67.500	.00092998	.00385992	.00372992	.01025979	.00132997	.00039999
90.000	.00119998	.00292994	.00172996	.00159997	.00000000	.00000000
112.500	.00039999	.00159997	.00026999	.00000000	.00000000	.00000000
135.000	.00132997	.00412991	.00079998	.00013000	.00000000	.00000000
157.500	.00172996	.01544968	.01158976	.00465990	.00052999	.00000000
180.000	.00252995	.01464970	.01224975	.01184975	.00026999	.00000000
202.500	.00252995	.01611966	.01344972	.01477969	.00399992	.00052999
225.000	.00212996	.01144976	.01278973	.02037958	.00385992	.00066999
247.500	.00106998	.00825983	.00572988	.01091977	.00146997	.00039999
270.000	.00146997	.01051978	.00772984	.00705985	.00185996	.00039999
292.500	.00119998	.00652986	.00598988	.00905981	.00052999	.00026999
315.000	.00132997	.00825983	.00798983	.00612987	.00066999	.00039999
337.500	.00039999	.00625987	.00612987	.00785984	.00159997	.00000000

- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 5

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00132997	.00492990	.00305994	.00000000	.00000000	.00000000
22.500	.00212996	.00825983	.01464970	.00000000	.00013000	.00000000
45.000	.00279994	.01038979	.00638987	.00000000	.00000000	.00000000
67.500	.00052999	.00545989	.00772984	.00000000	.00000000	.00000000
90.000	.00132997	.00265994	.00225995	.00000000	.00000000	.00000000
112.500	.00066999	.00079998	.00013000	.00000000	.00000000	.00000000
135.000	.00185996	.00172996	.00013000	.00000000	.00000000	.00000000
157.500	.00132997	.00732985	.00265994	.00000000	.00000000	.00000000
180.000	.00452991	.01051978	.00399992	.00000000	.00000000	.00000000
202.500	.00359993	.01704965	.01011979	.00000000	.00000000	.00000000
225.000	.00558988	.01118977	.00665986	.00000000	.00000000	.00000000
247.500	.00172996	.01104977	.00412991	.00000000	.00000000	.00000000
270.000	.00385992	.01411971	.00239995	.00000000	.00000000	.00000000
292.500	.00319993	.01118977	.00678986	.00000000	.00000000	.00000000
315.000	.00146997	.01118977	.00838983	.00000000	.00000000	.00000000
337.500	.00159997	.00718985	.01104977	.00000000	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 6

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00146997	.00265994	.00000000	.00000000	.00000000	.00000000
22.500	.00092998	.00305994	.00000000	.00000000	.00000000	.00000000
45.000	.00159997	.00399992	.00000000	.00000000	.00000000	.00000000
67.500	.00106998	.00092998	.00000000	.00000000	.00000000	.00000000
90.000	.00172996	.00212996	.00000000	.00000000	.00000000	.00000000
112.500	.00092998	.00013000	.00000000	.00000000	.00000000	.00000000
135.000	.00185996	.00172996	.00000000	.00000000	.00000000	.00000000
157.500	.00079998	.00119998	.00000000	.00000000	.00000000	.00000000
180.000	.00332993	.00159997	.00000000	.00000000	.00000000	.00000000
202.500	.00159997	.00159997	.00000000	.00000000	.00000000	.00000000
225.000	.00185996	.00225995	.00000000	.00000000	.00000000	.00000000
247.500	.00146997	.00212996	.00000000	.00000000	.00000000	.00000000
270.000	.00172996	.00305994	.00000000	.00000000	.00000000	.00000000
292.500	.00172996	.00185996	.00000000	.00000000	.00000000	.00000000
315.000	.00185996	.00332993	.00000000	.00000000	.00000000	.00000000
337.500	.00092998	.00185996	.00000000	.00000000	.00000000	.00000000

- ISCLT INPUT DATA (CONT.) -

- VERTICAL POTENTIAL TEMPERATURE GRADIENT (DEGREES KELVIN/METER) -

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 2	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 3	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 4	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 5	.200000E-01	.200000E-01	.200000E-01	.200000E-01	.200000E-01	.200000E-01
STABILITY CATEGORY 6	.350000E-01	.350000E-01	.350000E-01	.350000E-01	.350000E-01	.350000E-01

- WIND PROFILE POWER LAW EXPONENTS -

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.100000E+00	.100000E+00	.100000E+00	.100000E+00	.100000E+00	.100000E+00
STABILITY CATEGORY 2	.150000E+00	.150000E+00	.150000E+00	.150000E+00	.150000E+00	.150000E+00
STABILITY CATEGORY 3	.200000E+00	.200000E+00	.200000E+00	.200000E+00	.200000E+00	.200000E+00
STABILITY CATEGORY 4	.250000E+00	.250000E+00	.250000E+00	.250000E+00	.250000E+00	.250000E+00
STABILITY CATEGORY 5	.300000E+00	.300000E+00	.300000E+00	.300000E+00	.300000E+00	.300000E+00
STABILITY CATEGORY 6	.300000E+00	.300000E+00	.300000E+00	.300000E+00	.300000E+00	.300000E+00

```
                                        - SOURCE INPUT DATA -

C T SOURCE SOURCE     X           Y       EMISSION  BASE /
A A NUMBER  TYPE  COORDINATE  COORDINATE  HEIGHT   ELEV- /           - SOURCE DETAILS DEPENDING ON TYPE -
R P                  (M)         (M)        (M)    ATION /
D E                                                 (M)  /
------------------------------------------------------------------------------------------------------------------------------
X      1  STACK    450.00      365.00     1.00       .00 GAS EXIT TEMP (DEG K)= 298.00, GAS EXIT VEL. (M/SEC)= 20.00,
                                                         STACK DIAMETER (M)= 2.400, HEIGHT OF ASSO. BLDG. (M)=    .00, WIDTH OF
                                                         ASSO. BLDG. (M)=     .00, WAKE EFFECTS FLAG = 0
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC                             ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  4.32000E-01
X      2  AREA     215.00      365.00     1.00       .00 WIDTH OF AREA (M)=   75.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  8.98000E-06
X      3  AREA     182.00      304.00     1.00       .00 WIDTH OF AREA (M)=   75.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  8.98000E-06
X      4  AREA     320.00      365.00     1.00       .00 WIDTH OF AREA (M)=   75.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  5.11000E-07
X      5  AREA     330.00      550.00     1.00       .00 WIDTH OF AREA (M)=   75.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  5.11000E-07
X      6  AREA     182.00      365.00     1.00       .00 WIDTH OF AREA (M)=   35.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  1.00000E-08
X      7  AREA     150.00      275.00     1.00       .00 WIDTH OF AREA (M)=  330.00
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER           ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  6.76000E-06
WARNING - DISTANCE BETWEEN SOURCE       7 AND POINT X,Y=     500.00,      500.00 IS LESS THAN PERMITTED
X      8  VOLUME   108.60      641.40     1.00       .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                         STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=    5.00
                                                                                 - PARTICULATE CATEGORIES -
                                                                                    1      2      3
                                                         FALL VELOCITY (MPS)      .0040  .0180  .0480
                                                         MASS FRACTION            .2200  .4400  .3400
                                                         REFLECTION COEFFICIENT   .8000  .7400  .6200
                                                              - SOURCE STRENGTHS ( GRAMS PER SEC                             ) -
                                                                   SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                  1.79500E-01
```

- SOURCE INPUT DATA (CONT.) -

```
C T SOURCE SOURCE     X           Y       EMISSION  BASE /
A A NUMBER  TYPE  COORDINATE  COORDINATE  HEIGHT  ELEV- /            - SOURCE DETAILS DEPENDING ON TYPE -
R P                  (M)         (M)        (M)    ATION /
D E                                                 (M)  /
-------------------------------------------------------------------------------------------------------------------------
X       9 VOLUME    -32.80      782.80    1.00     .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                       STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                           - PARTICULATE CATEGORIES -
                                                                             1       2       3
                                                       FALL VELOCITY (MPS)      .0040   .0180   .0480
                                                       MASS FRACTION            .2200   .4400   .3400
                                                       REFLECTION COEFFICIENT   .8000   .7400   .6200
                                                            - SOURCE STRENGTHS ( GRAMS PER SEC                          ) -
                                                                 SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                1.79500E-01
X      10 VOLUME   -174.20      924.30    1.00     .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                       STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                           - PARTICULATE CATEGORIES -
                                                                             1       2       3
                                                       FALL VELOCITY (MPS)      .0040   .0180   .0480
                                                       MASS FRACTION            .2200   .4400   .3400
                                                       REFLECTION COEFFICIENT   .8000   .7400   .6200
                                                            - SOURCE STRENGTHS ( GRAMS PER SEC                          ) -
                                                                 SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                1.79500E-01
X      11 VOLUME   -315.70     1065.70    1.00     .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                       STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                           - PARTICULATE CATEGORIES -
                                                                             1       2       3
                                                       FALL VELOCITY (MPS)      .0040   .0180   .0480
                                                       MASS FRACTION            .2200   .4400   .3400
                                                       REFLECTION COEFFICIENT   .8000   .7400   .6200
                                                            - SOURCE STRENGTHS ( GRAMS PER SEC                          ) -
                                                                 SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                1.79500E-01
X      12 VOLUME   -457.10     1207.10    1.00     .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                       STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                           - PARTICULATE CATEGORIES -
                                                                             1       2       3
                                                       FALL VELOCITY (MPS)      .0040   .0180   .0480
                                                       MASS FRACTION            .2200   .4400   .3400
                                                       REFLECTION COEFFICIENT   .8000   .7400   .6200
                                                            - SOURCE STRENGTHS ( GRAMS PER SEC                          ) -
                                                                 SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                1.79500E-01
```

```
                                                   - SOURCE INPUT DATA (CONT.) -

C T SOURCE SOURCE     X           Y      EMISSION  BASE /
A A NUMBER  TYPE  COORDINATE  COORDINATE  HEIGHT  ELEV- /            - SOURCE DETAILS DEPENDING ON TYPE -
R P                  (M)         (M)        (M)   ATION /
D E                                                (M)  /
----------------------------------------------------------------------------------------------------------------------------
X       13 VOLUME    -598.10     1348.50    1.00      .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                          STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                              - PARTICULATE CATEGORIES -
                                                                                 1      2      3
                                                          FALL VELOCITY (MPS)     .0040  .0180  .0480
                                                          MASS FRACTION           .2200  .4400  .3400
                                                          REFLECTION COEFFICIENT  .8000  .7400  .6200
                                                               - SOURCE STRENGTHS ( GRAMS PER SEC                             ) -
                                                                    SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                   1.79500E-01
X       14 VOLUME    -739.90     1489.90    1.00      .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                          STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                              - PARTICULATE CATEGORIES -
                                                                                 1      2      3
                                                          FALL VELOCITY (MPS)     .0040  .0180  .0480
                                                          MASS FRACTION           .2200  .4400  .3400
                                                          REFLECTION COEFFICIENT  .8000  .7400  .6200
                                                               - SOURCE STRENGTHS ( GRAMS PER SEC                             ) -
                                                                    SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                   1.79500E-01
X       15 VOLUME    -881.40     1631.40    1.00      .00 STANDARD DEVIATION OF THE CROSSWIND SOURCE DISTRIBUTION (M)=  10.00
                                                          STANDARD DEVIATION OF THE VERTICAL SOURCE DISTRIBUTION (M)=   5.00
                                                                              - PARTICULATE CATEGORIES -
                                                                                 1      2      3
                                                          FALL VELOCITY (MPS)     .0040  .0180  .0480
                                                          MASS FRACTION           .2200  .4400  .3400
                                                          REFLECTION COEFFICIENT  .8000  .7400  .6200
                                                               - SOURCE STRENGTHS ( GRAMS PER SEC                             ) -
                                                                    SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                                   1.79500E-01
```

** ANNUAL GROUND LEVEL CONCENTRATION (MICROGRAMS PER CUBIC METER) FROM ALL SOURCES COMBINED **

- GRID SYSTEM RECEPTORS -

- X AXIS (DISTANCE, METERS) -

Y AXIS (DISTANCE, METERS)	-3000.000	-2000.000	-1500.000	-1000.000	-500.000	.000	500.000	1000.000	1500.000
	- CONCENTRATION -								
3000.000	.154322	.378256	.598347	.911966	1.173769	1.253367	1.241547	1.048814	.921459
2000.000	.148275	.295638	.623543	2.732063	3.999588	3.000382	2.401556	1.883574	1.282024
1500.000	.192584	.410255	.784549	5.113924	12.529500	5.490071	3.808425	2.463339	1.572774
1000.000	.246098	.527905	1.058403	2.471028	7.338008	13.881150	7.347954	3.296376	1.708664
500.000	.307253	.648150	1.055702	1.784715	3.298178	12.564150	4.361539	3.728064	1.775740
.000	.317789	.616529	.925453	1.460685	2.421234	4.620816	5.215021	2.730411	1.590411
-500.000	.316508	.613332	.831389	1.133185	1.601266	1.925251	1.798789	1.548757	1.158046
-1000.000	.330200	.532312	.702331	.921726	1.030704	1.040899	.959728	.962345	.846473
-1500.000	.307128	.485102	.611109	.657342	.761610	.668390	.649878	.655270	.583159
-2000.000	.291142	.439931	.472589	.515747	.532099	.487182	.475408	.449485	.462903
-3000.000	.262265	.304197	.319944	.338604	.309088	.298324	.293428	.278390	.283429

- GRID SYSTEM RECEPTORS -

- X AXIS (DISTANCE, METERS) -

Y AXIS (DISTANCE, METERS)	2000.000	3000.000
	- CONCENTRATION -	
3000.000	.714707	.494773
2000.000	.965434	.497773
1500.000	.954025	.556864
1000.000	1.073309	.552262
500.000	1.149789	.626684
.000	1.004321	.554940
-500.000	.854040	.527731
-1000.000	.711993	.453030
-1500.000	.561362	.399999
-2000.000	.419651	.365512
-3000.000	.281040	.254576

** END OF ISCLT PROGRAM, 15 SOURCES PROCESSED **

CALCULATE (CONCENTRATION=1,DEPOSITION=2)	ISW(1) = 1
RECEPTOR GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)	ISW(2) = 1
DISCRETE RECEPTOR SYSTEM (RECTANGULAR=1,POLAR=2)	ISW(3) = 1
TERRAIN ELEVATIONS ARE READ (YES=1,NO=0)	ISW(4) = 0
CALCULATIONS ARE WRITTEN TO TAPE (YES=1,NO=0)	ISW(5) = 0
LIST ALL INPUT DATA (NO=0,YES=1,MET DATA ALSO=2)	ISW(6) = 1
COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION) WITH THE FOLLOWING TIME PERIODS:	
HOURLY (YES=1,NO=0)	ISW(7) = 0
2-HOUR (YES=1,NO=0)	ISW(8) = 0
3-HOUR (YES=1,NO=0)	ISW(9) = 0
4-HOUR (YES=1,NO=0)	ISW(10) = 0
6-HOUR (YES=1,NO=0)	ISW(11) = 0
8-HOUR (YES=1,NO=0)	ISW(12) = 0
12-HOUR (YES=1,NO=0)	ISW(13) = 0
24-HOUR (YES=1,NO=0)	ISW(14) = 1
PRINT 'N'-DAY TABLE(S) (YES=1,NO=0)	ISW(15) = 0
PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE SPECIFIED BY ISW(7) THROUGH ISW(14):	
DAILY TABLES (YES=1,NO=0)	ISW(16) = 1
HIGHEST & SECOND HIGHEST TABLES (YES=1,NO=0)	ISW(17) = 1
MAXIMUM 50 TABLES (YES=1,NO=0)	ISW(18) = 1
METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1,CARD=2)	ISW(19) = 2
RURAL-URBAN OPTION (RURAL=0,URBAN MODE 1=1,URBAN MODE 2=2)	ISW(20) = 0
WIND PROFILE EXPONENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(21) = 1
VERTICAL POT. TEMP. GRADIENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(22) = 1
SCALE EMISSION RATES FOR ALL SOURCES (NO=0,YES>0)	ISW(23) = 0
PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1,NO=2)	ISW(24) = 1
PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWASH (YES=2,NO=1)	ISW(25) = 1
NUMBER OF INPUT SOURCES	NSOURC = 15
NUMBER OF SOURCE GROUPS (=0,ALL SOURCES)	NGROUP = 0
TIME PERIOD INTERVAL TO BE PRINTED (=0,ALL INTERVALS)	IPERD = 0
NUMBER OF X (RANGE) GRID VALUES	NXPNTS = 10
NUMBER OF Y (THETA) GRID VALUES	NYPNTS = 9
NUMBER OF DISCRETE RECEPTORS	NXWYPT = 0
NUMBER OF HOURS PER DAY IN METEOROLOGICAL DATA	NHOURS = 24
NUMBER OF DAYS OF METEOROLOGICAL DATA	NDAYS = 5
SOURCE EMISSION RATE UNITS CONVERSION FACTOR	TK =.10000E+07
ENTRAINMENT COEFFICIENT FOR UNSTABLE ATMOSPHERE	BETA1 = .600
ENTRAINMENT COEFFICIENT FOR STABLE ATMOSPHERE	BETA2 = .600
HEIGHT ABOVE GROUND AT WHICH WIND SPEED WAS MEASURED	ZR = 10.00 METERS
LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA	IMET = 2
ALLOCATED DATA STORAGE	LIMIT = 10000 WORDS
REQUIRED DATA STORAGE FOR THIS PROBLEM RUN	MIMIT = 4075 WORDS

*** Energy Fuels Main Facility - Hermit MAX E OF FACILITY ***

*** SOURCE DATA ***

SOURCE NUMBER	TYPE	WAKE	NUMBER PART. CATS.	EMISSION RATE TYPE=0,1 (GRAMS/SEC) TYPE=2 (GRAMS/SEC) *PER METER**2	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	HEIGHT (METERS)	TEMP. TYPE=0 (DEG.K); VERT.DIM TYPE=1 (METERS)	EXIT VEL. TYPE=0 (M/SEC); HORZ.DIM TYPE=1,2 (METERS)	DIAMETER TYPE=0 (METERS)	BLDG. HEIGHT TYPE=0 (METERS)	BLDG. LENGTH TYPE=0 (METERS)	BLDG. WIDTH TYPE=0 (METERS)
1	0	0	0	.43200E+00	450.0	365.0	1.0	1.00	273.00	20.00	2.40	.00	.00	.00
2	1	0	3	.27300E+00	108.6	641.4	1.0	3.00	3.00	10.00	.00	.00	.00	.00
3	1	0	3	.27300E+00	-32.8	782.8	1.0	3.00	3.00	10.00	.00	.00	.00	.00
4	1	0	3	.27300E+00	-174.2	924.3	1.0	3.00	3.00	10.00	.00	.00	.00	.00
5	1	0	3	.27300E+00	-315.7	1065.7	1.0	3.00	3.00	10.00	.00	.00	.00	.00
6	1	0	3	.27300E+00	-457.1	1207.1	1.0	3.00	3.00	10.00	.00	.00	.00	.00
7	1	0	3	.27300E+00	-598.5	1348.5	1.0	3.00	3.00	10.00	.00	.00	.00	.00
8	1	0	3	.27300E+00	-739.9	1489.9	1.0	3.00	3.00	10.00	.00	.00	.00	.00
9	1	0	3	.27300E+00	-881.4	1631.4	1.0	3.00	3.00	10.00	.00	.00	.00	.00
10	2	0	0	.89800E-05	215.0	365.0	1.0	3.00	.00	75.00	.00	.00	.00	.00
11	2	0	0	.89800E-05	182.0	304.0	1.0	3.00	.00	75.00	.00	.00	.00	.00
12	2	0	0	.51100E-06	320.0	365.0	1.0	3.00	.00	75.00	.00	.00	.00	.00
13	2	0	0	.51100E-06	330.0	550.0	1.0	3.00	.00	35.00	.00	.00	.00	.00
14	2	0	0	.10000E-07	182.0	365.0	1.0	3.00	.00	35.00	.00	.00	.00	.00
15	2	0	0	.67600E-05	150.0	275.0	1.0	3.00	.00	330.00	.00	.00	.00	.00

*** Energy Fuels Main Facility - Hermit MAX E OF FACILITY ***

* DAILY 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* ENDING WITH HOUR 24 FOR DAY 103 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 32.59062 AND OCCURRED AT (-500.0, 1500.0) *

Y-AXIS (METERS) /	X-AXIS (METERS) -2000.0	-1000.0	-500.0	.0	500.0	1000.0	1500.0	2000.0	3000.0
2000.0 /	.00000	.00000	.03397	.82708	.91949	1.05711	1.08765	1.07001	1.07572
1500.0 /	.00000	.00000	32.59062	9.50707	5.94730	4.21244	3.25352	2.77357	2.28842
1000.0 /	.00000	.00000	.00104	28.60751	13.21285	8.38229	6.63242	5.35837	3.54615
500.0 /	.00000	.00000	.00000	.03088	14.32547	19.98986	12.03195	8.27043	4.69292
.0 /	.00000	.00000	.00000	.00000	.41527	9.75253	5.63178	4.58933	3.83071
-500.0 /	.00000	.00000	.00000	.00000	.00008	.32091	3.58435	3.01546	2.26258
-1000.0 /	.00000	.00000	.00000	.00000	.00000	.00071	.28279	1.80009	1.47717
-1500.0 /	.00000	.00000	.00000	.00000	.00000	.00000	.00282	.24964	1.45468
-2000.0 /	.00000	.00000	.00000	.00000	.00000	.00000	.00002	.00714	.73319

EnecoTech

*** Energy Fuels Main Facility - Hermit MAX E OF FACILITY ***

* DAILY 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* ENDING WITH HOUR 24 FOR DAY 103 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 32.59062 AND OCCURRED AT (-500.0, 1500.0) *

Y-AXIS / (METERS) /	X-AXIS (METERS) 4000.0
2000.0 /	1.08444
1500.0 /	1.59391
1000.0 /	2.77515
500.0 /	3.23001
.0 /	2.93747
-500.0 /	1.47618
-1000.0 /	1.28236
-1500.0 /	.88589
-2000.0 /	1.03466

APPENDIX B

EMISSION INVENTORY

EnecoTech

TABLE B-1

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description: Haul road, product transport on unpaved road

Process Rate: 12 round trips per day

Emission Factor: E = k*5.9(s/12)(S/30)(W/3)**0.7*
(w/4)**0.5((365-p)/365)

where:
s = silt content (12%)*
S = vehicle speed (25 mph)**
p = average number of days with 0.01 or greater inches of precipitation (60)
W = average vehicle weight (15 tons)
w = number of wheels (10)
k = percent of material less than 30 microns (0.8)

Control Efficiency: None

Emission per Vehicle Mile: E(lbs/vmt) =
0.8*5.9(12/12)(25/30)(15/3)**0.7*
(10/4)**0.5([365-60]/365)
= 16.0

Emission Rate:
Daily: 16.0 * 12 trips * 2 (RT) = 384.0 lbs/day/mile
Annual: 384.0 * 260 = 49.92 tons/mile/year

---

* Silt content of 12% is standard EPA default value.
** Average speed expected on haul roads.

TABLE B-2

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description:	Ore loadout to ore stockpile
Process Rate:	300 ton per day, 260 days per year
Emission Factor:	E = 0.04 pounds/ton
Control Efficiency:	None
Emission Rate:	
Daily:	0.04 * 300 tons/day = 12.0 pounds/day
Annual:	260 day * 12.0 pounds/day = 1.56 (TPY)

TABLE B-3

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description: Ore loading from stockpile to haul trucks

Process Rate: 300 ton per day, 260 days per year

Emission Factor: E = 0.05 pounds/ton

Control Efficiency: None

Emission Rate:
Daily: 0.05 * 300 tons/day = 15.0 pounds/day
Annual: 260 day * 15.0 pounds/day = 1.95 (TPY)

TABLE B-4

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description:	Waste rock dumping to waste rock stockpile
Process Rate:	25000 tons maximum mine life or 10000 tons maximum per year maximum
Emission Factor:	E = 0.04 pounds/ton
Control Efficiency:	None
Emission Rate:	
Annual:	0.04 lbs/ton * 10000 tons = 0.20 ton/yr

TABLE B-5

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description: Wind erosion from distributed areas (includes ore, waste rock and topsoil stockpiles)

Process Rate: Entire disturbed area, 27.0 acres

Emission Factor: E = a*I*C*K*L*V (Universal soil loss equation)

where:
a is the amount remaining suspended 0.025
I is soil erodibility (38 tons/acre/year)
C is climate factor (1.00)
K is roughness factor (1.0)
L is the field width factor (1.0)
V is the vegetative cover factor (1.0)

Control Efficiency: None

Calculations: 0.025 * 38 * 1.0 * 1.0 * 1.0 * 1.0
= 0.95 tons/acre/yr

Emission Rate:
Annual: 0.95 tons/acre/year * 27.0 acres = 25.6 tons/year

TABLE B-6

ENERGY FUELS NUCLEAR HERMIT PROJECT

Source Description:	Mine vent
Process Rate:	200,000 standard cubic feet per minute (SCFM) exit flow rate from vent
Emission Factor:	0.002 grains per SCFM
Control Efficiency:	None
Emission Rate:	
Daily:	0.002 * 200,000 * 1440 = 82.3 lbs/day
Annual:	82.3 lbs/day * 365 = 15.0 tons/year

APPENDIX C

TSP CONCENTRATIONS

Second Quarter 1983

Third Quarter 1983

Fourth Quarter 1983

First Quarter 1984

ARIZONA STRIP PROJECT
SECOND QUARTER 1983
TSP CONCENTRATIONS

DATE	SAMPLER A	COLOCATED SAMPLER B
3/13/83	13	12
3/19/83	5	MSG
3/30/83	MSG	MSG
3/31/83	25	25
4/ 6/83	14	MSG
4/12/83	25	26
4/18/83	21	20
4/24/83	MSG	MSG
4/30/83	MSG	MSG
5/ 6/83	32	28
5/12/83	13	13
5/18/83	MSG	MSG
5/24/83	23	24
5/30/83	MSG	MSG
Arithmetic Mean:	19.0	21.1
Geometric Mean:	16.9	20.1
Standard Deviation	7.8	5.9

* Concentrations are adjusted to standard temperature and pressure.

ENECOTECH

ARIZONA STRIP PROJECT
FOURTH QUARTER 1983
TSP CONCENTRATIONS

DATE	SAMPLER A	COLOCATED SAMPLER B
9/ 3/83	16	17
9/ 9/83	14	15
9/15/83	16	19
9/21/83	20	23
9/27/83	10	10
10/ 3/83	7	9
10/ 9/83	8	8
10/15/83	14	14
10/21/83	16	15
10/27/83	16	20
11/ 2/83	9	10
11/ 8/83	7	7
11/14/83	14	15
11/20/83	7	7
11/26/83	6	7

Arithmetic Mean:	12.0	13.1
Geometric Mean:	11.2	12.1
Standard Deviation	4.5	5.2

* Concentrations are adjusted to standard temperature and pressure.

ARIZONA STRIP PROJECT
THIRD QUARTER 1983
TSP CONCENTRATIONS

DATE	SAMPLER A	COLOCATED SAMPLER B
6/ 5/83	36	33
6/11/83	36	46
6/17/83	59	56
6/23/83	24	23
6/29/83	26	29
7/ 5/83	30	29
7/11/83	22	23
7/17/83	29	21
7/23/83	19	20
7/29/83	20	20
8/ 4/83	20	19
8/10/83	17	18
8/16/83	MSG	14
8/22/83	14	11
8/28/83	30	20
Arithmetic Mean:	27.3	25.5
Geometric Mean:	25.5	23.4
Standard Deviation	11.3	11.9

* Concentrations are adjusted to standard temperature and pressure.

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ARIZONA STRIP PROJECT
FIRST QUARTER 1984
TSP CONCENTRATIONS

DATE	SAMPLER A	COLOCATED SAMPLER B
12/ 2/83	MSG	MSG
12/ 8/83	4	5
12/14/83	5	4
12/20/83	MSG	MSG
12/26/83	6	6
1/ 1/84	6	1
1/ 7/84	9	10
1/13/84	11	8
1/19/84	7	6
1/25/84	8	7
1/31/84	16	16
2/ 6/84	13	12
2/12/84	3	4
2/18/84	5	6
2/24/84	12	14
Arithmetic Mean:	8.1	7.6
Geometric Mean:	7.8	6.3
Standard Deviation	3.9	4.3

* Concentrations are adjusted to standard temperature and pressure.

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APPENDIX D

Joint Frequency Distributoin

From Airzona Strip Station Monitoring

March 1983 - March 1984

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS A
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

DIRECTION	SPEED CLASS INTERVALS (KNOTS) 1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.15	2.81	1.93	0.00	0.00	0.00	4.89	5.6
NNE	0.30	3.56	1.48	0.00	0.00	0.00	5.33	5.3
NE	0.44	3.70	0.89	0.00	0.00	0.00	5.04	4.9
ENE	0.00	1.19	0.30	0.00	0.00	0.00	1.48	5.0
E	0.15	2.37	1.19	0.00	0.00	0.00	3.70	5.4
ESE	0.30	0.89	0.00	0.00	0.00	0.00	1.19	4.0
SE	0.89	4.44	2.07	0.00	0.00	0.00	7.41	4.9
SSE	1.19	6.81	1.78	0.00	0.00	0.00	9.78	4.7
S	0.74	7.26	3.70	0.59	0.00	0.00	12.30	5.6
SSW	1.04	6.22	1.78	0.15	0.00	0.00	9.19	4.9
SW	1.04	4.30	3.56	0.00	0.00	0.00	8.89	5.6
WSW	0.00	2.37	1.48	0.00	0.00	0.00	3.85	5.8
W	0.89	4.89	2.22	0.44	0.00	0.00	8.44	5.5
WNW	0.44	1.93	3.26	0.00	0.00	0.00	5.63	6.2
NW	0.15	5.19	3.11	0.00	0.00	0.00	8.44	5.7
NNW	0.44	1.93	1.78	0.15	0.00	0.00	4.30	5.8
ALL	8.15	59.85	30.52	1.33	0.00	0.00	99.85	5.4

Calm (less than one knot) = 0.1%
Period mean wind speed = 5.4 knots
Percent occurrence for A stability class 9.3%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS B
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

SPEED CLASS INTERVALS (KNOTS)

DIRECTION	1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.88	1.58	1.41	0.35	0.00	0.00	4.22	5.8
NNE	0.70	1.93	2.11	0.35	0.00	0.00	5.10	6.0
NE	1.41	3.34	0.70	0.53	0.00	0.00	5.98	5.0
ENE	0.88	1.76	0.88	0.00	0.00	0.00	3.51	4.8
E	0.18	2.81	0.70	0.00	0.00	0.00	3.69	5.0
ESE	0.35	1.76	0.70	0.00	0.00	0.00	2.81	5.1
SE	1.05	4.04	1.93	0.00	0.00	0.00	7.03	4.8
SSE	0.35	8.96	4.57	0.18	0.00	0.00	14.06	5.6
S	1.23	4.04	4.04	1.23	0.00	0.00	10.54	6.3
SSW	1.41	5.80	2.81	2.11	0.00	0.00	12.13	6.2
SW	0.88	1.76	2.64	1.05	0.00	0.00	6.33	7.0
WSW	0.70	1.76	1.41	0.00	0.00	0.00	3.87	5.3
W	0.00	1.23	2.28	1.23	0.00	0.00	4.75	7.9
WNW	0.70	0.53	2.81	1.41	0.00	0.00	5.45	7.8
NW	0.18	2.46	3.51	1.41	0.00	0.00	7.56	7.2
NNW	0.00	1.58	1.41	0.00	0.00	0.00	2.99	6.0
ALL	10.90	45.34	33.92	9.84	0.00	0.00	100.00	6.1

Calm (less than one knot) = 0.0%
Period mean wind speed = 6.1 knots
Percent occurrence for B stability class 7.8%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS C
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

	SPEED CLASS INTERVALS (KNOTS)							
DIRECTION	1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.38	1.75	0.63	0.25	0.00	0.00	3.00	5.3
NNE	0.50	1.63	1.88	0.88	0.00	0.00	4.88	6.6
NE	0.63	2.88	1.63	0.25	0.13	0.00	5.50	5.9
ENE	0.38	3.13	1.13	0.25	0.00	0.00	4.88	5.3
E	0.50	1.63	0.75	0.00	0.00	0.00	2.88	4.7
ESE	0.75	1.00	0.13	0.00	0.00	0.00	1.88	4.0
SE	1.38	3.63	0.75	0.25	0.00	0.00	6.00	4.7
SSE	1.25	7.38	4.13	1.25	0.00	0.00	14.00	5.7
S	0.75	4.75	4.50	2.88	0.00	0.00	12.88	7.0
SSW	0.63	4.25	3.50	2.75	0.00	0.00	11.13	7.1
SW	0.50	1.75	2.63	2.50	0.13	0.00	7.50	8.2
WSW	0.25	1.38	1.50	1.25	0.00	0.00	4.38	7.4
W	0.75	0.50	1.88	1.38	0.00	0.00	4.50	8.0
WNW	0.50	1.00	2.25	2.13	0.00	0.00	5.88	7.9
NW	0.50	1.25	2.38	2.13	0.13	0.00	6.38	8.1
NNW	0.00	1.13	2.38	0.75	0.00	0.00	4.25	7.9
ALL	9.63	39.00	32.00	18.88	0.38	0.00	99.88	6.7

Calm (less than one knot) = 0.1%
Period mean wind speed = 6.7 knots
Percent occurrence for C stability class 11.0%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

ENECOTECH

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS D
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

DIRECTION	SPEED CLASS INTERVALS (KNOTS) 1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.48	2.03	1.24	0.65	0.10	0.00	4.50	6.8
NNE	0.34	1.34	1.93	1.99	0.31	0.00	5.91	8.9
NE	0.52	1.31	1.00	1.00	0.17	0.03	4.02	7.6
ENE	0.24	1.00	0.89	2.61	0.34	0.10	5.19	10.3
E	0.31	0.76	0.45	0.38	0.00	0.00	1.89	6.5
ESE	0.10	0.38	0.07	0.00	0.00	0.00	0.55	4.5
SE	0.34	1.10	0.17	0.03	0.00	0.00	1.65	4.4
SSE	0.41	3.75	2.75	1.10	0.14	0.00	8.15	6.8
S	0.58	3.68	3.06	2.92	0.07	0.00	10.31	7.6
SSW	0.58	4.13	3.40	3.75	1.03	0.14	13.03	8.9
SW	0.55	2.96	3.16	5.19	1.07	0.17	13.10	9.8
WSW	0.28	2.06	1.38	2.85	0.41	0.10	7.08	9.4
W	0.34	2.61	1.89	1.79	0.48	0.10	7.22	8.4
WNW	0.31	1.62	1.48	2.23	0.17	0.07	5.88	8.9
NW	0.34	1.99	1.99	1.44	0.14	0.07	5.98	7.9
NNW	0.10	1.62	1.51	1.99	0.28	0.00	5.50	9.2
ALL	5.84	32.31	26.37	29.94	4.71	0.79	99.97	8.5

Calm (less than one knot) = 0.0%
Period mean wind speed = 8.5 knots
Percent occurrence for D stability class 39.9%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

EnecoTech

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS E
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

DIRECTION	SPEED CLASS INTERVALS (KNOTS) 1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.52	1.73	1.05	0.00	0.00	0.00	3.31	5.3
NNE	0.84	3.20	5.72	0.00	0.05	0.00	9.81	6.2
NE	1.10	3.99	2.41	0.00	0.00	0.00	7.50	5.2
ENE	0.21	1.94	2.94	0.00	0.00	0.00	5.09	6.5
E	0.47	1.00	0.89	0.00	0.00	0.00	2.36	5.2
ESE	0.26	0.26	0.05	0.00	0.00	0.00	0.58	3.7
SE	0.73	0.68	0.05	0.00	0.00	0.00	1.47	3.4
SSE	0.47	2.68	0.94	0.00	0.00	0.00	4.09	5.1
S	1.63	4.04	1.47	0.00	0.00	0.00	7.14	4.7
SSW	1.31	6.66	3.67	0.00	0.00	0.00	11.65	5.3
SW	2.20	4.30	2.57	0.00	0.00	0.00	9.08	4.9
WSW	0.68	4.20	1.52	0.00	0.00	0.00	6.40	4.8
W	1.52	5.30	0.94	0.00	0.00	0.00	7.76	4.4
WNW	1.26	4.35	2.52	0.00	0.00	0.00	8.13	5.1
NW	0.58	4.35	2.99	0.00	0.00	0.00	7.92	5.5
NNW	0.63	2.78	4.30	0.00	0.00	0.00	7.71	6.2
ALL	14.43	51.47	34.05	0.00	0.05	0.00	100.00	5.3

Calm (less than one knot) = 0.0%
Period mean wind speed = 5.3 knots
Percent occurrence for E stability class 26.2%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS F
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

SPEED CLASS INTERVALS (KNOTS)

DIRECTION	1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	2.36	4.72	0.00	0.00	0.00	0.00	7.08	3.6
NNE	1.42	5.42	0.00	0.00	0.00	0.00	6.84	4.2
NE	2.83	6.60	0.00	0.00	0.00	0.00	9.43	3.9
ENE	1.89	1.65	0.00	0.00	0.00	0.00	3.54	3.4
E	3.07	3.07	0.00	0.00	0.00	0.00	6.13	3.1
ESE	1.65	0.24	0.00	0.00	0.00	0.00	1.89	2.5
SE	3.07	2.83	0.00	0.00	0.00	0.00	5.90	3.1
SSE	1.42	2.12	0.00	0.00	0.00	0.00	3.54	3.3
S	5.90	2.83	0.00	0.00	0.00	0.00	8.73	2.9
SSW	2.83	2.83	0.00	0.00	0.00	0.00	5.66	3.3
SW	3.30	3.54	0.00	0.00	0.00	0.00	6.84	3.0
WSW	2.36	3.77	0.00	0.00	0.00	0.00	6.13	3.4
W	3.07	5.42	0.00	0.00	0.00	0.00	8.49	3.3
WNW	3.07	3.54	0.00	0.00	0.00	0.00	6.60	3.2
NW	3.07	5.66	0.00	0.00	0.00	0.00	8.73	3.5
NNW	1.65	2.83	0.00	0.00	0.00	0.00	4.48	3.2
ALL	42.92	57.08	0.00	0.00	0.00	0.00	100.00	3.4

Calm (less than one knot) = 0.0%
Period mean wind speed = 3.4 knots
Percent occurrence for F stability class 5.8%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

FREQUENCY OF WINDS BY DIRECTION AND SPEED
FOR STABILITY CLASS ALL
DATA RECORDED FROM MARCH 1983 THROUGH MARCH 1984
GRAND CANYON - ARIZONA

SPEED CLASS INTERVALS (KNOTS)

DIRECTION	1,<3	3,<6	6,<10	10,<16	16,<21	>21	ALL	MEAN SPEED
N	0.59	2.11	1.13	0.32	0.04	0.00	4.19	5.9
NNE	0.58	2.35	2.77	0.92	0.14	0.00	6.76	7.0
NE	0.88	2.87	1.35	0.47	0.08	0.01	5.66	5.8
ENE	0.37	1.59	1.35	1.07	0.14	0.04	4.56	7.8
E	0.51	1.36	0.66	0.15	0.00	0.00	2.68	5.2
ESE	0.34	0.56	0.11	0.00	0.00	0.00	1.02	4.2
SE	0.82	1.91	0.51	0.04	0.00	0.00	3.28	4.4
SSE	0.65	4.46	2.32	0.59	0.05	0.00	8.07	5.9
S	1.25	4.20	2.76	1.63	0.03	0.00	9.87	6.4
SSW	1.02	5.05	3.09	1.98	0.41	0.05	11.60	7.1
SW	1.21	3.24	2.76	2.43	0.44	0.07	10.15	7.8
WSW	0.51	2.65	1.36	1.28	0.16	0.04	6.00	7.2
W	0.88	3.35	1.59	1.00	0.19	0.04	7.06	6.5
WNW	0.78	2.32	2.02	1.24	0.07	0.03	6.45	6.9
NW	0.55	3.08	2.40	0.92	0.07	0.03	7.04	6.6
NNW	0.34	1.96	2.27	0.89	0.11	0.00	5.57	7.3
ALL	11.27	43.07	28.44	14.93	1.94	0.32	99.96	6.7

Calm (less than one knot) = 0.0%
Period mean wind speed = 6.7 knots
Percent occurrence for ALL stability classes 100.0%

ENECOTECH INC.
SBWIND(1.0) 12/ 2/84

RADIOLOGICAL ASSESSMENT OF THE HERMIT PROJECT

KANAB PLATEAU -- ARIZONA STRIP

MOHAVE COUNTY, ARIZONA

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February 2, 1987

RADIOLOGICAL ASSESSMENT OF THE HERMIT MINE PROJECT
KANAB PLATEAU - ARIZONA STRIP - MOHAVE COUNTY, ARIZONA

SUMMARY OF CONCLUSIONS

The conclusions stated herein are based on an analysis of the Hermit Mine Project described in the text of this report.

1. Direct radiation from the mining operations will not be measureable at distances greater than a few hundred meters from the mine yard.

2. Radon gas releases from the site will not be detectable above normal fluctuations in the natural environment on the Kanab Plateau. Lung doses to residents of the nearest community, Fredonia, Arizona will be negligible.

3. Dust releases from the mine vent and ore piles will be on the order of 300 times less than limits set for facilities which require a radioactive materials license. While the Hermit Mine Project does not come under this jurisdiction, the low amount of release is noteworthy.

4. Surface water runoff from mining operations is not a problem since there will be no liquid effluent releases from the site.

5. Periodic radiological assays will be performed on water from the well which will be drilled at the mine site.

6. Ore transport will not expose individuals who reside along the haul route to any measureable increase in radiation dose. A few accidents should be expected during the life of the mine, but the radiological consequences of such an accident will be negligible.

Based on evaluations of the radiological aspects of the proposed operation, and the committments expressed by the mining company, there appears to be no radiological impacts on humans or the environment in the vicinity of the Hermit Project.

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RADIOLOGICAL ASSESSMENT OF THE HERMIT PROJECT

1.0 PROJECT OVERVIEW

Energy Fuels Nuclear, Inc. proposes to develop and operate an underground uranium mine at the Hermit Site on the Kanab plateau, approximately 22 miles (34 km) south, southwest of Fredonia, Mohave County, Arizona. The operation is expected to produce an average of approximately 300 tons per day of uranium ore and operate for approximately five years. Underground drilling may increase reserves, thus extending the operations life by a few more years. The ore body itself is situated in a breccia pipe formation located between 875 and 1,100 feet beneath the surface.

The high-grade ore will average 0.2 to 0.7% U3O8 and will be stored in a 150´x300´x10´(30,000 tons) stockpile. The low-grade ore will average 0.03 to 0.2% U3O8 and will be stored in a 150´x300´x20´ (65,000 tons) stockpile. The ore will be hauled in 25-ton capacity trucks to the mill in Blanding, Utah.

For comparison purposes only, the deposit at the proposed Hermit Site has several characteristics which are representative of the conditions at the three Hack Canyon uranium mines. The Hack Canyon Mines are located about 8 miles (11 km) south of the Hermit project and operated by Energy Fuels Nuclear, Inc. Therefore, where applicable, radiological and meteorological information has been obtained at the Hack Canyon Mines and applied to assess the potential impacts of the Hermit Project.

2.0 SITE CHARACTERISTICS

The Hermit Project will occupy about 23.6 acres on the Kanab Plateau. Figure 2.1 shows the topographical features of the area and its relationship to Kanab Creek and the Grand Canyon. Site elevation is 4890 feet (1466 m). (EFN 87)

The Hermit Project is located in large open area near the top of the Bulrush Canyon watershed. The general vegetative cover of the area is grasses and a small amount of sagebrush. Bare rock and soil are exposed over 50% of the area and there is no vegetation over three feet in height. There is not an obvious natural drainage or clearly delineated wash downslope from the Hermit Project.

Average rainfall in the area is approximately 15 inches per year. The amount of rainfall is about the same in the summer and winter, while the spring and fall are relatively dry. Summer precipitation usually is the result of thunderstorms which form over the heated canyon walls almost every afternoon from early July until the end of August. Although the storms are capable of producing locally heavy downpours, they rarely last more than 30 minutes and usually cease completely shortly after sundown.

Winter precipitation is not as consistent as that of summer, varying greatly from year to year in both amount and frequency. It is associated with middle latitude storms moving eastward from the Pacific Ocean and normally falls in gentle to moderate showers which may persist for several days. When these storms intensify over the California coast, move directly into Northern Arizona from the west, and meet a cold front sweeping down from the northwest, severe storms with heavy snow and strong winds can be expected. Most of the winter precipitation occurs as snow. (NWS 85)

Wind information has been collected from a site located near Sunshine Point -- approximately 9 miles (14 km) southeast of the Hermit Project. The annual wind rose information is presented in Figure 2.1 and the seasonal wind roses are shown in Figure 2.2. (FX 84) From the figures it can be seen that winds from the southerly sectors, with south-southwest being most frequent, dominate the wind pattern for the Kanab plateau. Throughout the year winds from the south-southeast through southwest occur nearly 40% of the time. East-southeast winds were the least frequent, occurring just over 1% of the time. Southerly winds tend to dominate throughout the hours of the day, though they may have an easterly component to them in the hours just before and just after sunrise when the surface heating is at a minimum. In the afternoon, as surface heating is maximized, the winds tend to shift to a more westerly direction. The westerly component is retained until there is sufficient surface cooling the next morning, at which time the winds back to a more easterly component. Winds tend to switch to a more westerly flow in the fall, and by winter westerly and northerly winds dominate slightly. In the spring the wind pattern begins to reverse and moves back to a more southerly flow. By summmer nearly 60% of the winds blow from the south-southeast through southwest sectors. Wind speeds average 7.6 miles per hour (3.4 m/sec). The highest average winds occur with east-northeast winds, but wind speeds in excess of 25 miles per hour (11 m/sec) occur most frequently with south-southwest winds. High winds almost exclusively occur with westerly component winds. Lowest average wind speeds occur with east-southeast and southeast wind. (FX 84)

The nearest communities are Fredonia, Arizona and Kanab, Utah (combined population 3,200) approximately 22 miles (34 km) north-northeast. Other population centers include Page, Arizona (population 5,000), about 75 miles (120 km) northeast; North Rim Visitors Center, about 40 miles (64 km) east-southeast; South Rim Visitors Center, about 45 miles (72km) southeast; Tusayan (permanent population about 80), about 55 miles (88 km) southeast; Supai (Havasupai Indian Reservation), about 30 miles (48 km) south; and, St. George, Utah (population 12,000) about 70 miles (112 km) northwest.

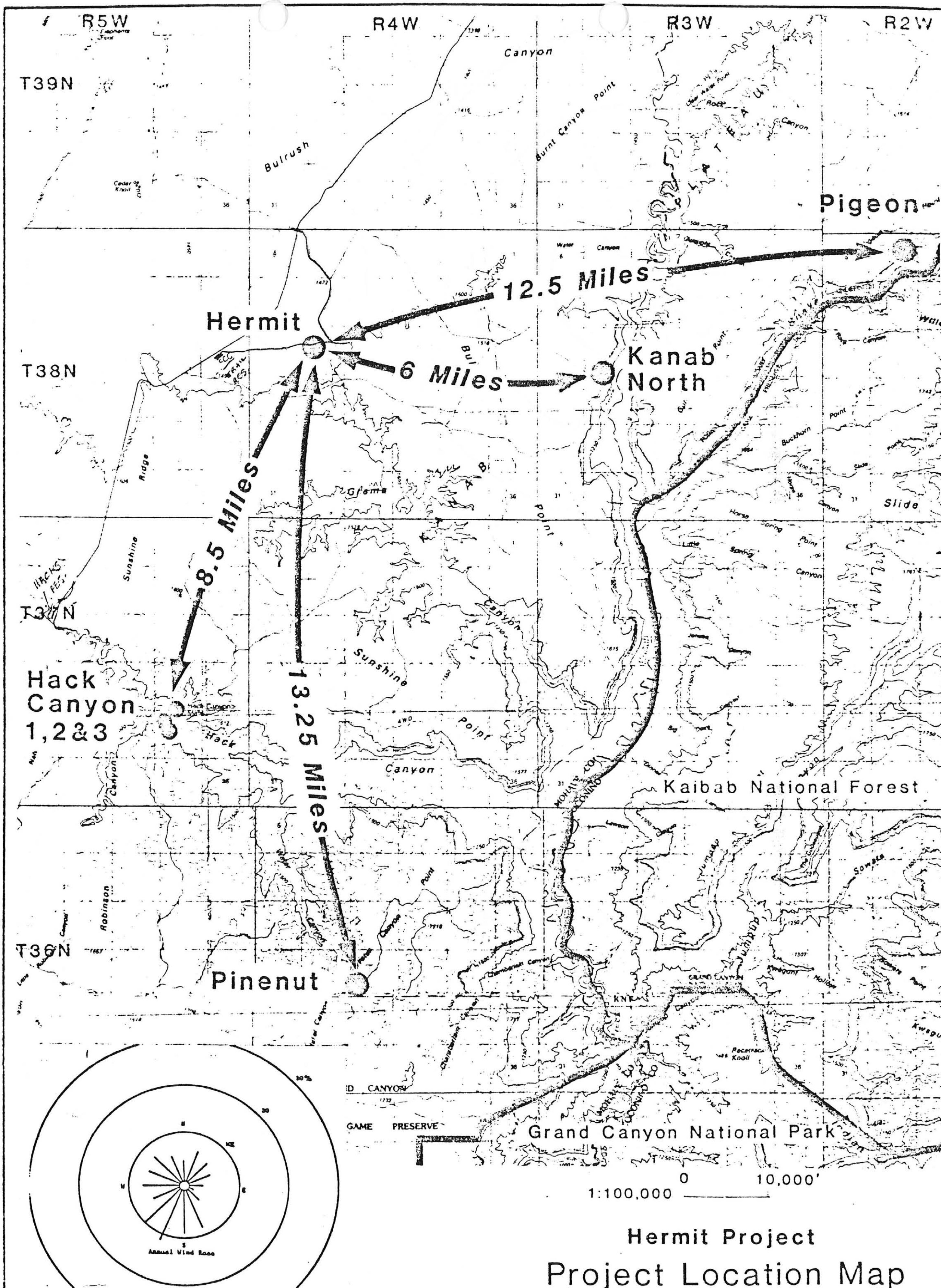

Figure 2.1 Area Topography and Annual Wind Rose

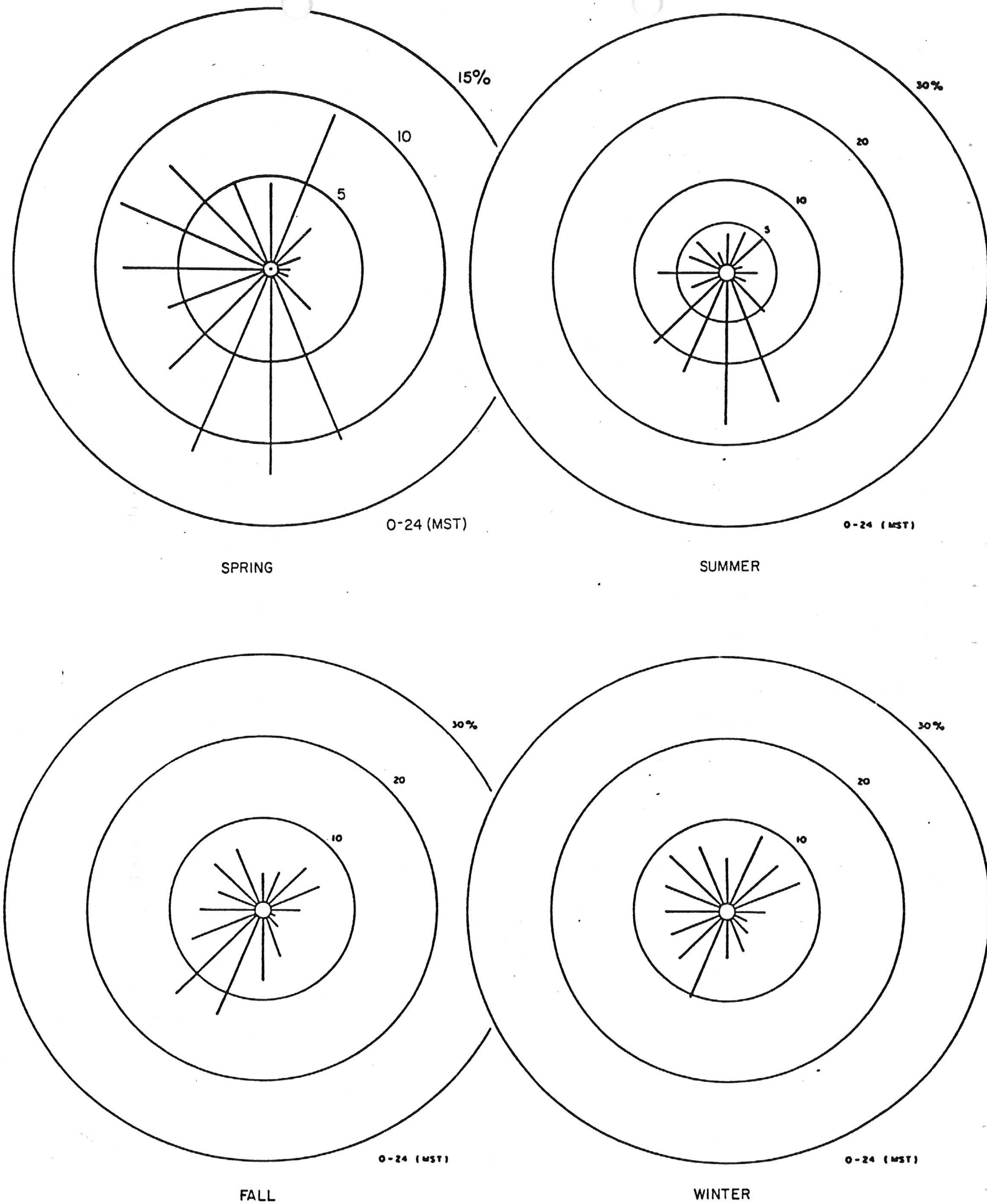

Figure 2.2 Seasonal Wind Roses (FX 84)

3.0 BASIC RADIATION INFORMATION

Radiation refers to energy emitted in the form of waves or particles. The characteristics which define wave energy may be found in the electromagnetic spectrum. The energy emitted is a function of the frequency of the radiation and is defined as:

$E = hv$ where:

E is energy
h is Planck´s constant and
v is the frequency of the wave.

When the available energy, E, is not sufficient to release orbiting electrons from an atom or molecule it is referred to as non-ionizing radiation. If, on the other hand, the energy is sufficient to eject an electron from its orbit the energy is a form of ionizing radiation.

Consider now the relationship between wavelength and frequency. Wavelength is inversely related to frequency by the mathematical expression:

$c = vl$ where:

v is velocity
c is the speed of light and
l is wavelength.

Note the inverse relationship between frequency and wavelength; as frequency increases, wavelength decreases.

3.1 Non-ionizing Radiation

Non-ionizing radiation occurs at the low frequency end of the electromagnetic spectrum. Examples of non-ionizing radiation, in order of increasing frequency include ultrasound, normal household current (60 cycle electricity), radiowaves, radar, microwave, infared, visible light, and some ultraviolet radiation. Given sufficient quantities, these forms of radiation may produce undesireable effects on the human body by heating (thermal effects) and/or physiological effects (called "non-thermal" effects). The U.S. Labor (OSHA) and Food and Drug (Radiological Health) regulations for non-ionizing radiation are based on the heating effects only. However, other nations recognize and acknowledge the controversial non-thermal possibilities and have adopted more stringent regulations for non-ionizing radiation. At present research is being conducted around the world to better understand the non-thermal phenomena associated with non-ionizing radiation.(LE 80) Although non-ionizing radiation is not a concern at the Hermit Project it is noteworthy in that it is not completely understood and regulations vary among nations.

3.2 Ionizing Radiation

As the frequency increases through the ultraviolet region, the energy from the electromagnetic radiation becomes sufficient to release orbiting electrons from the surrounding matter. This is ionizing radiation. Examples of ionizing radiation, in order of increasing frequency, include ultraviolet radiation, x-rays, gamma rays, and, finally, cosmic rays. In addition to wave or frequency type radiation emissions, several particles are also included in the general category of ionizing radiation. The particles of interest here include alpha particles and beta particles.

The form of radiation that is of interest at the Hermit Project is ionizing radiation. The specific types of ionizing radiation that need to be considered are x-rays, gamma rays, alpha particles and beta particles.

Like many chemicals and viruses, ionizing radiation is known to produce mutations (which may be beneficial or non-beneficial), is carcinogenic, and may cause genetic defects. However, the cause-effect relationship between forms of ionizing radiation and the potential for negative health effects is a function of many parameters including the amount of radiation received (dose), the rate in which the radiation is delivered (dose rate), the type of ionizing radiation (alpha, beta, x-ray, gamma), the organ of interest (whole body, thyroid, breast, lung, bone), age, sex, mental condition, and general health.

Occupational doses of ionizing radiation are regulated to minimize the probability that an individual will be exposed to doses of radiation which cause genetic effects or lethal somatic effects during a normal lifetime (with several orders of magnitude of conservatism built into the regulations). Limits on permissible doses to the public from regulated sources of ionizing radiation are reduced by a factor of 30 to provide an additional measure of safety. All regulatory limits exclude doses from the natural radiation environment AND from medical exposures (diagnostic and/or therapeutic). Ionizing radiation is probably the most studied and most well understood of all etiological agents. And, unlike regulations governing non-ionizing radiation, ionizing radiation regulations have worldwide acceptance among nations and among national and international radiation advisory commissions.

Finally, ionizing radiation regulations may be compared against some of the regulations which govern other hazardous substances such as air pollutants. It is worthy of note that only in the case of radiation are the standards for average exposure at about the same levels as that found in the natural radiation environment. For some of the other hazardous pollutants, the exposure levels are established in the area where adverse medical effects are definitely observable. This extremely conservative approach to radiation regulations evolved because the hazards of ionizing radiation were recognized early on and were subjected to detailed research as the sources and uses of ionizing radiation expanded. (ANS 80)

3.3 Types of Ionizing Radiation at the Hermit Project

The ionizing radiations which will be present at the Hermit mine will include x-rays, gamma rays, alpha particles and beta particles. These radiations are emitted from the radioactive materials found in and around the uranium ore body.

X-rays and gamma radiation have no mass or charge. They may be produced by x-ray machines, by ionization of atoms or molecules, or by the decay of radioactive atoms. Examples of radioactive materials which emit these types of electromagnetic radiation include radioactive Potassium-40, Cesium-137, Cobalt-60, Iodine-131, Radium-226, Bismuth-214 and Thallium-204. While this type of radiation has no mass it has great penetrating power and requires very dense materials for shielding. Diagnostic x-ray facilities often shield the walls and viewing windows with lead to prevent the release of the concentrated radiation they routinely and beneficially utilize. Similarly, radiation oncology (cancer therapy) units use massive quantities of radioactive Cobalt-60 and are shielded with considerable amounts of lead. In these units the gamma radiation is focused on the carcinoma by means of uranium collimators (uranium is used since it is about twice as dense as lead). Interestingly, radioactive materials which emit gamma radiation also emit beta particles.

Beta particles have a very small mass and a negative charge. Basically, beta particles are electrons which have been released from inside an atom as that atom decays and seeks a more stable configuration. While a few radioactive elements emit only beta particles, most decay by beta and gamma emissions . Examples of beta emitters include Carbon-14, Hydrogen-3, Cesium-137, Iodine-131, Thorium-234, Lead-214, Bismuth-214 and Lead-210. As the beta particles collide with orbiting electrons in the absorbing material they transfer a portion of their kinetic energy to the orbiting electrons. If the energy transfer is sufficient to cause an orbiting electron to be released from the attractive influence of the atom in the absorbing material, an ionization occurs. Beta particles may be readily stopped by light materials such as water, plastic or aluminum.

To conceptualize beta particle, x-ray and gamma radiation interactions with matter, consider a runaway car (the radiation source) in a forest (the absorbing material). If the car enters the forest with a specified velocity (kinetic energy) it may experience every conceivable type of collision from a glancing blow up to a head on collision. The car even has a probability, however small, of passing directly through the forest without striking any tree. Thus, these types of radiation may interact with the absorbing material in ways where the kinetic energy transfer ranges from zero (transmission) up to a total exchange (head-on collision).

Some radioactive materials may decay by releasing an alpha particle from its nucleus. The alpha particle has two positive charges and is identical to an ionized helium atom. Examples of alpha emitting radioactive materials include Uranium, Radium, Thorium, Polonium, Curium and Americium. Alpha particles are about 2,000 times larger and are ejected with about 10 times more kinetic energy than beta particles. Like beta particles, alphas dissipate their energy by ionizing collisions with the absorbing material. However, because of their large size alpha particles may be stopped by nothing more than a sheet of paper. Unfortunately, the deposition of such large quantities of energy in such a small area may cause the absorbing material to sustain a considerable amount of localized damage. Alpha particles are considered to be the greatest biological radiation hazard when ingested or inhaled. The critical areas are the lung, bone and the blood forming organs.

To conceptualize the interaction between alpha particles and matter consider a car in a corn field. If the car is pushed into the field with a specified velocity, then released, it will travel a straight path and eventually stop. A swath of destruction occurs as the vehicle imparts its kinetic energy to the corn stalks. Another car entering the field with identical kinetic energy will create another swath of similar length.

3.4 The Natural Radiation Environment

The natural radiation environment consists of cosmic radiation and many radioactive elements including Hydrogen-3, Carbon-14, Potassium-40, Rubidium-87, Uranium-235, Uranium-238 and Thorium-232. Importantly both Uranium-238 and Thorium-232 are ubiquitous in soil with average concentrations of a few parts per million. Each are ´parent´ elements of a radioactive decay series. The parents decay to daughters, or progeny, which are radioactive also. After many decays each chain terminates with the formation of stable lead. The thorium decay series is not significant in the Hermit ore body or other uranium deposits in Arizona so it will not be discussed here. Natural uranium is about 99.3% U-238 so the radiation contribution from the U-235 series is insignficant. The decay scheme for U-238 is shown in Table 3.1.

Table 3.1 Uranium-238 Decay Scheme

Radionuclide	Type of Decay	Remarks
Uranium-238	alpha	Chemical toxicity greater hazard than radiotoxicity
Thorium-234	beta	
Protactinium-234m	beta	
Uranium-234	alpha	
Thorium-230	alpha	
Radium-226	alpha and gamma	Chemically similar to calcium
Radon-222	alpha	Inert gas
Pollonium-218	alpha	
Lead-214	beta and gamma	
Bismuth-214	beta and gamma	
Pollonium-214	alpha	
Lead-210	beta	
Bismuth-210	beta	
Pollonium-210	alpha	
Lead-206	=====	Stable

Radioactive materials are present in air, water and soil. Their concentrations are expressed in units of radioactivity per volume or mass. Typical concentrations of naturally occurring uranium and Radium-226 in normal soil are on the order of 1 pico-Curie per gram. A pico-Curie (pCi) is equivalent to 2.22 atoms of the radionuclide decaying each minute - a very small number. Typical concentrations of Uranium and Ra-226 in surface, ground and domestic water are on the order of 1,3,2 pCi/L (L = liter) respectively - again, a very small number. Arizona´s uranium concentrations in water have been reported to be between 2.5 and 2.7 pCi/L.(LA 85) These values may vary considerably depending on the extent of uranium mineralization in the area being examined. Because the energy released by radioactive materials is known and quantifiable, once the intake of radioactive materials through air water and the food chain is determined as a consequence of such intake modes, it is possible to calculate the radiation dose delivered to the organ of interest.

3.5 Dose from Ionizing Radiation

When ionizing radiation deposits energy in living matter it produces a physical and biological effect which may be quantified in terms of dose. The actual damaging effects are thought to be caused by the production of reactive chemicals, the result of ionization of water molecules in the living cells. It is the chemicals which in turn may alter or destroy chromosomes. The radiation does not produce excessive heat nor is it suspected of reacting directly with chromosomes.

The units of dose are rem (roentgen equivalent man). However, because this unit is so large it is often useful to divide the value by one thousand and discuss radiation dose in terms of 1/1000 rem, or millirem (mrem). The dose rate may be described in terms of mrem per hour (mrem/hr), or mrem per year (mrem/yr) etc. Possible sources of radiation dose include cosmic ray interactions, radioactive materials in the natural radiation environment, medical ionizing radiation treatments, radioactivity in numerous consumer products, and radiation from the nuclear power fuel cycle. Examples of possible doses are listed in Table 3.2. Unless specifically stated, doses are expressed in terms of the amount of radiation delivered to the whole body.

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Table 3.2 Typical Radiation Doses

Source	millirem (mrem)	
Cancer treatment (to specific organ)	5,000,000	per cancer
Lethal Dose	450,000	instantaneous
First physiological effects	25,000	instantaneous
Maximum allowable average occupational dose (medical and natural background excluded)	5,000	per year
Maximum allowable dose to an individual member of general public (medical and natural background excluded)	500	per year
Cosmic ray doses to flight crew (McK 75)	380	per year
Average dose received by all workers in uranium mines, mills and power plants	365	per year
Average allowable dose to general public (medical and natural background excluded)	170	per year
Vicinity of Canyon Mine Project, Az.(McK 85)	70 - 125	per year
Arizona Strip near HERMIT Project (McK 85)	105	per year
Average dose from natural background	100	per year
Phoenix, Arizona (McK 85)	100	per year
Arizona Strip near Hack Canyon Mine and Kanab North Project (McK 85)	70	per year

Window Rock, Cove and Red Valley, Az.(McK 81)	70	per year
Average dose from diagnostic x-rays (McK 80)	70	per year
Control Room Operator at Nuclear Power Plant	50	per year
X-ray Technician	50	per year
Cigarettes dose to lung (Po-210 from U-238 decay chain present)	30	per pack
Water and food; U.S. average	25	per year
Work in granite buildings like U.S. Capitol	20	per year

===

3.6 Radon Gas and Dose Delivered from Progeny

A progeny of U-238 is Radon-222. Radon is a colorless, odorless and inert gas which diffuses into the atmosphere from rocks, soil and building materials. Normal environmental outdoor concentrations are generally less than 1 pCi/L. However, in uranium mines and energy efficient buildings, or where air stagnates as a result of reduced dilution (mixing with relatively radon-free outside air), radon concentrations may increase measurably.

However, radon itself poses no health concern. Rather it is the Radon progeny from Pollonium-218 to Lead-210 (see U-238 decay chain in Table 3.1) which need to be considered. Lead-210 is a radionuclide with such a long half life (time to decay to 1/2 of the original activity) that the radon daughter issue is considered to terminate at this point. All the Radon-222 progeny of interest are particulates and many decay by alpha particle emission. It is the alpha emitting progeny of Radon-222 which have been linked to lung cancer in uranium miners as well as lung cancer found in other underground miners. (CONG 67, BEIR 72)

To better understand the relationship between radon progeny concentrations and the units derived which quantify the permissible dose to an underground miner and the evolution of mining regulations during the late 1950´s it is necessary to develop a historical perspective on the issue.

Mining in Schneeburg (Central Europe) began about 1400 A.D., first for copper, iron and silver, then for several metals and finally for Uranium. A lung disease peculiar to workers in these mines was described as early as 1500 A.D., but not recognized as cancer until 1879. The etiological role of radon (Rn-222) was not suspected until about 1932 and not generally accepted until the 1960´s. Recognizing the problem, the U.S. Atomic Energy Commission established a concentration limit for uranium mines of 100 pCi/L in 1955.(NCRP 84) However, since the progeny of Rn-

222 are the source of the health problem a means had to be developed to quantify the permissible dose from the presence of the daughters.

In 1957 the U.S Health Service introduced the working level (WL) unit in an attempt to quantify the exposure (dose) delivered to the lungs from radon daughters. Its reason for the particular value was to set a level which "appears to be safe, but not unnecessarily restrictive to industrial operations." (BL 82)
By definition,

> A "working level" (WL) is a standard measure of radon daughter concentration in air. It is an expression of potential alpha energy. One WL is any combination of radon daughters per liter of air that will result in the emission of 1.3E+05 (130,000) Mev of alpha energy in their decay through Po-214.

Whenever radon and progeny are present in identical concentrations, a special situation exists which is called ´secular equilibrium.´ If this condition is satisfied (which rarely occurs in nature) then 100 pCi/L of Rn-222 is equal to one Working Level: That is to say,

100 pCi/L Rn-222 = 1 WL.

A "working level month" (WLM) is a standard measurement of cumulative exposure. A WLM is an exposure equivalent to working in an atmosphere containing 1 WL of radon daughters for 173 hours (this is sometimes rounded to 170 hours). To determine the cumulative WLM multiply the WL measured in the atmosphere by the number of hours/year exposed and divide by 170 hours/month. The result is WLM per year (WLM/yr) and this value may then be converted into an expression of <u>dose to the bronchial epithelium (lung tissue)</u>. This requires that a number of conservative assumptions be made to account for daughter product deposition, radioactive build-up and decay, removal by mucociliary clearance and physical dose to specific cells in the lungs. The generally accepted result is that;

1 WLM = 5,000 mrem occupational dose to the bronchial epithelium.

For continuous, non-occupational, environmental exposures to radon progeny additional assumptions are made regarding daughter product concentrations in outdoor air, breathing rates of an average individual (which is about 0.5 times that of a working miner), and the number of cumulative working-level-months of radon daughter exposure for an average individual surrounded by air at a constant concentration of one WL (which for continuous exposure is about 25 WLM/yr), then,

1 pCi/L Rn-222 = 625 mrem dose to the bronchial epithelium from the daughter products,

and

1 pCi/L Rn-222 = 0.005 WL. (USNRC 79)

Radon concentrations (pCi/L), daughter exposures (WL), and doses to the LUNG (mrem/yr) are correlated in Table 3.3.

Table 3.3 Radon Doses to Lung Compared to Radon Gas Concentrations and Radon Progeny Exposure

Source of Radon/progeny	Concentration or working level	lung dose (mrem/year)
Occupational limit, underground mining	4 WLM/yr	20,000
U.S. uranium miners, current average (NCRP 84)	2 WLM/yr or less	10,000
Hack Canyon Miners (average) (HU 85)	2.2 WLM/yr	11,000
Average exposure to public from natural environment (NCRP 84)	0.2 WLM/yr(3 mWL)	375
Average radon levels atop mill tailings pile (MO 79)	10 pCi/L	6,250
Energy efficient homes (may be much higher) (WS 86)	5 pCi/L	3,125
Guideline for homes (USEPA 86)	4 pCi/L	
Concrete buildings in Arizona (McK 85, NCRP 75)	1.7 pCi/L	1,062
Conference Room, Canyon Squire Inn, night of public meeting on Canyon Mine Project (McK 85)	1.2 pCi/L	750
New Mexico, average outside air (MO 79)	0.5 pCi/L	312
Western U.S. Average outside air (USNRC 79)	0.2 pCi/L	125
Canyon Mine Site (McK 85)	0.2 pCi/L	125
Hermit Mine Site (McK 87)	0.2 pCi/L	125
Historical Cabin, Bright Angel Lodge, South Rim (McK 85)	0.2 pCi/L	125

In a mine environment radon and radon progeny may be diluted easily to acceptable concentrations by forced ventilation. The objectives are to remove the radon gas as it diffuses from the ore into the mine atmosphere, but before it has a chance to decay, AND to flush the mine environment with fresh, outside air. It is not uncommon to find ventilated mine atmospheres with radon and progeny concentrations which approach outside air. Measurements obtained by McKlveen from 1979 to present have identified ventilated mine environments with radon progeny concentrations that are less than his ´energy efficient´ home.

3.7 Summary of Concepts: Radioactivity, Radiation, Working Level, Exposure and Dose

Unstable atoms decay to seek a more stable nuclear configuration. The rate of radioactive decay may be expressed in terms of radioactivity: One Curie = 3.7 E+10 decays (disintegrations) per second. The types of radiation include alpha particles, beta particles, gamma radiation or combinations thereof. They are ejected from the nucleus of the atom with a specific amount of kinetic energy. As the radiation passes through matter various interactions occur and the kinetic energy is dissipated. The energy deposited has a physical effect on the material and may be expressed in units of exposure (gamma rays in air) or dose (any type of radiation interacting with any material) by use of appropriate, mathematical conversion factors. Exposure in air is expressed in units of Roentgen. When converted to express radiation interactions with any material the units become rad (radiation absorbed dose) where one rad equals 100 ergs of energy deposited in 1 gram of material (any material). However, if the material is alive, an additional correction factor may be applied to account for the fact that different types of radiation produce different "biological effects." For example, alpha particles are assigned a biological effectiveness which is twenty times greater than beta or gamma radiation. For this reason alpha particles are considered to be the most hazardous type of radiation. The biological effectiveness of beta particles and gamma rays is unity. The term used to describe the physical and biological effect of radiation on living matter is rem (roentgen equivelent man). It may be calculated by multiplying the rad dose by the appropriate biological equivalent factor.

If the rem dose of radiation is to the delivered entire body it is called "whole body" radiation, or "whole body" dose. Also, the rem dose may be used to quantify the dose to a specific organ: For example, rem dose to a hand, rem dose to the thyroid, rem dose to the intestine, or, rem dose to the lung.

When measuring the radiological consequences of the natural radiation environment the characteristics of beta particles and gamma radiations are such that the conversion factors from exposure to dose and to dose in living matter is such that it is practical to assume that the radiation exposure and dose terms are equivalent; that is, to say, 1 Roentgen = 1 rad = 1 rem.

Alpha emitters pose a special concern when they are inhaled. Therefore, the concept of "Working Level" was developed to quantify the lung dose to uranium miners. Working Level may be converted to rem dose to the lung.

Under certain circumstances radioactive materials may be a concern when ingested. Soluble radionuclides may be transferred to the blood stream while insolubles will be excreted. If the radionuclide is also a heavy metal, such as uranium or thorium, chemical toxicity may become the major concern. For example, radiation regulations for uranium are based on its chemical toxicity to the kidney. Proper hygiene and routine bioassays (urine samples or mucus swipes) ensure miners are not ingesting radionuclides.

3.8 General Perspectives Concerning Risks Associated with Dose

The radiation information may be summarized by analyzing their contributions to population dose. The main contribution to the dose received by individuals (about 87%) is due to the natural radiation environment. This includes indoor exposure to radon decay products which is the largest single source of exposure. The largest man-made contribution (about 11.5%) is from the use of ionizing radiation in medical procedures.(HU 84)

The maximum exposures from the natural radiation environment are on the order of 1,300 mrem/yr and occur in locations such as Kurala, India and sites in Brazil. The inhabitants of these areas have been studied and no adverse health affects observed. It should be emphasized that these values are almost three times the maximum occupational dose limits (see Table 3.2). The maximum radon and progeny concentrations were recently found in homes in an area around Boyertown, Pennsylvania.(DV85) The homes were apparently built on top of a uranium deposit known as the Reading Prong and concentrations as high as 2700 pCi/l have been found; this will result in a lung dose of about 1,687,500 mrem/yr. If secular equilibrium is assumed then the concentration is equal to 27 WL. If an individual occupies the residence for 12 hours each day then the cumulative yearly expression becomes 700 WLM. This is approximately 175 times the allowed occupational exposure for uranium miners. See Table 3.3 for additional comparisons.

The main health concern from radiation exposure is cancer. Radiation sensitive organs include the blood (leukemia), lungs and breasts. However, only about 4% of all carcinomas are generally thought to be radiation induced; the remainder are caused by chemicals, viruses and other etiological agents. Radiation effects have been observed at very high doses. However, no studies have shown detrimental effects from radiation doses which approach the regulatory limits for occupational workers. (BEIR 80)

With respect to lung cancer, definite correlations have been made above 1,000 WLM (5,000,000 mrem), cumulative exposure, and correlations with slightly increased lung cancer levels appear to have been made for cumulative levels above 100 WLM (500,000 mrem). Cumulative exposure means the sum total of all exposures received during a lifetime. The correlations are based on studies of uranium miners who worked in unventilated mines where the exposures were several times today's regulated levels (i.e. on the order of 10 WLM/yr or greater). However, studies of U.S. miners with less than 60 WLM (300,000 mrem) cumulative exposure indicate a deficit in lung cancers (statistically not significant) rather than an excess in lung cancer. Also, it has been found that U.S. uranium miners experience less lung cancer than uranium miners in other countries and also other non-uranium mining operations (i.e. studies of zinc miners in Sweden). (CONG 67, BEIR 72, BEIR 80)

The use of miners and mining environments to create a data base for the evaluation of etiological agents is extremely difficult and the results which attempt it must be viewed with caution. For example, an investigation of respiratory abnormalities in New Mexico uranium miners evaluated a considerable amount of data and appropriately concluded, "Because of the complexity of exposures in the uranium mining environment and the additional effects of cigarette smoking, epidemiological investigations of miners cannot satisfactorily quantify the specific effects of radon-daughter exposure on lung function. Reduction of non-malignant respiratory disease morbidity and mortality in uranium miners requires control of each potentially hazardous exposure: radon daughters, silica, diesel exhaust and cigarette smoking." (SA 84) Another study which researched miners exposed to low levels of alpha radiation attempted to compare the incidence of mortality and cancers in miners from an underground mine with average alpha radiation concentrations in the range of 0.07 to 0.40 WL with incidences in miners in another mine with average concentrations equal to or less than 0.02 WL. In an absolute sense the higher cancer rates (including lung cancer) were found in the mine with the lower alpha radiation concentration, but after a statistical evaluation of the data the article rightfully concludes, "The study population is too small to repudiate the hypothesis of increased health risk after exposure to low levels of alpha radiation." (LE 86)

A recently published review of all studies and all available information up to 1984 concluded that, assuming current WL exposures found in today's mine environment and the current average time of 10 years that a U.S. uranium miner spends in the mine, an average U.S. uranium miner may have up to a 0.5% increase in risk of developing lung cancer. For comparison, there is a 0.5% increase in risk of death caused by working in industries which are classified as "safe industries". (NCRP 84)

For comparison, using the same studies and information it can be estimated that for the annual, environmental radon progeny exposure to the public (0.2 WLM) (NCRP 1984), there is a lifetime risk of death from lung cancer of 1800 per million exposed. For the U.S. this translates to about 400,000 deaths (out of a population of over 220,000,000). For the case of energy efficient homes, it would not be unreasonable to expect a doubling of the radon daughter concentrations (see Table 3.3). Based on this increase an additional 1800 lung cancer deaths per million population (who live in these homes) can be anticipated. Put in terms of increased risk, the lifetime risk of a lung cancer death due to environmental radon progeny is on the order of 0.2 %. For those living in an energy efficient home the risk is doubled, or is about the same as that for a U.S. uranium miner. Finally, the total probability of death from all forms of cancer is on the order of 17%.

Mutations and genetic effects are concerns also. By extrapolating data obtained at very high doses it can be estimated that the doubling dose (that dose necessary to double the number of mutations that normally occur due to environmental radiation) is between 20,000 and 250,000 mrem. However, no effects have ever been observed at doses on the order of 100,000 mrem or less. Furthermore, studies of individuals living in areas where the natural radiation is considerably above average have shown no adverse effects.

4.0 URANIUM MINING RADIATION REGULATIONS

The pertinent regulations which govern the radiological aspects of uranium mining operation are summarized here.

Note: CFR = Code of Federal Regulations

<u>30 CFR 57</u> Mine Safety and Health Administration

No Uranium miner permitted to receive more than 4 WLM/year.

Records kept on all miners where concentrations of radon daughters are in excess of 0.3 WL.

Respirators required when levels exceed 1 WL.

Additional protection against radon gas itself required when radon daughter concentrations exceed 10 WL.

If gamma radiation levels exceed 2 mrem/hr dosimeters must be worn and records kept. Limit of 5 rems/yr.

Note: The regulations apply only to uranium mining activities. They do not apply to other underground mining operations or other possible sources of enhanced radiation such as energy efficient buildings.

U.S. EPA National Interim Primary Drinking Water Standards (1976)

If gross alpha particle activity in water is greater than 5 pCi/L, perform Ra-226 analysis. If Ra-226 analysis greater than 3 pCi/L, perform Ra-228 analysis. There are other regulations if gross alpha exceeds 15 pCi/L or gross beta activity exceeds 50 pCi/L.

40 CFR 61 Environmental Protection Agency

Subpart B--- National Emission Standard for Radon-222 Emissions from Underground Uranium Mines.

Governs the positioning of bulkheads to reduce radon releases from areas of inactivity within the mine.

49 CFR Transportation

Governs proper containers and methods for transporting ore from mine to mill.

5.0 RADIOLOGICAL ASSESSMENT OF HERMIT MINE

The radiological assessment program will be categorized into background radiation, airborne radioactivity, surface and ground water radioactivity, and transportation. Where possible radiological data will be compared with the existing regulations or the natural radiation environment.

5.1 Background Radiation

Four monitoring stations which measure the background gamma radiation were established around the Hermit Project on September 19, 1986. The sites are approximately 1/4 mile (0.4 km) north, south, east and west of the proposed mine.

Other monitoring stations are in place at the Pinenut, Kanab North and Pigeon Mines, and, an extensive monitoring network has been established at the Canyon Mine. Since the gamma radiation data for all mine sites is being collected using identical detection methods and the entire region has similar radiation characteristics, any changes from existing background will be obvious.

Initial onsite measurements made in September, 1986 and January, 1987 (McK 87) indicate that the background gamma radiation exposure rates are on the order of 105 mrem/yr. For comparisons with other environments refer to Table 3.2.

During mine operation the radiation levels in the vicinity of the uranium ore stockpile will be on the order of 1 mrem/hr. Since radiation levels around the ore stockpile on the ridge above the Pigeon mine were found to decrease to background at a distance of a few hundred meters from the pile, the levels at the Hermit mine should do the same. Thus, it is anticipated that gamma radiation will remain unchanged at the monitoring stations during mine operation.

5.2 Airborne Radioactivity

Radon gas will diffuse from the ore stockpiles and be exhausted from the mine vent. Once airborne the gas will be transported away from the area by prevailing winds and will decay to its progeny. Radon progeny will be exhausted from the mine vent also. However, they quickly decay and become no concern.

Uranium and all progeny will be present in dust blown off the ore stockpiles and in dust released from the mine vent.

The potential impact from these radionuclides may be determined based on the magnitude of each release and the prevailing meteorological conditions. Several computer codes are available which model the atmospheric dispersion of radionuclides. The MILDOS Code, developed to study releases from uranium mills, was selected to quantify the radon gas releases while the Industrial Source Code was used to generate isopleths of the potentially radioactive dust.

The natural background radon gas concentrations in the vicinity of the Hermit Project are on the order of 0.2 pCi/L. (McK 87) Increases in radon fro the mining operations are presented in Table 5.1. Source term for the calculations and a description of MILDOS are presented in Appendix B.

Table 5.1 pCi/L Increase in Radon Gas Levels from the Hermit Mine

Distance from Site (km)	North	East	South	West
1.5	0.15	0.15	0.06	0.04
2.5	0.07	0.07	0.04	0.02
3.5	0.05	0.04	0.02	0.01
35	0.002*	0.002	0.001	0.001

* Nearest permanent community

Radon concentrations will be slightly above background, but will not be detectable above normal background fluctuations. The rem dose to the lung at the nearest residence is about equal to that received from one puff on a cigarette, or flying on a commercial airliner from San Diego to Los Angeles.

Radioactivity in dust emissions from the ore piles and mine vent was analyzed using the Industrial Source Code. A discussion of the model is provided in the air quality report for the Canyon Mine Project. (ST 85) The computer run was performed using only the process related emissions in tons per year (TPY) from the mine vent (15 TPY), loadout of ore to stockpile (1.56 TPY), ore loadout to haul trucks (1.95 TPY), and, wind erosion of stockpiles (2.73 TPY) which total 21.24 TPY. (ST 86) Isopleths of the mine and ore dust blown are presented in Figure 5.1.

Assuming that all the potentially radioactive dust is 1% uranium (rather than the anticipated 0.7% in the high grade and 0.2% in the low grade ore piles), the 1 ug/m-3 dust isopleth has a natural uranium concentration of 0.01 ug/m-3. For comparison purposes only, this concentration may be compared with the 10 CFR 20 regulation limit of 3.0 ugm/m-3 for natural airborne uranium releases to an uncontrolled area at facilities which possess a radioactive source materials license. Although the uranium mine is not governed by 10 CFR 20 regulations the releases are, nevertheless, approximately 300 times below this limit.

In summary there will be no signficicant radiological impact on the environment from the release of radon gas or dust from the mine site.

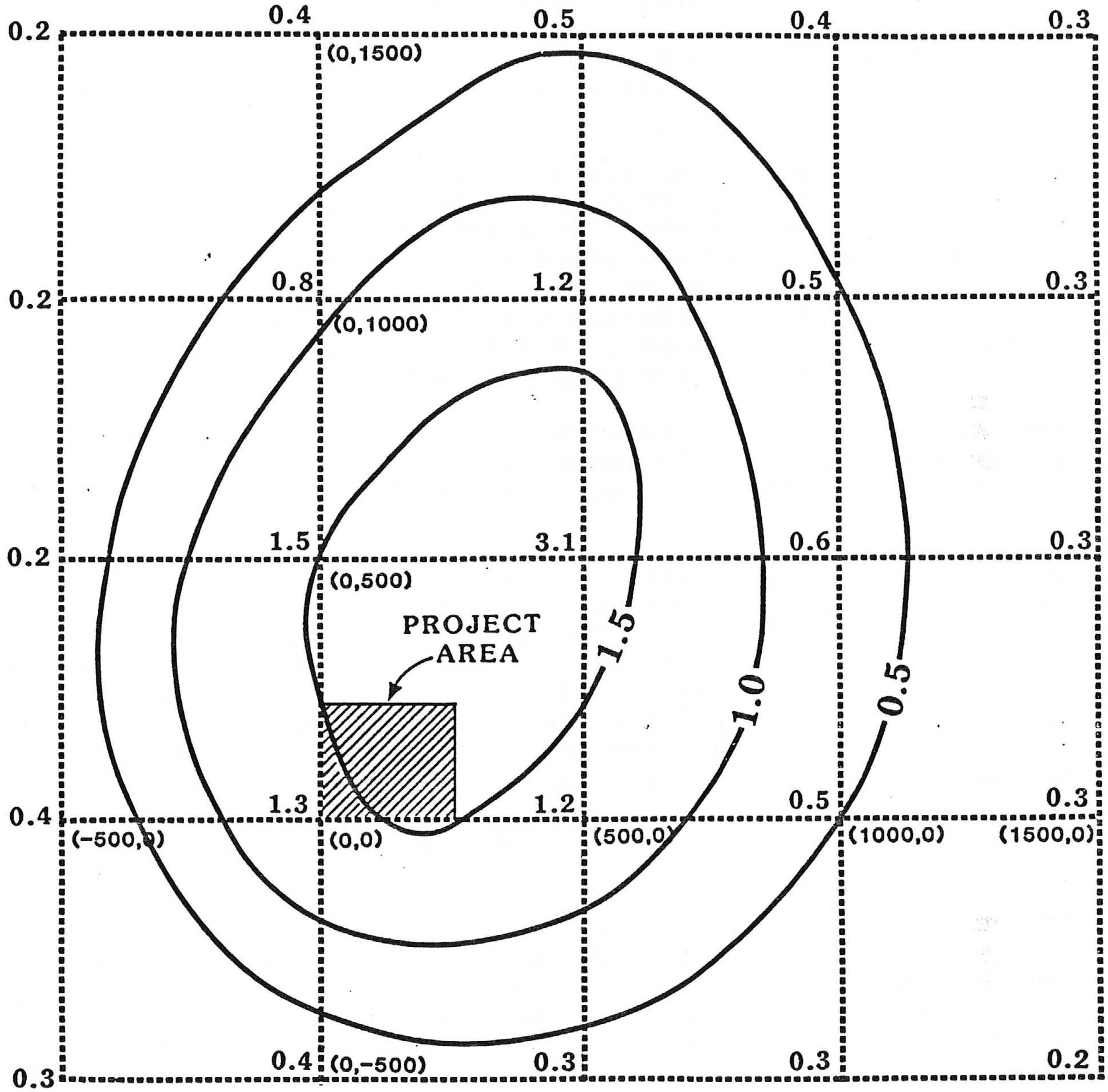
5.3 Groundwater

A well is to be drilled at the Hermit Project. Water samples will be collected routinely from the well and radiological assays performed to determine if changes occur during mining operations.

5.4 Surface Water

Surface runoff falling within the mine area will be collected in a surface-water evaporation pond. The pond will be located just inside the mine yard and will be sized to hold mine yard runoff from a 100 year - 24 hour storm event.

Water diversion facilities on the south perimeter will be constructed to ensure that any surface runoff from the 200 acre upslope watershed will be diverted around the site and will not be allowed to enter the mine area of operations. (EFN 87)



Sec. 17, T39N, R4W
Mohave County, Arizona

Scale: 1" 1000'

EnecoTech
Denver, Colorado

PROCESS EMISSION CONCENTRATION

Units Are Micrograms per Cubic Meter

PROJECT Hermit

FILE NO. 105-004 DATE Feb 87 FIGURE NO. 5.1 p. 24

5.5 Ore Transport Radiation and Radioactivity

Ore will be shipped via independent truck contractors using double-trailer trucks of 25-ton capacity. Each load will be covered with a tarpaulin, lapping over the side about a foot and secured every few feet around the truck bed. Thus, wind erosion, storms, and uneven roads will not cause loss of material during transit.

Direct radiation from an ore truck will be about 2 mrem/hr at the truck bed, about 0.3 mrem/hr on the shoulder of the roadbed and normal background at about 60 m (96 ft) from the trailer. As a truck passes, individuals standing on the shoulder of the highway will receive a dose of radiation too small to quantify. Thermoluminescent dosimeters have been placed at several sites along existing haul routes, but have not detected any changes in radiation levels from the natural radiation environment. (DM 85)

The truck driver will receive measureable radiation and doses to about 500 mrem/yr may be expected. As shown in Table 3.2, this dose is only slightly higher than that received by airline flight crews.

Truck accident statistics include three categories of events: collisions, noncollisions, and other events. "Collisions" are between the transport vehicle and other objects, whether moving vehicles or fixed objects. "Noncollisions" are accidents involving only the one vehicle, such as when it leaves the road and rolls over. Accidents classified as "other events" include personal injuries suffered on the vehicle, persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring on a standing vehicle. The probability of a truck accident of any kind is about 1.3E-06/km. (USNRC 79)

The mine will ship an average of 12 trucks loads per day to the mill in Blanding, Utah. The mill is about 300 miles (480 km) away. Thus, the probability of an accident is about 7.5E-03 per day OR about one accident of some type every 130 days. It should be noted that only a fraction of all accidents will result in ore spillage. Nevertheless, a couple of spillage accidents should be anticipated during the operational life of the mine.

The ore from the mine is moist, uncrushed rocks and will contain only a small percentage of respirable dust which might be released during an accident. For an ore truck accident it is reasonable to assume that about 2.1 kg (4.6 lbm) of ore dust might be released to the atmosphere.(USNRC 79) If all the dust were in the respirable range then a maximum individual 50 year lung dose commitment would be on the order of 130 mrem at 500 m (1600 ft) and 14 mrem at 2000 m (6500 ft) from the accident scene. (USNRC 79) Direct radiation would be the same whether or not the ore were in the truck. Thus, an individual must remain on top of the ore for about 50 hours per week in order to receive the suggested weekly occupational exposure limit, OR, remain atop the pile for about 80 hours before receiving the suggested, yearly non-occupational exposure limit. The remoteness of the haulage route, the low specific activity of the material (amount of radioactivity per gram of ore) and the ease with which the contamination can be removed (shovel ore into another truck) results in a potential impact which should not be considered signficiant.

Energy Fuels Nuclear has committed to a timely, aggressive and thorough clean up of any spillage. (EFN 84, EFN 87)

5.6 Radiation in Mine Environment

The miners can expect direct radiation levels to be on the order of 0.8 mrem/hr. (HU 85) The direct radiation limits, dosimetry and record keeping requirements are mandated by 30 CFR 57. Theoretically, a miner can remain at or near the high-grade ore body during entire work period and not exceed the weekly guidelines (100 mrem) or the annual limit (5,000 mrem).

Radon gas and progeny will be flushed from the mine with a 150,000 cfm vent fan. Based on measurements atop the Hack Canyon Mine vent, radon gas concentrations will be on the order of 2400 pCi/L and 1600 mWL.(McK 85) Thus, the daughters will be present at approximately 10% of their potential equilibrium values. This means that much of the radon gas will be removed from the mine before it is able to decay to its hazardous daughter products. The occupational radon progeny limit is 4 WLM/yr. Miners at Hack Canyon are currently experiencing an average of about 2.2 WLM/yr.

Currently, uranium miners work an average of 10 years underground (NCRP 84); thus the cumulative 10 to 25 WLM is well below the 100 WLM value where studies indicate possible increases in lung cancer might appear.

6.0 PROPOSED RADIOLOGICAL MONITORING PROGRAM

The proposed radiological monitoring program involves collection of appropriate data before the mine is operational. Additional measurements will be made as needed during mine operation and in the event of an accidental release of radioactivity to the wash. A final survey will be conducted at the time the mine is closed. Each part of the monitoring program will be described here.

6.1 Preoperational Baseline Information

The preoperational baseline data collection program will last one year and will involve background measurements of direct gamma radiation, radon gas and progeny concentrations, and radioactivity concentrations in air, and soil.

Direct gamma radiation measurements are being obtained on a quarterly basis by at least two independent monitoring devices and at a minimum of 4 locations. Passive thermoluminescent dosimeters will provide cumulative dose information. Readings from a pressurized ion chamber and/or two micro-R scintillometers will be recorded whenever the thermoluminescent dosimeters are exchanged. Initial measurements are reported in Appendix A.

Quarterly radon concentration measurements are being made at the 4 sites using Terradex alpha track-etch detectors. The first measurements are reported in Appendix A. Passive radon measurements are also being made at the Pinenut, Pigeon, Kanab North and Canyon Mine Sites. Data can be used to determine the local variations in radon concentrations and to monitor for any cumulative impacts from the increased uranium mining activities.

A water sample has been collected from the stock tank located near the proposed mine site. Radionuclide assay for baseline data is in progress.

Water samples from Kanab Creek (DM 85) and the Colorado River (McK 86) have been analyzed and may be used to monitor for changes in radioactive material concentrations. However, as a result of variations in water flow rates (dilution factors) and leaching of ore from the many exposed deposits which are located around the Arizona Strip, Grand Canyon, and, the Little Colorado River, no noteworthy manmade increases should be anticipated.

A soil sample has been collected from an area downslope from the site. It will be assayed specifically for Ra-226 and gamma spectrometry performed to determine baseline concentrations of Th-232, Tl-208, K-40, and, Cs-137 (from fallout).

Passive dust samples have been collected at the four monitoring sites to obtain background information on the amount of natural radioactivity in the dust around the mine.

6.2 Operational Measurements

The quarterly thermoluminescent dosimetry measurements and scintillometer measurements will continue at the four established monitoring sites. Pressurized ion chamber measurements will be performed at least once per year to confirm the thermoluminescent dosimetry and scintillometer readings. Additional sites may be established at the mine and along the haulage route as deemed necessary.

Based on time and need, radon measurements will be performed in and around the mine site. The objective will be to collect sufficient radon information to ensure no noteworthy increase in radon gas occurs downwind from the site and to monitor for any cumulative impacts which might occur as a result of increased mining activities.

Passive dust monitoring will continue and will be used to monitor for significant changes in airborne radioactivity.

Soil samples will be obtained only as needed to delineate possible radionuclide increases from accidental releases or to ensure that ground water, if present, will not be adversely impacted.

Water sampling will continue at any operating on-site wells. The collection program will be integrated with the water sampling programs currently in progress at the other mining operations on the Arizona Strip. It is hoped that the water results and associated information may be used by the Bureau of Land Management, Forest Service and Park Service to assist with ongoing, long-term assessments of water quality in the Grand Canyon area.

Whenever a haulage accident occurs a radiological report will be prepared. The report will contain such information as the amount of material spilled, the extent of area affected, measures taken to provide an adequate cleanup, results of the final radiological survey, and estimates of any possible non-occupational exposures.

7.0 SUMMARY

Energy Fuels Nuclear, Inc. intends to design, construct, and operate a uranium mine at the Hermit Site. When the mine is closed the area will be cleaned up to the extent dictated by regulations which are applicable at the the time of closure.

Based on an evaluation of the direct radiation, radon and dust emissions previously described herein, and the commitment by Energy Fuels Nuclear not to allow a liquid release from the mine yard, there do not appear to be any adverse radiological environmental impacts from the project.

During mine operation the direct radiation from the ore stockpiles will probably not be measureable at distances greater than about 350 meters from the mine site. At greater distances, it will not be possible to distinguish the mine induced radiation from the variations in the natural radiation environment which currently exist in the vicinity of the site.

Ore transport to the mill will not expose inhabitants along the haulage route to any statistically significant doses of radiation. A few accidents may occur during the life of the mine where ore spillage occurs. Energy Fuels Nuclear has commited to a thorough and timely cleanup of any spill.(EFN 84, EFN 87) The radiation from the ore will not pose a health hazard.

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APPENDIX A BACKGROUND RADIATION MEASUREMENTS

Hermit Project

D I R E C T   G A M M A   R A D I A T I O N

Gamma Radiation: uR/hr = microRoentgens per hour

LOCATION AND DATE	THERMOLUMINESCENT DOSIMETRY	PRESSURIZED ION CHAMBER	SCINTILLOMETER MICRO-R METER
North of Mine Site			
9/19/86	site established	13	11.5
1/12/87	data being processed	*	11.0
East			
9/19/86	site established	13.1	12.0
1/12/87	data being processed	*	11.5
South			
9/19/86	site established	13.4	13.5
1/12/87	data being processed	*	12.5
West			
9/19/86	site established	12.8	12.0
1/12/87	data being processed	*	11.0

* no measurement made

R A D O N   G A S

Radon Concentration: pCi/L = picoCuries per liter of air
Average concentration between 9/19/86 & 1/12/87

LOCATION	TERRADEX TRACK ETCH
North	lost
South	2.3 (on ground covered with snow) (results not considered accurate)
East	0.1
West	0.2

APPENDIX B: RADON DAUGHTER DOSE CALCULATIONS

1.0 Background

A highly conservative approach was used to assess the dispersion of radon gas from the high grade and low grade ore piles. This conservatism included: (1) determining the annual radon source term from the maximum sizes of the piles assumed to occur concurrently, (2) calculating the radon release from the ore piles based on the highest estimated U_3O_8 concentration, (3) selecting the largest calculated value of the annual radon release from the piles, (4) using meteorological data collected at Sunshine Point, and (5) modeling the dispersion at selected locations using the MILDOS Code. (NR-80)

The annual radon source term from the stack release was determined using experimental data from measurements performed on the Hack Canyon mine vent by McKlveen (McK-85).

2.0 High Grade and Low Grade Ore

During the course of mining operations at the Hermit Mine two ore piles may be developed on site. The high grade pile consists of rock containing 0.2 to 0.6% U_3O_8. The other contains ore with 0.05 to 0.2% U_3O_8.

The high grade ore pile will eventually reach a maximum size of 150x300x10 feet, while the low grade ore pile may reach a maximum size of 150x300x20 feet. It will be conservatively assumed in developing the source term for the analysis that both piles reach their maximum size concurrently. The piles are not presumed to be covered with any natural or artificial cover.

3.0 Evaluation of Radon Dispersion from Ore Piles and Mine Stack and Vents

The radium in the rock material in the ore and waste piles emits radon gas which diffuses to the surface of the pile and then into the surrounding air.

The radium concentration in the rock is determined from the fact that a concentration balance is reached (secular equilibrium) in the material among the radionuclides in the uranium decay chain where 0.1% U_3O_8 = 282 pCi/gm Ra-226 (DO-83). Thus, using measured concentrations of U_3O_8 permits evaluation of radium concentration as follows:

3.1 High Grade Ore Pile

$$\text{Ra-226 concentration} = \frac{\text{Ore Grade}}{0.1\%\ U_3O_8} \times 282\ \text{pCi/gm} = \frac{0.6\%\ U_3O_8}{0.1\%\ U_3O_8} \times 282\ \text{pCi/gm}$$

$$= 1692\ \text{pCi/gm}$$

3.2 Low Grade Ore Pile

$$\text{Ra-226 concentration} = \frac{0.2\%\ U_3O_8}{0.1\%\ U_3O_8} \times 282\ \text{pCi/gm}$$

$$= 564\ \text{pCi/gm}$$

3.3 Radon Emission From Piles

The radon emission from the piles is now evaluated by two different accepted approaches with the more conservative (larger) emission being used as the source term. In the first approach, the annual radon release source term for the two piles is calculated from the solution of the diffusion equation for an infinite slab in the vertical dimension.

$$J_o = (C_{Ra})\ E\ [\lambda(D_o/P_o)]^{1/2} \times 10^4$$

Where:

J_o = the radon-222 flux (pCi/m^2-sec)

C_{Ra} = Radium concentration (pCi/gm)

ρ = density of the rock material (gm/cm^3) = 2.50 gm/cm^3

E = Emanation coefficient

$$= \frac{\text{Radon activity that escapes pore space}}{\text{Radon activity in a grain of material}}$$

= 0.2

λ_{R_n} = Radon decay constant = 2.11×10^{-6} sec^{-1}

D_o = Diffusion coefficient for rock material (cm^2/sec)

P_o = Porosity of rock material

The ratio (D_o/P_o) is a function of the moisture content (m) of the material and can be expressed as:

$$\frac{D_o}{P_o} = 0.106 \exp - [(0.20)(m)]\ \frac{m^2}{sec}$$

Using a moisture content of 10% (range is 8-12%) and a porosity of 0.2 as representative of the distribution in the piles give $(D_o/P_o) = 7.87\times10^{-3}\ cm^2/sec$.

The annual Radon-222 release J(Ci) is then equal to:

$$J = J_o A k$$

Where:

A = the area of the pile (m^2)

$k = 3.154\times10^7$ sec/yr.

3.3.1 Radon Emission: Method One

3.3.1.1 Release from High Grade Ore Pile

$$J_o = (1692)\ \frac{pCi}{gm}\ (2.50\frac{gm}{cm^3})(0.2)[(2.11\times10^{-6}sec^{-1})\ (7.87\times10^{-3}\ \frac{cm^2}{sec})]^{1/2} \times 10^4$$

$$J_o = 1090\ pCi/m^2\text{-sec.}$$

and $J = (1090\ pCi/m^2\text{-sec})(5017\ m^2)(3.154\times10^7\ sec/yr)$

$J = 173$ Ci

3.3.1.2 Release from Low Grade Ore Pile

$$J_o = (564\ pCi/gm)(2.50\ gm/cm^3)(0.2)[2.11\times10^{-6}sec^{-1})\ (7.87\times10^{-3}cm^2/sec)]^{1/2} \times 10^4$$

$$J_o = 363\ pCi/m^2\text{-sec}$$

and $J = (363\ pCi/m^2\text{-sec})(5852\ m^2)(3.154\times10^7\ sec/yr)$

$J = 67$ Ci

3.3.1.3 Total Release

The total annual Radon release from the 2 piles is 173 + 67 = 240 Ci.

3.3.2 Radon Emission: Method Two

In the second method for evaluating the source radon emission from the piles, the NRC accepted approach (NR-80) of using a radon flux-to-radium concentration ratio of 1 is used. With this approach:

$$J_o/C_{Ra} = 1.0$$

and $$J = (1.0)(C_{Ra})(A)(k)\left(\frac{1\ Ci}{1x10^{12}\ pCi}\right)$$

3.3.2.1 Release from High Grade Ore Pile

$$J = (1.0\ \frac{gm}{m^2\text{-sec}})(1692\ \frac{pCi}{gm})(5017\ m^2)(3.154x10^7\ \frac{sec}{yr}\ (\frac{Ci}{10^{12}pCi})$$

$$J = 268\ Ci$$

3.3.2.2 Release from Low Grade Ore Pile

$$J = (1.0\ \frac{gm}{m^2\text{-sec}})\ (564\ \frac{pCi}{gm})(5852\ m^2)(3.154x10^7\ \frac{sec}{yr})(\frac{Ci}{10^{12}pCi})$$

$$J = 104\ Ci$$

3.3.2.3 Total Release

The total annual radon release from the 2 piles is 268 + 104 = 372 Ci.

3.3.3 Radon Release Used as Source Term

To assure that the most conservative approach is considered, the value of 372 Ci/yr radon release is rounded up to 400 Ci/yr and used as the source term for the dispersion analysis.

3.4 Radon Emission From Mine Vent

An exhaust vent radon concentration was found to be on the order of 2,400 pCi/l and rose approximately 30 feet at the Hack Canyon mine. (McK 85). Since the mine environment at the Hermit will resemble the Hack Canyon mine, the 150,000 cfm (cubic feet per minute) vent fan at the Hermit will release 5,370 Ci/yr of radon gas. This value was rounded upward to 5,400 Ci/yr and used as the source term for radon release from the Hermit mine vent.

3.5 Environmental Radon Concentrations from Emissions from Piles and Stack

The radon concentrations in the environment around the site resulting from the annual emission of 400 Ci from the piles and 5400 Ci from the stack is calculated using the MILDOS dispersion model. (ST 86).

The MILDOS model was specifically developed for use in evaluating airborne release from uranium processing and disposal facilities and is relevant to the releases from the ore and waste piles and mine stack. This model is also accepted by regulatory agencies as a for dose projections in licensing actions. Applying the model involves determination of the source-term for each case being evaluated and use of the source term in conjunction with meteorological and demographic parameters as input data. The results of the modeling effort are the concentrations and doses (if desired) for the exposed individual and the population within 80 kms of the site.

The MILDOS model simulates emissions of radioactive materials from fixed point source locations and from areal sources using sector-averaged Gaussian plume dispersion model. Mechanisms such as deposition of particulates, resuspension, radioactive decay and ingrowth of daughter radionuclides are included in the transport model. Annual average air concentrations are computed. Results are reported in Section 5.2, Table 5.1.

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