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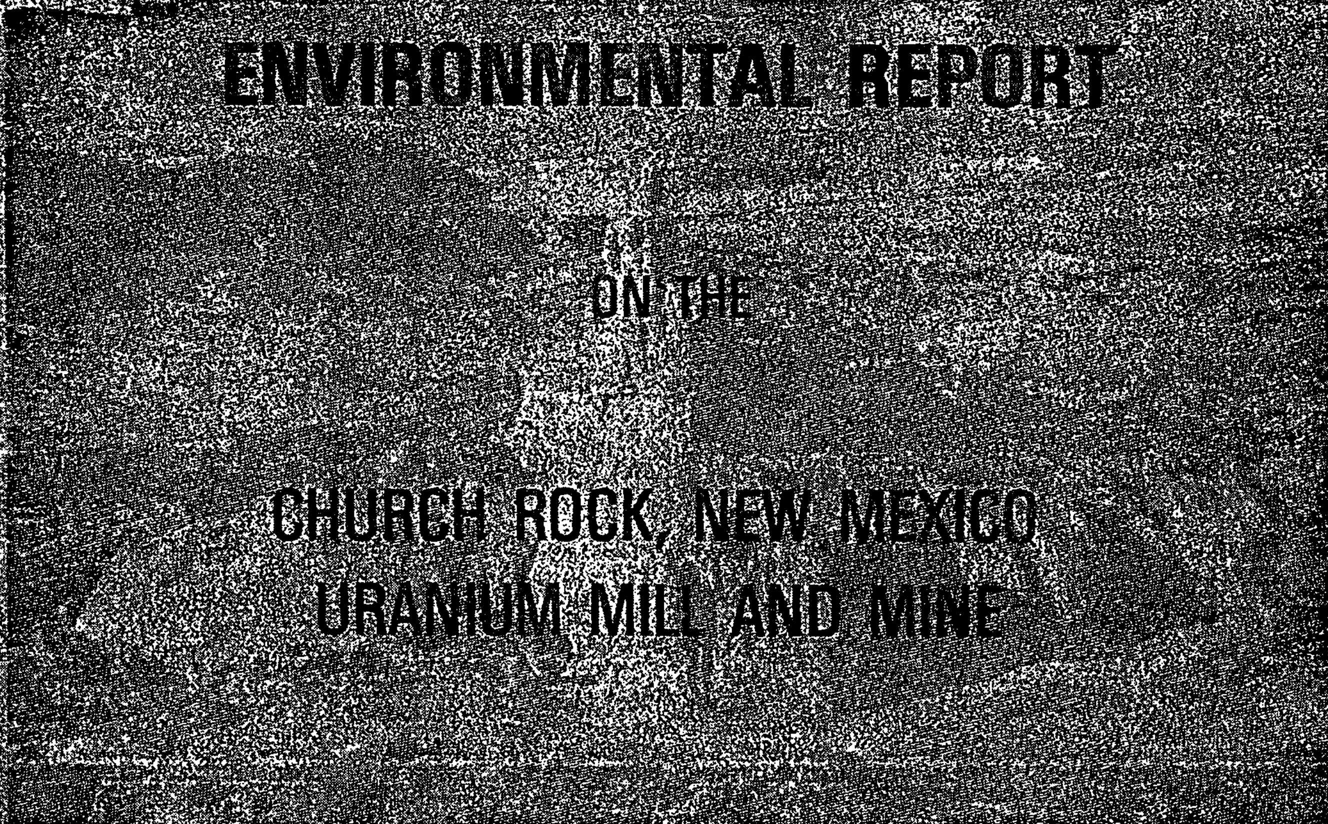
APPLICANT'S



ENVIRONMENTAL REPORT

ON THE

CHURCH ROCK, NEW MEXICO URANIUM MILL AND MINE

VOLUME I

UNITED NUCLEAR
CORPORATION

VOL I

ENVIRONMENTAL REPORT - CHURCH ROCK MILL AND MINE

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1975

APPLICANT'S ENVIRONMENTAL REPORT ON THE CHURCH ROCK, NEW MEXICO URANIUM MILL AND MINE

Volume 1

United Nuclear Corporation
Mining and Milling Division

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LOCAL CONTRIBUTORS

The Church Rock Uranium Mill Environmental Report was prepared under the direction of United Nuclear Corporation, Mining and Milling Division. Local contributors to the project are identified below:

PROJECT DIRECTOR

David D. Turberville
Vice President
United Nuclear Corporation

INDIVIDUAL CONTRIBUTORS AND CONSULTANTS

H. John Abbiss
Manager, Safety and Environmental Services
United Nuclear Corporation

Walter L. Gould, Ph.D.
Professor of Agronomy
New Mexico State University

J. O. Greenslade
Manager of Operations
United Nuclear Corporation

Paul S. Grigg
Field Recorder
Museum of New Mexico

Marc McRae
Geologist
United Nuclear Corporation

Steward L. Peckham
Curator-in-Charge
Division of Anthropology
Museum of New Mexico

John W. Shomaker
Consulting Hydrologist

INDIVIDUAL CONTRIBUTORS AND CONSULTANTS, continued

David H. Snow
Curator of Archeology
Museum of New Mexico

G. A. Swanquist
Metallurgical Superintendent
United Nuclear Corporation

Regge N. Wiseman
Staff Archeologist
Museum of New Mexico

APPENDICES, VOLUME 2

CHURCH ROCK URANIUM MILL
ENVIRONMENTAL REPORT

SECTION 1.0
PROPOSED ACTIVITIES

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

1.0 PROPOSED ACTIVITIES

United Nuclear Corporation's Mining and Milling Division, the Applicant, with division offices in Albuquerque, New Mexico, and corporate headquarters in Elmsford, New York, proposes to construct and operate a uranium mill on its property 16 miles northeast of Gallup, New Mexico. This report identifies, describes, and quantifies the potential environmental impact of the proposed mill and is submitted as "other related material" to the New Mexico Environmental Improvement Agency for their use during evaluation of Applicant's Radioactive Material License Application. The mill will operate in conjunction with an underground mine currently owned and operated by Applicant.

ACTIVITY SUMMARY

Mine

Applicant's mine was opened in February 1968 and began producing ore in June 1969. The main shaft is 1788 ft deep with working levels at 1500 ft and 1700 ft underground. The modified room and pillar mining method is used in conjunction with both conventional drilling and blasting, and a continuous mechanical miner. The mined ore is trucked about 85 miles to a uranium mill owned and operated by the Kerr-McGee Corporation.

The mine tailings, having insufficient uranium content for current economical recovery, are placed in piles near the mine shaft. These piles may later be leached on site or processed through the proposed mill for uranium removal should either process prove to be economically feasible. The remaining waste material may be used as mine backfill at the end of the operation.

Mill

Mill operation is expected to begin June 1, 1977, and during the first 2 years it will process 2000 tons of ore per day (TPD). Thereafter, the mill will process 3000 TPD, the design capacity. However, provisions are being made to allow for the expansion of mill production to 4000 TPD. Consequently, environmental impact calculations in this report use the 4000 TPD capacity in order to estimate fully potential impacts.

The mill will employ the conventional acid leach, solvent extraction process designed to produce a semi-refined uranium compound commonly called "yellowcake." The uranium content of the processed ore will range from 0.1% to 0.5% and average 0.2%.

During the life of the proposed mill, an estimated 20,440,000 tons of uranium ore will be crushed and chemically processed to yield an estimated 46,000 tons of yellowcake. The yellowcake, after further processing steps by others, will be available as fuel for nuclear reactors to produce electricity.

The crushed ore, after the uranium has been removed, forms coarse and fine wastes commonly called mill tailings. These tailings will be pumped into a tailings pond. Some of the coarse tailings will be used to raise the height of the tailings dam, and some may also later be recovered and used as mine backfill.

ENVIRONMENTAL IMPACT SUMMARY

Operation of the mine and mill will release natural uranium, Th-230, Ra-226, and Rn-222 into the environment. Greater than 99% of the mine releases of radionuclides results from pumping mine water into an adjacent arroyo. The remaining fraction of 1%, mostly Rn-222 and its daughter products, is exhausted from the mine to the atmosphere.

The process chemicals, mill tailings and radionuclides will be contained in a tailings pond. After solar evaporation, the 160 acre pond will be covered with soil and revegetated for long-term stabilization and containment of these wastes. As a result, liquid releases from the mill will evaporate into the atmosphere except for limited seepage into the soil under the tailings pond.

Boiler combustion products and trace quantities of process chemicals will be released to the atmosphere from mill activities. Natural uranium, Th-230, Ra-226, and Rn-222 will be released to the atmosphere from unprocessed ore piles, milling activities, and from mill tailings.

People, living within a 5 mile radius of the proposed operations, will receive radiation exposures averaging less than 1.2% above the natural background radiation contributions. These same people may also be exposed to minute amounts of boiler combustion products and process chemicals.

ACTIVITY BENEFIT SUMMARY

Construction and operation of the proposed mill will provide employment for local personnel over a 17 year period, and state and local taxes. After further processing of the yellowcake produced, the resultant nuclear reactor fuel will yield 1.6 trillion kilowatt-hours of electricity. An equivalent amount of electricity generated from fossil fuels would require burning 2.6 billion barrels of oil or 0.6 billion tons of coal.

CHURCH ROCK URANIUM MILL
ENVIRONMENTAL REPORT

SECTION 2.0
THE SITE

2.0 THE SITE

The proposed mill will be located in a sparsely populated, semi-arid area approximately 16 miles northeast of Gallup, New Mexico. The site is approximately 0.7 mile from the existing Church Rock Uranium Mine operated by Applicant. The mill and tailings pond will lie entirely on Applicant's property.

2.1 SITE LOCATION AND LAYOUT

The proposed mill and tailings pond will be located in Section 2, Township 16N, Range 16W, of McKinley County, New Mexico. The location of the proposed site with respect to state, county, and other political subdivisions, such as farms, railroads, and highways, is presented in Figure 2.1-1. The location of the plant perimeter and the exclusion area boundaries is presented in Figure 2.1-2. The elevation contours in the general vicinity of the property are presented in Figure 2.1-3.

The Applicant owns a total of 602 acres of land and 360 acres of mineral rights in the Church Rock area. In addition, Applicant leases 33,484 acres, of which 31,030 acres lie on the Navajo Indian Reservation. The mine surface activity presently occupies approximately 60 acres. The mill complex will occupy approximately 20 acres which will be leveled and graded. The tailings pond system will occupy approximately 160 acres upon completion of the project after an estimated 15 years of operation. As soon as the proposed mill ceases operation, the tailings pond area will be covered and restored as close as possible to its natural state.

The perimeter of land Section 2, as described above, has been fenced with barbed wire to exclude livestock. The mill will be enclosed by a chain link fence 6 ft high topped with barbed wire. Both fences will be posted with "No Trespassing" signs. There are no other proposed uses or modifications for the property.

The Kerr-McGee Navajo Uranium Mine is located about 1 mile north of the proposed mill site. Mine water from both the Kerr-McGee Mine and Applicant's Mine is discharged into Pipeline Canyon which transverses Applicant's property.

State Highway 566 transects Applicant's property between the proposed mill and tailings pond locations and ends at the mine. Mill tailings will be pumped through piping beneath the Highway. The nearest railroad is approximately 10 miles south of the site.

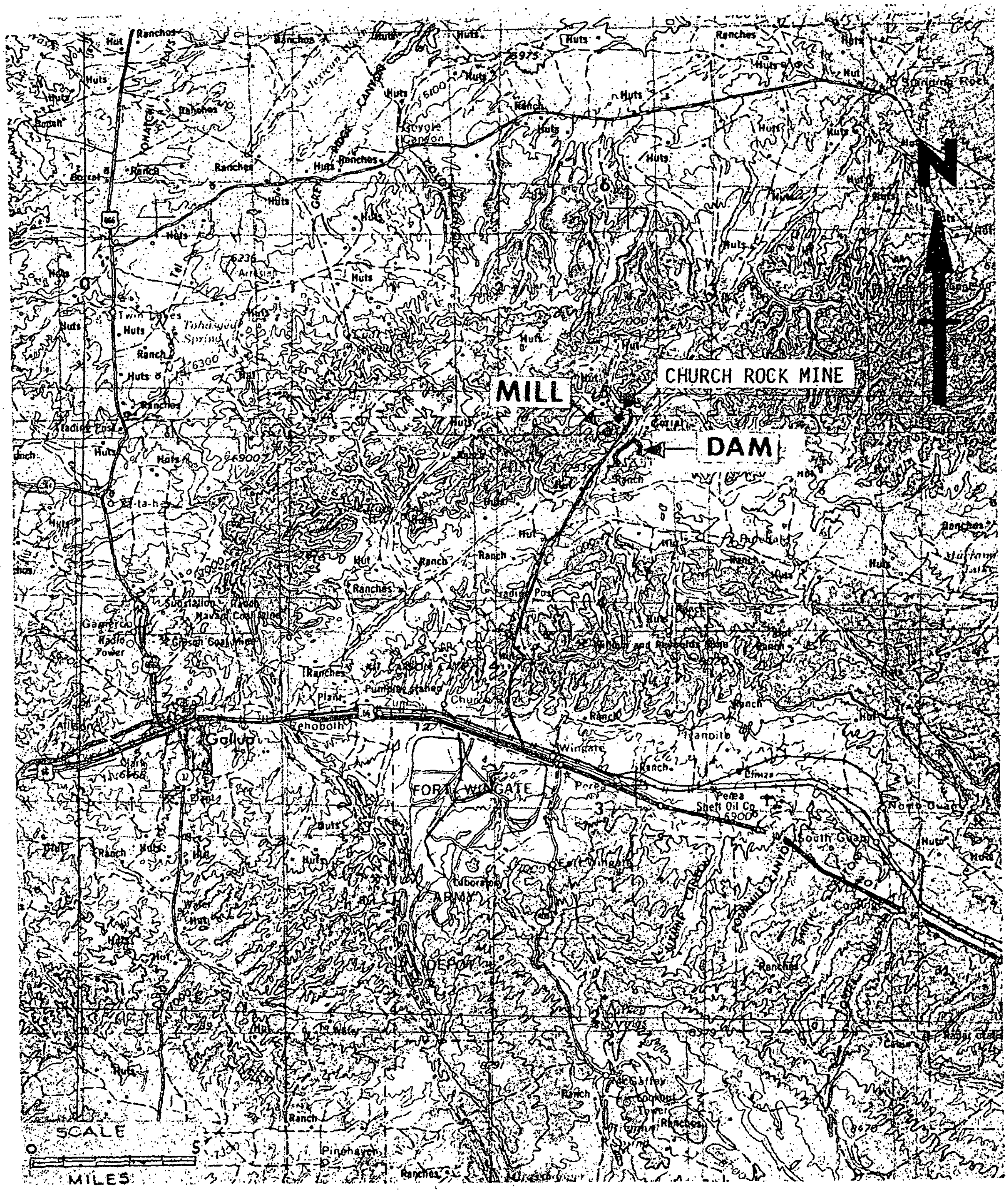


FIGURE 2.1-1 SITE LOCATION WITH RESPECT TO SETTLEMENTS, FARMS, RAILROADS, AND HIGHWAYS

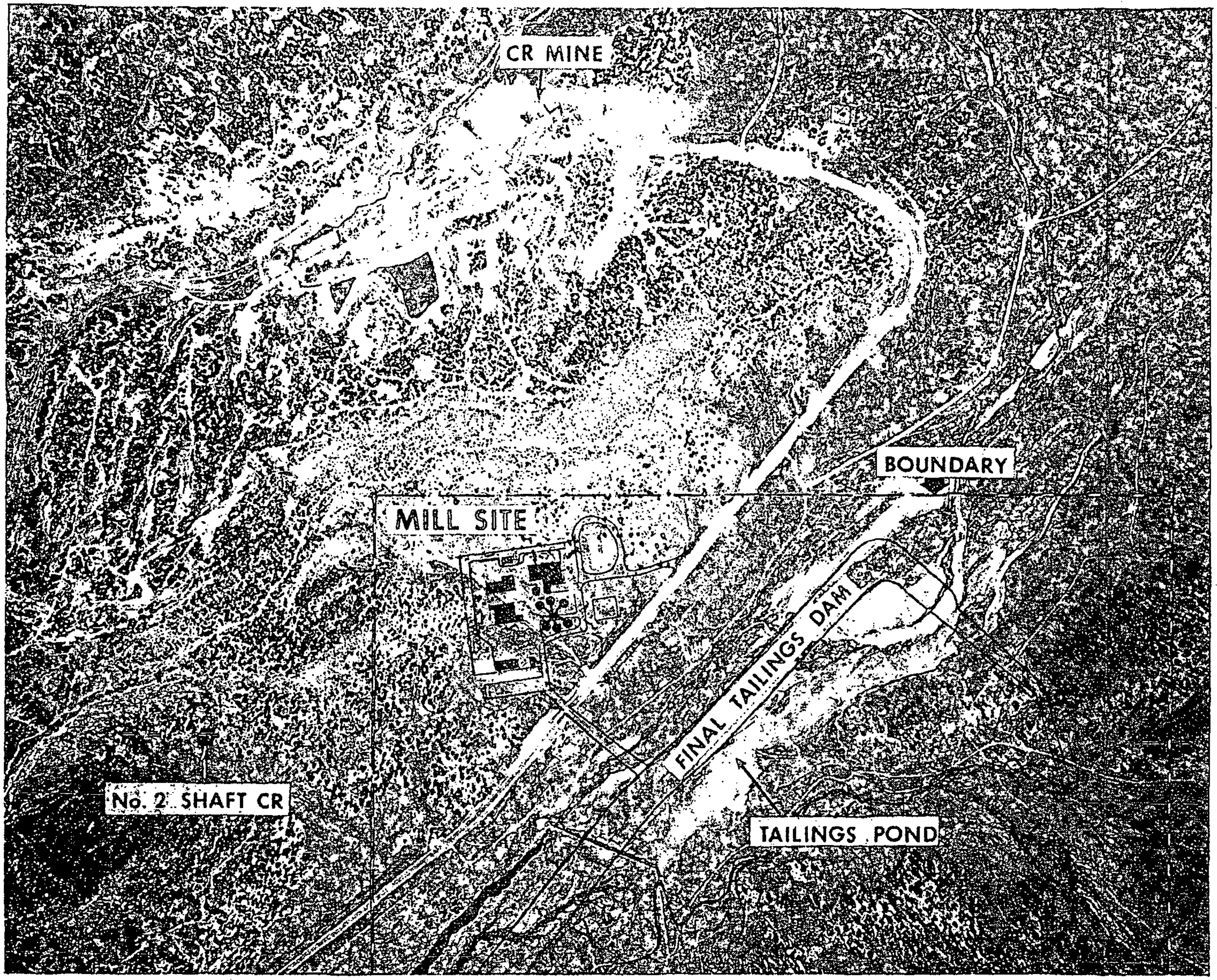


FIGURE 2.1-2
PLANT PERIMETER
AND EXCLUSION
AREA BOUNDARIES

SCALE
0 500' 1000'

N

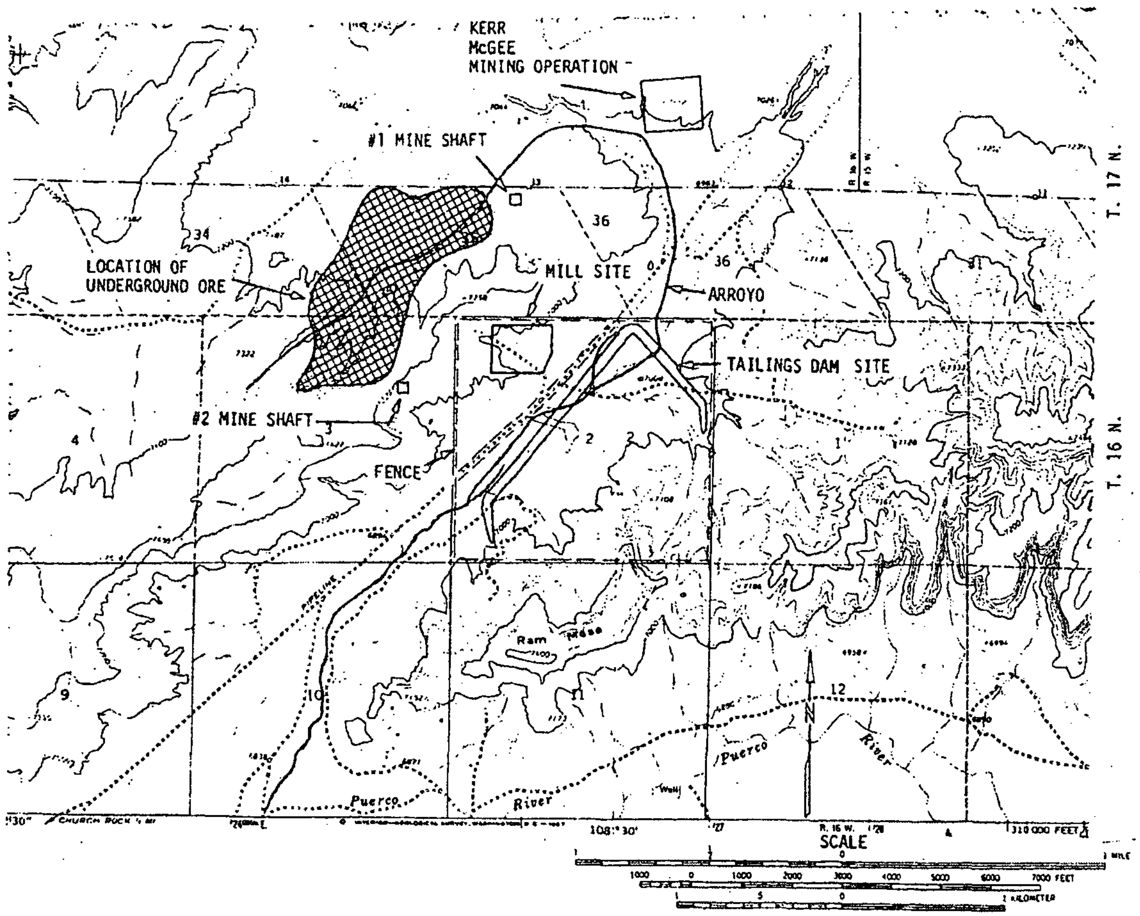


FIGURE 2.1-3 ELEVATION CONTOURS

2.2 REGIONAL DEMOGRAPHY AND LAND USE

Brief History

In 1879 or 1880 the westward push of the Atlantic and Pacific Railroad, now the Atchison, Topeka, and Santa Fe Railroad, marked the beginning of settlement in the area near Gallup, New Mexico. Gallup came into existence as a village around 1882.

In 1895 Gallup was selected as a divisional terminal for the railroad, and consequently the area became a trading center for settlers, ranchers, and Indians. By 1898 the coal industry had developed and numerous companies were organized.

The railroad is still important to the economy of McKinley County, as is Interstate 40 (US 66), the main highway for east-west travel.

In the 1950s sizeable uranium discoveries in the Ambrosia Lake District of McKinley County raised uranium mining to economic prominence. Today, mining is still economically important in the county and is expected to expand as the demand for energy increases.

Section 6.1.4.2 describes the methods used to survey the regional demography and land use. The results of the survey are presented below.

Population

McKinley County, like the rest of the State of New Mexico, is the home of several distinct cultures: Native American, such as Navajos, Zunis, and Hopis; Spanish American; and Anglo American.

Both the county and the state of New Mexico are sparsely populated. In 1970 the population density of McKinley County was 7.9 persons/sq mile as compared to 8.4 persons/sq mile for the state and 56 persons/sq mile for the United States. In 1970 Gallup accounted for approximately 34% of the county's population.

Populations for Gallup, McKinley County, the state, and the nation are presented in Table 2.2-1. Both the state and McKinley County experienced considerable growth during the 1950 to 1960 decade; in fact, each grew twice as fast as the nation as a whole. During this same period Gallup, with a 55% increase in population, grew three times as fast as the nation as a whole.

TABLE 2.2-1

POPULATION: U.S., STATE, COUNTY, CITY[a]

	Population (thousands)			Percent Change	
	1950	1960	1970	1950-60	1960-70
United States	151,326	179,323	203,212	+18.5	+13.3
New Mexico	681	951	1,016	+39.6	+ 6.8
McKinley County	27.6	37.2	43.2	+34.8	+16.1
Gallup	9.1	14.1	14.6	+54.9	+ 3.5

The state's population increase is related to two nationwide trends that characterized the 1950s: accelerated urbanization, and a general migration to the urban centers of the west. During the 1950s, Albuquerque, the largest city in New Mexico, experienced a population increase of 107.8%.

Other factors that influenced population increases of McKinley County and Gallup include: a reduction in the infant mortality rate due to the Bureau of Indian Affairs (BIA) public health hospitals, a growth in the mining industry, and an annexation to Gallup in the 1950s, which increased the city census count but did not affect the county's census.

Projected populations for New Mexico and McKinley County are presented in Table 2.2-2. Figures 2.2-1 and 2.2-2 identify the current population distribution within 5 miles of the proposed mill site.

Employment

Data on the occupations of McKinley County's and New Mexico's civilian labor forces for 1971 are compared in Table 2.2-3. The employment pattern for McKinley County is fairly consistent with that of the rest of the state with one major exception: the county provides only 3.9% of New Mexico's civilian labor force, yet provides 12.2% of the state's mining labor force. In addition, McKinley County provides approximately 5% of New Mexico's transportation labor force, which indicates that the Atchison, Topeka, and Santa Fe Railroad is still important to the county's economy.

(a) University of New Mexico, 1972.

TABLE 2.2-2

PROJECTED POPULATION[a]
(in thousands)

	1980	2000	2020
New Mexico	1155	1458	1792
Albuquerque	372	473	585
McKinley County	47	54-59	65-85

Note: The projections in this table were made mid-year 1972 by the Bureau of Economic Analysis and Bureau of Business Research, University of New Mexico. The 1980 population estimate of 47,000 for McKinley County had been reached by mid-1973.

(a) University of New Mexico, 1972.

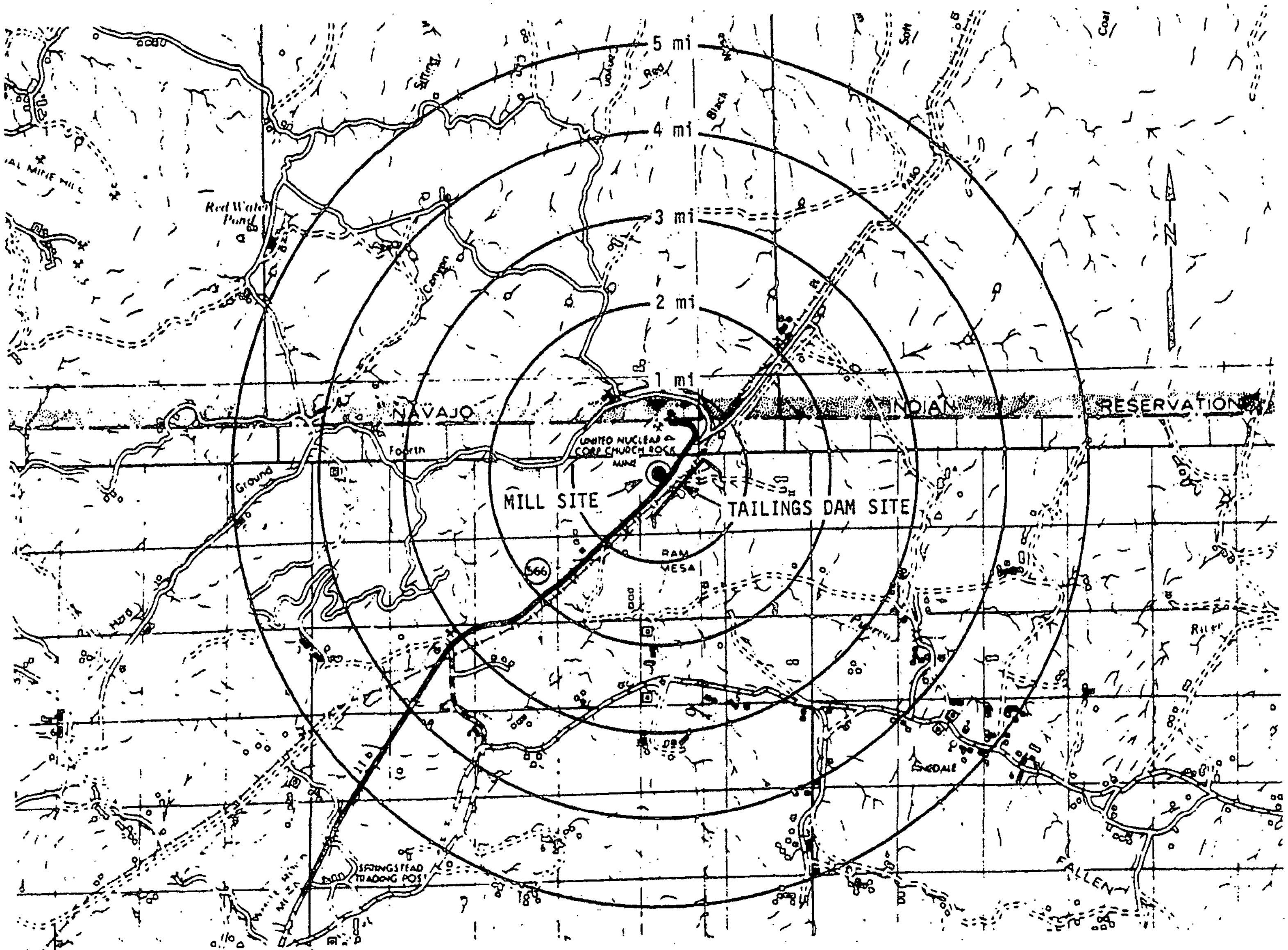


FIGURE 2.2-1 RESIDENCES IN VICINITY OF MILL SITE

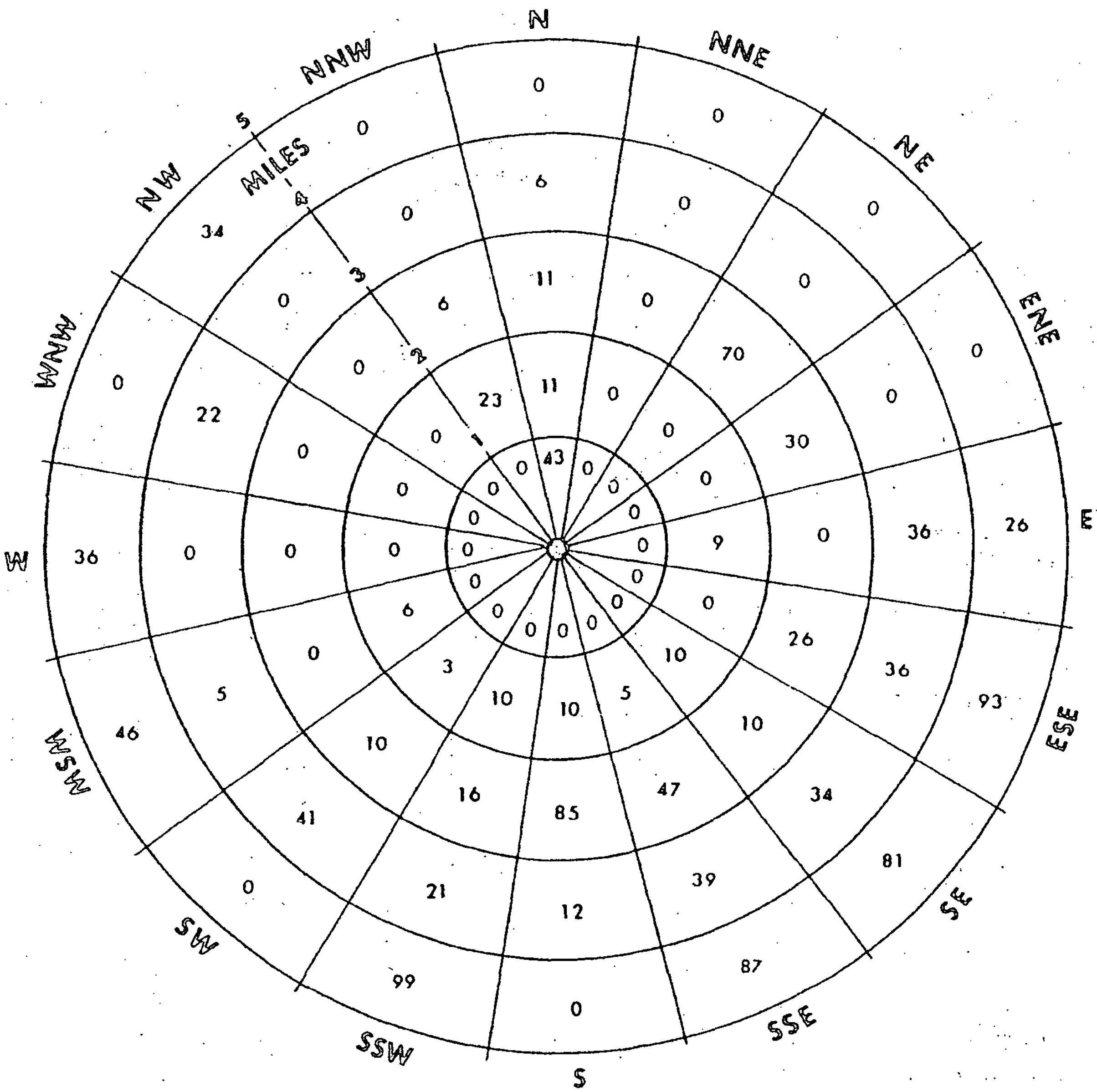


FIGURE 2.2-2 NUMBER OF INHABITANTS WITHIN
5 MILES OF MILL SITE

TABLE 2.2-3

CIVILIAN LABOR FORCE[a]

	New Mexico	McKinley County	% of County Civilian Labor Force	County % of State
Civilian labor force	387,800	15,199	100.	3.9
Employment	362,500	14,255	93.8	3.9
Manufacturing employment	21,300	633	4.2	3.0
Nonmanufacturing	279,500	12,117	79.7	4.3
Mining	16,200	1,982	13.0	12.2
Contract construction	19,200	406	2.7	2.1
Transportation, communications, utilities	20,400	968	6.4	4.7
Wholesale and retail trade	64,200	2,560	16.8	4.0
Finance, insurance, real estate	13,400	233	1.5	1.7
Services	54,200	2,271	14.9	4.2
Government	92,100	3,697	24.3	4.0
Miscellaneous	41,600	1,147	7.6	2.8
Agricultural	20,100	358	2.4	1.8

(a) University of New Mexico, 1972. Percentages calculated by Applicant.

Employment in Gallup centers around retail and wholesale trade, petroleum refining, coal and uranium mining, light manufacturing, transportation, tourism, and government services, which include administrative offices for about 140,000 American Indians of the Navajo, Zuni, and Hopi tribes.

Personal Income

Per capita personal income figures for selected years in McKinley County, New Mexico, and the U.S. are presented in Table 2.2-4. The per capita personal income of McKinley County is 35% below the New Mexico average and 49% below the national average for the years listed.

TABLE 2.2-4

PER CAPITA PERSONAL INCOME FOR SELECTED YEARS[a]
(Dollars)

Year	McKinley County	New Mexico	U.S.
1950	840	1177	1496
1959	1604	1914	2161
1965	1338	2242	2770
1969	1988	2848	3708
1971	2489	3256	4195
1972	2669	3853	5041

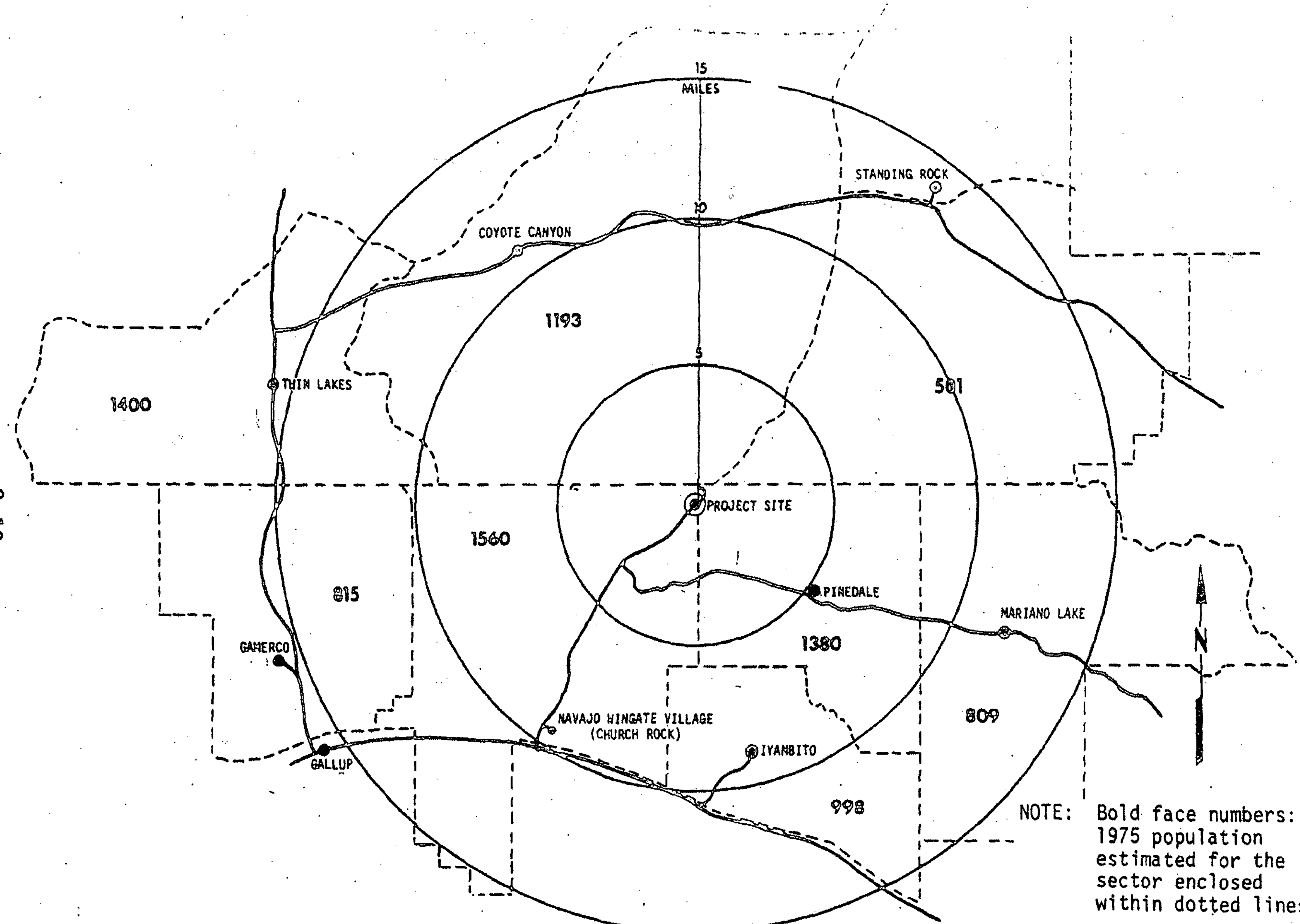
Note: Adjusted for the number of residents.

Local Communities

The largest community near the proposed mill site is Gallup, with an estimated population in 1975 of 19,400. All other communities within 15 miles of the site are rural. Figure 2.2-3 locates these rural communities in relation to the mill site and presents a current population estimate for areas surrounding the communities.

McKinley County covers an area of over 5700 sq miles and has over 13,300 students from various cultural and linguistic backgrounds. The county-wide school system consists of five high schools, three junior high schools, and 21 elementary schools, including special education for the handicapped. The parochial

(a) University of New Mexico, 1972.



NOTE: Bold face numbers: 1975 population estimated for the sector enclosed within dotted lines.

FIGURE 2.2-3 POPULATION ESTIMATES OF RURAL AREAS SURROUNDING MILL SITE

school system includes two high schools, three junior high schools and five elementary schools. In addition, many pre-school children attend Headstart Schools, most of which are administered by the Bureau of Indian Affairs. The locations of the schools in the vicinity of Applicant's proposed mill site are identified in Figure 2.2-4, and the enrollments are listed in Table 2.2-5.

The hospital closest to the mill site is the 40-bed Rehoboth Christian Hospital, located 12 miles southwest of the project site. Gallup has two hospitals: the 80-bed McKinley General Hospital and a 200-bed Public Health Services Hospital, which provides care for the American Indians in the area.

Transportation

The area surrounding the proposed mill site is served by a system of highways that range in quality from Interstate 40, through state-maintained primary and secondary roads, to unsurfaced dirt roads. The major artery from the proposed site is State Highway 566, which extends from the site 10 miles southwest to an intersection with Interstate 40 (US 66). Interstate 40 is the main highway for east-west travel.

A 1973 traffic count by the New Mexico State Highway Department established an average of over 8880 vehicles/day passing a point on I-40 east of Gallup. U.S. Highway 666, approximately 15 miles west of the site, is the main highway running north and south from Gallup.

The Gallup area is serviced by the mainline Santa Fe Railroad which includes Amtrak trains, by two transcontinental bus lines, and by Frontier Airlines. The Gallup Municipal Airport has lighted runways and a FAA Flight Service Station. Other airstrips in the area are located at Crownpoint, Grants, and Granado. Major airline service is available at the Albuquerque International Airport, 135 miles east of Gallup. Highway and railroad locations are identified in Figure 2.1-1.

Land Use

The Kerr-McGee Navajo Mine complex and Applicant's mine are the only industrial sites within 5 miles of the proposed mill. Kerr-McGee Navajo Mine is located approximately 1 mile north of the mill site and employs 40 people. The Applicant's mine is less than a mile north of the proposed mill site and employs 172 people.

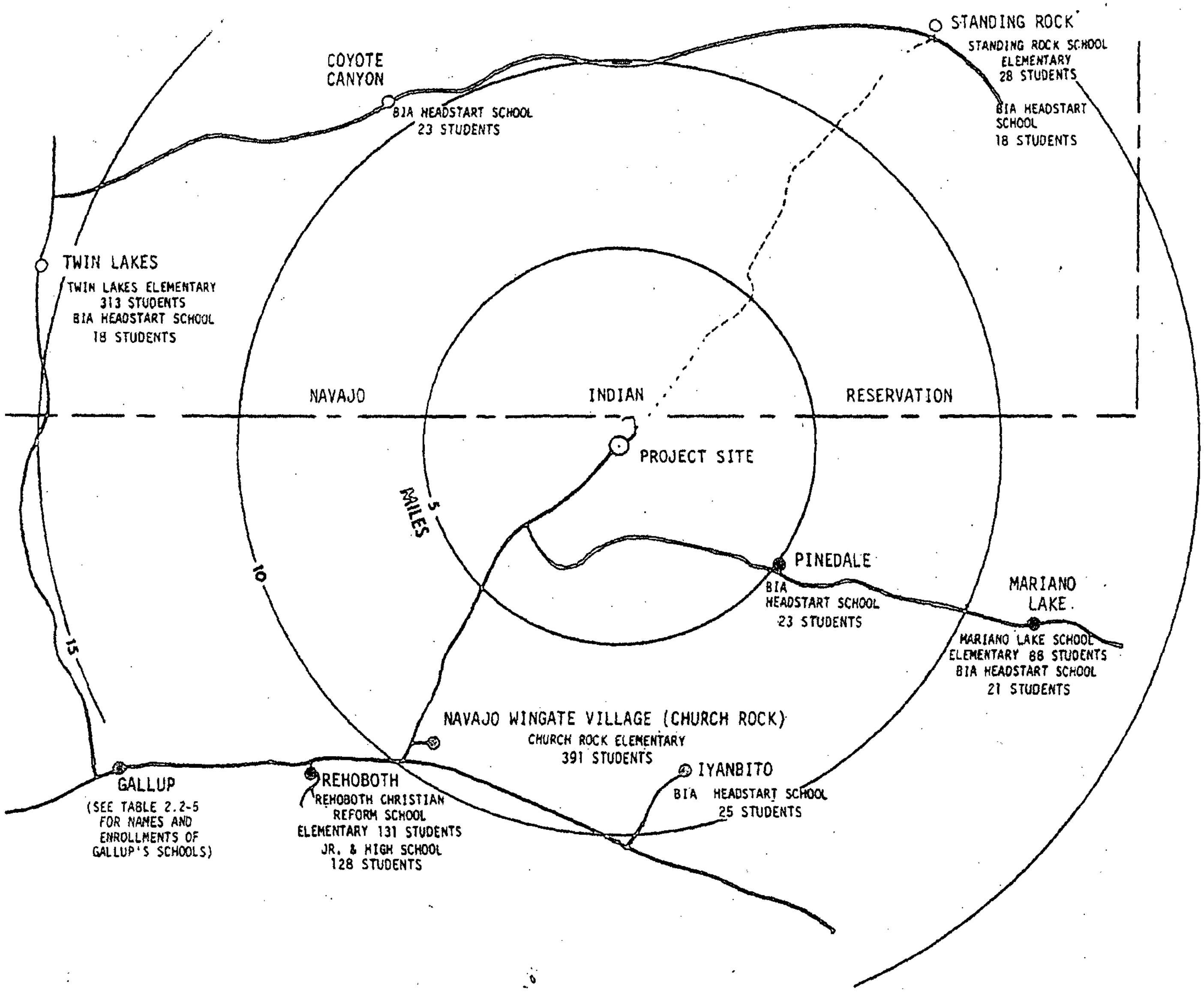


FIGURE 2.2-4 SCHOOLS IN THE MILL SITE VICINITY

TABLE 2.2-5

PRESENT SCHOOL ENROLLMENTS, AREA SURROUNDING MILL SITE[(a)]

Elementary Schools	Location	1974 Enrollment
Aileen Roat	Gallup	502
Indian Hills	Gallup	305
Jefferson	Gallup	406
Lincoln	Gallup	302
Red Rock	Gallup	426
Roosevelt	Gallup	316
Sky City	Gallup	115
Sunny Side	Gallup	127
Washington	Gallup	308
St. Francis School	Gallup	148
Cathedral Elementary	Gallup	340
Church Rock	Church Rock	391
Twin Lakes	Twin Lakes	313
Mariano Lake (BIA)	Mariano Lake	88
Standing Rock (BIA)	Standing Rock	28
Rehoboth Christian	Rehoboth	131
Jr. and Sr. High Schools		
Gallup Jr. High	Gallup	850
Gallup High	Gallup	1433
John F. Kennedy Jr. High	Gallup	834
Cathedral Jr. and Sr. High	Gallup	126
Rehoboth Christian Jr. and Sr. High	Rehoboth	128
Special Education		
Wilson	Gallup	33
Headstart Schools		
BIA	Coyote Canyon	23
BIA	Iyanbito	25
BIA	Mariano Lake	21
BIA	Pinedale	23
BIA	Standing Rock	18
BIA	Twin Lakes	18

(a) League of Women Voters, 1974; Galindev, no date.

In Ciniza, 12 miles south-southeast of the proposed mill, a petroleum refining operation owned by the Shell Oil Company employs 140 people. Approximately the same distance to the southwest, a natural gas refraction and compression plant owned by El Paso Natural Gas Company employs 137 people. The Department of Army maintains the Fort Wingate Depot 16 miles south-southwest of the site and employs 309 people.

A coal strip-mine operation is conducted in the area by Pittsburg-Midway Coal Mining Company. In addition, bentonite, oil, helium, lignite, and natural gas are obtained and processed in the outlying sectors of the Gallup area.

All of the territory within a 5 mile radius of the proposed mill site is within McKinley County. Table 2.2-6 identifies the land ownership in McKinley County and the State of New Mexico.

TABLE 2.2-6

LAND OWNERSHIP IN NEW MEXICO AND McKINLEY COUNTY[a]

Land Ownership	Area, Acres	Percent of Total
New Mexico		
Federal	26,735,431	34.3
Indian Trust	7,348,563	9.5
State	9,413,017	12.1
Private and other	34,369,229	44.1
Total	77,866,240	100.0
McKinley County		
Federal	564,580	16.2
Indian Trust	2,158,410	61.7
State	183,974	5.3
Private and other	588,076	16.8
Total	3,495,040	100.0

Most of the land within 5 miles of the proposed site is used for livestock grazing. Approximately half of the land is on the Navajo Indian Reservation. Though not within the reservation boundary, the other half is inhabited almost solely by Navajo Indians.

(a) University of New Mexico, 1972.

Figure 2.2-5 presents those boundaries where individuals, if continuously present, might be exposed to radioactive materials in excess of 1% of natural background. The boundary delineation is based on the calculated exposures in the prevailing wind direction (WSW) at the proposed site. See Section 5 for the dose calculation method.

Locations of Nuclear Fuel Facilities

There are 27 uranium mines within a 50 mile radius of the proposed mill site. These mines are listed in Table 2.2-7 and are located in Figure 2.2-6. With the exception of three mines, all of the operating mines are located in the Ambrosia Lake District, approximately 40 miles east-southeast of the site. The three exceptions include: Applicant's mine adjacent to the mill site; the Kerr-McGee Navajo Mine, approximately 1 mile north of the mill site; and the Homestake F-33 Mine, approximately 50 miles to the southeast.

Uranium ore is now processed by three mills in the Grants-Ambrosia Lake area. A fourth mill in the area is no longer operating. These mills are listed in Table 2.2-8 and are located in Figure 2.2-6.

There are several nonproducing claims just north of the proposed mill site on the Navajo Indian Reservation. Companies having mineral claims in this area are Anaconda, Conoco, Earth Resources, Gulf Oil, Humble Oil, Kerr-McGee, Mobil Oil, Nu-Beth, Phillips Petroleum, Ranchers Exploration, and the Applicant.

2.3 REGIONAL HISTORIC, SCENIC, CULTURAL AND NATURAL LANDMARKS

Anthropologists calculate that New Mexico has been an inhabited area for some 20,000 years. Evidence exists that the Sandia and Folsom people once roamed this region. Indians later built stone and adobe cities, the impressive ruins of which suggest a high level of culture.

Two of these ruins in McKinley County are listed in the National Register of Historic Places. These ruins and their locations are as follows:

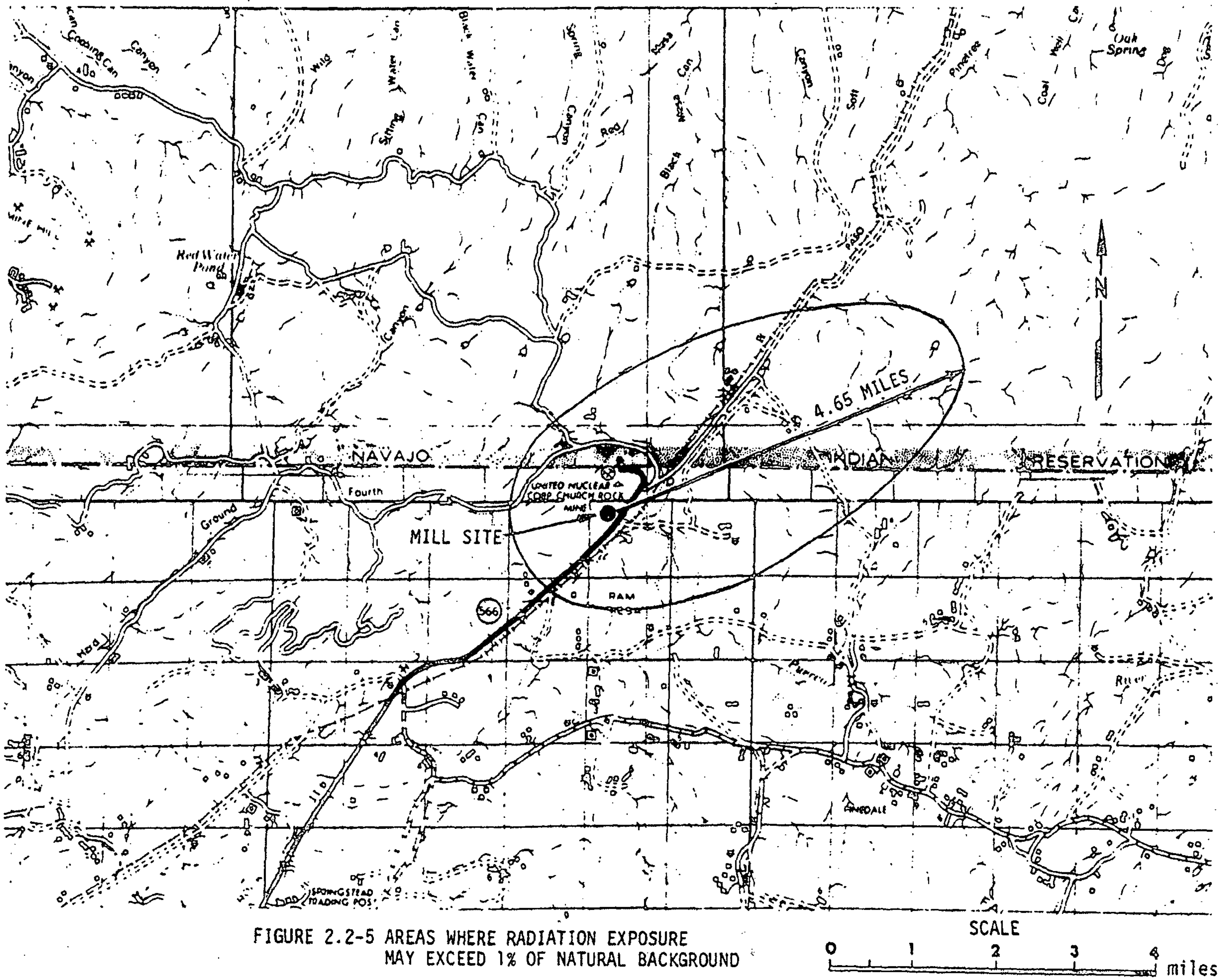


FIGURE 2.2-5 AREAS WHERE RADIATION EXPOSURE
MAY EXCEED 1% OF NATURAL BACKGROUND

TABLE 2.2-7 (Page 1 of 3)

URANIUM MINES WITHIN A 50 MILE RADIUS OF MILL SITE

Mine and Status[a]	Location
	McKinley County
NE Church Rock Mine United Nuclear Corporation Underground, operational	Church Rock Sec. 35 T.17N, R.16W
Church Rock Mine #1 United Nuclear Corporation Underground, closed	Church Rock Sec. 17 T.16N, R.16W
Kerr-McGee Navajo Mine Kerr-McGee Corporation Underground, operational	Church Rock Sec. 35 T.17N, R.16W
Westranch Mine Hydro Nuclear Corporation Underground, closed	Smith Lake area 16 miles north of Prewitt, 20 miles west of Grants
Evelyn Mine Clark & Company Underground, closed	Smith Lake area 12 miles north of Prewitt on I-40, 20 miles west of Grants
Mac No. 1 Mine, Grants United Nuclear-Homestake Partners Underground, closed	Smith Lake area 18 miles north of Thoreau
Ann Lee Mine United Nuclear Corporation Underground, closed	Ambrosia Lake NW$\frac{1}{2}$ Sec. 28 T.14N, R.9W
Dog Mine Four Corners Exploration Company Underground, closed	Ambrosia Lake
Johnny M. Mine Rancher Explorations & Development Corporation Underground, under development	Ambrosia Lake 2 miles southeast of Sec. 36 mine
Kerr-McGee Sec. 17 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake SW$\frac{1}{4}$ Sec. 17 T.14N, R.9W

TABLE 2.2-7 (Page 2 of 3)

Mine and Status	Location
	McKinley County
Kerr-McGee Sec. 19 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 19 T.14N, R.10W
Kerr-McGee Sec. 22 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 22 T.14N, R.10W
Kerr-McGee Sec. 24 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake SW¼ Sec. 24 T.14N, R.10W
Kerr-McGee Sec. 30 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 30 T.14N, R.9W
Kerr-McGee 30 West Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake W¼ Sec. 19 T.14N, R.10W
Kerr-McGee Sec. 33 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 33 T.14N, R.9W
Kerr-McGee Sec. 35 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 35 T.14N, R.9W
Kerr-McGee Sec. 36 Mine Kerr-McGee Corporation Underground, operational	Ambrosia Lake Sec. 36 T.14N, R.9W
Sandstone Mine United Nuclear Corporation Underground, closed	Ambrosia Lake Sec. 34 T.14N, R.9W
Sec. 25 Mine Bailey & Fife Underground, operational	Ambrosia Lake Sec. 25 T.14N, R.9W
Sec. 27 Mine United Nuclear Corporation Underground, operational	Ambrosia Lake Sec. 27 T.14N, R.9W

TABLE 2.2-7 (Page 3 of 3)

Mine and Status[a]	Location
	McKinley County
Spencer Mine Kerr-McGee Corporation Underground, closed	Ambrosia Lake 4 miles south of Kerr-McGee mill
UN-HP Sec. 15 Mine United Nuclear-Homestake Partners Underground, closed	Ambrosia Lake Sec. 15 T.14N, R.10W
UN-HP Sec. 23 and Mine General United Nuclear-Homestake Partners Underground, operational	Ambrosia Lake Sec. 23 T.14N, R.10W
UN-HP Sec. 25 Mine United Nuclear-Homestake Partners Underground, operational	Ambrosia Lake Sec. 25 T.14N, R.10W
UN-HP Sec. 29 and 32 Mine United Nuclear-Homestake Partners Underground, operational	Ambrosia Lake Sec. 29 and 32 T.14N, R.9W
	Valencia County
F-33 Mine Homestake Mining Company Underground, operational	North of Grants Sec. 33 T.12N, R.9W

(a) Longacre, 1973.

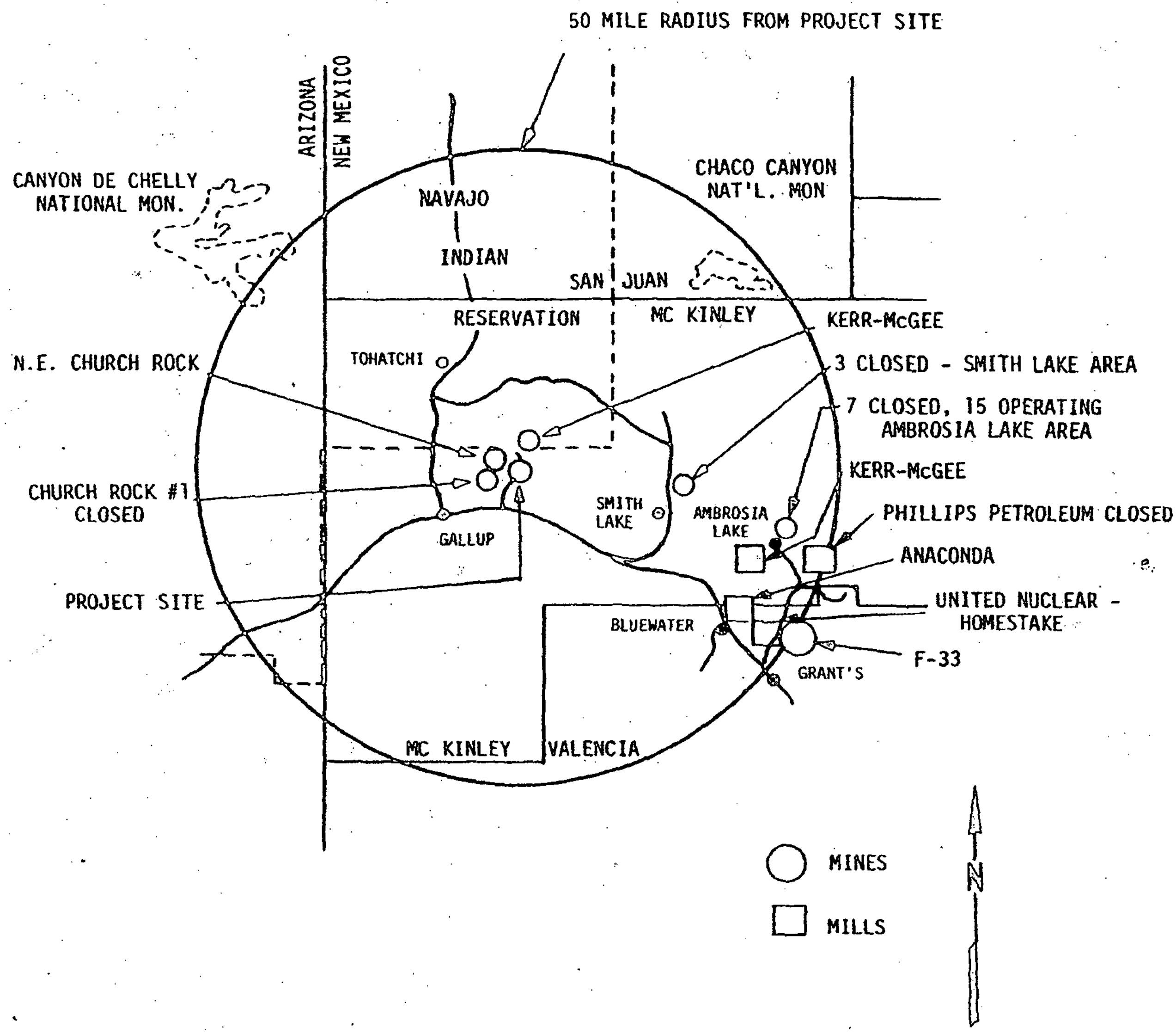


FIGURE 2.2-6 NUCLEAR FACILITIES WITHIN A 50 MILE RADIUS OF MILL SITE

TABLE 2.2-8

URANIUM MILLS[a]

1. Kerr-McGee Corporation Mill, Kerr-McGee Corporation; P. O. Box 218, Grants, New Mexico, 87020. Bill Stevens, Manager

   Located in the Ambrosia Lake district approximately 23 miles north of Grants on State Route 509. The mill and related activities spread over the entire sq mile of Sec. 31, T.14N, R.9W, N.M.B. and P.M. This is approximately 42 miles ESE of the proposed mill site.

2. Phillips Petroleum Ambrosia Mill, in the Ambrosia Lake District, approximately 2 miles from the Kerr-McGee mill.

   Located in Sec. 28, T.14N, R.9W, N.M.B. and P.M. The mill is closed.

3. Anaconda Bluewater Mill, the Anaconda Company, New Mexico Operations; P. O. Box 638, Grants, New Mexico, 87020. A. J. Fitch, Manager

   Located approximately 12 miles northwest of Grants on Interstate 40 in T.12N, R.11W, N.M.B. and P.M. This is approximately 41 miles SE of the proposed project site.

4. United Nuclear-Homestake Partners Mill; P. O. Box 98, Grants, New Mexico, 87020. Paul M. Price, General Manager

   Located 9 miles north of Grants by Route 66; by Route 53. The Mill is 46 miles SE of the proposed project. The mill is in Sec. 26, T.12N, R.10W, N.M.B. and P.M.

(a) Mills are shown on Figure 2.2-6.

Ruin	Location
Manuelito complex (scenic panorama of sandstone cliffs and prehistoric ruins)	Manuelito vicinity 6 miles south of Manuelito on secondary roads. Approximately 35 miles southwest of the project site.
Chaco Canyon National Monument (prehistoric pueblo ruins)	Ruins are in three separate areas of McKinley County, the closest being 22 miles east of the project site in the Crownpoint vicinity.

Other properties in McKinley County that the New Mexico Planning Office, Cultural Properties Review Committee regards eligible for inclusion in the National Register of Historic Places are:

- Heshotauthla Ruin
- Zuni Pueblo
- Zuni Mission Church
- Soldado Ruin
- Yellow House Ruin
- Kechipawan
- Kwakima
- Kyakima
- Matsaki
- Village of the Great Kivas
- Tohatchi Village

With the exception of Tohatchi Village, all of these sites are located from 20 to 40 miles south of Gallup on the Zuni Indian Reservation. Tohatchi Village is 22 miles north of Gallup, or approximately 19 miles northwest of the Applicant's proposed mill site. Construction and operation at the site will not affect these recognized areas.

While not of national significance, three archaeological sites have been identified on the proposed project site. Two of these sites, recorded as LA 11617 and LA 11618 in the Museum of New Mexico Archaeological Survey Catalog,[a] have been given archaeological clearance surveys by the Museum of New Mexico. The third unrecorded site is near LA 11618. The locations of these sites are identified in Figure 2.3-1.

The LA 11617 site is apparently the remains of a one-room Indian field house with very little associated pottery. The LA11618 site is less defined, containing pottery but no architecture. The archaeological clearance survey of this site found that the pottery is associated with a coal deposit and has a yellowish color. This suggests the use of coal for pottery-firing.

(a) Museum of New Mexico Planning Office.

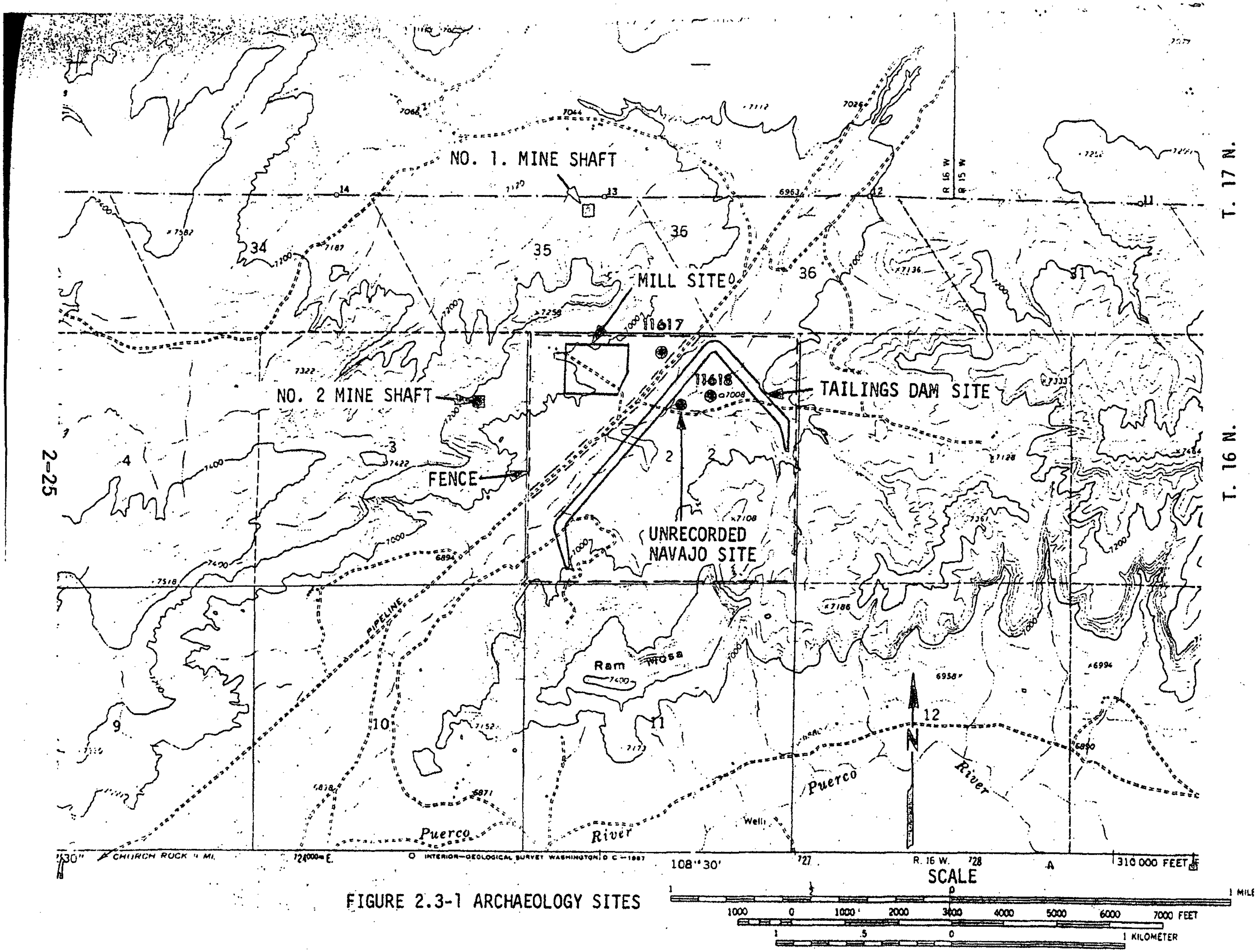


FIGURE 2.3-1 ARCHAEOLOGY SITES

Since LA 11618 and the undesignated ruin will be disturbed by the tailings pond, excavation of these sites will be funded by Applicant and conducted under the direction of the Museum of New Mexico. The LA 11617 ruin site, adjacent to the proposed mill, will be protected by Applicant in accordance with the instructions from the Museum of New Mexico. Since none of the sites will be disturbed by the construction, excavation could begin after the mill's construction but must be completed prior to the use of the tailings pond. Any archaeological discovery made during construction will be preserved in place or excavated in accordance with the instructions provided by appropriate state authorities.

The Grants Lava Flow, known in Spanish as the Malpais, is the only natural landmark in New Mexico listed in the National Register of Natural Landmarks. It extends approximately 25 miles south of Grants and is flanked on the east by State Highway 117 and on the west by State Highway 53. Other unlisted natural landmarks in the immediate area include: Ram Mesa, 1 mile to the south-southeast; White Rock Mesa, 6 miles to the southwest; and Pyramid Rock, 9 miles to the southwest.

The proposed mill site is adjacent to the existing State Highway 566 and to a power transmission line. The short mill access roads and utility lines will not interfere with known archaeological sites.

2.4 GEOLOGY

The mill site is located in the northwest corner of New Mexico, west of the Continental Divide on the San Juan Basin of the Colorado Plateau. The basin is bounded at the north by the San Juan Mountains, at the east by Sierra Nacimiento (Nacimiento Uplift) and Rio Grande River (Rio Grande Depression), at the south by Zuni Mountains (Zuni Uplift), and at the west by Chuska Mountains and Defiance Plateau (Defiance Uplift). These regional features are presented in Figure 2.4-1.

The basement rock units in the San Juan Basin are of the precambrian era, which is some 600 million years old, and are generally covered by sedimentary deposits of the Paleozoic, some 200 to 500 million years old, and younger eras. Major stratigraphic and time divisions are presented in Table 2.4-1.

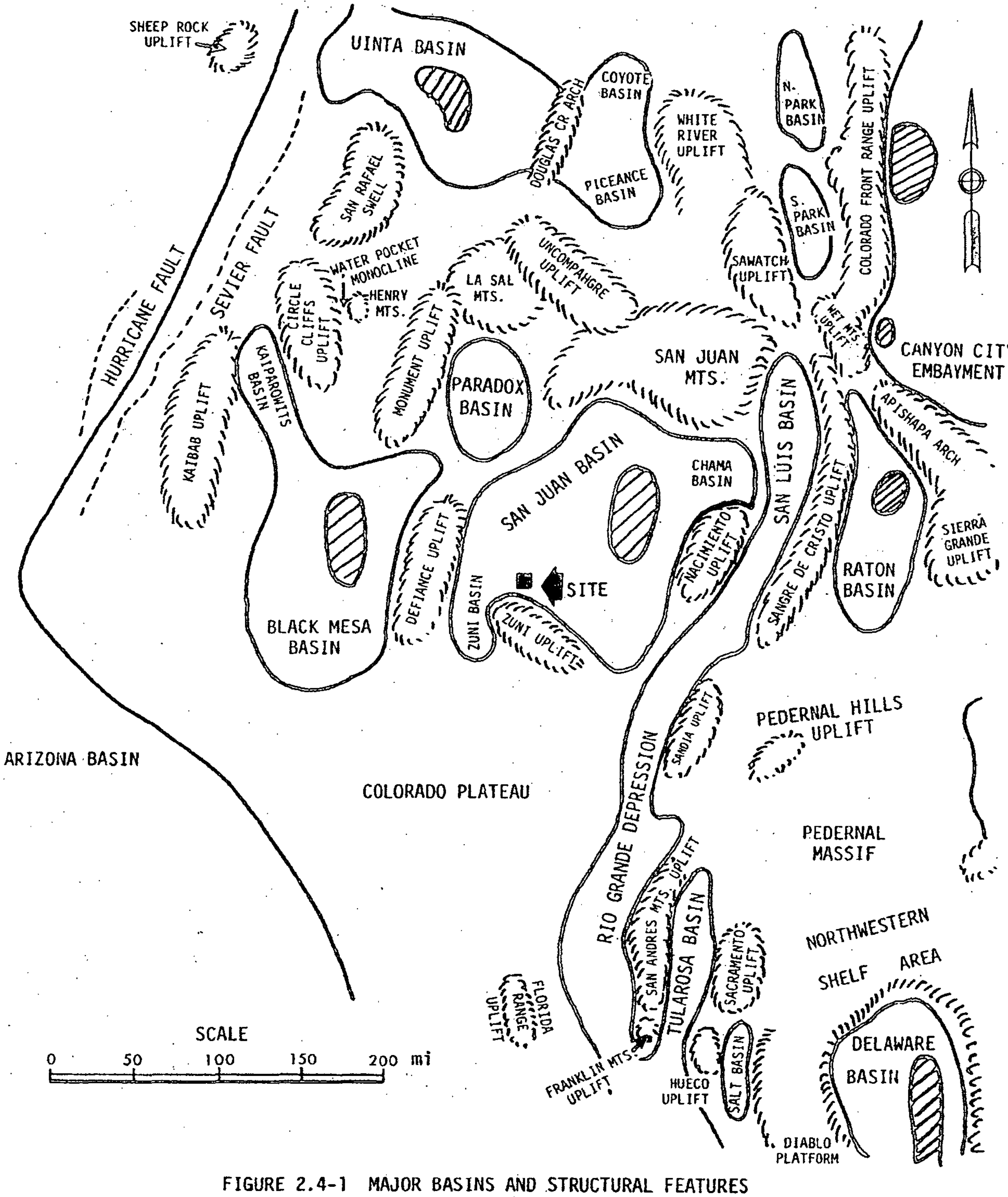


FIGURE 2.4-1 MAJOR BASINS AND STRUCTURAL FEATURES

TABLE 2.4-1 (Page 1 of 2)
MAJOR STRATIGRAPHIC AND TIME DIVISIONS[a]

Subdivisions in Use by the U. S. Geological Survey			Age estimates commonly used for boundaries (in million years)[b]	
Era or Erathem	System or Period	Series or Epoch	(c)	(d)
Cenozoic	Quaternary	Holocene		
		Pleistocene		
			1.5-2	1.8
	Tertiary	Pliocene		
			ca. 7	5.0
		Miocene		
			26	22.5
		Oligocene		
			37-38	37.5
		Eocene		
			53-54	53.5
		Paleocene		
			65	65
Mesozoic	Cretaceous[e]	Upper (Late) Lower (Early)		
			136	
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)		
			190-195	
	Triassic	Upper (Late) Middle (Middle) Lower (Early)		
			225	
Paleozoic	Permian[e]	Upper (Late) Lower (Early)		
			280	
	Pennsylvanian[e]	Upper (Late) Middle (Middle) Lower (Early)		
			320	
	Mississippian[e]	Upper (Late) Lower (Early)		
			345	
	Devonian	Upper (Late) Middle (Middle) Lower (Early)		
			395	
	Silurian[e]	Upper (Late) Middle (Middle) Lower (Early)		
			430-440	
	Ordovician[e]	Upper (Late) Middle (Middle) Lower (Early)		
			ca. 500	
	Cambrian[e]	Upper (Late) Middle (Middle) Lower (Early)		
			570	
Precambrian	Time subdivisions of the Precambrian: Precambrian Z--base of Cambrian to 800 m.y. Precambrian Y--800 m.y. to 1,600 m.y. Precambrian X--1,600 m.y. to 2,500 m.y. Precambrian W--older than 2,500 m.y.			

(a) USGS, 1972.

(b) Estimates for ages of time boundaries are under continuous study and subject to refinement and controversy. Two scales are given for comparison:

(c) Geological Society of London, 1964.

(d) Berggren, W. A., 1972.

In addition to these, a useful time scale for North American mammalian stages is given by:

Evernden, J. F., et al, 1964. Potassium-argon dates and the Cenozoic mammalian chronology of North America: Amer. Jour. Sci., v. 262, p. 145-198.

(e) Includes provincial series accepted for use in U. S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms--early, middle, and late--may be used for eras, for periods where there is no formal subdivision into early, middle, and late, and for epochs. Informal rock terms--lower, middle, and upper--may be used where there is no formal subdivision of an era, system, or series.

PROVINCIAL SERIES ACCEPTED FOR USE IN U.S. GEOLOGICAL SURVEY REPORTS

Series	Age	Region
Gulfian	Late Cretaceous	Texas, Louisiana, Oklahoma, Arkansas, Mississippi, and Alabama.
Comanchean	Early and Late Cretaceous	
Coahuilan	Early Cretaceous	Texas, Louisiana, Arkansas, Mississippi, and Alabama.
Ochoan	Late Permian	Texas and New Mexico.
Guadalupian	Early and Late Permian	Do.
Leonardian	Early Permian	Do.
Wolfcampian	Early Permian	Do.
Virgilian	Late Pennsylvanian	Arkansas, Oklahoma, Kansas, Missouri, Nebraska, and Iowa.
Missourian	do	
Des Moinesian	Middle Pennsylvanian	
Atokan	do	
Morrowan	Early Pennsylvanian	
Chesterian	Late Mississippian	Indiana, Kentucky, Tennessee, Illinois, Iowa, and Missouri.
Meramecian	do	
Osagean	Early Mississippian	
Kinderhookian	do	
Cayugan	Late Silurian	New York and Michigan.
Niagaran	Middle Silurian	Do.
Alexandrian	Early Silurian	Missouri, Illinois, and Michigan.
Cincinnatian	Late Ordovician	Ohio, Indiana, Kentucky, Tennessee, Michigan, Wisconsin, and Iowa.
Mohawkian	Middle Ordovician	New York, Michigan, Wisconsin, and Iowa.
St. Croixan	Late Cambrian	Iowa, Minnesota, Wisconsin, and Michigan.

The San Juan Mountains and the Sierra Nacimiento (Nacimiento Uplift) consist primarily of terrestrial volcanic rocks of Tertiary Ages, which are some 2 to 63 million years old. In the area of the Rio Grande Depression, the rock units consist of thick sedimentary deposits of the Late Tertiary Period and the Quaternary Period, which are less than 2 million years old. The Rio Grande Depression is bounded at the east by the Sangre de Cristo Uplift, which consists primarily of Archean sedimentary and volcanic rocks of the early Precambrian Era.

The Zuni Mountains and Defiance Plateau consist of rock units similar to those of the San Juan Basin. However, both Uplifts also contain sedimentary and volcanic rocks of the early Precambrian Era. The geology of the region is presented in Figure 2.4-2. The faults and tectonic structure of the region are presented in Figure 2.4-3. Normal faults, those perpendicular to the formation in which they occur, are located along both the western and eastern boundaries of the Rio Grande Depression as well as along the Zuni and the Defiance Uplifts.

The Applicant's mine and proposed mill site are located in Pipeline Valley, an incised valley system transecting the outcrops of the southwestern rim of the San Juan Basin. The valley system is bounded by three of the lower members of the Upper Cretaceous Mesa Verde Group: the Dalton Sandstone, the Mullato Shale Tongue, and the Dilco Coal Members of the Crevasse Canyon Formation. Figure 2.4-4 presents a stratigraphic column at the mine shaft.

Bore hole cuttings from the tailings pond area show alternating series of interbedded, continuous to discontinuous shale interfingered with sandstone lenses to depths of 240 ft. This formation is characteristic of the Dilco Coal Member.

The mine shaft collar has been poured at the approximate point of contact of the Mullato Shale Tongue with the overlying Dalton Sandstone. This places the mine shaft site somewhat higher than the proposed mill site in the stratigraphic sequence.

In the vicinity of the project site, the steep vertical cliffs bounding the Pipeline Valley are composed of the resistant sandstone phase of the Dilco Coal, with occasional interruptions of thin bands of black to gray shale and discontinuous coal seams. Downstream, the valley widens into the valley of the Rio Puerco of the West, which lies mostly in the Cretaceous Mancos Shale.

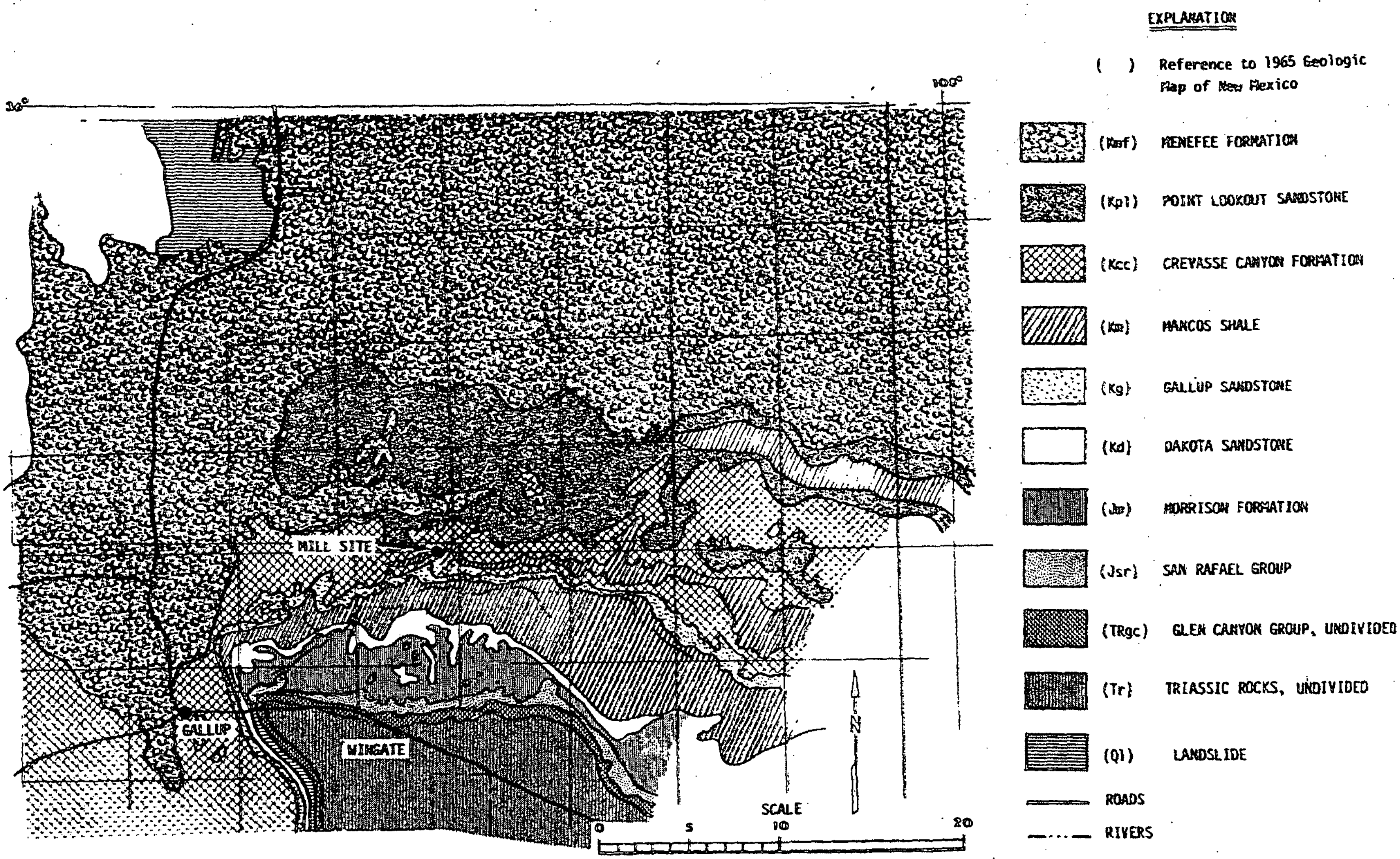


FIGURE 2.4-2 GEOLOGIC MAP OF AREA SURROUNDING MILL SITE

Soil

The alluvium of the Pipeline Valley is typical of this high, semiarid region. The valley floor is a product of the erosional and weathered disintegration of the Dilco Coal Member intermixed with the windblown, disintegrated Mancos Shale topsoil from the North Fork Valley of the Rio Puerco of the West. The alluvium, a product of this mix of finely divided Manco Shale and silty Dilco sandstone and mudstone, carries a high percentage of clay. The typical composition is a brown, fine-grained, medium-dense silty and sandy soil with sandstone fragments and thin interbedded clay seams. The soil has a coefficient of permeability of less than 3.8 ft/year. The alluvium varies in depth from 3 ft at the north end of the mill site to over 106 ft against the cliffs on the east side of the valley. Steep soil banks along stream channels may be more than 10 ft high.

The results of the exploratory drilling and research of available ground water data indicate that a general ground water table does not exist within the alluvium at the site. The ground water encountered in some of the borings is believed to be perched on the underlying rock. This water level probably fluctuates considerably, depending upon precipitation. However, at some point downstream in the Rio Puerco drainage basin, the water contained in the alluvium probably is in direct communication with a permanent, general ground water table.

Structure

The regional rock outcroppings form part of the southwestern edge of the San Juan Basin. The proposed site occupies a small portion of one such outcropping, the western margin of the Chaco Slope. The regional dip averages about 1° to the northeast but due to localized warping, may approach 3° in the site area.

Jointing

Local jointing assumes two principal orientations, $\pm$ N 65°W and $\pm$ N 25°E, the N 65°W pattern being the dominant set. The N 65° W set is a result of the Zuni uplift and the N 25°E set is an expression of the Gallup sag.

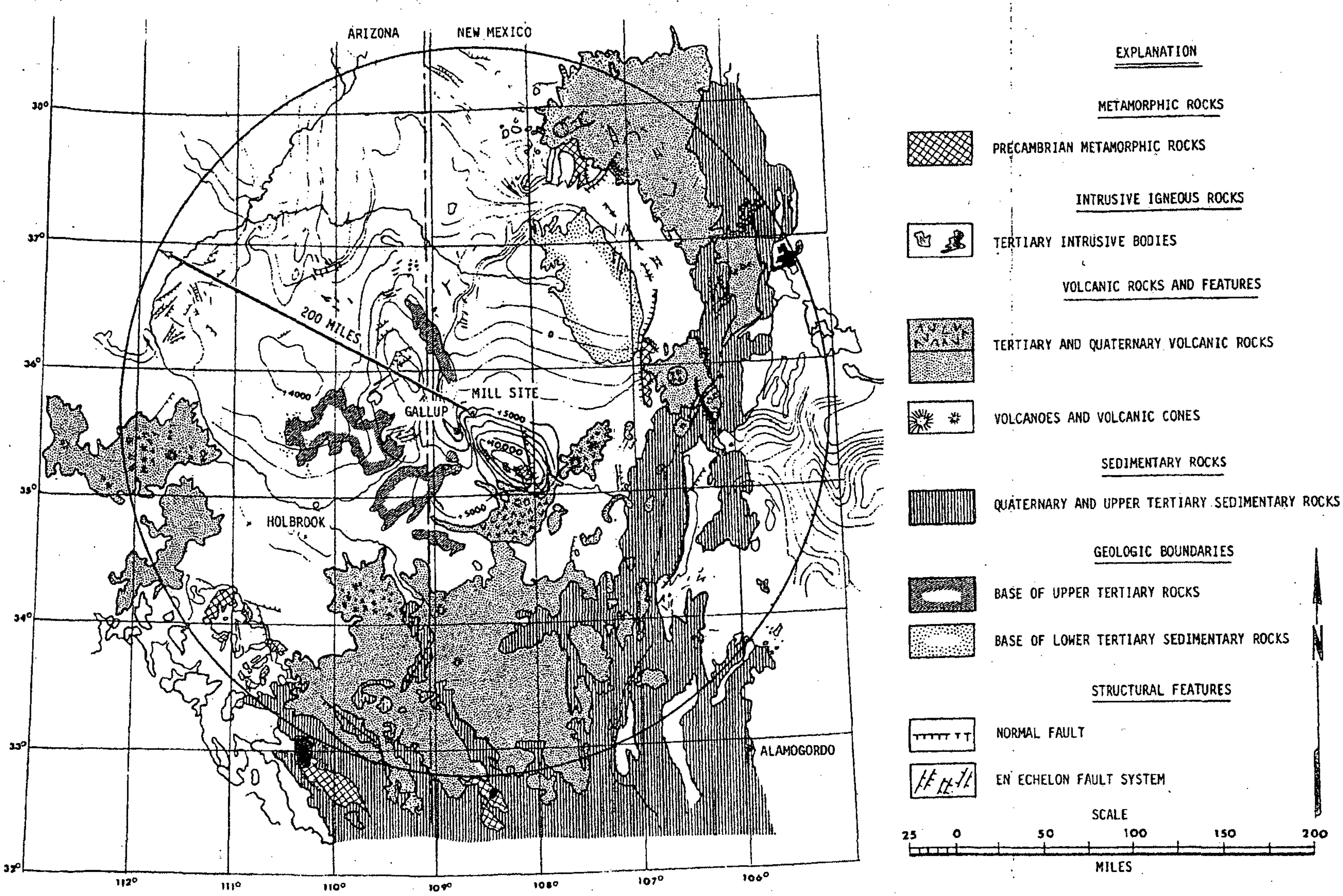


FIGURE 2.4-3 TECTONIC MAP OF AREA SURROUNDING MILL SITE

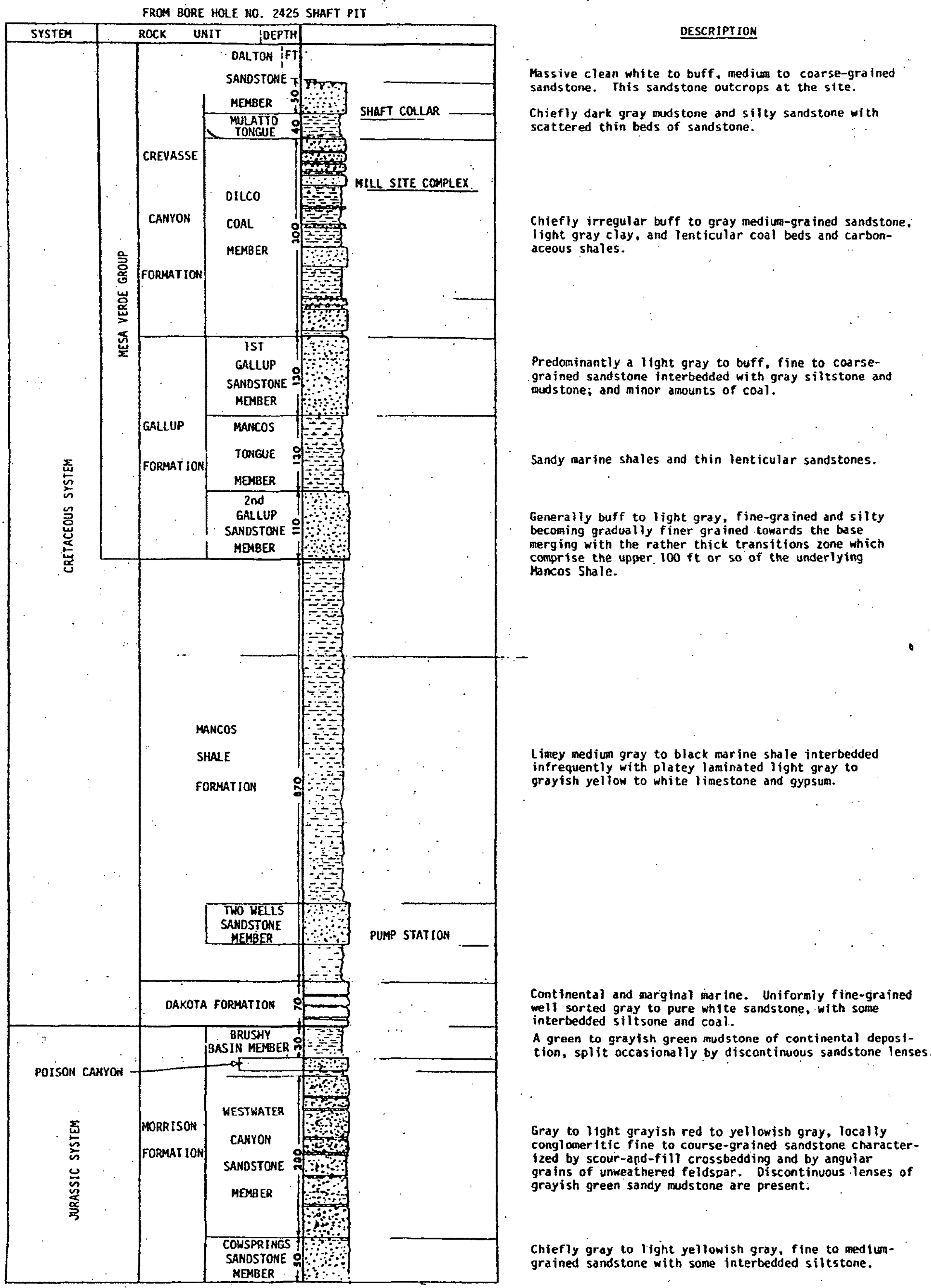


FIGURE 2.4-4 STRATIGRAPHIC COLUMN AT MINE SHAFT

Transverse joints in the massive sandstone members are more widely spaced than those in the mudstone units, which indicates great variations in dimensional strength. Joints in claystone and mudstone are abundant, but individual fractures are not as persistent or continuous as they are in the massive sandstone beds. The joint orientation differs considerably in superadjacent members.

The arrangement of the alternating sandstone and mudstone stratigraphic series indicates severely limited intercommunication of the formations by the passive joint systems.

Faulting

The USGS structural contour map,[a] based on the bottom of the Dakota Sandstone, shows no positive evidence of any major faulting in the site area. However, valley development in the area appears to have followed and been influenced by principal fracture and jointing orientations.

Stratigraphy

The stratigraphic setting is confined to the Cretaceous and Jurassic systems. Their various rock units and their thickness in stratigraphic order are described and illustrated in Figure 2.4-4.

A lithologic section along a portion of the proposed tailings pond dam (Figure 2.4-5) shows the typical composition of the alluvium in the upper part of the Dilco Coal Member. Numerous lenticular beds of shale, silt, sand, and clays are apparent.

Ore Mineralization

The raw ore averages about 0.2% uranium with only trace amounts of other minerals that currently fail to warrant commercial interest. The processing of the Church Rock mine ore bodies will not affect future utilization of other mineral resources.

(a) USGS, O.M. 158

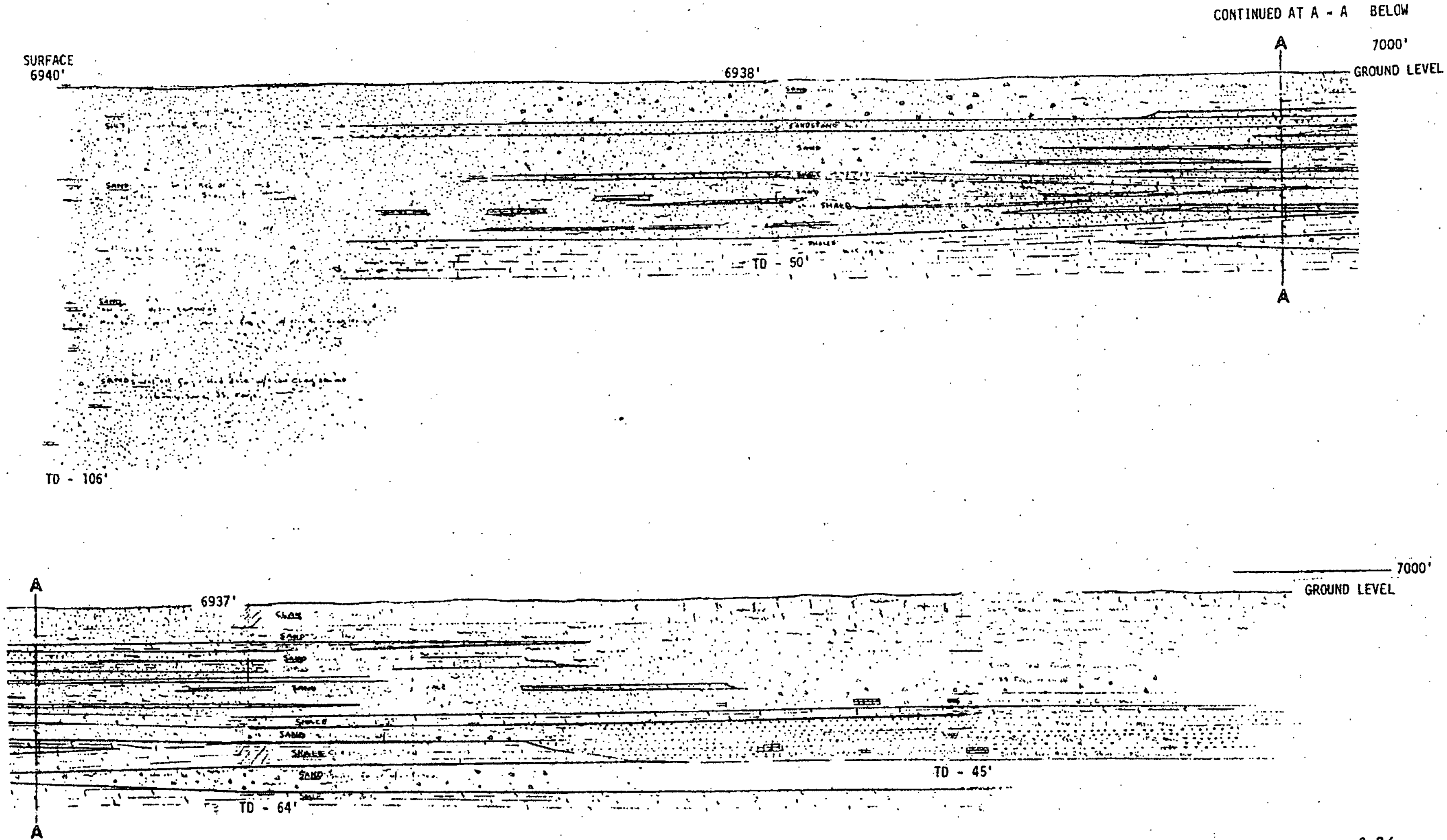


FIGURE 2.4-5 LITHOLOGIC SECTION UNDER TAILINGS POND

Ground Water

The hydrologic properties of Applicant's proposed site, such as porosity and permeability, are discussed in Section 2.6, Hydrology.

2.5 SEISMOLOGY

The proposed site is designated by the current Uniform Building Code as Zone 2 on the Seismic Risk Map. Possible seismic effects in Zone 2 are negligible damage in buildings of good design and slight to moderate in well-built, ordinary structures. These effects correspond to Intensity VII on the Modified Mercalli Intensity Scale.

A computer search of reported earthquakes from 1931 to 1973 within 200 miles of the site was made through a file from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration. The findings are shown in Appendix A. The known earthquakes from 1852 to 1931 were also compiled from Earthquake History of the United States.[a] To permit quantitative analysis, the intensities of the historic earthquakes were converted to magnitudes by using Richter's method.[b] The data are shown in Figure 2.5-1.

The majority of earthquakes have been related to faults along the northeastern boundary of the San Juan Basin. These faults generally divide the San Juan Basin into the old basement rock unit to the west and the uplift and depression of younger rock unit to the east. Earthquakes along these faults have exhibited magnitudes up to 6 on the Richter Scale and intensities up to VIII on the Modified Mercalli Scale.

(a) Coffman and Von Hoke, 1973.
(b) Richter, 1958.

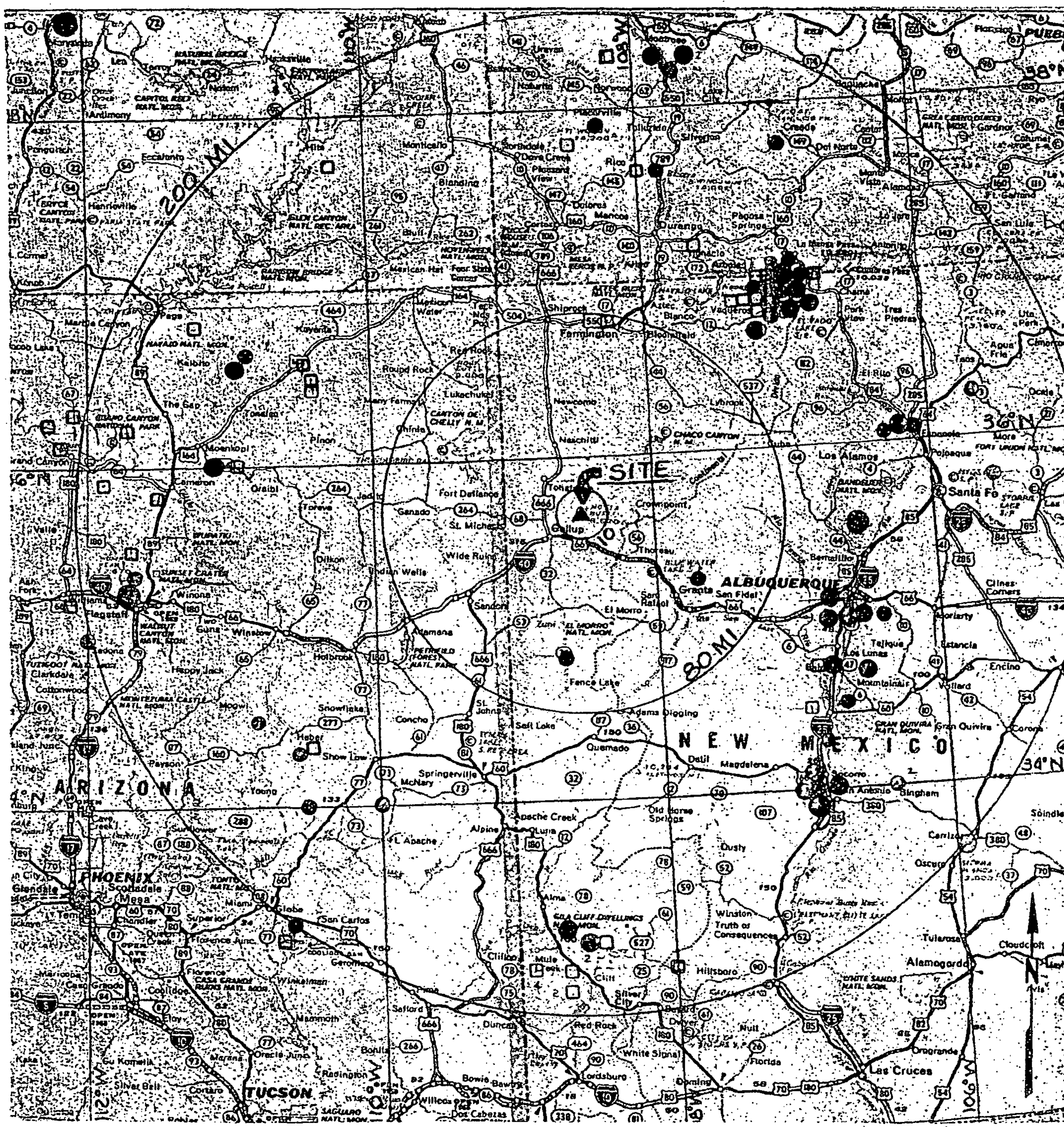


FIGURE 2.5-1 EARTHQUAKE EPICENTERS SURROUNDING MILL SITE

SOURCE: U. S. DEPT. OF COMMERCE
NATIONAL OCEANIC & ATMOS. ADMIN.

MAGNITUDE

- 3.5 to 4.5
- 4.5 to 5.5
- >5.5
- UNCERTAIN

Other earthquakes originating from tertiary volcanic units far southwest of the site have exhibited magnitudes up to 5.5 and intensities to VII. Two earthquakes with magnitudes of 3.9 and 4.4 have been recorded along the 50 mile long fault near the Zuni Uplift. No recorded earthquakes have been associated with the Defiance Uplift.

2.6 HYDROLOGY

2.6.1 Ground Water

Well Inventory

Water supply wells in the vicinity of the proposed mill site are identified on Figure 2.6-1. Data concerning the aquifer tapped, the owner, principal use, and other available information are presented in Table 2.6-1. Published information[a] is supplemented by information from field checks and examination of Navajo Tribal Water Development records. Information on the chemical quality of water from some of the wells is presented in Table 2.6-2.

Aquifers

Alluvium

Water-bearing alluvium is present in the principal drainages of the basin of the North Fork of the Rio Puerco. The alluvium has been tapped by wells in a number of places (see Figure 2.6-1 and Table 2.6-1) primarily for small quantities of domestic and stock water, which are withdrawn by windmill or hand-operated pumps. Water quality is highly variable because recharge is derived from local storm flows in very small drainages, but is ordinarily good to fair with total dissolved solids ranging from less than 200 mg/liter to somewhat over 1000 mg/liter.

(a) Davis, et al, 1963.
Kister, L. R., and Hatchett, J. L., 1963.
McGavock, et al, 1966.
Shomaker, J. W., 1971.

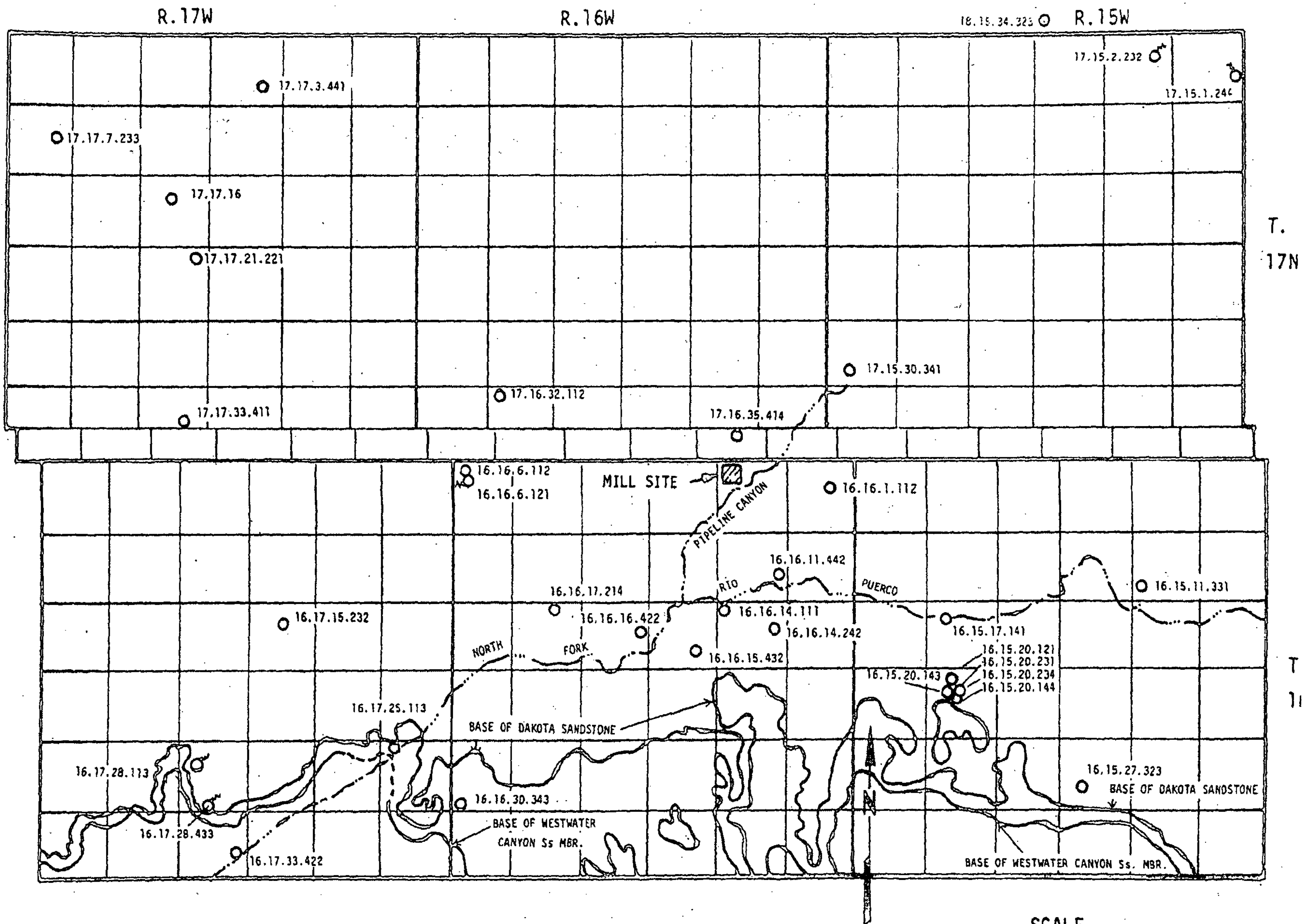


FIGURE 2.6-1 LOCATION OF WATER WELLS
NEAR MILL SITE

SCALE
0 1/2 1
MILES

TABLE 2.6-1

WELLS AND SPRINGS IN THE VICINITY OF APPLICANT'S PROPOSED SITE

(Page 1 of 2)

Location number and name (a)	BIA Number	Elev.	Depth, ft	Aquifer (b)	Water level, ft	date	Yield during test, gal/min	Drawdown at yield shown, ft	Use of water (c)	Type of pump (d)	Conductance, µmho @ 25° C
16.15.11.331	16T-509	7015	953	Kd,Jmw	355	1960	8	25	D,S	W	1290
16.15.17.141	16T-348	6900	410	Kd	flow	1957	8	242	D,S	W	960
					87	1974					
16.15.20.121	16T-514	6975	496	Kd	63	1959	24	335	D		1600
20.143	16GS-105			Qal							
20.144	16GS-105			Qal							
20.231	16GS-105			Qal							
20.234 Pinedale TP	---			Km?							
16.15.27.323		7178									
16.16. 1.112	16K-319	7128	963	Kd	320	1948	7	490	D,S	W	1060 cased to 956
16.16. 6.112	14N-70	7010	---	Kcd	---	----	0.5	---	D,S		436
S 16.16. 6.121		7030									
16.16.11.442		6855		Qal							
16.16.14.111		6838		Qal							
16.16.14.242		6905	525	Jmw	54	1974			D,S	P	
16.16.15.432	16T-513	6875	318	Jmw	181	1959	33	20	D,S		1390
					257P	1974					
16.16.16.422		6799		Qal							
					144	1968					
16.16.17.214 Old Churchrock Mine		6808		Jmw	319	1974				N	
16.16.17.214	16T-532	6810	450	Kd							
16.16.30.343 Springstead TP		6870	505	Jmw,Jcs	211	1956	5				
16.17.15.232	16T-510	6818	680	Kd,Jmw	103	1960	26	240	D,S	W	1500
					253P	1974					
16.17.25.113	16K-340	6682	141	Qal	37	1954	23	68	D,S	W	1810
S 16.17.28.133		6860	---	Kd	---	----	--	---	U	-	
S 28.433		7010	---	Kd	---	----	--	---	U	-	
16.17.33.422	16K-336	6651	122	Qal	34	1955	15	28	D,S	W	1330
S 17.15. 1.244 Rock Spring		6920	---	Kpl	---	----		---			
S 17.15. 2.232 Oak Spring		6880	---	Kpl	---	----					
17.15.30.341	15T-303	7038'	614	Kg	305	1952	23	50	D,S	W	3120 cased to 537
					318P	1974					
17.16.32.112	14K-313	7010	622	Kg	235	1953	20	128	D,S	W	1780
17.16.35.414 Applicant's water well		7180?	1650	Jmw-Kd?	900	1969	20		D	P	499

TABLE 2.6-1 (Page 2 of 2)

Location number and name (a)	BIA Number	Elev.	Depth, ft	Aquifer (b)	Water level, ft.,	date	Yield during test, gal/min	Drawdown at yield shown, ft.	Use of water (c)	Type of pump (d)	Conductance, µmho @ 25° C
17.17. 3.441	14T-320	6379	726	Kg?	434	1958	65	31	D,S	W	
17.17. 7.233	14A- 79	6240	873	Kcd	flow	1952	82 ('51) 30 ('55)		D,S,I		455
17.17.16.	14A- 14		7	Qal	6	1955	---		S		3370
S 17.17.21.221 Coal Mine Spring	14N- 57?	6470	---	Qal	---	----	0.	--	D		
17.17.33.411	14T-321	7060	1082	Kmf-Kcc	flow 400	1960 1967	15	30	D,S	W	2700
18.15.34.323	15T-535	6760			211	1974			S	W	

(a) S designates Spring

(b) Aquifers: Qal, alluvium; Kcc - Crevasse Canyon Formation; Kcd - Dalton Sandstone Mbr. of Crevasse Canyon Formation; Kmf - Menefee Formation; Kpl - Point Lookout Sandstone; Kg - Gallup Sandstone; Km - Mancos Shale; Kd - Dakota Sandstone; Jmw - Westwater Canyon Sandstone Mbr. of Morrison Formation; Jcs - Cow Springs Sandstone

(c) Use of water: D, domestic; S, stock; U, unknown; I, industrial

(d) Type of pump: W, windmill; P, electric powered; N, none

TABLE 2.6-2

SELECTED CHEMICAL ANALYSES OF GROUND WATER IN THE VICINITY OF PROPOSED MILL SITE

(constituents in milligrams per liter unless otherwise noted)

Location number and name	BIA Number	Aquifer (a)	Date Sampled	Silica SiO_2	Calcium Ca	Magnesium Mg	Sodium plus potassium Na + K	Bicarbonate HCO_3	Carbonate CO_3	Sulfate SO_4	Chloride Cl	Fluoride F	Nitrate NO_3	Total dissolved solids	Conductance µmho @ 25° C
16.15.20.		Qal	8-1949	12	72	14	13	258	0	43	4	0.6	2.2	288	480
20.		Qal	5-1950	15	42	13	8	160	0	40	2	0.2	0.1	199	331
20.234 Pinedale TP		Km?	8-1949	12	170	55	161	359	0	590	50	0.4	24.0	1240	1710
16.16. 1.112	16K-319	Kd	6-1955	14	1.6	1.9	262	518	39	74	8	1.4	1.5	658	1060
16.16. 6.112	14N- 70	Kcd	5-1955	18	57	20	0.9	130	0	102	9	0.4	0.0	271	436
16.17.25.113	16K-340	Qal	6-1954	12	139	44	264	890	0	314	24	0.6	13.0	1250	1810
16.17.33.422	16K-336	Qal	9-1953	5.8	80	19	227	776	0	91	26	1.4	0.3	832	1330
17.15.30.341	15T-303	Kg	6-1955	15	157	89	504	297	0	1520	16	2.1	0.6	2450	3120
17.16.32.112	14K-313	Kg	5-1955	17	218	99	72	271	0	835	11	0.8	0.0	1390	1780
17.16.35. Kerr McGee Mine		Jmw	11-1973	17	11	8.4	131.6	220	21	110	3.6	0.3	---	412	663
17.17. 7.233	14A- 79	Kcd	6-1949	--	3	0.9	105	237	0	38	4	0.2	0.5	268	455
17.17.16	14A- 14	Qal	5-1955	--	--	--	---	409	0	---	32	1.2	0.3	530	3370
Applicant's Mine		Jmw	11-1973	17	2.2	0.3	121.4	215	31	45	5.2	0.2	---	329	550

(a) Aquifers: Qal, alluvium; Kcc, Crevasse Canyon Formation; Kcd, Dalton Sandstone Mbr. of Crevasse Canyon Formation; Kmf, Menefee Formation; Kpl, Point Lookout Sandstone; Kg, Gallup Sandstone; Km, Mancos Shale; Kd, Dakota Sandstone; Jmw, Westwater Canyon Sandstone Mbr. of Morrison Formation; Jcs, Cow Springs Sandstone

The nearest well that withdraws water from the alluvium below the proposed tailings pond site is along the east line of Section 16 (well 16.16.16.442). The well taps alluvium in the main stem of the North Fork of the Rio Puerco 0.5 mile below the confluence of Pipeline Canyon and more than 2 miles below the proposed tailings dam site. This well is equipped with a hand pump, and the water is used for domestic and stock purposes.

Sandstones of the Crevasse Canyon Formation

The Dalton Sandstone Member of the Crevasse Canyon Formation forms the cliffs northwest of the proposed mill site and lies above the water table throughout the vicinity of the mine and proposed mill site. Accordingly, only geologic units below the Dalton will be considered in the following discussion. See Figure 2.6-2. Several sandstones below the Dalton, but still within the Crevasse Canyon Formation, are potential minor aquifers. These lie within the Dilco Coal Member, and near the mill site they total less than 50 ft in thickness. Water yields from the Dilco are expected to be small, perhaps up to 20 gal/min, and are of variable but generally poor quality because of their close association with coal and carbonaceous shale.

Permeability of sandstone in the Dilco Coal Member has not been determined. However, permeability and transmissivity values are expected to be comparable to values obtained for members of the Crevasse Canyon Formation. Field and laboratory measurements of samples from the outcrop of the Crevasse Canyon formation indicate a permeability ranging from 0.6 to 1.7 ft/day.[a] These samples should be representative of the material just beneath the proposed tailings pond.

Aquifer tests for a 267 ft section of Gallup sandstone in the City of Gallup's Munoz-1A water well (section 17, T.16N, R.18W) indicated a transmissivity of approximately 2000 (gal/day)/ft.[b] The permeability was approximately 1 ft/day. Electric logs showed the Dilco sandstone units to be similar to those of the Gallup.

(a) Cooley, et al, 1969.
(b) Mercer and Cooper, 1970.

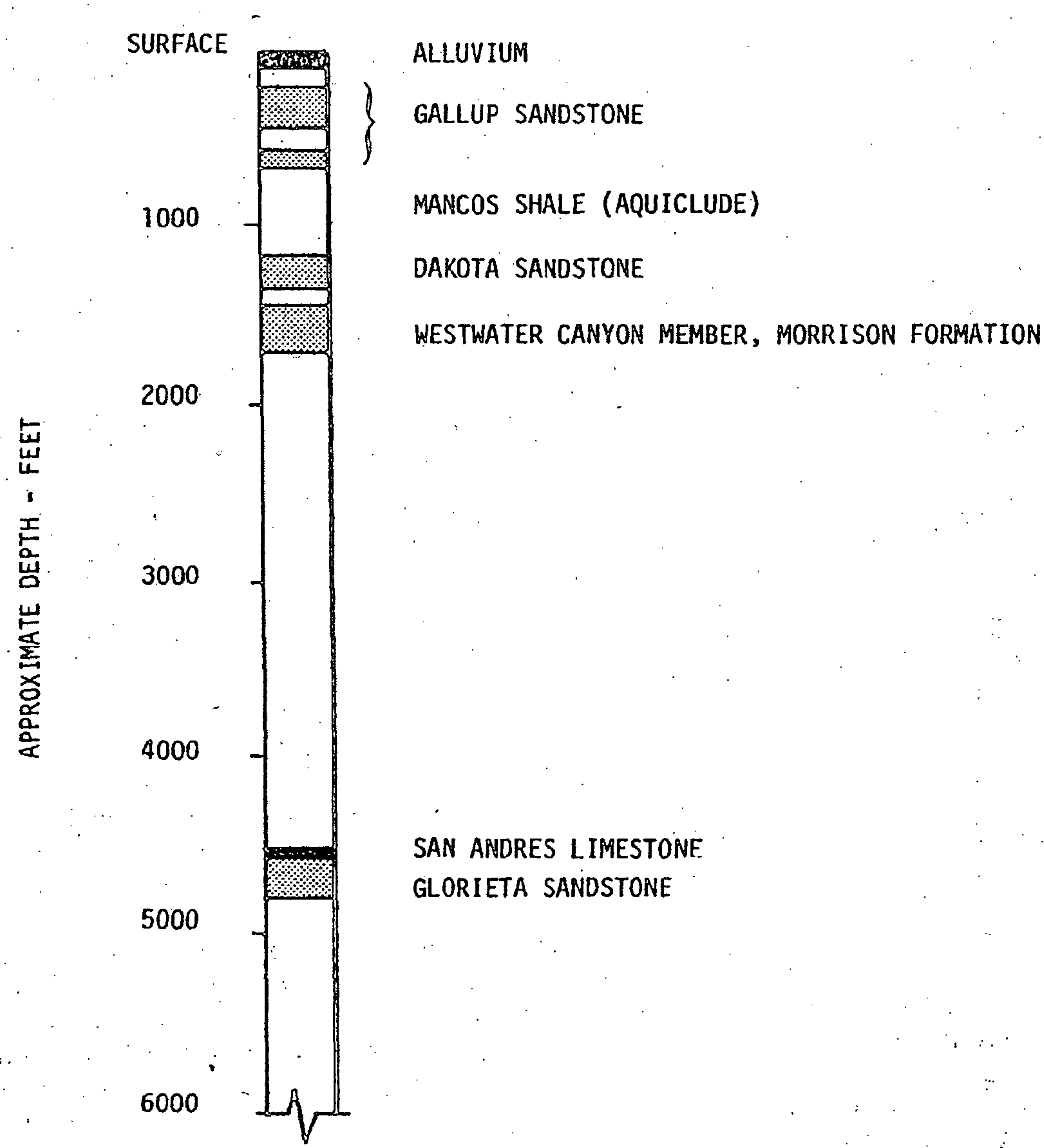


FIGURE 2.6-2 PRINCIPAL AQUIFERS AND AQUICLUDES BENEATH TAILINGS POND AREA

A structural dip in the area of the proposed mill extends northward at a rate averaging about 240 ft/mile. At the point where water from the tailings pond will partially recharge the sandstone, the gradient is steeper, but in a short distance the gradient flattens to coincide with the bedding planes.

Based upon a permeability of about 1.0 ft/day and at a gradient of 240 ft/mile, water movement would be 0.24 ft/day or about 88 ft/year downdip from the tailings pond in the zone above the point of confinement. Due to decreasing gradient, further movement would be less.

Gallup Sandstone

The first sandstone unit considered to be part of the Gallup Sandstone aquifer occurs 180 ft below the proposed tailings pond. See Figure 2.6-2. This sandstone underlies a section of approximately 110 ft of sandy and carbonaceous shales, very thin lenticular sandstones, and coal, which is below the Dilco sands and assigned to the Dilco Coal Member of the Crevasse Canyon Formation. The sandstones comprising the Gallup sandstone aquifer have a net thickness of approximately 210 ft. The uppermost sandstone, approximately 35 ft thick, is referred to as the Gallegos Member. It is separated from the next major sandstone by approximately 45 ft of sandy marine shale and interbedded thin sandstones. The second major sandstone, also approximately 45 ft thick, is considered the lower part of the Gallegos Member. Near the proposed mill site the Gallegos Member rests directly on the "first Gallup Sandstone," which appears from electric log measurements to include about 85 ft of sandstone. The first Gallup Sandstone rests upon approximately 130 ft of sandy marine shale and thin lenticular sandstones assigned to the Mancos Shale which, in turn, rests upon the "second Gallup." The second Gallup is correlative with the "massive Gallup" that can be traced over a large area in the Southern San Juan Basin.

All of these sandstones are considered part of the "Gallup aquifer." The sandstones are assumed to be hydraulically connected, at least in some areas toward the southwest where the intervening marine shale tongues pinch out and the transgressive and regressive sandstones merge. From the logs of many wells drilled into the Gallup, it is not possible to determine with assurance which particular sandstones are providing water to the well.

The upper sandstones described above are variable in thickness, generally becoming thinner toward the northeast. The two lowest beds, referred to as the first Gallup and second Gallup, are the most persistent, but only the lower

second Gallup continues as a massive sandstone into the central part of the San Juan Basin. The upper sandstones of the Gallup aquifer are of irregular lithology and generally are composed of light-gray to buff, or pink, fine-to-medium-grained sandstone sometimes with coarser-grained channel fillings. The upper units also contain a number of thin shale beds. The two lower sandstone beds are generally buff to light gray, fine-grained and silty, and the lowest, second Gallup, becomes gradually finer-grained towards the base, merging with the rather thick transition zone which comprises the upper 100 ft of the underlying Mancos Shale.

Although the Gallup is the principal aquifer in a number of wells near the city of Gallup, including four supply wells at Window Rock Junction, the Gallup aquifer has not been extensively utilized in the area of Applicant's mine. See Table 2.6-1. Records show only two wells completed in the Gallup near the mine. These are well 17.16.32.112, approximately 3.5 miles north-northeast of the mine, and well 17.15.30.341, approximately 2.5 miles northeast of the mine in the valley of Pipeline Canyon. Neither of these wells penetrates more than a small part of the Gallup aquifer. Specific capacities of these two wells are 0.15 and 0.46 (gal/min)/ft, respectively. Water quality is only fair, with total dissolved solids being 1390 and 2450 mg/liter. Water from both wells is high in sulfate concentration. See Table 2.6-2.

Dakota Sandstone

The top of the Dakota Sandstone aquifer is approximately 1160 ft below the tailings pond area. See Figure 2.6-2. The Dakota is separated from the Gallup Sandstone by approximately 500 ft of Mancos Shale, which is composed primarily of dark gray and greenish-gray shales with thin interbedded sandstones. The Mancos has very low relative permeability and is considered an aquiclude.

The upper member of the Dakota Sandstone, termed the Two Wells Member, is approximately 61 ft thick. It is composed of an upper massive sandstone unit approximately 47 ft thick, a lower, fairly massive sandstone about 8 ft thick, and an intermediate shale zone. The massive sandstone units are highly resistive and "clean" and can be assumed to contain relatively high quality water.

Below the Two Wells Member lies the Whitewater Arroyo Shale, which is approximately 56 ft thick and is generally similar to the main body of the Mancos Shale. The Whitewater Arroyo Shale, a tongue of the Mancos Shale, merges with the main body north-eastward in the San Juan Basin. Like the main body of the Mancos Shale, the Whitewater Arroyo Shale has very low permeability. Beneath the Whitewater Arroyo Shale is an unnamed member of the Dakota, approximately 66 ft thick, made up of six ledges of clean, resistive sandstone separated by marine shale. The net thickness of resistive sandstone in this lower unit is approximately 38 ft.

Four wells in the vicinity of Applicant's mine draw water from the Dakota aquifer. These wells are designated 16.15.17.141, 16.15.20.121, 16.16.1.112, and 17.16.35.414. The first well mentioned is located about 1.5 miles north of Pinedale Trading Post, 4 miles southeast of the Applicant's mine, and is equipped with a windmill and pump jack. The well is used for domestic and stock water supplies. The second well mentioned is at the Pinedale Chapter House, 5 miles southeast of the Applicant's mine, and is equipped with a submersible pump. The well is used primarily as a domestic water supply. The third well is about 1.5 miles east-southeast of Applicant's mine and is equipped with a windmill. This well is also used for domestic and stock water supplies. The last mentioned is Applicant's water well which draws water from both the Dakota and, below it, the Westwater Canyon Sandstone Member of the Morrison Formation.

Well 16.15.17.141 is open to only 10 ft of the aquifer and has a specific capacity of 0.03 (gal/min)/ft. Water quality is fair with a conductance of 160 µmhos. Well 16.15.20.121 is open to approximately 90 ft of the Dakota Sandstone aquifer, 55 ft of which is in the Two Wells Member and approximately 35 ft of which is in the lower, unnamed member of the Dakota. This well has a specific capacity of 0.07 (gal/min)/ft. Water quality is relatively poor, having a conductance of 1600 µmhos. This poor water quality is probably due to completion of the well in both the upper and lower zones. The "shaliness" of the lower zone can cause a high dissolved solids content. Well 16.16.1.112 is open to only 7 ft of the aquifer, probably in the Two Wells Member, and has a specific capacity of only 0.01 (gal/min)/ft. Specific conductance of the water is 1060 µmhos. Applicant's water well, 17.16.35.414, probably draws water from both the Dakota and the Westwater Canyon Member of the Morrison.

However, the similarity in quality between the water from the well and the water pumped from the mine indicates that most of the water pumped from the well is drawn from the Westwater Canyon Member.

Water levels in all four of the wells mentioned above have declined in the past few years. This indicates that there is some hydraulic connection between the Dakota and the Westwater Canyon Member from which water is pumped in Applicant's mine. This phenomenon is discussed at greater length in the following section.

Westwater Canyon Sandstone

The Westwater Canyon Member of the Morrison Formation is the most significant aquifer beneath the tailings pond area. See Figure 2.6-2. This sandstone lies at a depth of 1420 ft below the proposed tailings pond and is separated from the base of the Dakota Sandstone by approximately 75 ft of green shale interbedded with sandstone. The Westwater Canyon Member includes approximately 135 ft of what appears to be relatively resistive sandstone with a total thickness of 280 ft. The sandstone is typically light gray to pale yellowish-brown with minor breaks of greenish-gray shale. The sandstone is generally poorly sorted, ranging from fine- to coarse-grained, and often contains channel fillings, coarse-grained sand, and conglomerate.

The coefficient of transmissivity for the Westwater Canyon Member generally falls in the range of 1000 to 2500 (gal/day)/ft for wells in the Crownpoint and Borrego Pass area east of Applicant's mine. Wells west of the mine indicate poorer transmissivity for the Westwater Canyon Member. Aquifer tests of the City of Gallup's Munoz-1A well indicate that neither the Westwater Canyon Member nor the Dakota contribute a significant amount of water to that well.[a] However, toward the center of the San Juan Basin the Morrison is a potentially important aquifer. Strong water flows attributed to the Westwater Canyon Member have been noted during uranium test drilling in a band from Coyote Canyon through Standing Rock and at a point a few miles north of Crownpoint.

(a) Mercer and Cooper, 1970.

Another well in the Westwater Canyon Member has been recently completed in T. 23 N., R. 14 W. Municipal water supplies are also drawn from the Westwater Canyon at Crownpoint. The quality of water within the Westwater Canyon Member is typified by that pumped from the Applicant's mine. Quality is generally good with conductance less than 700 µmhos and total dissolved solids not much more than 400 mg/liter.

Comparisons were made of recent water level measurements with those taken before pumping from the Applicant's mine began in 1968. See Table 2.6-1. Examination of the water level data for the old Church Rock mine indicates that a considerable cone of depression may be developing because of pumping from the Applicant's and Kerr-McGee's mines. The water level in the old Church Rock mine, approximately 3.2 miles from the Applicant's mine, has dropped nearly 175 ft since pumping began. The levels in four windmill wells tapping the Westwater Canyon also appear to have fallen. The water level in well 16.16.15.432, approximately 2.6 miles from the Applicant's mine, was measured in 1959 at 181 ft. By August 1974 the level had dropped to 257 ft.

Well 16.15.17.141, approximately 4 miles from Applicant's mine, was flowing at about 0.25 gal/min in November 1957. Based upon the specific capacity reported when the well was bail tested in 1957, the shut-in head should have been about 8 ft above land surface. In August 1974 measurements indicated a shut-in head level of 87 ft below land surface, without pumping for at least 12 hours.

The water level in a well drilled in 1968, No. 16.16.14.242, was measured in August 1974 at 54 ft. Based on the two wells mentioned above, that level seems higher than expected. Either the cone is developing irregularly, or depending upon permeability, pressure declines are considerably different in various zones of the Morrison and Dakota.

Deeper Aquifers

Several stratigraphic units which yield water in other areas are present below the Westwater Canyon Member at the proposed mill site. However, little is known about the aquifers' water-bearing characteristics. These units include, in descending order, the Bluff Sandstone, the Summerville Formation, the Todilto Limestone, the Entrada Sandstone, all of Jurassic age; the Wingate Sandstone and several sandstone units in the Chinle Formation, all of Triassic age; the San Andres Limestone and the Glorieta Sandstone, both of Permian age. None of these units

are tapped for water near the proposed mill site because adequate supplies have been available from more shallow formations.

2.6.2 Surface Water

Characteristics of the Drainage System Near the Mill Site

The proposed mill site lies near Pipeline Canyon, which is a tributary to the North Fork of the Rio Puerco in the drainage basin of the Little Colorado River. See Figure 2.6-3. The North Fork of the Rio Puerco drains approximately 280 sq miles, of which 18.7 sq miles comprise the drainage area of Pipeline Canyon above the mill site. All of the watercourses within the North Fork drainage are normally dry arroyos except during storm runoffs. During the dry season, the only measurable surface water originates from Applicant's and the Kerr-McGee's mines.

No surface water diversions or control structures exist below the mill site, and only one significantly large impoundment exists above. This impoundment is capable of storing 10 acre-ft of water for erosion control and stock needs. An erosion control dam is located at approximately the center of the tailings dam site.

Downstream uses of surface water are limited to occasional livestock watering. The subflow in the alluvium in the North Fork is tapped by several shallow wells. This water, technically ground water, is derived from storm flows passing down the arroyos and is pumped for domestic and stock-watering use.

Flood Frequency and Duration, Pipeline Canyon

The peak discharge of flood water in Pipeline Canyon is difficult to estimate except by comparison with similar drainages. Discharge per unit of drainage area can be plotted against the drainage area in terms of "highest known discharge," regardless of record length or recurrence interval. Such an envelope curve for the Rio Puerco and its tributaries is presented in Figure 2.6-4. This curve serves as an approximation because differences in the characteristics of the drainage basins are not taken into account. Based on the 18.7 sq mile drainage area of Pipeline Canyon above the proposed mill site, a discharge of 6400 ft^3/sec, 340(ft^3/sec)/sq mile, is anticipated.

Chemical Analyses

The chemical analyses of surface water samples are presented in Section 2.10.

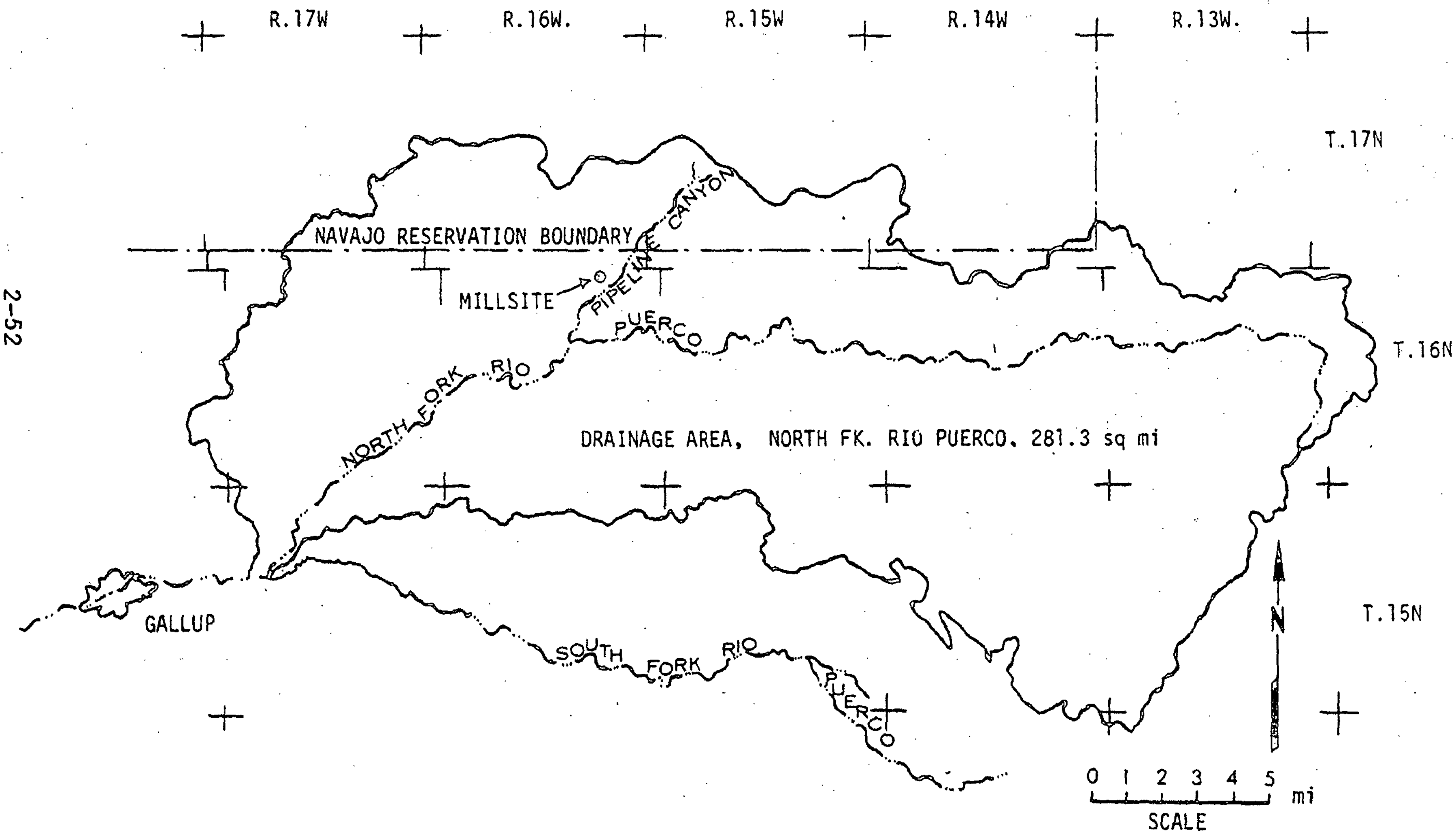


FIGURE 2.6-3 DRAINAGE AREA OF NORTH FORK OF RIO PUERCO

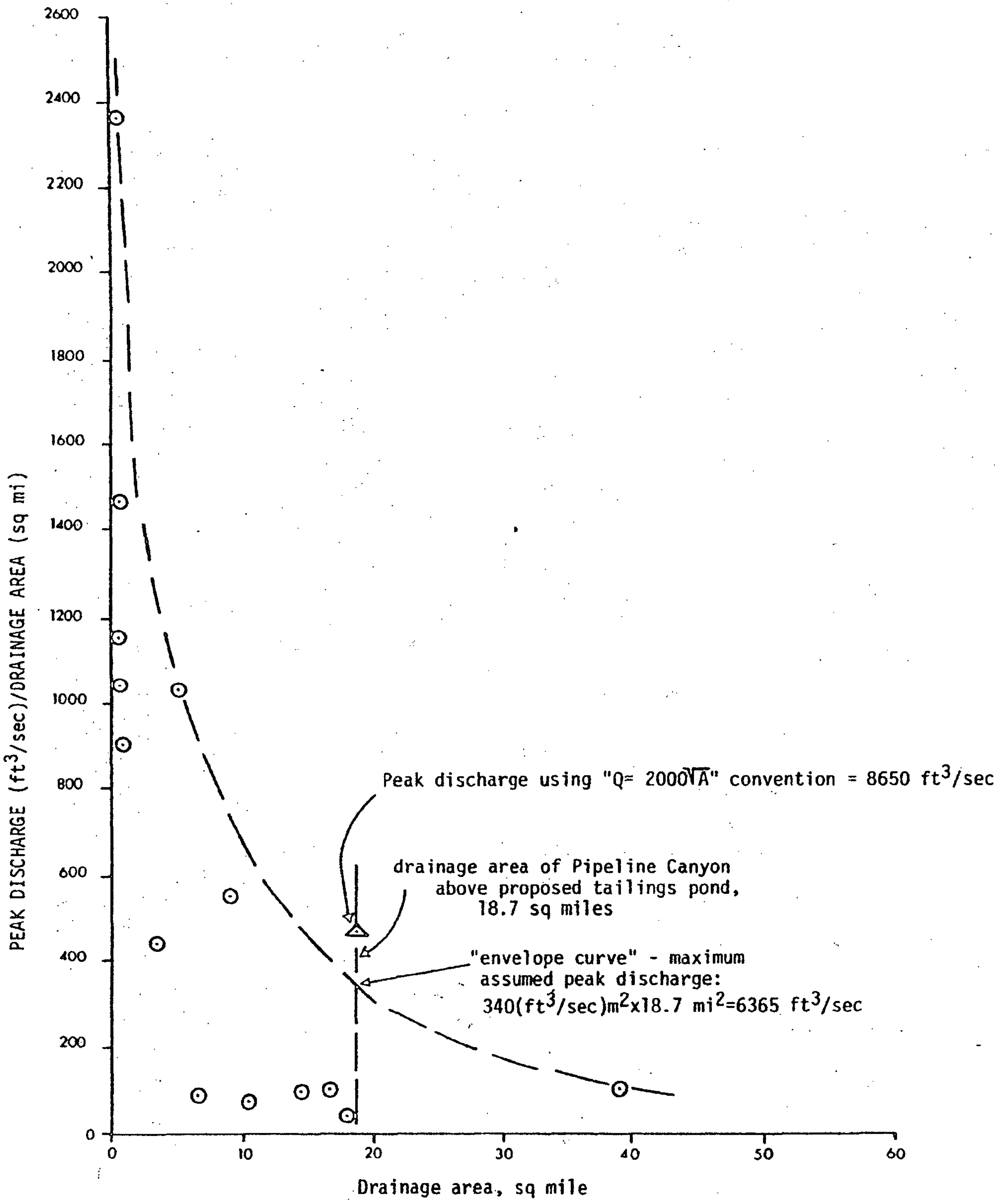


FIGURE 2.6-4 COMPARISON OF PEAK DISCHARGE WITH DRAINAGE AREA FOR RIO PUERCO AND TRIBUTARIES

2.7 METEOROLOGY

Introduction

Most of the climatological data has been taken from Climatological Summary for Gallup, New Mexico.[a] Gallup has the nearest national weather service station, approximately 16 miles southwest of the proposed mill site.

The site area has an arid-to-semiarid continental climate with sunshine approximately 70% of that possible. Rainfall is light and occurs primarily during the summer. The mill site is located in a valley that extends southwest through Gallup and then through broken high-plateau country into Arizona. The country surrounding the proposed site is rough and broken with rocky buttes and ridges, and is crossed by many arroyos. The elevation at the Gallup station is 6465 ft, compared with 7000 ft at the mill site. Hence, wind data for the two areas are similar, and temperature, humidity, and precipitation values should vary only slightly due to the elevation differences. The Gallup data, therefore, provide a close approximation of site conditions.

Temperature, Precipitation and Relative Humidity

Monthly and annual summaries of temperature means and extremes at Gallup are presented in Table 2.7-1 for the period from 1938 to 1960. Because of the elevation, summer days are generally cool, with highs in the mid-80s. Winter temperatures are low, with minimum readings of 0 F or below for an average of 10 days/year. Rapid daytime warming to above freezing is typical during the winter.

Table 2.7-2 presents monthly and annual precipitation, including snowfall, data for the area. The mean annual precipitation is 10.7 inches, with 43% of the annual moisture falling during the period of July through September. Most of this summer moisture falls during brief but occasionally heavy, summer thunderstorms. Extended rains or cloudy periods are uncommon. Much of the winter precipitation falls as snow, with snowfall depths commonly 4 to 6 inches.

Relative humidity data are not available for the Gallup area. The U.S. Weather Bureau estimates that because of the lower temperatures associated with the elevation of the area, relative

(a) Department of Commerce, 1972.

TABLE 2.7-1 MEAN AND EXTREME TEMPERATURES GALLUP, NEW MEXICO (1938-1960) (a)

Month	Temperature (°F) — Means: Daily Max.	Means: Daily Min.	Means: Mo.	Extremes: Record High	Year	Record Low	Year	Mean number of days — Temperatures — Max.: 90° & above	Max.: 32° & below	Min.: 32° & below	Min.: 0° & below
Jan	42.7	13.9	28.6	65	1954+	-18	1955+	0	3	31	4
Feb	46.2	17.5	32.1	69	1957	-23	1951	0	2	27	2
Mar	52.6	22.9	37.9	75	1946	- 6	1948	0	1	28	*
Apr	63.3	31.0	46.9	83	1943	8	1945	0	0	19	0
May	72.9	37.6	55.2	95	1946	15	1953	*	0	7	0
June	83.3	45.6	64.5	99	1956	24	1950	7	0	1	0
July	87.2	52.9	70.0	99	1958	36	1949	11	0	0	0
Aug	84.4	52.6	68.2	97	1954	26	1948	5	0	0	0
Sept	79.2	44.9	62.0	99	1950	14	1950	1	0	1	0
Oct	67.2	33.5	50.4	87	1953	12	1949	0	0	15	0
Nov	53.3	19.9	36.4	73	1953+	-15	1952	0	1	28	1
Dec	45.6	14.5	29.9	65	1949+	-17	1945	0	3	30	3
Year	64.8 (b)	32.2 (b)	48.5 (b)	99	July 1958+	-23	Feb 1951	24	10	187	10

*Less than 0.5 day but greater than 0 day.
+Also in earlier years.
(a) Department of Commerce, 1972.
(b) average

TABLE 2.7-2 PRECIPITATION, GALLUP, NEW MEXICO[a]
(1938-1960)

Month	Precipitation Totals (Inches) Mean	Greatest Daily	Year	Snow, Sleet Mean	Max. Mo.	Year	Greatest Daily	Year	Mean No. of Days Precipitation Equals or Exceeds 0.1 Inch
Jan	0.64	0.62	1952	5.7	12.0	1960	6.0	1945	3
Feb	0.69	0.93	1948	5.7	15.0	1939	8.0	1942	2
Mar	0.78	1.09	1954	5.9	17.8	1945	5.0	1945+	3
Apr	0.65	0.83	1952	2.1	9.5	1945	5.0	1945	2
May	0.55	0.60	1954	0.3	3.0	1944	3.0	1944	2
June	0.46	0.94	1952	0	0	--	0	--	1
July	1.74	1.90	1954	0	0	--	0	--	4
Aug	1.81	1.27	1947	0	0	--	0	--	5
Sept	1.05	1.64	1941	T	T	1945	T	1945	3
Oct	1.00	1.50	1941	T	T	1959+	T	1959+	3
Nov	0.51	0.60	1940	2.2	16.5	1952	5.0	1952	2
Dec	0.77	0.75	1955	6.8	15.5	1941	8.0	1955	3
Year	10.65	1.90	July 1954	28.7	17.8	Mar 1945	8.0	Dec 1955+	33

T Trace, an amount too small to measure

\+ Also in earlier years

(a) Department of Commerce, 1972.

humidity at the proposed mill site should be higher than the relative humidity which occurs in the lower desert regions. The average annual relative humidity for the site is estimated to be 55%, based on U.S. Weather Bureau data. Diurnal variations are expected to range from 70% in early mornings to 30% later in the day.

Wind Speed and Direction

Wind speed and direction measurements for Gallup, obtained from the National Climatic Center in Ashville, North Carolina, were available only for January 1973 through February 1974. Table 2.7-3 and Figure 2.7-1 summarize the annual frequency distributions for these data. Wind records prior to January 1973 are not available for Gallup. Average monthly frequency distributions of wind speed and direction are presented in Figure 2.7-2. Based on these data, the surface wind speeds in the area are generally moderate, averaging 6.9 mph. Wind speeds are greatest in the spring, averaging 9.1 mph in April and least in winter, averaging 5.3 mph in January. The maximum wind speeds reported during this period were approximately 35 mph, gusting to 46 mph. The most frequent winds are southwesterly through westerly, with a total frequency of 48%. The available data are not sufficient to summarize monthly and annual Pasquill stability classes.

Severe Weather

Prolonged rains or cloudy periods are rare. However, summer cloudbursts can produce excessive runoff and local flash flooding in the rough, sparsely vegetated terrain. During the summer, hail is occasionally associated with thundershowers. No tornado has ever been reported in the Gallup area.

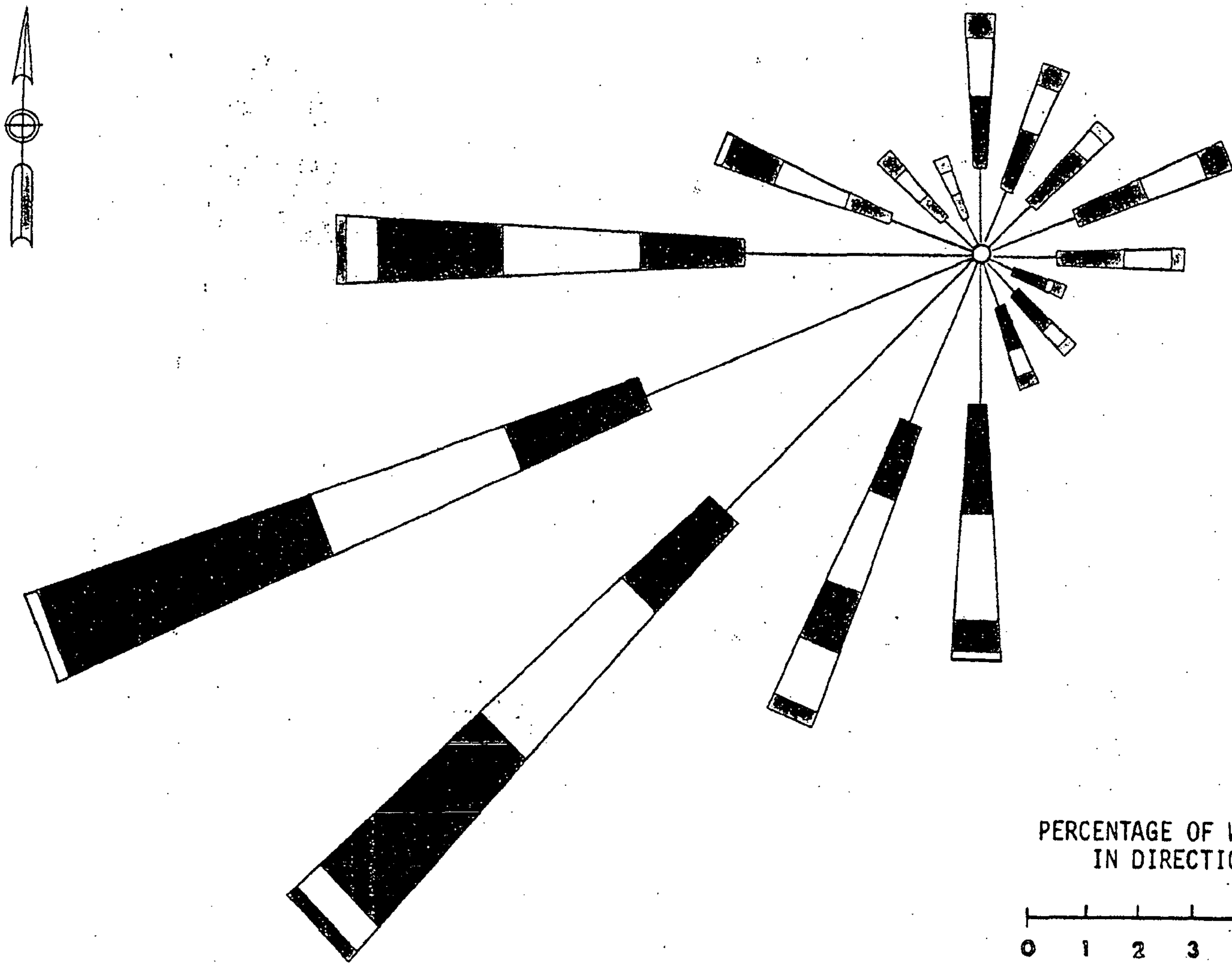
Most winter storms are not accompanied by excessive wind; thus, heavy drifting or blizzard conditions rarely occur. Temperature extremes are presented in Table 2.7-1.

Local Meteorology

A mechanical weather station has been installed at Applicant's proposed mill site and has been recording meteorological data since May 1975. These on-site wind data indicate that prevailing winds are southwesterly through westerly and are in agreement with the Gallup data.

TABLE 2.7-3 WIND DATA, GALLUP, NEW MEXICO, RELATIVE FREQUENCY DISTRIBUTION (%) FROM JANUARY 1973 TO SEPTEMBER 1974

Direction	0-3 mph	4-7 mph	8-12 mph	13-18 mph	19-24 mph	Over 24 mph	Ave. mph
N	1.63	1.29	1.12	.39	.01	.00	5.6
NNE	1.32	1.23	.77	.30	.04	.00	5.4
NE	1.26	1.45	.61	.19	.01	.00	4.9
ENE	1.76	1.43	1.24	.40	.03	.00	5.5
E	1.41	1.25	.79	.31	.06	.01	5.4
ESE	.61	.70	.21	.16	.01	.01	5.3
SE	.93	.88	.41	.15	.01	.00	4.9
SSE	.90	.87	.51	.21	.02	.01	5.6
S	2.66	1.97	2.00	.62	.11	.01	5.9
SSW	3.26	1.57	2.84	1.12	.24	.06	6.8
SW	6.16	2.15	3.58	4.12	1.03	.17	8.2
WSW	6.65	2.61	3.85	3.96	1.37	.22	8.2
W	4.28	1.87	2.58	2.39	.59	.09	7.6
WNW	1.83	.84	1.32	1.03	.12	.01	7.1
NW	.87	.54	.55	.46	.03	.00	6.7
NNW	.72	.48	.50	.22	.02	.00	6.0
						Average	6.2



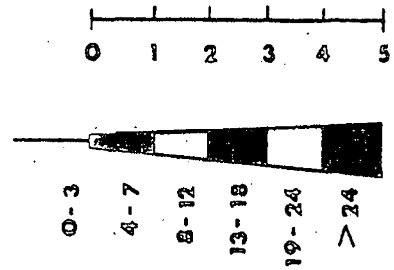


FIGURE 2.7-1

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE ANNUAL CONDITIONS

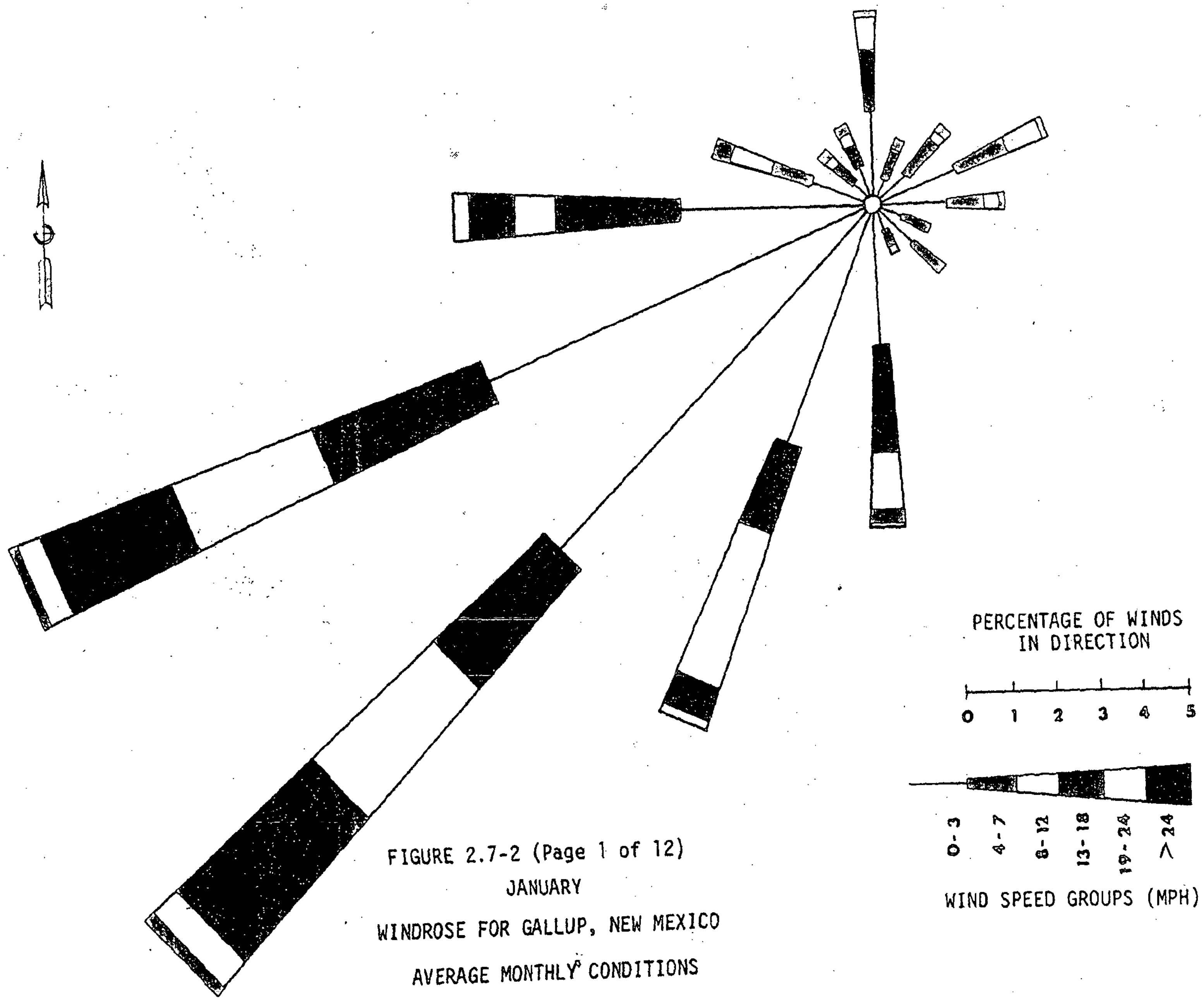


FIGURE 2.7-2 (Page 1 of 12)
JANUARY
WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS

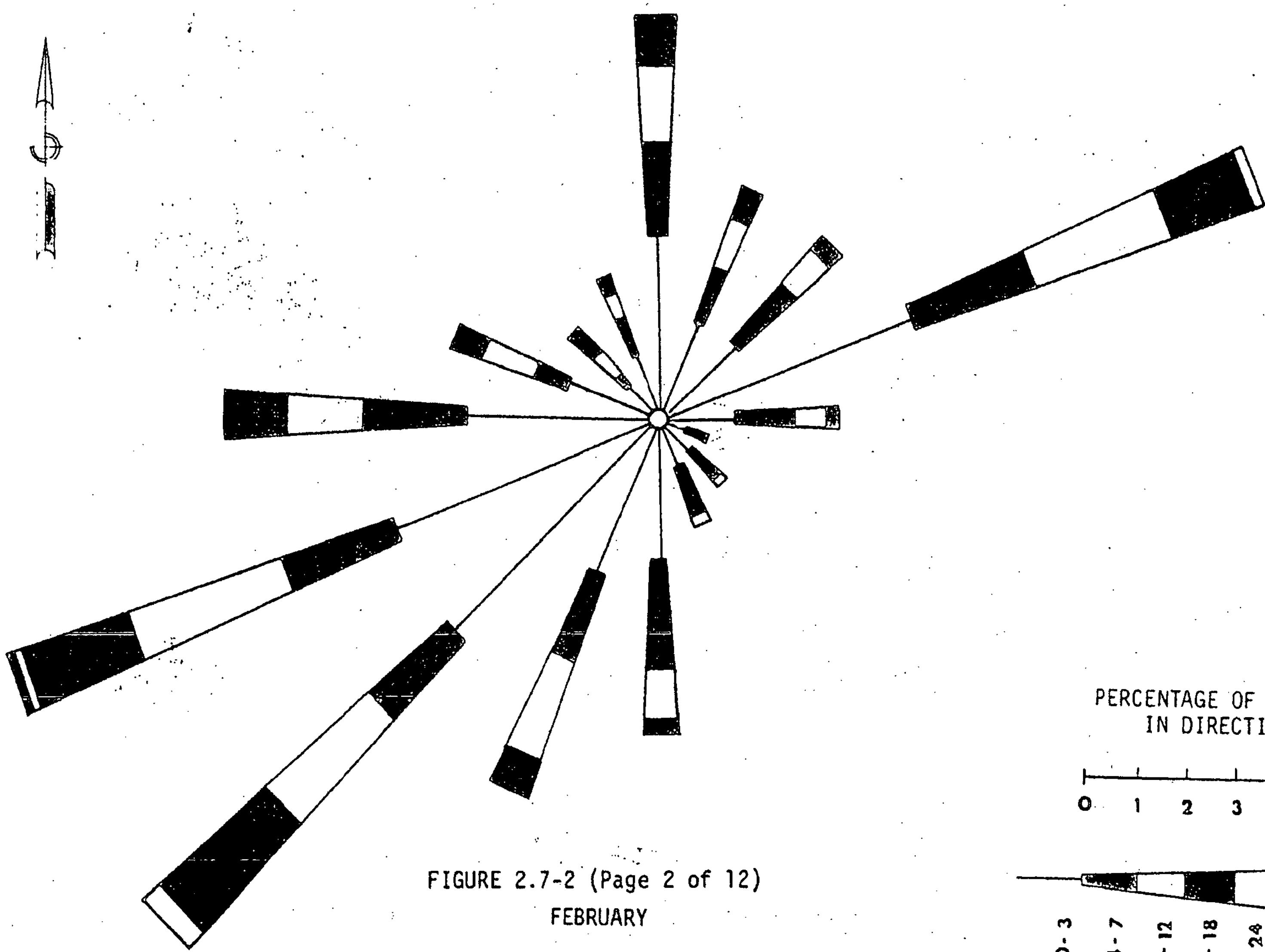


FIGURE 2.7-2 (Page 2 of 12)
FEBRUARY

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS

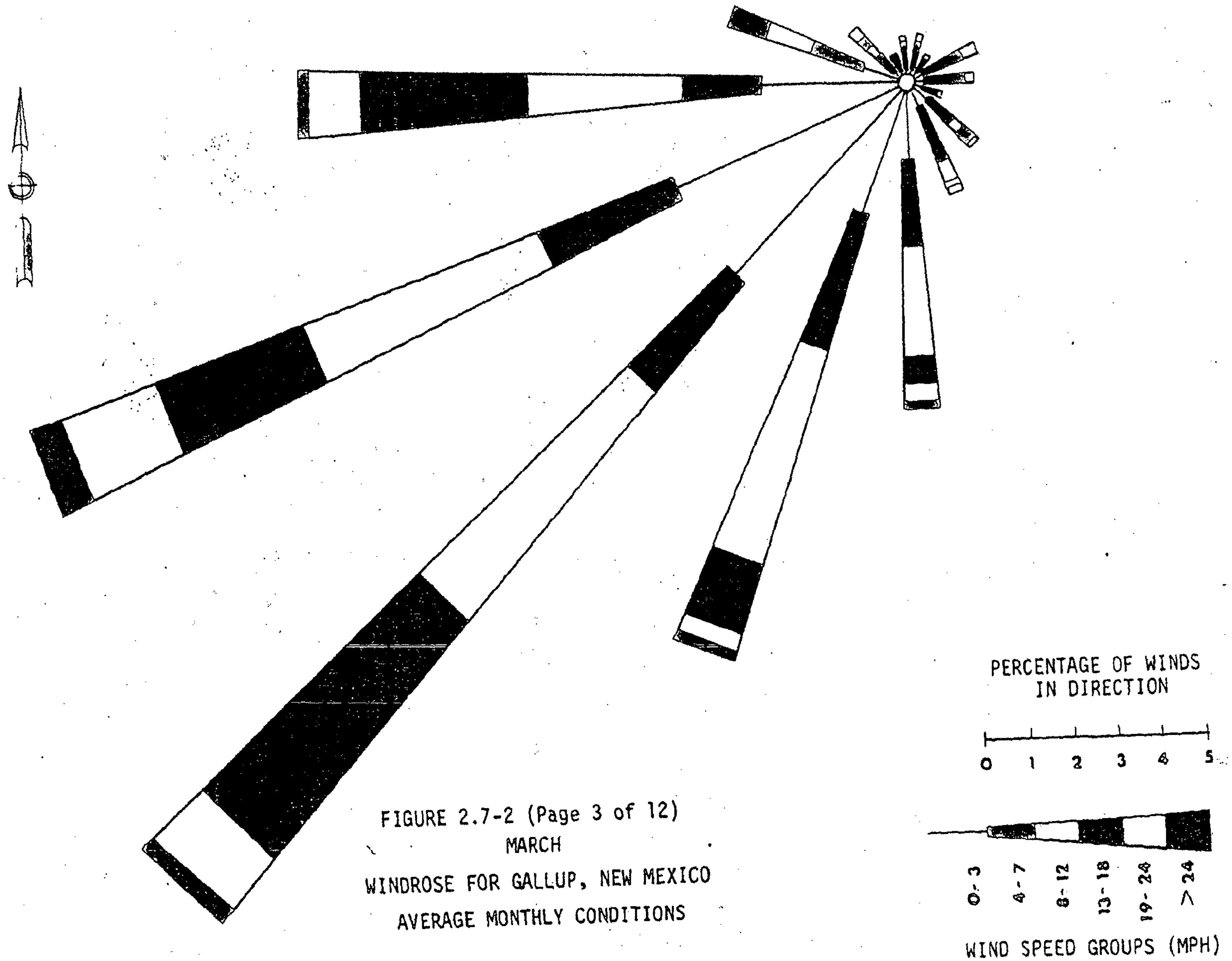


FIGURE 2.7-2 (Page 3 of 12)
MARCH
WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS

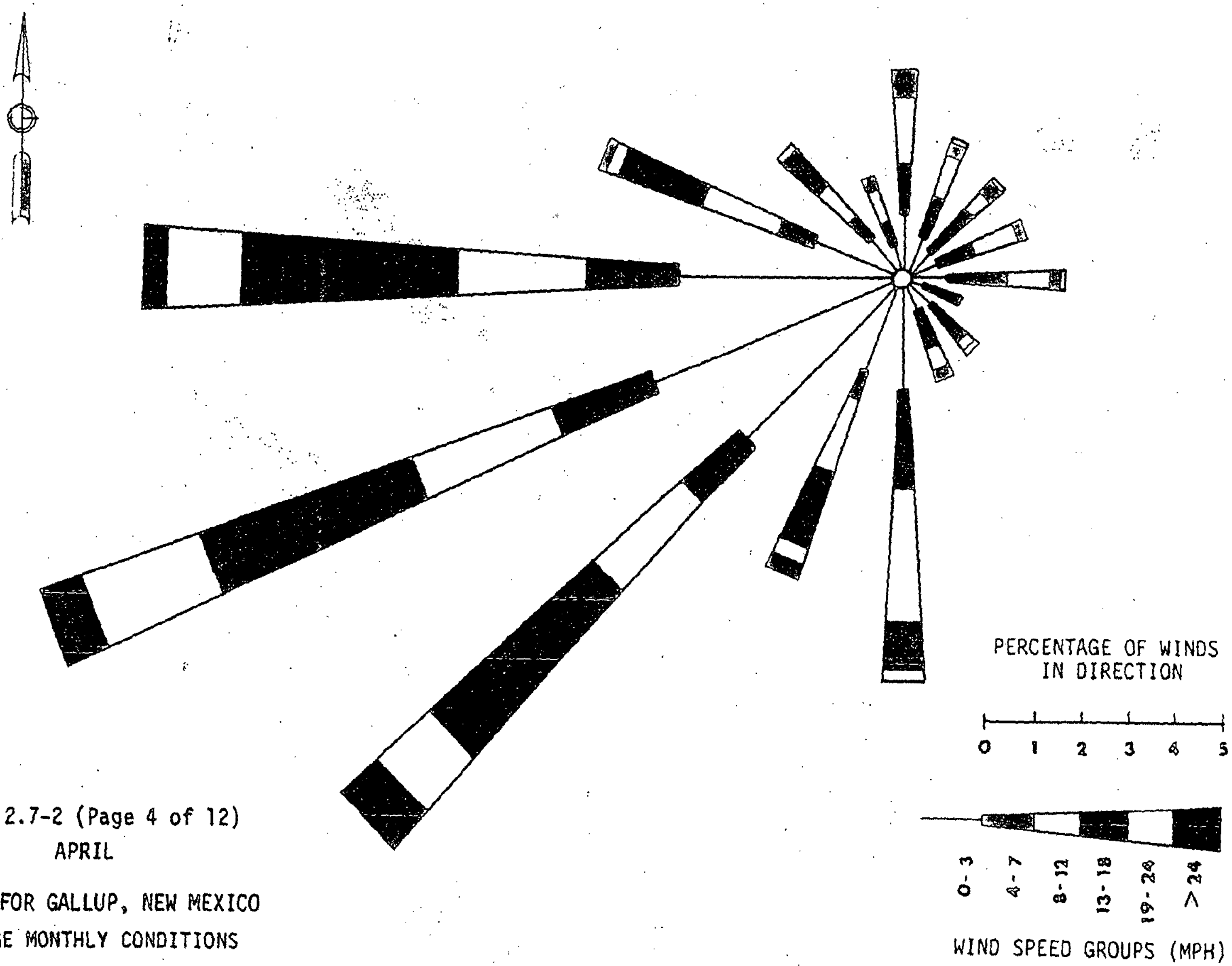


FIGURE 2.7-2 (Page 4 of 12)
APRIL

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS

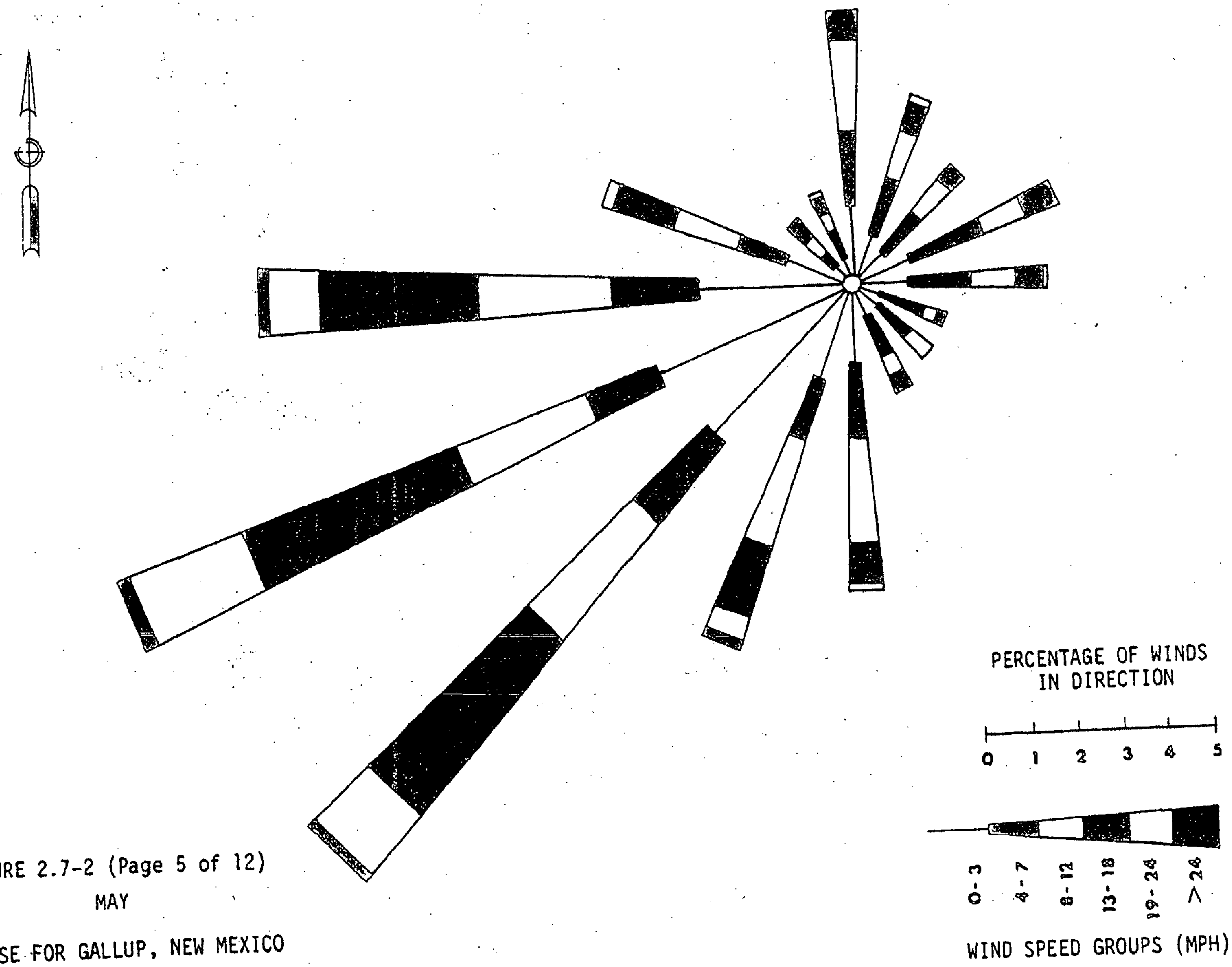
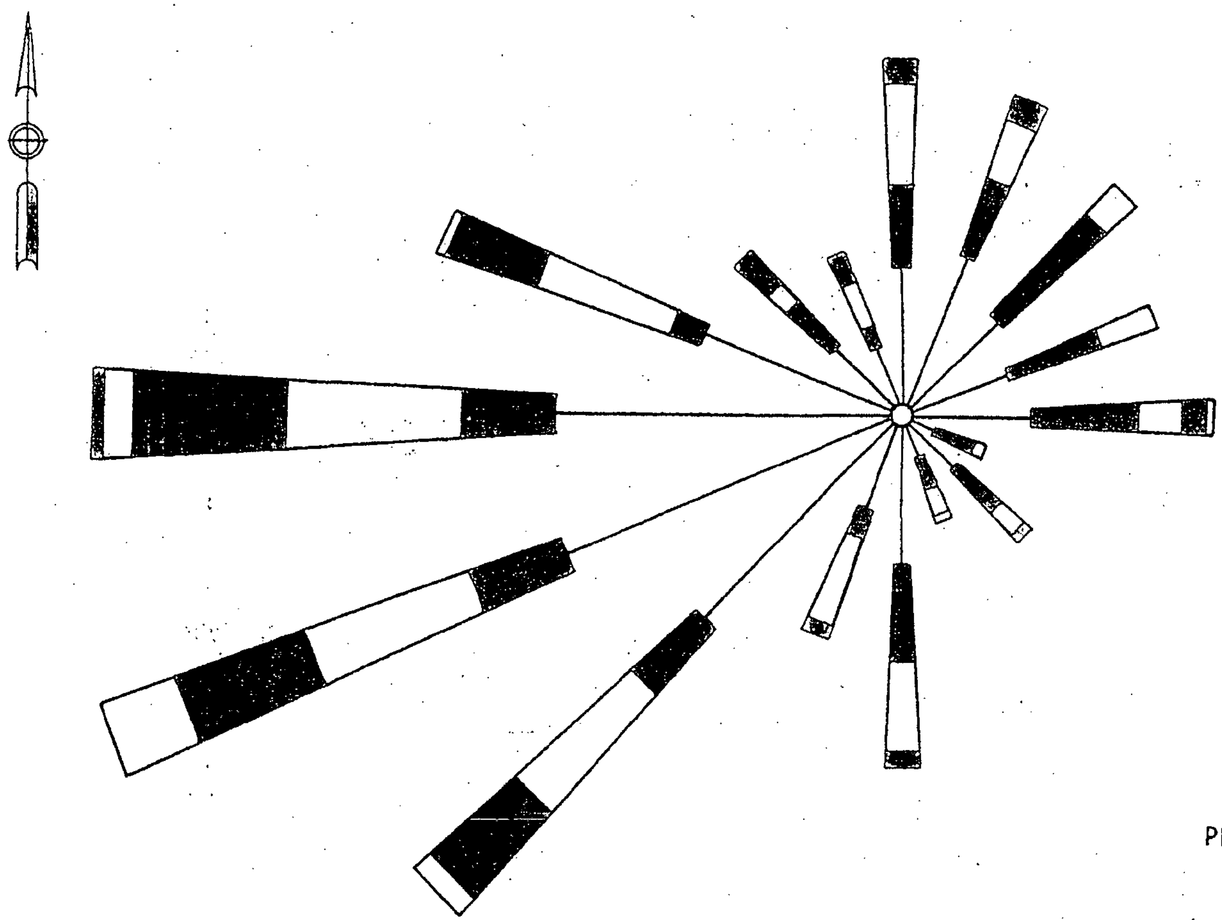


FIGURE 2.7-2 (Page 5 of 12)
MAY

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS



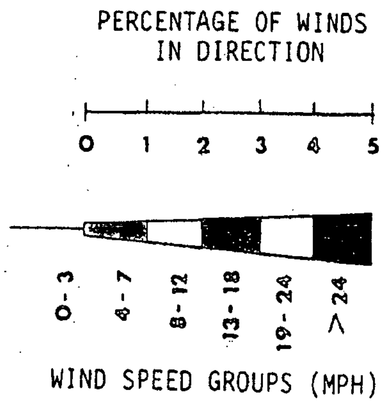
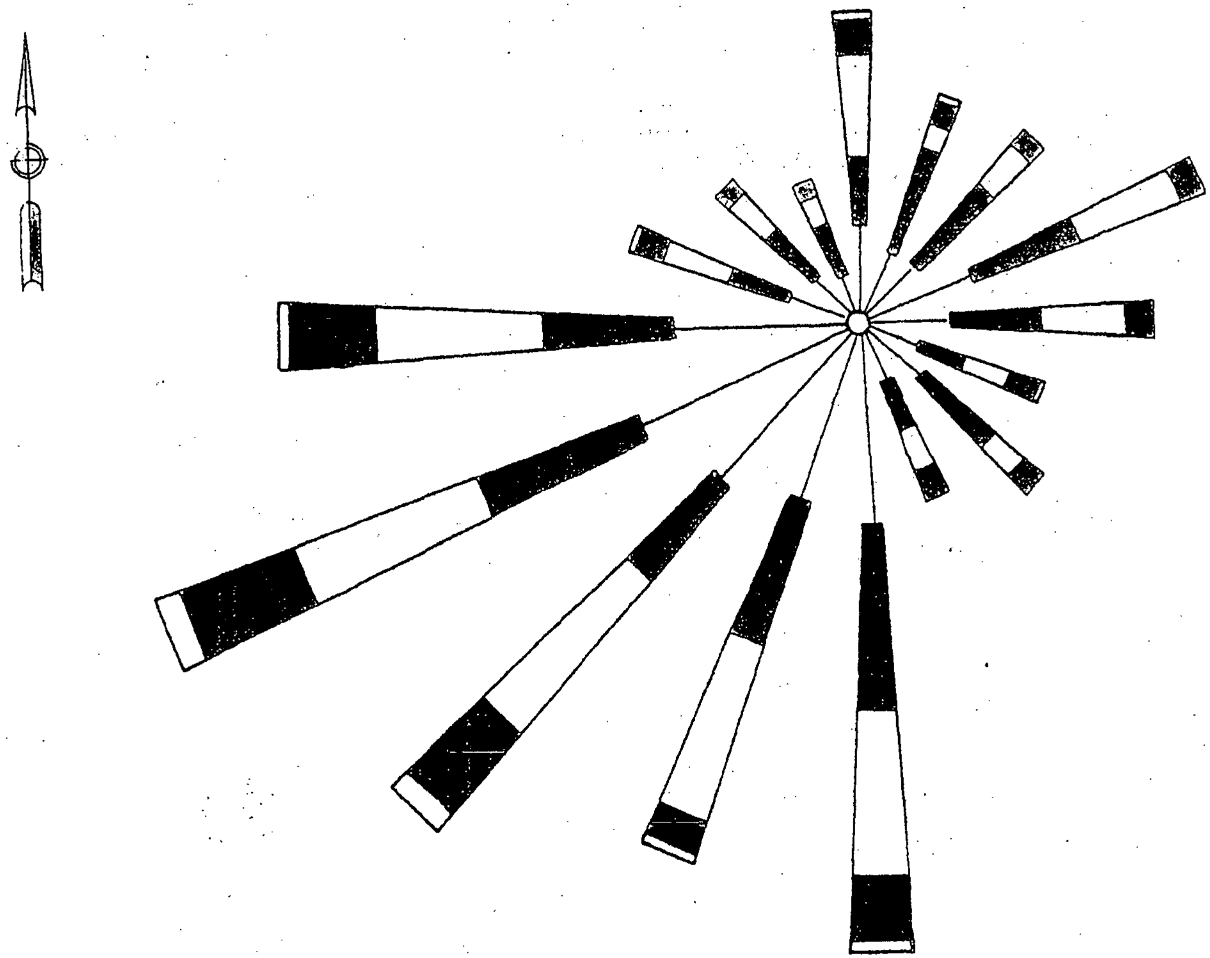


FIGURE 2.7-2 (Page 6 of 12)
JUNE

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS



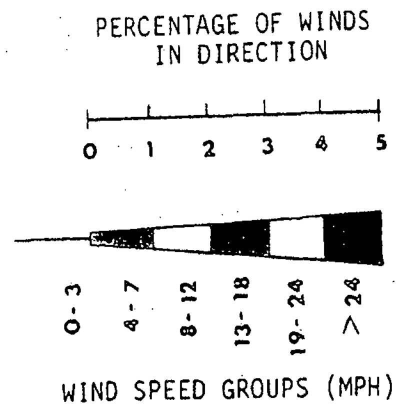
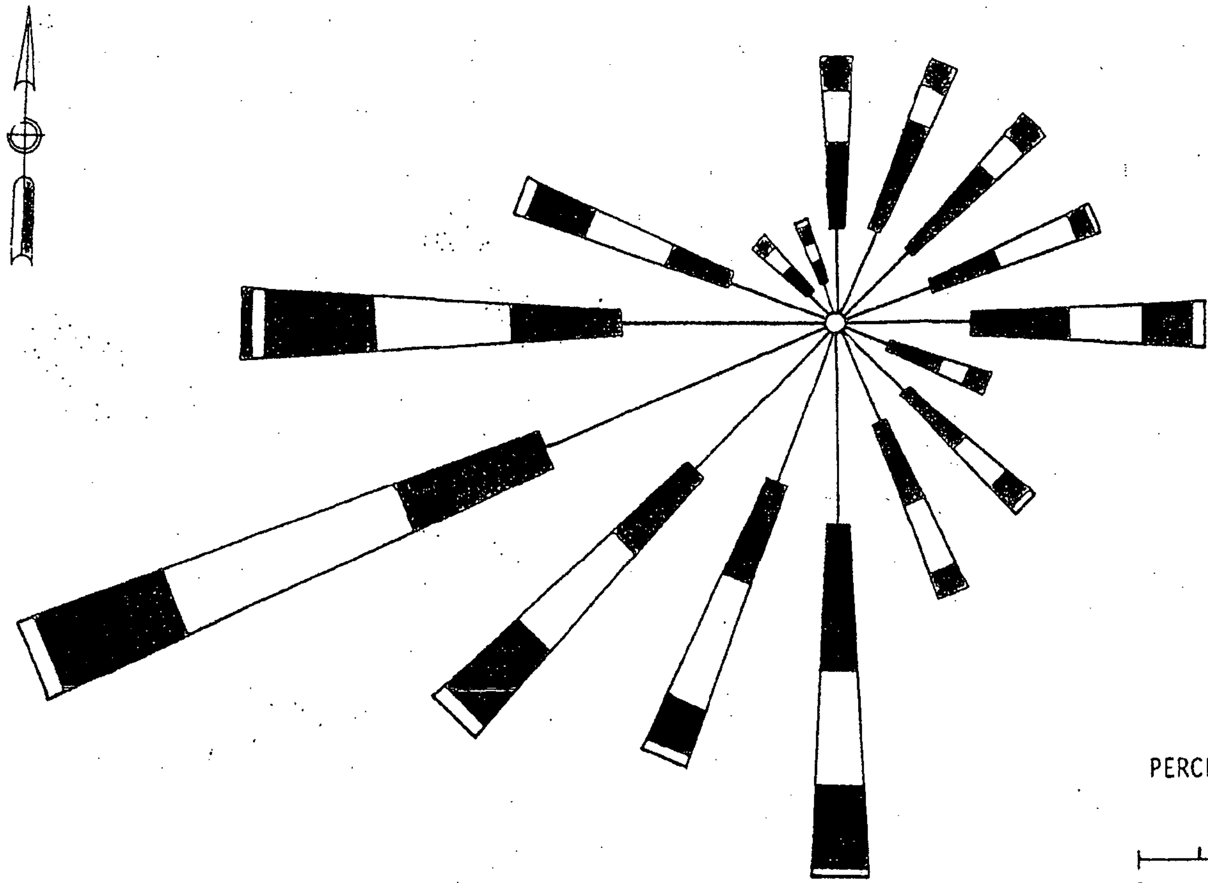


FIGURE 2.7-2 (Page 7 of 12)

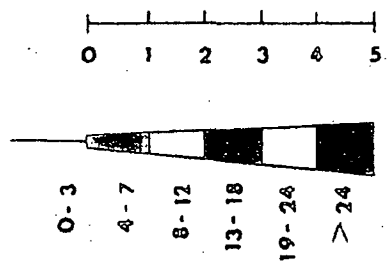
JULY

WINDROSE FOR GALLUP, NEW MEXICO

AVERAGE MONTHLY CONDITIONS



PERCENTAGE OF WINDS IN DIRECTION

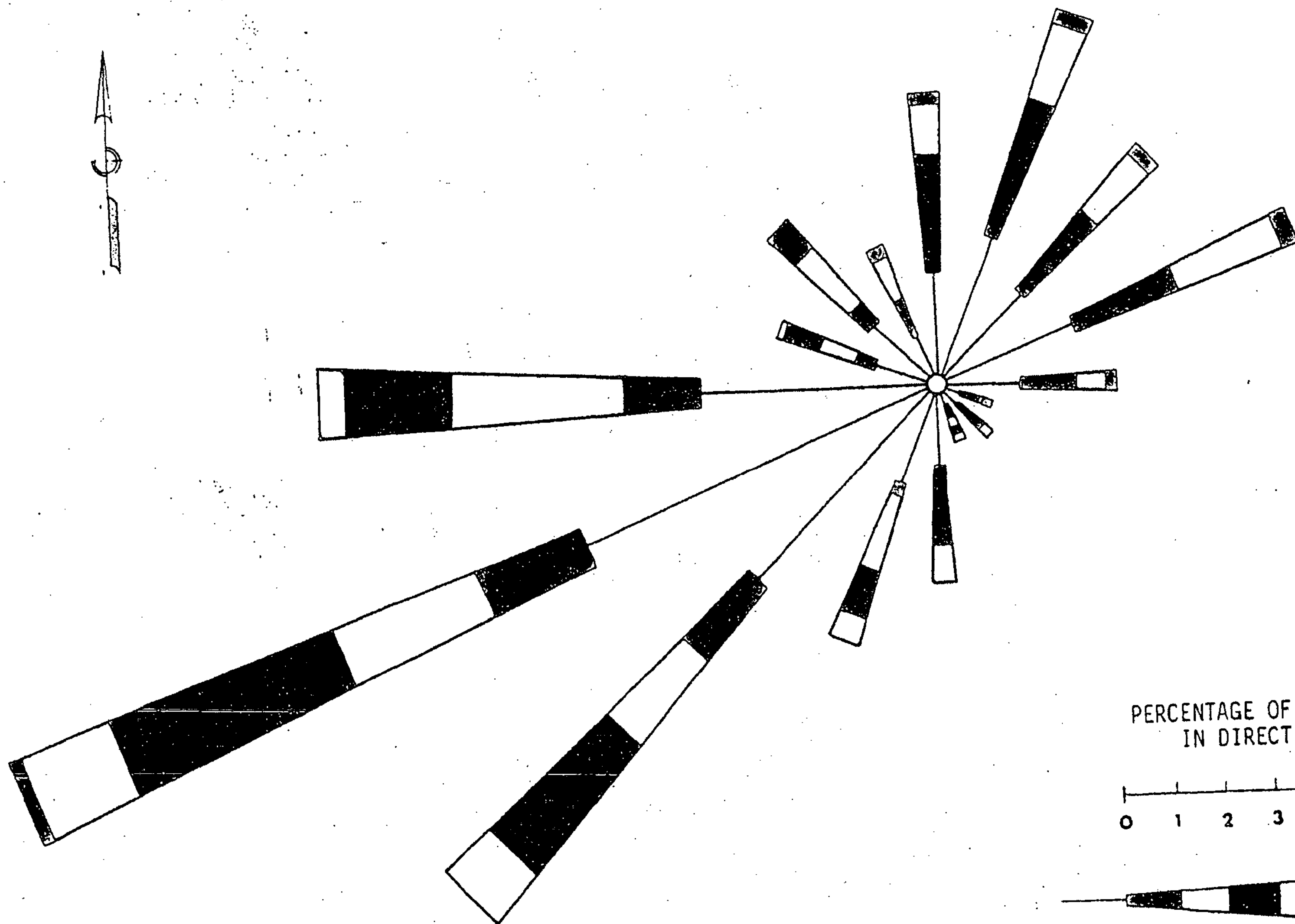


WIND SPEED GROUPS (MPH)

FIGURE 2.7-2 (Page 8 of 12)

AUGUST

WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS



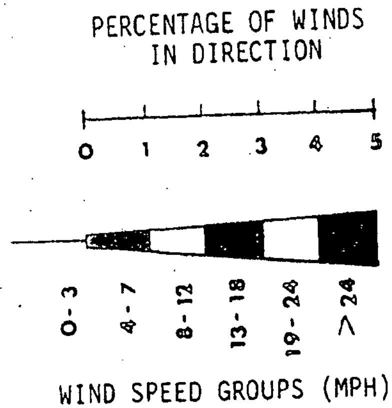


FIGURE 2.7-2 (Page 9 of 12)
SEPTEMBER
WINDROSE FOR GALLUP, NEW MEXICO
AVERAGE MONTHLY CONDITIONS

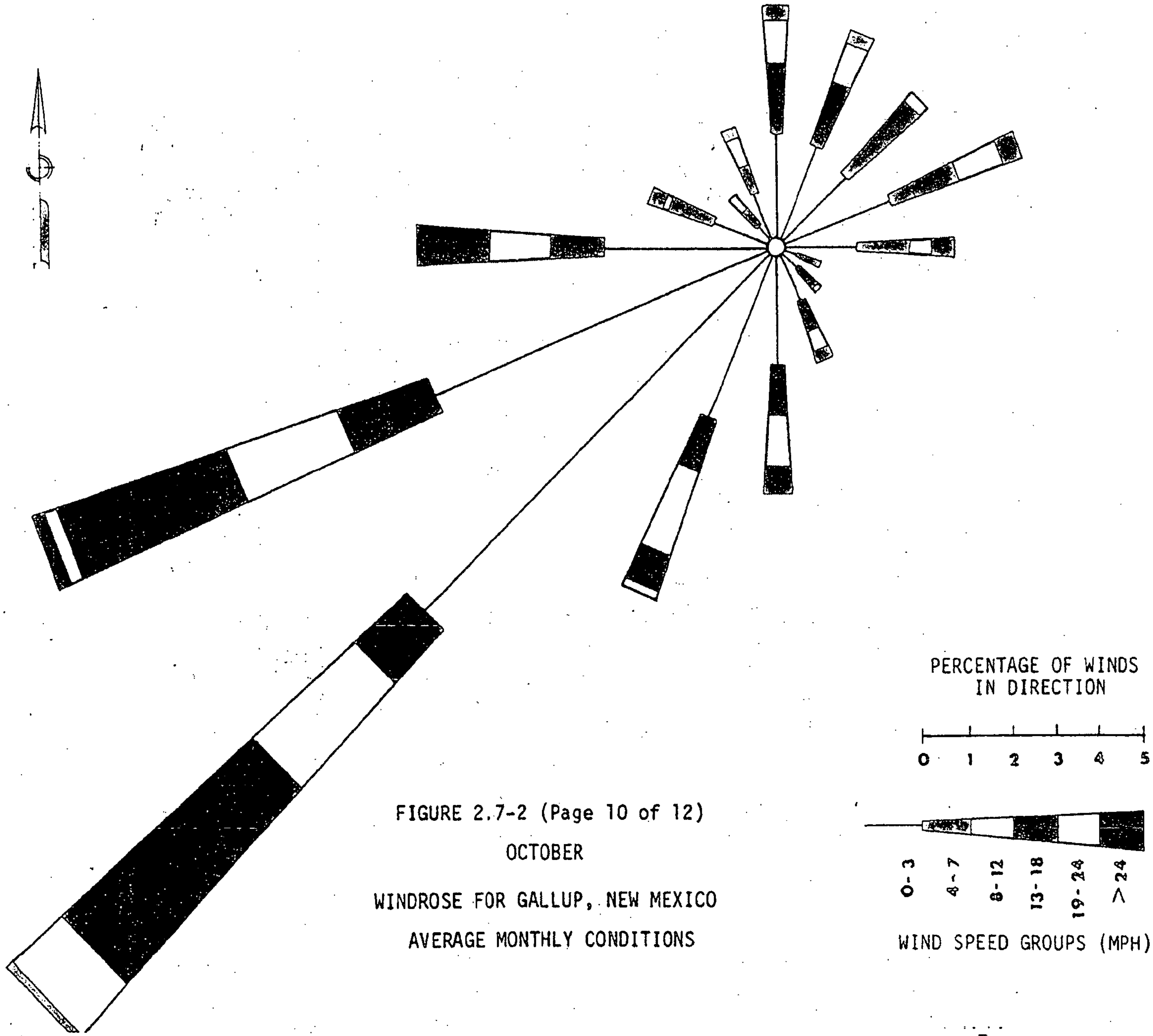


FIGURE 2.7-2 (Page 10 of 12)

OCTOBER

WINDROSE FOR GALLUP, NEW MEXICO

AVERAGE MONTHLY CONDITIONS

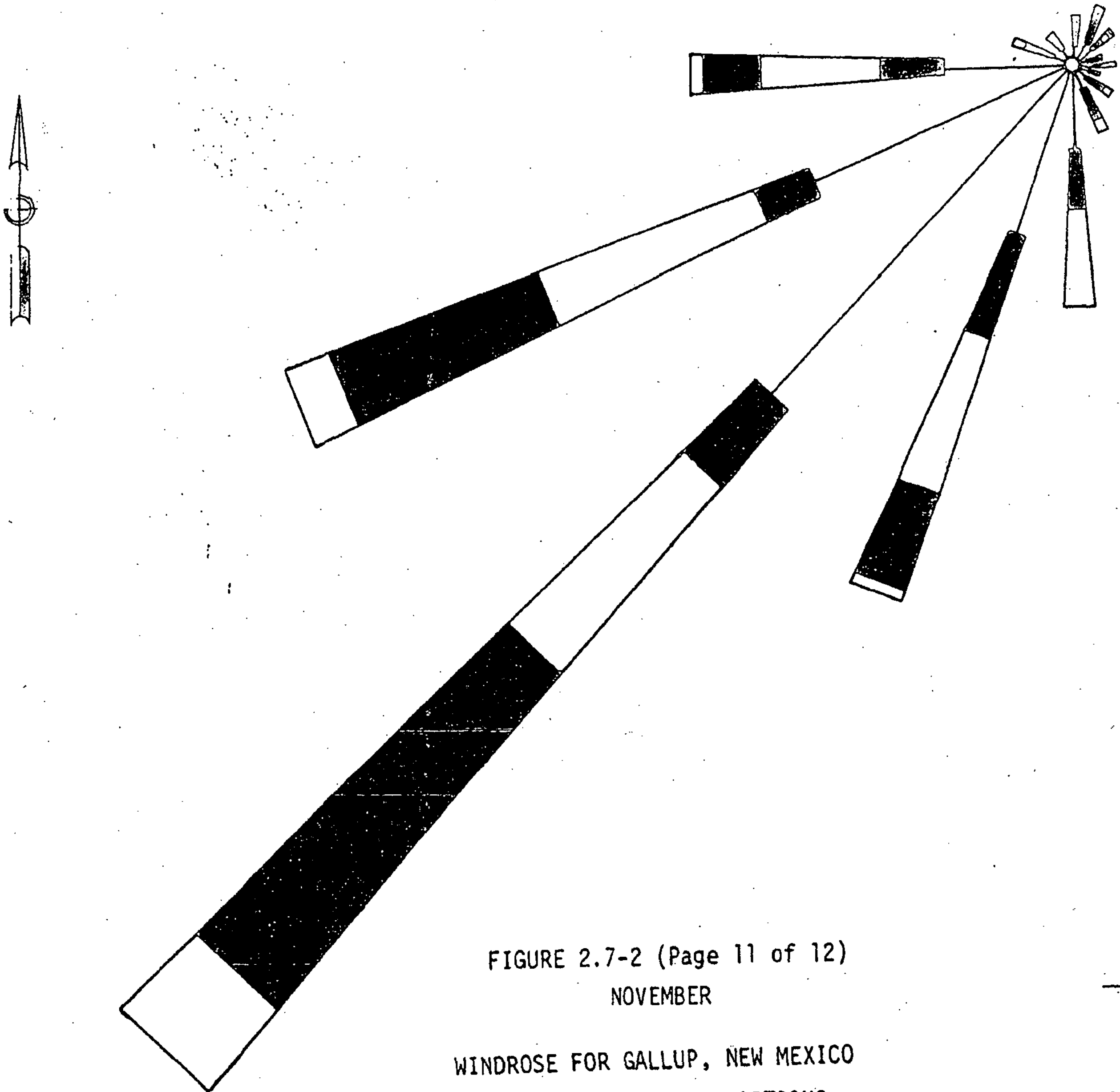
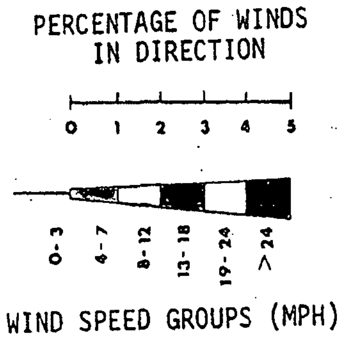


FIGURE 2.7-2 (Page 11 of 12)

NOVEMBER

WINDROSE FOR GALLUP, NEW MEXICO

AVERAGE MONTHLY CONDITIONS



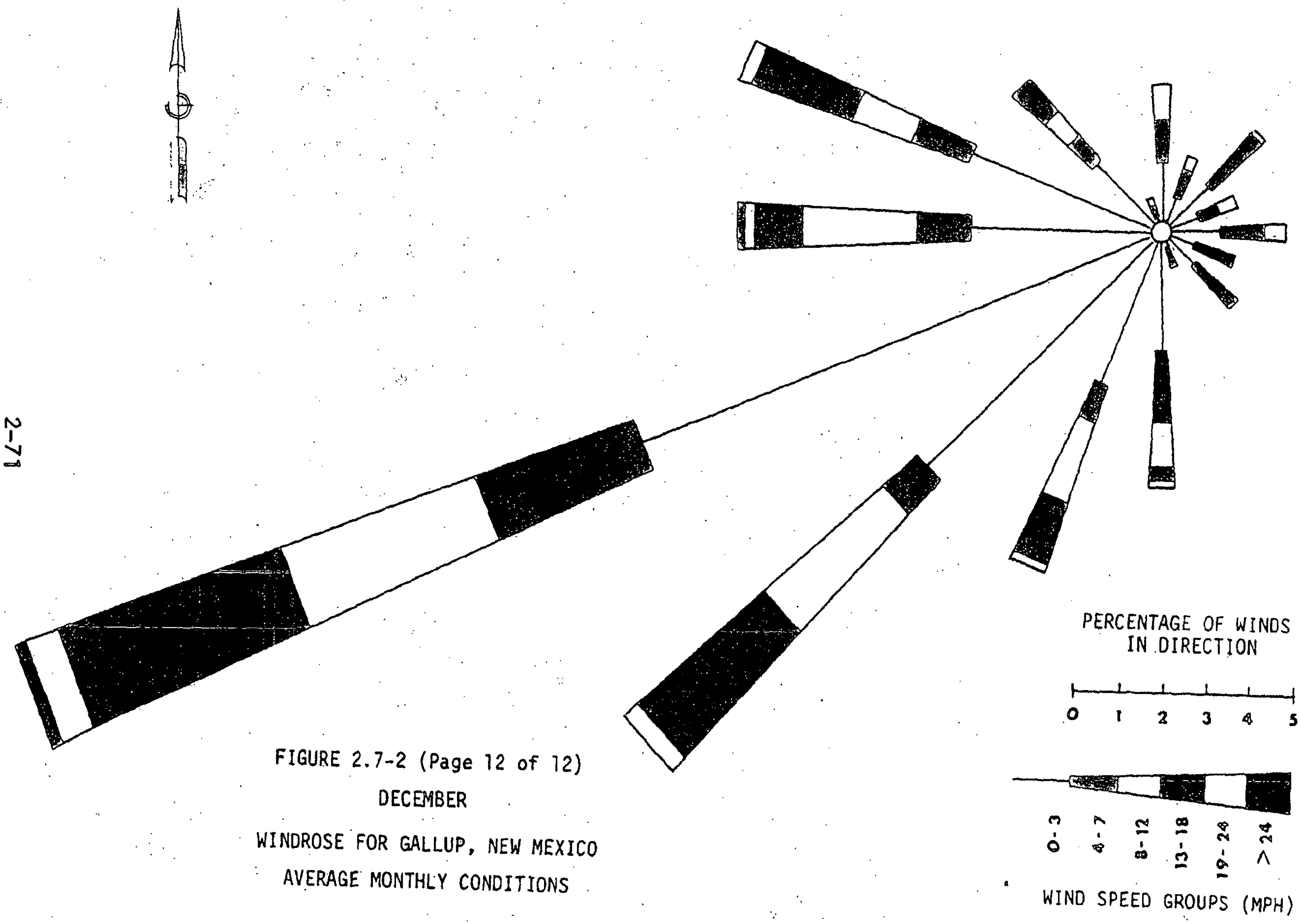


FIGURE 2.7-2 (Page 12 of 12)

DECEMBER

WINDROSE FOR GALLUP, NEW MEXICO

AVERAGE MONTHLY CONDITIONS

2.8 ECOLOGY

Site Description

The proposed mill site is located on sparsely populated, semiarid land. Applicant's mine has been operating near the mill site for 6 years, and the potential stresses that may be imposed by the mine on the region's ecology are included in the survey of the region's ecology. The survey was conducted during the summer 1974 and provides a baseline upon which potential environmental stresses imposed on the region's ecology by construction and operation of the proposed mill can be evaluated.

Two major soil associations are found in the area. First, the Rock Land - Travessilla association, on approximately two-thirds of the area, is characterized by steep canyon walls and escarpments with sloping fans and valley floors below the canyon walls and escarpments. Second, the Lohmiller - San Mateo association comprises the central portion of the area and is characterized by level to very gently sloping flood plains and swales.

Vegetation

Vegetation was sampled using line-point sampling for aerial cover[a] and botanical composition.[b] A total of 24 sampling locations were selected in the three major vegetation areas as described below: alluvial valley and plains, 10 locations; sagebrush-grassland, 5 locations; pinyon-juniper, 9 locations. Figure 2.8-1 is a map of the vegetation areas.

Alluvial valley and plains: Vegetation on the alluvial valley and plains area is dominated by grasses. See Table 2.8-1. Blue grama (Bouteloua gracilis) and sand dropseed (Sporobolus cryptandrus) equally dominate the area, with western wheatgrass (Agropyron smithii) prevailing in a few locations. See Table 2.8-2. Perennial vegetative cover is relatively low, but varies from areas void of plants, i.e. flooded areas, to areas having nearly 100% cover, such as an area covered by red muhly (Muhlenbergia repens). Annual forbs are common in this area and Russian thistle (Salsola kali) is the most abundant. In some parts of the plains area broom snakeweed (Gutierrezia sarathrae) dominates, and rubber rabbitbrush (Chrysothamnus nauseosus) is common.

(a) Heady, et al, 1959.
(b) Owensby, 1973.

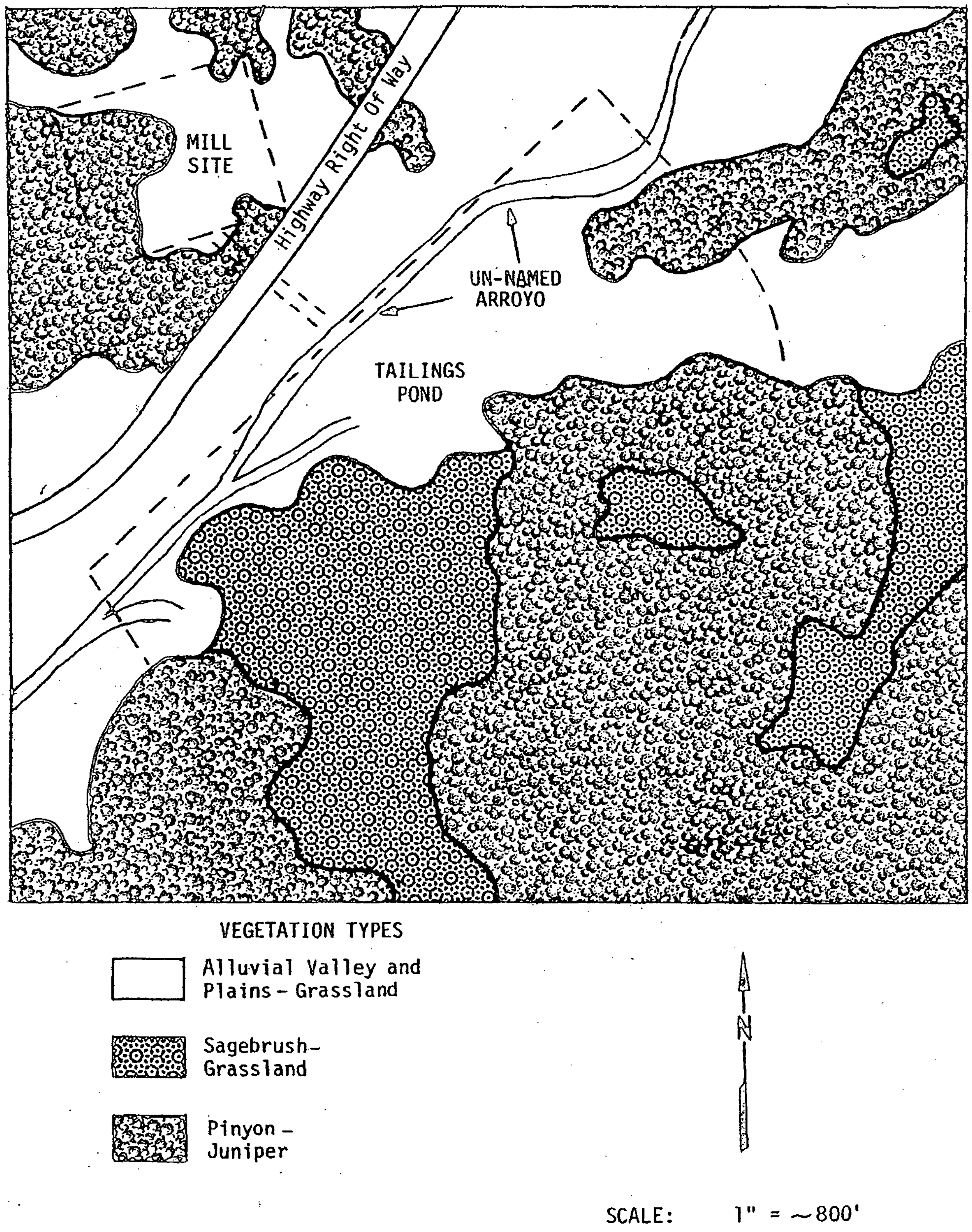


FIGURE 2.8-1 VEGETATION TYPES ON THE APPLICANT'S PROPERTY

TABLE 2.8-1

SUMMARY OF PLANT COMPOSITION
AND AERIAL COVER OF PERENNIAL VEGETATION

	Vegetation Types					
	Alluvial Valley and Plains		Sagebrush-Grassland		Pinyon-Juniper	
	% Comp	% Cover	% Comp	% Cover	% Comp	% Cover
Understory						
Grass	82.3	17.1	50.2	9.6	39.0	4.2
Forbs	0.0	0.0	3.6	0.0	35.6	0.0
Shrubs	16.7	3.7	46.2	17.0	24.5	3.9
Total[(a)]	99.0	20.8	100.0	26.6	99.1	8.1
Overstory						
Oneseed juniper						3.9
Pinyon pine				1.2		11.5
Total				1.2		15.4

(a) Percent composition may not add to 100 due to rounding errors.

TABLE 2.8-2 (Page 1 of 3)

PLANT COMPOSITION AND AERIAL COVER ON ALLUVIAL VALLEY AND PLAINS, SAGEBRUSH-GRASSLAND AND PINYON-JUNIPER AREAS

Common Names	Alluvial valley and plains % Comp.	Alluvial valley and plains % Cover	Sagebrush-grassland % Comp.	Sagebrush-grassland % Cover	Pinyon-juniper % Comp.	Pinyon-juniper % Cover
Grasses						
Blue grama	35.5	9.9	31.4	8.2	20.8	2.8
Bottlebrush squirreltail	0.1		0.4		0.1	
Bristlegrass	X[(a)]					
False buffalograss	1.8	0.5				
Fescue			0.4		0.4	
Foxtail barley	X					
Galleta	0.1		0.8		10.1	1.2
Indian ricegrass	0.4		4.6		6.0	0.1
Inland saltgrass	0.7	0.5				
Muhly						0.1
Needle and thread			X			
Red muhly	X					
Sand dropseed	37.8	5.7	2.8	0.4	1.5	0.1
Sixweeks grama	X					
Subalpine needlegrass			X			
Western wheatgrass	5.9	0.5	9.8	1.0	X	
Total grasses	82.3	17.1	50.2	9.6	38.9	4.3
Forbs						
Aster					0.8	
Aster, babywhite			3.6		10.0	
Annual bursage	X					
Bladderpod			X			
Cholla					X	
Common dandelion	X					
Common ragweed	X					
Deer's tongue					2.5	
Desert baileya	X					
Eaton penstemon			X			
Fireweed summer cypress	X					
Fleabane	X					
Fleabane horseweed	X					
Four-o'clock					0.1	
Gianthyssop			X			
Gilia					4.5	
Globemallow	X					

Common Names	Alluvial valley and plains % Comp.	Alluvial valley and plains % Cover	Sagebrush-grassland % Comp.	Sagebrush-grassland % Cover	Pinyon-juniper % Comp.	Pinyon-juniper % Cover
Forbs (continued)						
Globemallow, scarlet					X	
Gumweed	X					
Hedgehog cactus					X	
King lupine					X	
Lambsquarter	X					
Lemonweed	X					
Mammillaria	X					
Mentzelia					0.4	
Milkvetch, grandcover			X			
Milkvetch, Rusby					0.9	
Pingue			X		10.6	
Prickly pear	X		X			
Purslane	X		X			
Redroot pigweed	X					
Rockymountain beeplant	X		X			
Russian thistle	X		X			
Salsify					X	
Sand verbena	X					
Silverlead nighshade	X					
Thistle	X					
White margin spurge					X	
White prairie clover			X		X	
Wholeleaf Indian paintbrush			X		X	
Wild buckwheat						
Wild buckwheat, James			X		3.1	
Wild lettuce	X				X	
Wild potato			X			
Wright deervetch					X	
Yucca, datil					X	
Yucca, soaptree					0.3	
Total forbs			3.6		33.2	

TABLE 2.8-2 (Page 3 of 3)

Common Names	Alluvial valley and plains % Comp.	Alluvial valley and plains % Cover	Sagebrush-grassland % Comp.	Sagebrush-grassland % Cover	Pinyon-juniper % Comp.	Pinyon-juniper % Cover
Shrubs						
Big sagebrush	0.8	0.1	28.8	13.6	4.7	1.9
Black sagebrush			X		X	
Broom snakeweed	13.8	2.5	16.2	3.0	12.7	1.4
Condalia	X				X	
Fourwing saltbush	0.2	0.2	0.2	0.2		
Fringed sagewort	X		0.6		6.3	0.4
Gambel oak					X	
Gray horsebrush			X		X	
Mexican cliffrose					0.2	
Mountain mahogany					0.1	
Rubber rabbitbrush	1.6	0.9	0.2	0.2	0.2	0.1
Threadleaf groundsel			X			
Whitethorn acacia					X	
Wild buckwheat			X			
Winterfat	0.3		0.2		X	
Wright sagewort					0.3	0.1
Total shrubs	16.7	3.7	46.2	17.0	24.5	3.9
Trees						
Oneseed juniper			X			3.9
Pinyon pine				1.2		11.5
Ponderosa pine	X				X	
Total trees				1.2		15.4

(a) An "X" means the species were found growing in the vegetational area, but was not recorded on any transect. Generally these species are not common.

Sagebrush-grassland: Over one-half of the plant composition in this area is grass, with an aerial cover of less than 10%. See Table 2.8-1. Shrubs dominate the vegetative aspect and have 17% aerial cover. The most abundant shrub is big sagebrush (*Artemisia tridentata*), which is often found associated with broom snakeweed. Blue grama is common in the area, and western wheatgrass is occasionally found. Trees are relatively uncommon in this area; however, there is some invasion of pinyon pine (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*) into the upper slopes of the sagebrush-grassland.

Pinyon-juniper: Of the three vegetation areas studies, this area had the least understory cover. See Table 2.8-1. The trees which dominate the area have over 15% aerial cover. Ground cover varies from sparse to fairly dense cover in which broom snakeweed and sages are common. However, in some parts there is only bare ground and rocks under the trees. The grasses, the most common understory plants, are dominated by blue grama and galleta (*Hilaria jamesii*) over much of the area, with Indian ricegrass (*Oryzopsis hymenoides*) existing in part of the area. Forbs comprise over one-third of the botanical composition but contribute very little to the aerial cover. Pingue (*Hymenoxys richardsoni*) and babywhite aster (*Aster leucelene*) each contribute 10% or more to the total understory composition. Gilia (*Gilia sp.*) and James wild buckwheat (*Eriogonum jamesii*) are also found in parts of the pinyon-juniper area.

A listing by scientific name of all species found is presented in Table 2.8-3.

An estimate of grazing capacity[a] for the three vegetation areas is presented in Table 2.8-4. Excluding the highway right of way, the estimated grazing capacity is 4.5 animal unit years (AUY) for the area. An AUY is the 1 year forage requirement of a 1000 pound cow with calf. The low grazing capacity for this rainfall regime is due to the low vegetative productivity, caused by excessive livestock grazing in the past.

(a) Collier, et al, 1937; Gould, et al, 1972; Pickford, 1940.

TABLE 2.8-3 (Page 1 of 3)

PLANT SPECIES FOUND ON APPLICANT'S PROPERTY

Scientific name	Common name
Grasses	
Agropyron smithii	Western wheatgrass
Bouteloua barbata	Sixweeks grama
Bouteloua gracilis	Blue grama
Distichlis stricta	Inland saltgrass
Festuca sp.	Fescue
Hilaria jamesii	Galleta
Hordeum jubatum	Foxtail barley
Muhlenbergia repens	Red muhly
Muhlenbergia sp.	Muhly
Munroa squarrosa	False buffalograss
Oryzopsis hymenoides	Indian ricegrass
Setaria sp.	Bristlegrass
Sitanion hystrix	Bottlebrush squirreltail
Sporobolus cryptandrus	Sand dropseed
Stipa columbiana	Subalpine needlegrass
Stipa comata	Needle and thread
Forbs	
Abronia pumila	Sandverbena
Agastache sp.	Gianthyssop
Amaranthus retroflexus	Redroot pigweed
Ambrosia artemisiifolia	Common ragweed
Aster leucelene	Babywhite aster
Aster sp.	Aster
Astragalus humistratus	Groundcover milkvetch
Astragalus rusbyi	Rusby milkvetch
Baileya multiradiata	Desert baileya
Castelleja integra	Wholeleaf Indianpaintbrush
Chenopodium album	Lambsquarter
Cleome serrulata	Rocky mountain beeplant
Cirsium sp.	Thistle
Cryptantha crassisepala	Deer's tongue
Echino cactus	Hedgehog cactus
Erigeron canadensis	Horseweed Fleabane
Erigeron sp.	Fleabane
Eriogonum jamesii	James wild buckwheat
Eriogonum sp.	Wild buckwheat
Euphorbia albomarginata	Whitemargin spurge

Scientific name	Common name
Franseria acanthicarpa	Annual bursage
Gilia sp.	Gilia
Grindelia aphanactis	Gumweed
Hymenoxys richardsoni	Pingue
Kochia scoparia	Fireweed summercypress
Lactuca sp.	Wild lettuce
Lesquerella sp.	Bladderpod
Lotus wrightii	Wright deervetch
Lupins kingii	King lupine
Mammillaria sp.	Mammillaria
Mentzelia sp.	Mentzelia
Mirablis sp.	Four-o'clock
Opuntia sp.	Cholla
Opuntia sp.	Prickly pear
Pectis papposa	Lemonweed
Penstemon eatoni	Eaton penstemon
Petalostemon candidum	White prarieclover
Portulaca olerzca	Purslane
Salsola kali	Russian thistle
Solanium eleagnifolium	Silverleaf nightshade
Solanum jamesii	Wild potato
Sphaeralcea coccinea	Scarlet globemallow
Sphaeralcea sp.	Globemallow
Taraxacium officinale	Common dandelion
Tragapogon sp.	Salsify
Yucca baccata	Datil yucca
Yucca elata	Soaptree yucca
<u>Shrubs</u>	
Acacia constricta	Whitethorn acacia
Artemisia frigida	Fringed sagewort
Artemisia nova	Black sagebrush
Artemisia tridentata	Big sagebrush
Artemisia wrightii	Wright sagewort
Atriplex canescens	Fourwing saltbush
Cercocarpus montanus	Mountain mahogany
Chrysothamnus nauseosus	Rubber rabbitbrush
Condalia sp.	Condalia
Cowania mexicana	Mexican cliffrose

Scientific name	Common name
Eriogonum sp.	Wild buckwheat
Eurotia lanata	Winterfat
Gutierrezia sarathrae	Broom snakeweed
Quercus gambelii	Gambel oak
Senecio longilobus	Threadleaf groundsel
Tetradymia canescens	Gray horsebrush
Trees	
Juniperus monosperma	Oneseed juniper
Pinus edulis	Pinyon pine
Pinus ponderosa	Ponderosa pine

(a) Common names are mostly taken from A. A. Beetle, 1970. Recommended plant names. Res. J. 31. Agric. Exp. Sta. Univ. of Wyoming.

TABLE 2.8-4

GRAZING CAPACITY AND ACREAGES OF THE ALLUVIAL VALLEY AND PLAINS, SAGEBRUSH-GRASSLAND, AND PINYON-JUNIPER AREAS

Type	Acres	Forage Acre Factor	Forage Acres	Animal Unit Years
Alluvial valley and plains	208	0.0639	13.29	2.1
Sagebrush-grassland	135	0.0665	8.98	1.4
Pinyon-juniper	277	0.0225	6.23	1.0
Total	620[a]		28.50	4.5

(a) The highway right of way, approximately 20 acres, is not included in the above.

Normally, the only surface water on the mine and proposed mill site originates from Applicant's and Kerr-McGee's mines and is discharged into an unnamed arroyo adjacent to the site. Consequently, a survey of aquatic plants was not considered relevant to the environmental impact of the facility.

Animals

A sample of the small mammal population present on the mine and proposed mill site was obtained by trapping animals. Only the deer mouse was observed in large numbers on the site. Based on the trapping results, an estimate of the small mammal density is presented below:

Species	Small Mammal Population per Section
Deer mouse	723
Pinyon mouse	26
Western harvest mouse	26
Little pocket mouse	52

A survey of other wildlife on the site was conducted by visual observations of both the animals and the signs of their presence. A complete listing of the observations is presented in Table 2.8-5.

Important Species

Based on recreational and limited monetary value, the only important[a] wildlife species in the area is the mule deer, which is not abundant. Signs of these animals were observed in the pinyon-juniper area along the south and east side of the proposed site. Some tracks were observed along an erosion control dam near the center of the site. The animals apparently were going to the arroyo for water.

A few mourning doves were observed using the flood plain to feed and to consume gravel. None of the rare or endangered avian predators were observed in the area. However, both the bald and golden eagles may periodically frequent the steep bluffs. None of the remaining species seen in the area are restricted to the habitat types of the area. No sheep, goats, or cattle were observed on the mine and proposed mill site, and in the future

(a) AEC, 3.8.

TABLE 2.8-5

FAUNA OBSERVED ON OR NEAR APPLICANT'S PROPERTY

COMMON NAME	SCIENTIFIC NAME	NUMBER OBSERVED
MAMMALS		
Black-tailed jackrabbit	*Lepus californicus*	2
Desert cottontail	*Sylvilagus auduboni*	3
Cliff chipmunk	*Eutamias dorsalis*	3
Deer mouse	*Peromyscus maniculatus*	29
Pinyon mouse	*Peromyscus truei*	1
Western harvest mouse	*Reithrodontomys megalotis*	1
Little pocketmouse	*Perognathus longimembris*	2
BIRDS		
Red-tailed hawk	*Buteo jamaicensis*	1
Common raven	*Corvus corvax*	6
Sparrow hawk	*Falco sparverius*	2
Mourning dove	*Zenaidura macroura*	18
Pinyon jay	*Gymnorhinus cyanocephala*	numerous
Brewer's blackbird	*Euphagus cyanocephalus*	11
Red-shafted flicker	*Colaptes cafer*	1
Western kingbird	*Tyrannus verticulis*	7
Western bluebird	*Sialia mexicana*	11
Cliff swallow	*Petrochelidon pyrrhonota*	5
Chipping sparrow	*Spizella passerina*	8
Rock wren	*Salpinctes obsoletus*	5
REPTILES		
Prairie lizard	*Sceloporus undulatus consobrinus*	1
SIGN NOTED		Signs Observed
Mule deer	*Odocoileus hemionus*	6 sets tracks
Coyote	*Canis latranis*	1 set tracks
Porcupine	*Erethizon dorsatum*	numerous
Badger	*Taxidea taxus*	4 burrows
Woodrat	*Neotoma* sp.	3 dens

all forms of livestock will be excluded from the area by fences. Aquatic animals are not present on the site because of the absence of a suitable habitat.

Plant species used as feed for the deer are not considered "important species" because neither the deer nor the grasses and shrubs used as food are limited to the mine and proposed mill site. No plant or animal species have been identified as critical to the structure and function of the ecosystem, nor have any rare or endangered species as defined by the U. S. Fish and Wildlife Service been observed in the area.

Environmental Stresses

Before mill construction environmental stresses in the area have resulted from mining activities, construction of State Highway 566, installation of a gas line, and overgrazing of domestic animals. No histories of infections or epidemics have been identified. The presence of arroyos indicates a history of flooding and erosion. Additional environmental stresses which would be placed on the area by the presence of the mill are described below.

Except for the areas where vegetation will be destroyed by the construction of the mill and the tailings pond, the productivity and density of vegetation should increase with the exclusion of livestock. This should have favorable effects, for increased vegetative cover will stabilize the soil and improve the habitat for local wildlife species.

Mule deer, the only identified "important species" in the area, are not confined to the proposed site for food and water. Their principal source of radiation exposure will be through the ingestion and inhalation of radionuclides released in ventilation air from the mill, in the ground water discharged from the mine, and from ore dusts. Radionuclides obtained from such sources will not pose a significant environmental stress on the mule deer. See Section 5.1.

The acidic nature (pH 1.5-2.0) of the water discharged to the tailings pond will make the water unpalatable for animals in the area but should not harm them through direct contact. Other forms of wildlife will move out or be destroyed by construction activities but they should not be further affected by the operation of the mine and proposed mill.

2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS

Radiological data collected under Applicant's preoperational effluent and environmental monitoring program are presented below for each medium monitored. Additional data will become available for review as sampling is conducted under the proposed schedule presented in Section 6. However, information collected to date provides substantial data for evaluation of the background radiological characteristics of the proposed mill site.

Surface Water

Most surface water originates from the mine, passes through the series of mine water settling ponds, and discharges to an arroyo which receives an equal volume discharge from the Kerr-McGee mine, located northeast of Applicant's mine. Results from samples of mine water, settling pond water, and arroyo water are presented as mine and surface water quality data in Table 2.9-1.

Ground Water

The two ground water sampling wells that will be located next to the proposed tailings pond have not been drilled, but will be available for ground water sampling before the mill becomes operational. Mine water quality data are presented in Table 2.9-1, and ground water quality data collected by the Kerr-McGee Corporation are presented below:

Location	Formation	Depth ft	U_3O_8 µg/liter	Ra-226 pCi/liter
Church Rock HZ shaft well	Gallup	1263	<0.1	5.0
Old Church Rock mine Well (16.16.17.212)	Dakota	450	0.2	5.0
East Puerco River Well (16.16.15.432)	Dakota-Westwater	318	<0.1	2.0

TABLE 2.9-1

MINE AND SURFACE WATER QUALITY

Date Collected	Alpha dpm/liter	Beta dpm/liter	Th-230 pCi/liter	Ra-226 pCi/liter	Natural U µg/liter	Sampling Location[b]
5-28-71				107		1700 ft level
5-28-71				32		1500 ft level
5-28-71				1251 (a)		1500 ft level
5-28-71				62		1200 ft level
5-28-71				2.5		1700 ft level
5-28-71				2		1500 ft level
5-28-71				67.2		1500 ft level
5-28-71				2.2		1200 ft level
5-28-71				10.4		Settling pond #1 inlet
11-8-71				6.1		Settling pond #1 inlet
10-24-72					51	Settling pond #1 inlet
12-22-72					2100	Settling pond #1 inlet
12-22-72					5500	1500 ft level
12-22-72					400	1700 ft level
12-22-72					25	1700 ft level
12-22-72					17	1700 ft level
12-22-72					400	1700 ft level
12-29-72			1			1700 ft level
12-29-72				1.6		1700 ft level
12-29-72			5			1700 ft level
12-29-72			4	8.2	1400	Settling pond #1 inlet
4-2-74			225			Settling pond #1 inlet
10-10-74	3431	1041	75	11	1126	Settling pond #2 outlet
10-10-74	4443	1279	80	20	1466	Figure 6.1-1 site #2
10-10-74	3667	768	5	18	1494	Figure 6.1-1 site #3
10-10-74	6825	1354	60	7	1636	Figure 6.1-1 site #4
10-10-74	5396	678	2	4	1664	Figure 6.1-1 site #5
11-27-74				18	1343	Settling pond #1 outlet
3-3-75	1132			5	1013	Settling pond #1 outlet
3-4-75	18			10	805	Settling pond #1 outlet
3-5-75	98			32	743	Settling pond #1 outlet
6-4-75	3729	1028	36	41	2310	Figure 6.1-1 site #1
6-3-75	1410	189	78	0.53	1600	Figure 6.1-1 site #2
6-3-75	557	64	14	3.9	920	Figure 6.1-1 site #3
6-4-75	1341	160	56	13	1540	Figure 6.1-1 site #4
6-4-75	1068	151	10	64	1450	Figure 6.1-1 site #5
Average	2543	670	46	22	1426	

(a) Datum not included in average.
(b) The levels presented are for mine depths.

Airborne Radioactivity

The following data on background, airborne, particulate radioactivity were collected at the locations specified in Figure 6.1-1.

Date Collected	Gross Alpha pCi/m³	Gross Beta pCi/m³	Th-230 pCi/m³	Ra-226 pCi/m³	Natural U μg/m³	Sample Location
10-2-74	0.0000	0.000				1
10-2-74	0.0000	0.000				2
10-2-74	0.0000	0.000				3
10-2-74	0.0003	0.000				4
6-3-75	0.000	0.020	0.0000	0.00000	0.013	1
6-3-75	0.000	0.010	0.00000	0.00000	0.068	2
6-4-75	0.000	0.015	0.00000	0.0021	0.018	3
6-4-75	0.000	0.021	0.00000	0.0107	0.009	4

The combined concentration of short-lived radon daughter products[a] was measured May 2, 1975, at given downwind distances from the two operating ventilation shafts of Applicant's mine. Shaft No. 2 is currently closed. The findings presented below are expressed in working levels (WL). Working levels measure the concentration of all short-lived radon daughters in a liter of air. One WL is defined as the total alpha particle energy in a liter of air from the complete decay of 100 pCi of each of the short lived daughter products. Current federal regulations specify that miners shall not work for more than 168 hrs in any given month in mine atmospheres averaging more than 0.1 WL.

Downwind Distance from Ventilation Shaft No. 1	WL Sample 1	WL Sample 2	WL Sample 3
0 ft (as close as possible)	0.2	0.2	0.2
50 ft	0.4	0.4	0.4
100 ft	0.0	0.0	0.0
150 ft	0.0	0.0	0.0
200 ft	0.0	0.0	0.0

All determinations from ventilation shaft No. 3 measured 0.0 WL.

(a) The short-lived radon daughter products are: Po-218, Pb-214, Bi-214, and Po-214.

Soil

Soil samples were obtained from the locations specified in Figure 6.1-1. The samples were segregated into two layers, surface samples 0 inch to 2 inches deep and subsurface samples 2 inches to 4 inches deep. The samples permit identification of both surface contamination and penetration of radionuclides through the soil. Soil data are summarized below:

Date Collected	Alpha dpm/g	Beta dpm/g	Th-230 pCi/g	Ra-226 pCi/g	Nat U μg/g	Sampling Location and Type
						Surface Samples
10-16-74	4.5	3.9	0.0	0.0	<1	#1
10-16-74	5.6	5.3	0.47	0.25	2	#2
10-16-74	10.4	4.7	0.47	0.62	<1	#3
10-16-74	26.7	3.9	0.43	0.91	<1	#4
6-3-75	6.0	3.7	0.44	0.54	1.4	#1
6-3-75	10.2	8.9	0.63	1.13	2.1	#2
6-4-75	6.8	7.3	0.65	0.60	1.7	#3
6-4-75	12.7	3.3	0.43	0.41	2.5	#4
Average	10.4	5.1	0.44	0.43	<1.7	
						Subsurface Samples
10-16-74	5.5	3.9	0.25	0.43	<1	#1
10-16-74	12.7	5.6	0.41	0.39	7	#2
10-16-74	7.9	3.9	0.39	0.49	7	#3
10-16-74	27.9	4.3	0.43	0.72	<1	#4
6-3-75	5.9	3.1	0.39	0.47	1.9	#1
6-3-75	20.7	10.0	0.57	0.39	1.6	#2
6-4-75	15.1	7.4	0.60	0.71	1.7	#3
6-4-75	12.8	6.0	0.49	0.69	1.6	#4
Average	13.6	5.5	0.44	0.54	<2.9	

Vegetation

Samples of local vegetation were collected at the sites specified in Figure 6.1-1. Each sample was selected as representative of the leafy green plant material favored by mule deer. The data are summarized below:

Date Collected	Alpha dpm/g	Beta dpm/g	Th-230 pCi/g	Ra-226 pCi/g	Nat.U μg/g	Sampling Location
10-16-74	3.3	7.9	0.0	0.17	<1	#1
10-16-74	0.0	8.9	0.0	0.00	<1	#2
10-16-74	0.0	13.6	0.0	0.00	<1	#3
10-16-74	3.0	9.8	0.0	0.00	<1	#4
6-3-75	0.0	30.2	0.0	0.0	0.9	#1
6-3-75	0.0	25.3	0.0	0.0	1.1	#2
6-4-75	0.0	26.4	0.0	0.0	0.4	#3
6-4-75	0.0	12.3	0.0	0.0	0.2	#4
Average	0.8	16.8	0.0	0.2	<0.8	

Background Dose Rates

The background whole body dose rate has been estimated using thermoluminescent dosimeters (TLD) placed at the locations specified in Figure 6.1-1. The average dose rate is 189 mrem/yr, based on data acquired from October 17, 1974, through April 17, 1975. Individual sample results are presented below:

Location	Dose (mrem)
#1	93
#2	100
#3	88
#4	96
#5	(a)
Average dose for 6 months	94.5
Average annual dose rate	189

2.10 OTHER ENVIRONMENTAL FEATURES

The chemical composition of surface water samples taken from the arroyo receiving water discharged from both Applicant's and Kerr-McGee's mine is presented in Table 2.10-1. The samples were obtained from locations specified in Figure 6.1-1.

The chemical analysis of ground water samples has been presented in Table 2.6-2.

(a) The TLD at location #5 was vandalized.

TABLE 2.10-1

CHEMISTRY OF SURFACE WATER
(mg/liter)

Analysis	SAMPLES COLLECTED 10-10-74					SAMPLES COLLECTED 6-3-75 AND 6-4-75					Average
	Loc #1	Loc #2	Loc #3	Loc #4	Loc #5	Loc #1	Loc #2	Loc #3	Loc #4	Loc #5	
Bicarbonate	195.	203.	197.	203.	209.	205.	203.	196.	201.	202.	201.
Calcium	2.38	3.87	6.47	7.77	17.06	16.9	89.6	227.	28.7	24.0	42.4
Carbonate	15.1	8.5	12.3	5.0	<1.0	12.5	1.2	<0.1	9.6	10.7	7.6
Hardness	7.1	9.8	13.4	38.1	68.4	9.7	421.	555.	90.3	87.4	130.0
Magnesium	0.7	1.2	3.1	2.6	3.5	2.3	88.1	144.	24.1	11.5	28.1
Nitrate	<0.1	<0.1	0.1	0.1	0.4	0.6	2.1	5.0	0.6	0.8	1.0
Phosphate	0.36	1.00	1.84	0.20	0.28	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
Potassium	0.66	0.86	0.94	1.78	3.54	0.36	1.4	2.0	0.58	1.0	1.3
Sodium	136.	136.	105.	105.	104.	137.	149.	144.	107.	130.	125.
Sulfate	81.	85.	98.	98.	112.	59.	474.	656.	140.	56.	186.
Suspended Solids	68.	318.	566.	2312.	5660.	356.	8900.	7200.	1600.	3400.	3038.
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.02	<0.01	<0.01
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.01	<0.01	<0.01	<0.01	0.01	0.020	0.008	0.033	0.018	0.009	0.01
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.009	<0.001	<0.001	0.002
Mercury	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	0.03	<0.01	0.02	0.01	0.01
Zinc	0.01	<0.01	0.02	0.01	0.04	0.18	0.11	0.376	0.272	0.14	0.12
pH	8.64	8.68	8.70	8.54	8.32	8.90	8.37	8.41	8.81	8.68	8.61

CHURCH ROCK URANIUM MILL
ENVIRONMENTAL REPORT

SECTION 3.0
THE MILL AND MINE

3.1 External Appearance of Mill
3.2 Mill Circuit
3.3 Source of Mill Wastes and Effluents
3.4 Control of Mill Wastes and Effluents
3.5 Sanitary and Other Mill Waste Systems
3.6 Mining Activities

3.0 THE MILL AND MINE

This section describes the proposed mill's appearance, processes, and effluents, and the current mine operation and its effluents.

3.1 EXTERNAL APPEARANCE OF MILL

The prominent features of the proposed mill will be the main process building, the six outside thickener tanks, the solvent extraction and leaching equipment, the garage and shop, and the administration building. The plant buildings and equipment layout including the exclusion area fence, are shown in Figure 3.1-1.

Although the location of the proposed mill is remote and the plant will be visible only from one road that ends 0.5 mile north of the mill, the architectural design and color scheme of the mill will be harmonious with the environment. Figure 3.1-2 presents an artist's conception of the mill.

Cuts and embankments will be landscaped to provide a pleasing appearance that will also protect against erosion. Trees and shrubs will be planted to enhance the appearance of the mill complex.

The design of the proposed tailings pond will be such that the tailings will not protrude above the skyline. Gently rolling surfaces and flat side slopes will further present a pleasing view when the area has been replanted with native vegetation at the completion of operations.

3.2 MILL CIRCUIT

The initial design capacity of the proposed mill is 3000 tons per day of ore (TPD). During the first 2 years of operation, however, the mill will process approximately 2000 TPD while undergoing operational optimization of the uranium extraction process. Provisions have been made to allow expansion of input to 4000 TPD should the need arise.

The proposed mill will contain seven operating sections illustrated in the simplified flow chart presented in Figure 3.2-1. Added flow chart details are found in Figure 3.2-2. Quantitative mill

TABLE 2.10-1

CHEMISTRY OF SURFACE WATER
(mg/liter)

Analysis	Loc #1	Loc #2	Loc #3	Loc #4	Loc #5	Loc #1	Loc #2	Loc #3	Loc #4	Loc #5	Average
	SAMPLES COLLECTED 10-10-74					SAMPLES COLLECTED 6-3-75 AND 6-4-75					
Bicarbonate	195.	203.	197.	203.	209.	205.	203.	196.	201.	202.	201.
Calcium	2.38	3.87	6.47	7.77	17.06	16.9	89.6	227.	28.7	24.0	42.4
Carbonate	15.1	8.5	12.3	5.0	<1.0	12.5	1.2	<0.1	9.6	10.7	7.6
Hardness	7.1	9.8	13.4	38.1	68.4	9.7	421.	555.	90.3	87.4	130.0
Magnesium	0.7	1.2	3.1	2.6	3.5	2.3	88.1	144.	24.1	11.5	28.1
Nitrate	<0.1	<0.1	0.1	0.1	0.4	0.6	2.1	5.0	0.6	0.8	1.0
Phosphate	0.36	1.00	1.84	0.20	0.28	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
Potassium	0.66	0.86	0.94	1.78	3.54	0.36	1.4	2.0	0.58	1.0	1.3
Sodium	136.	136.	105.	105.	104.	137.	149.	144.	107.	130.	125.
Sulfate	81.	85.	98.	98.	112.	59.	474.	656.	140.	56.	186.
Suspended Solids	68.	318.	566.	2312.	5660.	356.	8900.	7200.	1600.	3400.	3038.
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.02	<0.01	<0.01
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.01	<0.01	<0.01	<0.01	0.01	0.020	0.008	0.033	0.018	0.009	0.01
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.009	<0.001	<0.001	0.002
Mercury	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	0.03	<0.01	0.02	0.01	0.01
Zinc	0.01	<0.01	0.02	0.01	0.04	0.18	0.11	0.376	0.272	0.14	0.12
pH	8.64	8.68	8.70	8.54	8.32	8.90	8.37	8.41	8.81	8.68	8.61

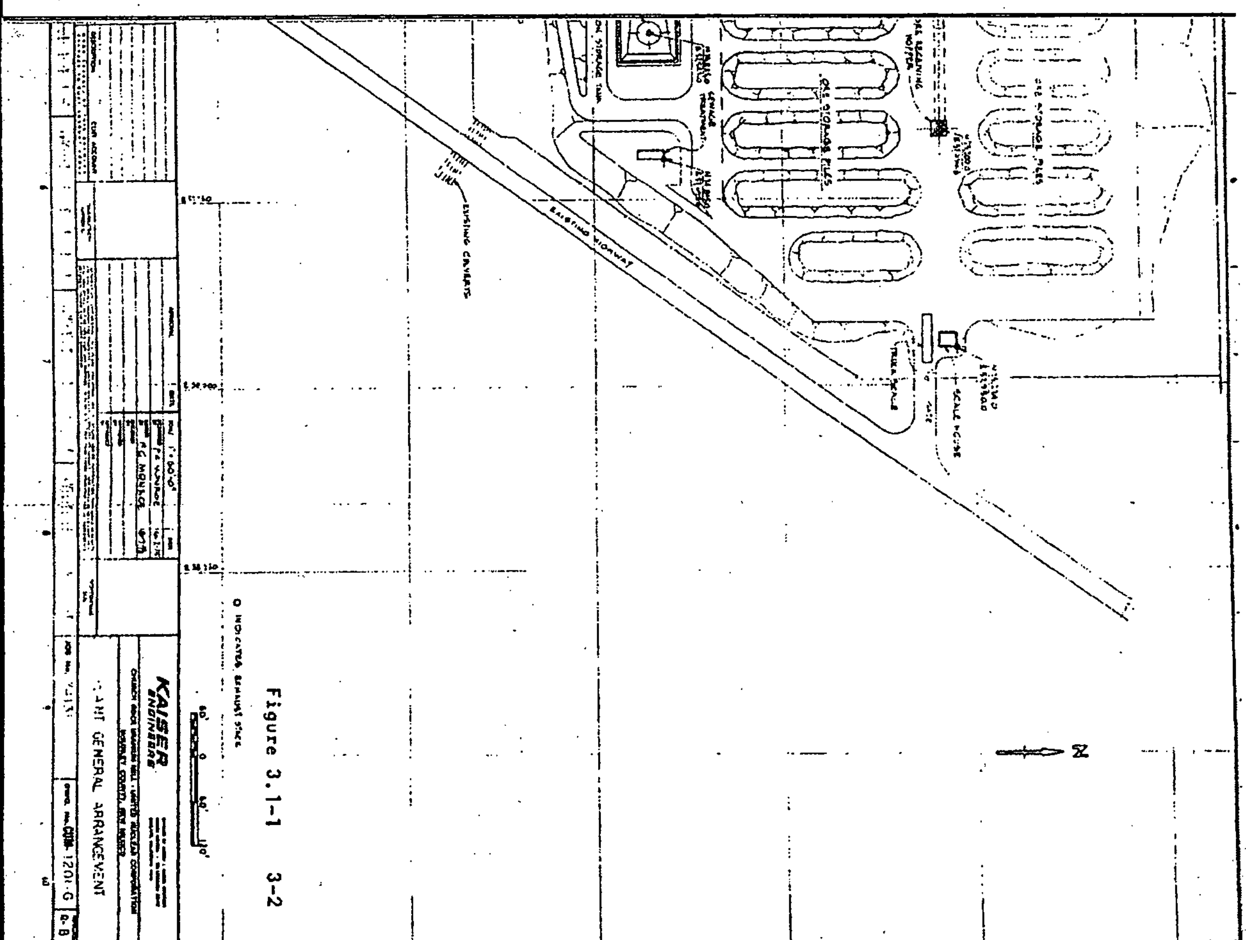


Figure 3.1-1

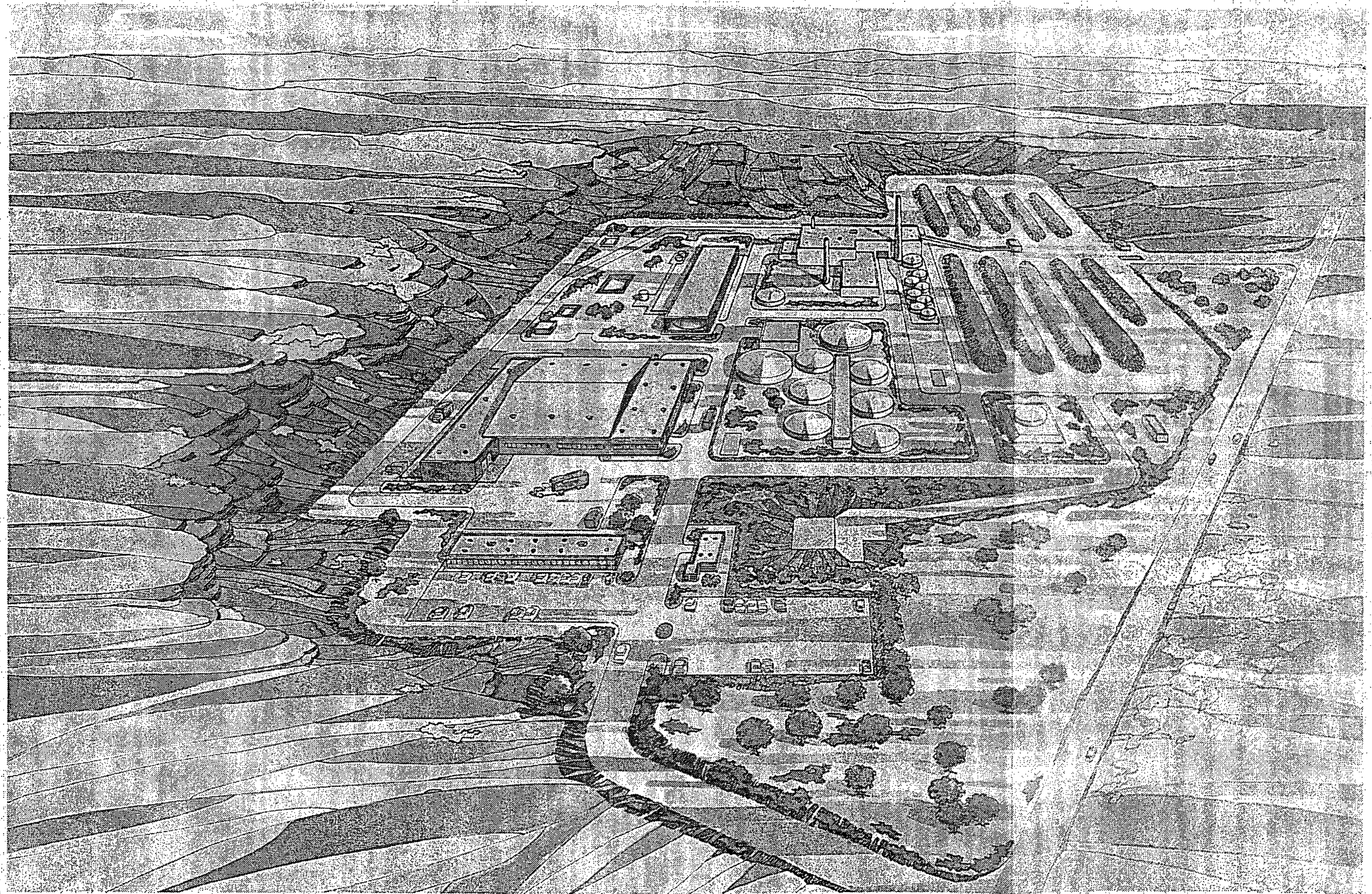


FIGURE 3. 1-2 ARTIST'S CONCEPTION OF APPLICANT'S MILL

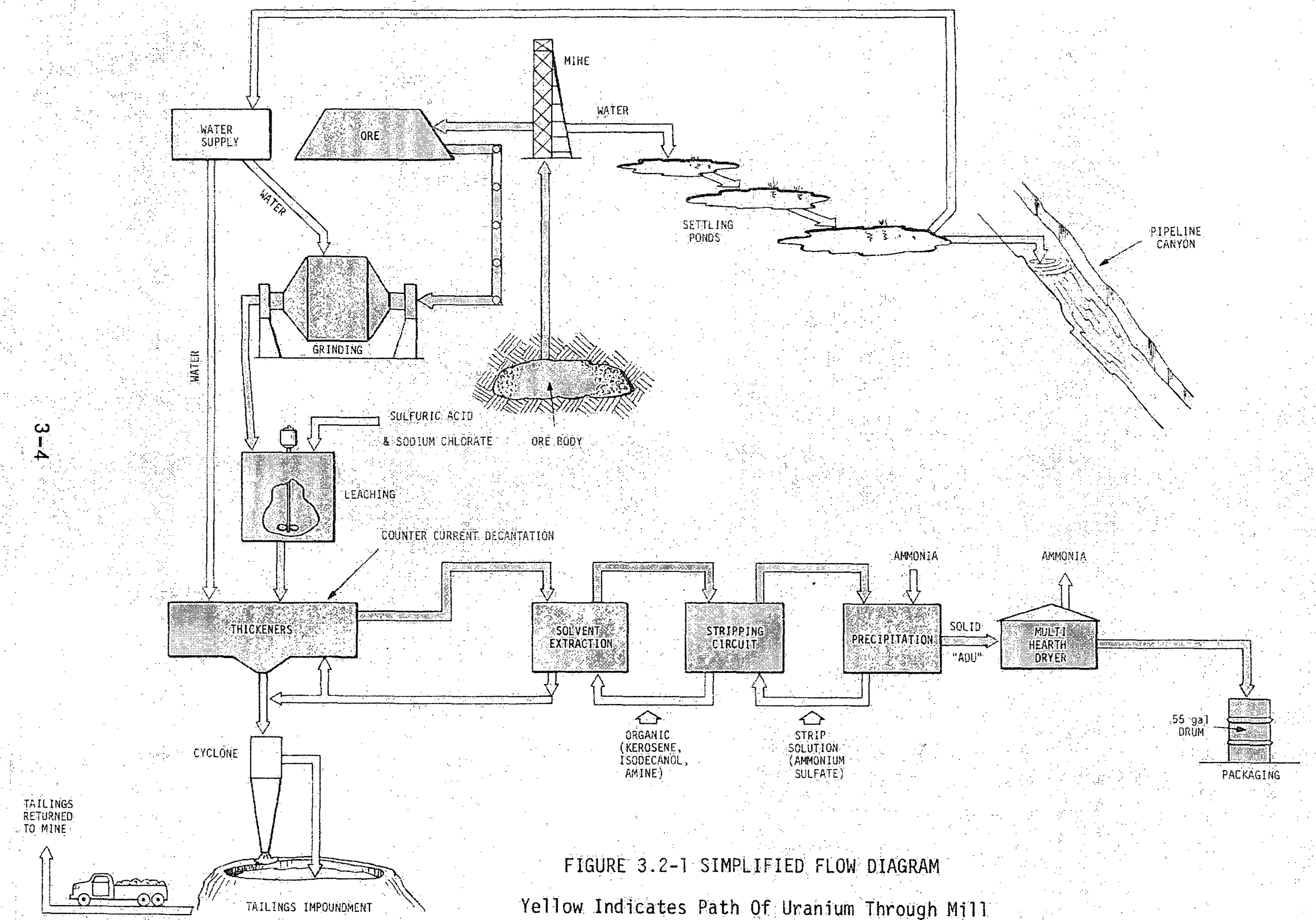


FIGURE 3.2-1 SIMPLIFIED FLOW DIAGRAM

Yellow Indicates Path Of Uranium Through Mill

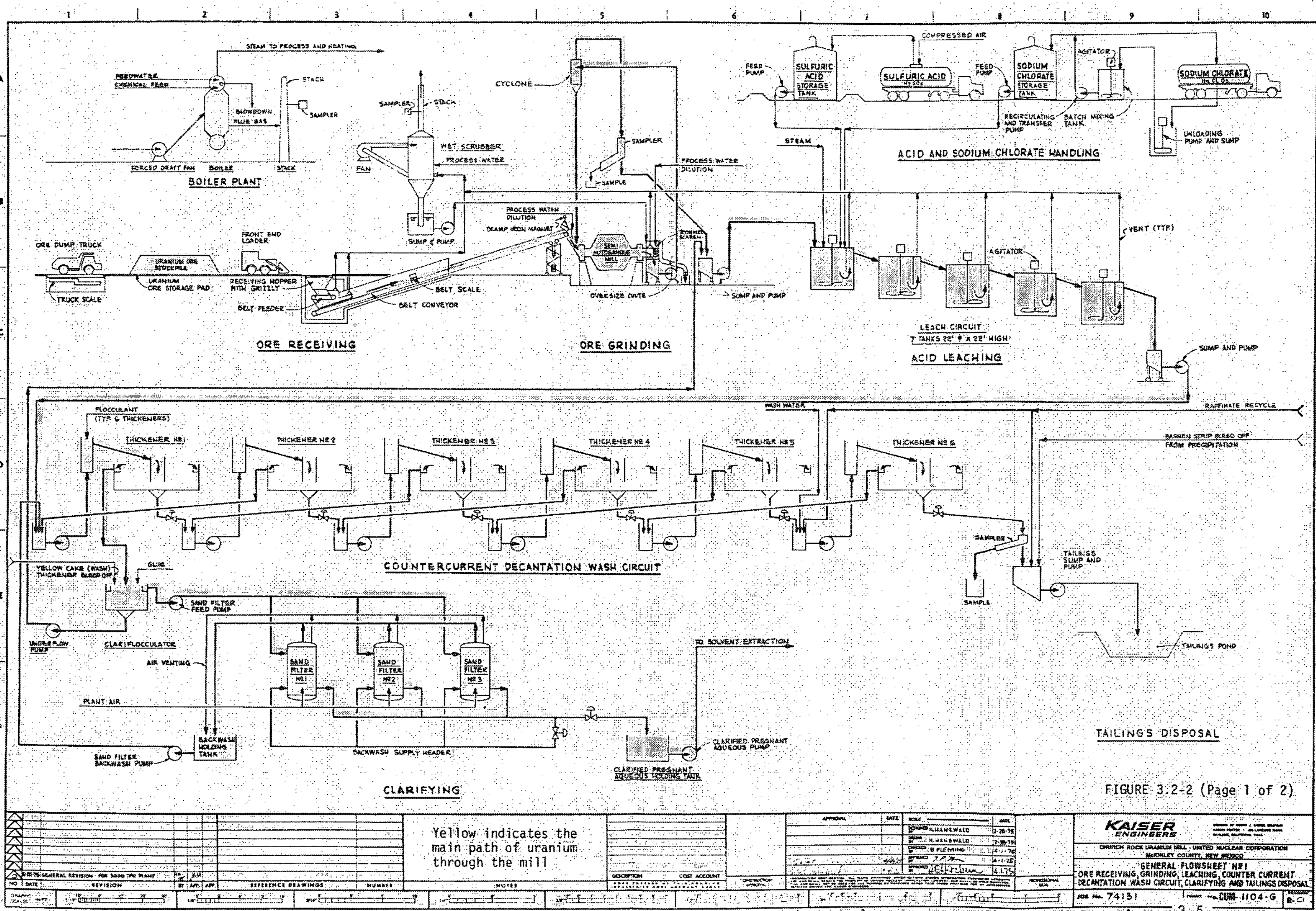


FIGURE 3.2-2 (Page 1 of 2)

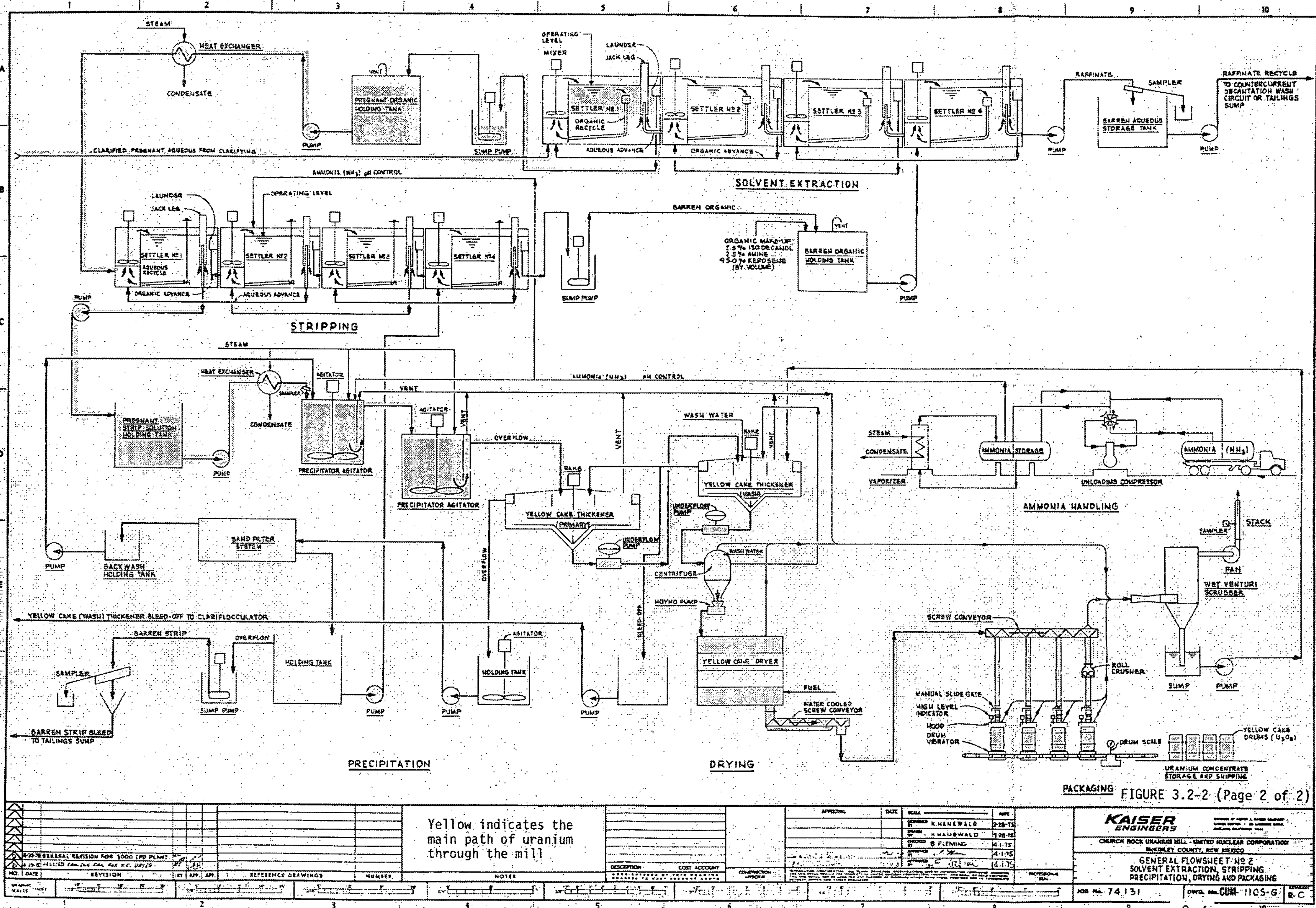


FIGURE 3.2-2 (Page 2 of 2)

input and output values are presented in Figure 3.2-3. Projected material balance values are presented in Tables 3.2-1 and 3.2-2.

The quantified material balance, input, and output values represent best estimates for current design. When the mill begins operation, these estimated values may change as a result of operational adjustments designed to minimize chemical consumption and to maximize yellowcake production.

The mill will extract uranium from the Church Rock ore by way of the following generalized process. The mill will grind the ore in water to form a slurry. The slurry will be routed to leaching tanks and mixed with sulfuric acid and sodium chlorate to dissolve the uranium. The resultant mixture of ground ore, acid and water will be transferred from the leaching tanks to the thickeners which are also called the countercurrent decantation section. Here the uranium bearing liquid will be separated from the ore solids that will be pumped to the tailings pond. The uranium-bearing solution will be filtered and then routed to the solvent extraction section.

In the solvent extraction section, the uranium-bearing water solution will be brought into contact with an organic solution composed of kerosene, an organic amine, and isodecanol. The amine will form a chemical complex with the uranium, holding it in the organic solution. This organic solution will then be routed to the stripping section. The water solution, called raffinate, will be routed to the countercurrent decantation section for recycle.

The stripping solution will be composed of water containing ammonium ions. Here the uranium will be re-extracted from the organic solution into water and routed to the precipitation section where ammonia will be added to precipitate the uranium as ammonium diurnate (ADU). The ADU will be heated in a dryer to drive off water and traces of ammonia to form yellowcake, the final product. Then the yellowcake will be packaged and shipped off site for further processing by others into nuclear reactor fuel.

A more detailed description of each major mill circuit is presented below.

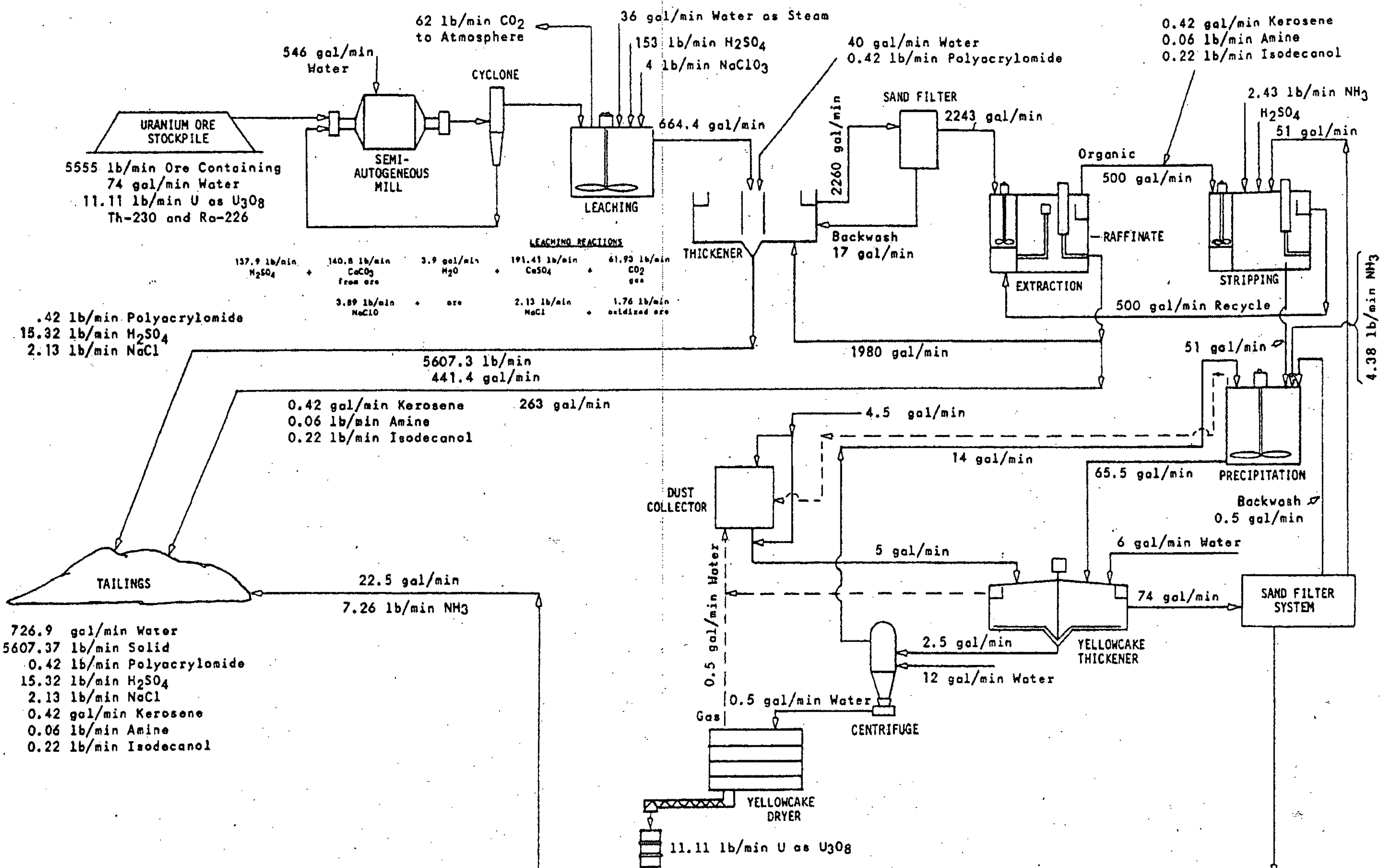


FIGURE 3.2-3 QUANTITATIVE INPUT AND OUTPUT OF THE MILL PROCESS

TABLE 3.2-1

MATERIAL BALANCE MILL INPUT

Point Where Added	Solids lb/min	Water gal/min	H_2SO_4 lb/min	$NaClO_3$ lb/min	Polyacrylamide lb/min	Kerosene gal/min	Amine lb/min	Isodecanol lb/min	NH_3 lb/min
Ore	5555	74.							
Grinder		546.							
Leaching		3.12		3.89					
Leaching		1.38	153.25						
Leaching		36.[a]							
Thickener		40.			0.42				
Solvent extraction						0.42	0.06	0.22	
Stripping									2.43
Precipitator									4.83
ADU thickener		6.							
Centrifuge		12.							
Dust collector		4.5							
Total	5555	723. (6001 lb/min)	153.25	3.89	0.42	0.42	0.06	0.22	7.26

(a) As steam

TABLE 3.2-2

MATERIAL BALANCE MILL OUTPUT

	To Atmosphere	To Tailings Pond									Product
Point of Release	Gaseous CO_2 lb/min	Solids lb/min	Water gal/min	H_2SO_4 lb/min	NaCl lb/min	Polyacrylamide lb/min	Kerosene gal/min	Amine lb/min	Isodecanol lb/min	NH_3 lb/min	Yellowcake lb/min
Leaching	61.93										
Thickener		5607.37	441.4	15.33	2.13	0.42					
Extraction			263.				0.42	0.06	0.22		
Sand Filter			22.5							7.26	
Dryer											12.08
Total	61.93	5607.37	727. (6033. lb/min)	15.33	2.13	0.42	0.42	0.06	0.22	7.26	12.08

Ore Handling and Storage

Ore trucks from the mine will be weighed and then will dump the ore onto a 30,000 ton capacity ore pad. A 4.5 yd^3 front end loader will then transfer the ore to a receiving hopper equipped with an apron feeder and a grating (grizzly). A conveyor belt will transfer the ore from the hopper to the grinding section.

Grinding Section

The grinding mill will be a semiautogenous mill 18 ft in diameter by 6 ft long. A total of 500 gal/min of mine water will be added to the ore in the grinding section. The semiautogenous mill discharge will be directed to a cyclone from which the denser material will be returned to the grinder and the slurry, containing 50 to 55% finely ground solids, will be routed to the leaching section.

Leaching Section

The seven to 10 tank leaching section will combine the slurry from the cyclone with sulfuric acid (H_2SO_4) and sodium chlorate ($NaClO_3$) to dissolve the uranium from the ore. The pH and oxidation potential will be monitored. Sulfuric acid will be used to adjust pH, and sodium chlorate will be used to adjust oxidation potential.

Complete dissolution of the uranium is expected to require 55 lb of sulfuric acid and 1.4 lb of sodium chlorate per ton of ore. Steam, equivalent to 36 gal/min water, will be added to heat the leach solution. The pulp will flow by gravity from one tank to another, each tank being 15 inches lower than the preceding tank. The expected retention time will be approximately 10 hr. The discharge, 50% solids with a pH of 1.2, from the final leach tank will be pumped to the countercurrent decantation (CCD), or thickener section.

Countercurrent Decantation (CCD) Section

The term countercurrent describes two phases that pass through a process in opposite directions. In the CCD section, solids from the leaching section, along with some liquid, will enter the number one thickener tank. They will be pumped to each tank serially and will be disposed of as tailings from the number six thickener. In contrast, raffinate, a byproduct from the solvent extraction section, will be introduced at the number six thickener and will pass through the CCD section to the number one thickener which will wash the uranium-bearing solution from the solid particles. This flow pattern assures that solids sent to tailings

are given a final wash with a solution that is relatively free of uranium. Raffinate is used instead of mine water to reduce the volume of waste generated.

The thickeners will be designed to separate more solids per square foot of area than conventional thickeners. The settling area is designed for 0.4 ft^2/ton in 24 hr. Each thickener will be 45 ft in diameter. The suspended solid content of the overflow from the first thickener is expected to be less than 400 mg/liter. The underflow of the last thickener, containing approximately 4 mg/liter of U_3O_8 in the solution and approximately 0.005 to 0.01% U_3O_8 in the solids, will be pumped as 50% solids the 4000 ft to the tailings pond. The only chemical addition in the CCD section will be polyacrylamide, a flocculant used to accelerate settling. The anticipated use is 0.15 lb/ton of ore.

The overflow from the number one thickener is the uranium bearing solution from the CCD section. The solution will pass through sand filters before transfer to the solvent extraction section. The sand filters will be periodically backwashed and the backwash water returned, at about 17 gal/min, to the mixer of the number two thickener. Two sand filters will operate at all times. The other filters may be removed from service for backwash.

Solvent Extraction and Stripping Sections

The solvent extraction section will receive the "clarified pregnant" aqueous solution from the CCD section. The uranium will first be extracted into an organic phase consisting of kerosene with about 2.5% each of organic amine and isodecanol. This uranium-bearing organic solution will then be pumped to the stripping section where the uranium will be re-extracted into water containing ammonium sulfate. These two processes will use liquid ion exchange to provide uranium in a water solution free of other minerals in the ore. Extraction into and later out of the organic phase is a function of the acidity in the aqueous phase. Both the solvent extraction and stripping sections will use countercurrent flow.

The solvent extraction section will consist of four mixer-settler units. Each mixer tank will have a volume of 380 ft^3, and each settler will provide about 1800 ft^2 of settling area.

The filter effluent, from the CCD circuit, carrying approximately 0.7 g/liter U_3O_8, will be pumped to the first mixer-settler. This "pregnant aqueous" solution will mix with the organic solution in the first mixer. After settling, the aqueous solution will be pumped to the second mixer. By the time the aqueous solution

leaves the number four settler, the U_3O_8 concentration will be reduced to 0.003 g/liter or less. This acidic, "barren" aqueous solution, called raffinate, will be recycled to the CCD section or routed to tailings. About 1900 gal/min of the organic solution from each settler will be recycled through the mixer of the same number. The organic solution will advance through the extraction section at approximately 500 gal/min and will extract uranium to a final concentration of approximately 2.5 g/liter U_3O_8.

The "pregnant" organic solution will then be pumped to the stripping section, the second portion of the purification process. The stripping section will also consist of four mixer-settlers. Each mixer unit will have a volume of 380 ft^3, and each settling unit will provide an area of about 500 ft^2.

The strip solution will contain about 130 g/liter of ammonium sulfate in water and will flow at 51 gal/min. The flow rate difference between the aqueous and organic solutions will result in a 10 fold concentration of uranium to about 25 g/liter U_3O_8 in the strip solution.

The barren organic solution from the stripping sections will be recycled to the extraction section. Before the solution is reused, kerosene, amine, and isodecanol may be added to replace that lost. Anticipated consumption rates for kerosene, amine, and isodecanol are: 0.15 gal, 0.02 lb, and 0.08 lb, respectively, per ton of ore. The uranium bearing strip solution will be routed to a holding tank, and then to the precipitation section.

Precipitation and Washing Sections

The uranium-bearing strip solution will be heated to 160 F and routed to the two stage precipitation section, where gaseous ammonia will be added. The uranium will precipitate as ADU, which is primarily a mixture of uranium hydroxides and ammonium diurinate. The precipitation process will be monitored by careful pH control.

The ADU will be separated from the water and impurities in a two-stage yellowcake thickener section. Slurry from the precipitators will be pumped to a primary thickener 35 ft in diameter. The underflow, containing about 33% solids, will be mixed with wash water and transferred to the second thickener 17 ft in diameter. The underflow from the second thickener will be transferred to a cyclone seperator or centrifuge for further dewatering. The

slurry from the centrifuge will contain about 60% solids and will be routed to the dryer. The excess water will be returned to the second yellowcake thickener.

The overflow of the second, or washing, thickener will be pumped to the first thickener. The overflow of the first, or primary, thickener will pass through a second sand filter system. The solids from the filter backwash will be collected in a holding tank and pumped to the first precipitator to reclaim the uranium. The solution effluent of the sand filters will be pumped to the number four mixer of the stripping section or to the tailings pond.

Drying Section

A cascade, dual-hearth dryer will be fired by either No. 6 fuel oil or propane gas to approximately 800 F. The drying process will drive off some of the ammonia and most of the water to convert the ADU to yellowcake. The yellowcake will then be transferred by screw conveyors to packaging drums. Large chunks of yellowcake will be crushed before packaging.

The 55 gal drums will be vibrated to insure complete filling. Filled drums will be sampled, weighed, and sent by roller conveyor to storage until shipped. Dust from the yellowcake handling and drying operations will be collected by a wet scrubber and returned to the process. Based on 4000 TPD input, the mill will produce about 18,000 lb of yellowcake/day.

Tailings Disposal System

Uranium occurs in nature as low grade ore. Consequently, 99.8% of the material removed from the mine will become a waste product. In addition, the use of chemicals in the extraction and purification of the uranium will add chemicals to the liquid wastes. These wastes will be routed to a tailings pond. See Section 3.4.

About 900 gal/min of tailings slurry, containing about 55% solids, will be pumped from the mill to the tailings pond. Most of this waste comes from the CCD section. The slurry will be discharged through cyclones at the crest of the dam. The overflow of the cyclones, containing most of the very fine solids and liquid, will be discharged into the pond for settling.

The coarse material, mostly sand, will be used for raising and constructing the dam and for backfilling in the mine during the later stages of the project.

Construction of the dam will continue throughout the life of the project and will consist of placing, spreading, and compacting the coarse sands from the cyclone underflow. The centerline of the dam will remain constant.

3.3 SOURCES OF MILL WASTES AND EFFLUENTS

The solid and liquid waste from mill operations will be combined for disposition at a single location. Gaseous effluents from each process will be treated as necessary and discharged from two stacks. The generation and composition of these solid, liquid, and gaseous effluents is discussed in the sections which follow.

Solid and Liquid Waste

Solid and liquid waste from the mill process will be pumped to the tailings pond. See Section 3.4. A tailings sampler will be provided downstream of all effluent sources that empty into the tailings pond.

The tailings slurry will consist of water, solids from the ore, and relatively small amounts of chemicals from the mill process. The slurry will carry particles ranging in size from very fine slimes to coarse sands. A partial separation of the coarse sands from the water and slimes will be performed at the crest of the tailings dam by cyclone separators. The coarse sand will be used to raise the height of the dam. The slimes, as well as most of the liquid, will be deposited near the center of the tailings pond. The solids will settle, adding to the clay liner. The liquid will evaporate.

The chemicals in the tailings pond liquid will originate from the mill process. The anticipated quantities are presented in Table 3.2-2. The mill process will use sulfuric acid to dissolve the uranium in the ore and the by-products will be calcium sulfate and some hydrogen and sulfate ions. Most of the hydrogen ions will react in the process with carbonate in the ore to yield water and carbon dioxide, and the remaining hydrogen ions, as well as the sulfate ions, will be discharged into the tailings pond.

Sodium chlorate, an oxidizing agent, will be reduced in the process to sodium chloride which will be discharged into the tailings pond. Ammonia, used in the precipitation stage, will ultimately be discharged into the tailings pond where the ammonia will combine with sulfuric acid to form ammonium sulfate.

Polyacrylomide, the flocculating agent, will enter the tailings pond in its original chemical form and is expected to decompose. Kerosene, isodecanol, and amine will be recycled in the mill process. Some loss of these materials is expected because of their emulsificiation and dissolutions with aqueous solutions which will be discharged to the tailings pond. Separation of these materials has not been observed in tailings ponds of currently operating uranium mills. These chemicals are expected to decompose in place, though some of the more volatile components may evaporate.

The uranium content of the tailings solids will be approximately 0.005%. The quantity of other radionuclides in the tailing pond is discussed in Section 5.1.2.

Gaseous Effluents

The gaseous effluent discharge locations from the proposed mill are illustrated in Figure 3.1-1. The quantity and concentration of gaseous effluents is presented in Table 3.3-1 along with applicable air quality standards.

3.4 CONTROL OF MILL WASTES AND EFFLUENTS

The effluents emitted from the proposed mill will be minimized to the extent practicable. The "better features of current practice," as stated by the Environmental Protection Agency,[a] are incorporated in the design of the mill. The control methods used on the various gaseous effluent streams as well as the plans for solid and liquid waste retention are discussed below.

Gaseous Effluent Control

The ore stockpile and ore handling conveyors will be sprayed with water as necessary to minimize dust. Since the grinding operation could generate considerable dust, mine water will be added to the ore before it is ground. In addition, the grinding area will be serviced by a wet scrubber and an exhaust stack, which will also service the leaching section. All stacks from the proposed mill will be provided with sampling ports for air sampling should it become necessary in the future.

The precipitator, dryer, and yellowcake handling areas will be ventilated through a wet venturi-type scrubber. This high efficiency wet scrubber will consist of a series of impingement baffle plates wetted from above. The air drawn in from the bottom

(a) EPA-520-9-73-3-B.

TABLE 3.3-1

GASEOUS NONRADIOACTIVE EFFLUENTS

Gaseous Effluent Discharge Point	Prior Treatment	Potential Contaminant	Volume of Gas	Contaminant Concentration	Quantity of Contaminant Discharged	State Air Quality Standards[a]
Stack from precipitator, dryer and yellowcake handling	Venturi-type wet scrubber	NH_3	9000 ft^3/min	11.1 mg/m^3	9 lb/day	None
Stack from grinding area and leach tanks	Wet scrubber	Ore dust	7000 ft^3/min	Near zero	Trace	60 ug/m^3 AGM[b] ambient air
		Acid mist		NA[c]	Trace	None
		CO_2		18%	62 lb/min	None
Stack from laboratory	HEPA filter	Misc chemicals	2000 ft^3/min	NA	NA	None
Solvent extraction outdoor facility	None	Kerosene	NA; open air process	NA	Trace	0.19 ppm hydrocarbon 3 hr average ambient air
Ore piles and conveyor	Kept wet	Dust	NA	Near zero	Trace	60 gu/m^3 AAM[e] ambient air
Tailings pond	Kept wet	Kerosene	NA	NA	Trace[f]	0.19 ppm hydrocarbon 3 hr average ambient air

(a) State requires any source releasing more than 2000 lb/year of any contaminant to register as an air pollution source and requires a permit for untreated contaminant releases of 10 lb/hr or 25 tons/yr. See also Section 12.
(b) Annual geometric mean.
(c) NA - not applicable or unknown.
(d) High efficiency particulate air filter.
(e) Annual arithmetic mean.
(f) Most of kerosene used stays in tailings.

of the scrubber will be accelerated as it passes through holes in the plates, imparting kinetic energy to both the particulates and scrubber solution. This process will separate the water into tiny droplets to more efficiently capture particulates in the air. The air and water stream will then impinge on small plates mounted above holes in the baffles. By coalescing the droplets, this impingement will provide efficient dissolution of soluble gases. A fixed blade moisture eliminator will be mounted at the top of the scrubber to insure that water droplets are not carried out the stack with the cleaned air.

Liquid Effluent Control - Tailings Dam

Mill tailings, including all process liquid effluents, will be pumped to an on-site tailings pond located in the southeastern half of the property. See Figure 3.4-1. The tailings pond will be formed by a tailings dam, built from native clays and compacted coarse tailings. In addition to receiving liquid, slimes, and coarse tailings from the proposed mill, the pond will also collect stormwater runoff from the downstream face of the tailings dam and treated sanitary sewage in freezing weather. Except for the very small quantity of liquid that will percolate into the ground, the tailings pond liquid will evaporate. A portion of the coarse tailings will be used either as mine backfill or for dam construction, and the remainder will be retained within the pond area.

Construction of the tailings dam will continue throughout the operating life of the proposed mill. Beginning as a starter dam, with an average height of 12 ft, the dam will be raised to a final average height of 70 ft. The completed dam will provide a storage capacity of approximately 365 million ft^3. The available evaporation area of the tailings pond will be approximately 160 acres. During operation of the mill the tailings pond will always contain liquid. After operations cease the tailings pond liquid will evaporate and the pond bed will be covered with soil. The entire area will then be revegetated. Design considerations and construction of the tailings dam are discussed below.

Evaporation Rates

Average monthly evaporation rates for the tailings pond were obtained from an evaporation map for shallow reservoirs in New Mexico.[(a)] This map indicates an evaporation rate of 50 inches/year at the mill site. Average monthly evaporation and precipitation rates are listed as follows:

(a) Hale, et al, 1965.

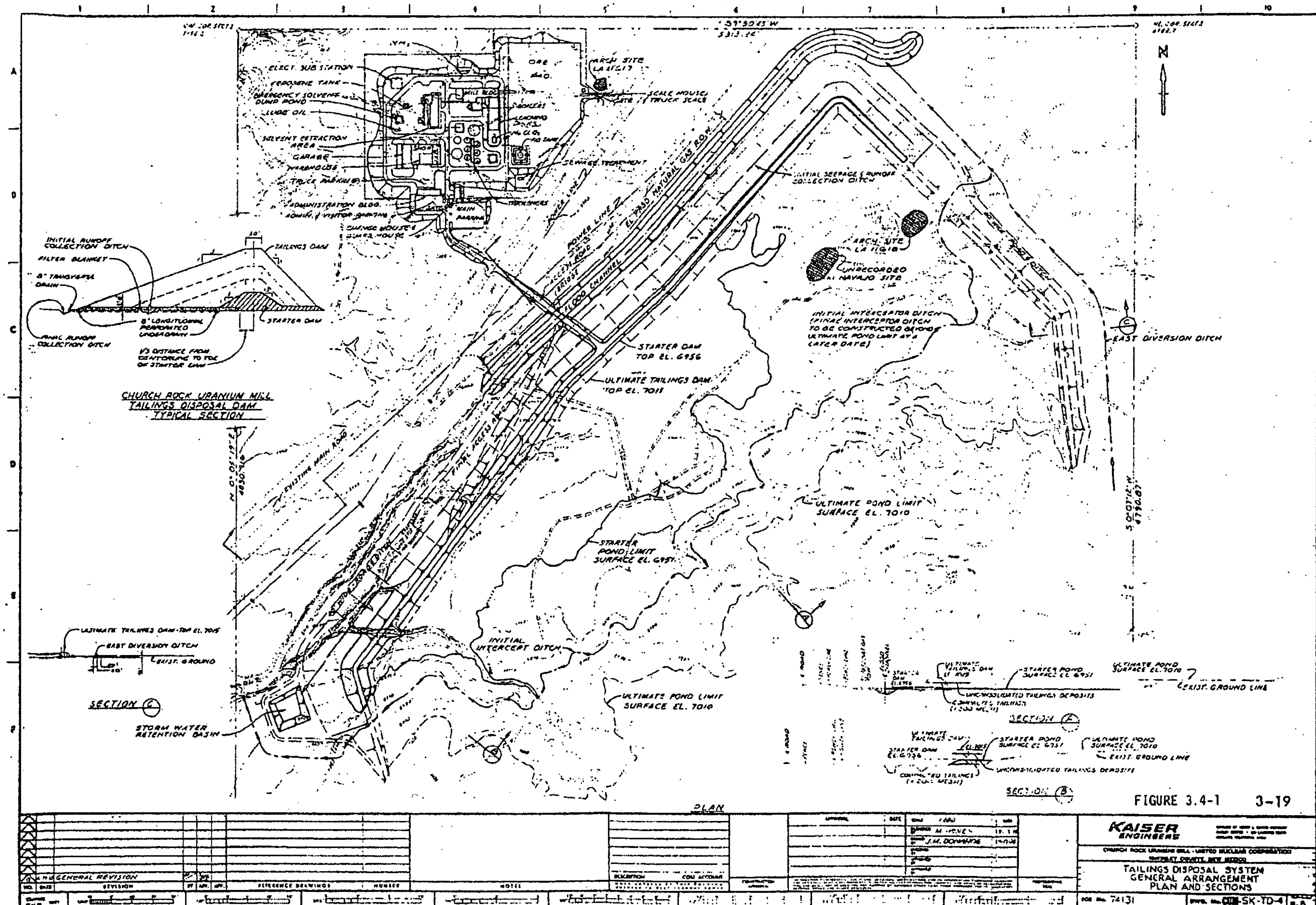


FIGURE 3.4-1 3-19

Month	Evaporation, in	Precipitation, in
January	0.5	0.84
February	0.5	0.90
March	2.5	1.02
April	4.5	0.85
May	7.0	0.71
June	8.5	0.60
July	8.0	2.25
August	7.0	2.34
September	6.0	1.36
October	3.0	1.30
November	1.5	0.67
December	1.0	0.99
Total	50.0	13.83

During part of the year water may evaporate from the tailings pond at a faster rate than water is added. Sprinkling will prevent the drying of the fine mesh tailings and dispersion by the wind.

Precipitation

Design monthly and annual rainfall is based on rainfall records for Gallup, New Mexico, from 1938 to 1972. Records for 1938 to 1960 were obtained from the U. S. Weather Bureau and for 1961 to 1972 from a consulting hydrologist.[a]

The design annual rainfall of 13.83 inches/year was calculated by projecting the consecutive 15 year averages of annual rainfall for the recorded period to a 100 year return frequency using the Gumbel method of extreme values. Design monthly rainfall was obtained by proportioning the design annual rainfall with the average monthly rainfall for the period of record. See values listed above.

A maximum probable storm of 20 inches was used for design of the tailings pond. This value was based on designs of similar uranium tailings dams which have been approved by the State of New Mexico. Since flood runoff will be routed toward the Rio Puerco by a series of diversion canals, only water falling within the pond boundaries will be retained. The maintenance of a minimum 5 ft freeboard will prevent tailings pond overflow during flood conditions.

(a) Shomaker, Consulting Hydrologist.

Percolation

Borehole permeability tests were performed at three locations on the proposed site as described in Appendix D. Data indicate the site is underlain by a layer of alluvial deposit, with thickness from a few feet to more than 100 ft. Permeability coefficients of 3.8, 4.0, and 27.0 ft/year were measured, with the higher value corresponding to horizontal permeability due to stratifications of silty sands. The vertical coefficient of permeability is probably less than the lower value. The coefficient of permeability of the compacted starter dam has been estimated to be 1 ft/year or less. Laboratory tests on a sample of tailings processed to simulate the dam shell indicate a coefficient of permeability of 2375 ft/year. Thus, although the starter dam is relatively impermeable, the completed dam will be free draining.

Stability

The alluvial deposit under the proposed site consists of layers of medium-dense, fine-to-medium sand and silt, and medium-stiff clay. The bedrock generally consists of moderately weathered sandstone.

The relative density of the sand was determined by a count of standard penetration blows to reach one foot.[a] Above a depth of 20 ft, the lower bound relative density varies from 80% to 45%. At depths greater than 20 ft, the relative density is approximately 45%.

Settling

Consolidation and classification test data, along with general experience with the types of deposits involved, indicate that much of the alluvium present at the proposed site would be substantially weakened by saturation. Under stresses that will be imposed, relatively large settlements will likely occur. Based upon the consolidation test data and assuming 90 ft of compressible alluvium, settlements of approximately 1.3 ft are estimated for the starter dam, with settlements ranging to approximately 2.2 ft for the ultimate height of the dam. Settlements in areas of shallow rock will be slight; thus, transition zones between areas of deep alluvium and solid rock will be subjected to relatively larger differential settlements.

Construction of the dam to its final height will take place over 15 years and will use saturated tailings. Consequently, the settlement should not cause any structural weaknesses. The starter

(a) A count of standard penetration blows is the number of times a 140 lb weight is dropped on a 2 inch O.D. blunt nosed shaft to penetrate 1 ft.

dam will not become saturated until the start of mill operation. Observation of the starter dam during early stages of operation will enable Applicant to perform any maintenance that may be necessary.

Liquefaction

When saturated sand is subjected to vibration it decreases in volume, with a loss of water. This water release results in increased pore pressure. If the pore pressure equals the overburden pressure, the soil looses its strength and behaves like a liquid. This phenomenon, called liquefaction, is a possible consequence of an earthquake. The bedrock acceleration from the maximum probably earthquake is evaluated in Appendix A.

Liquefaction is possible only when the soil is saturated. The liquefaction potential of the soil decreases with increased overburden pressure and relative density. The downstream portion of the dam will be made of compacted coarse tailings having a relative density of 70% or more. In addition, drainage will be provided so most of the structure will not be saturated. Under these conditions, potential for liquefaction and/or significant strain during an earthquake of 0.1 g maximum ground acceleration with 10 or less significant cycles will be essentially nonexistent.

The liquefaction potential of the downstream (toe) area of the proposed dam was evaluated because the soil there may become saturated at a shallow depth, and the overburden pressure is relatively small. The results indicate that liquefaction is unlikely during an earthquake with the maximum ground acceleration less than 0.1 g and less than 10 significant cycles. See Appendix A.

The foundation soils beneath the dam would have much higher overburden pressure and therefore lower potential for liquefaction than the dam itself has. The tailings in the pond will consist mainly of saturated silt and sand. Analysis indicates that the tailings in the storage area would very likely liquefy when subjected to the aforementioned earthquake. Consequently, the dam will be constructed to retain the liquified contents in case of an earthquake.

Dam stability was analyzed by using Bishop's Modified Method, the Ordinary Methods of Slices, and a computer program, STABR, developed at the University of California at Berkeley. This program is able to locate the critical slip surface and to calculate

the minimum factor of safety. Due to the high potential of liquefaction during an earthquake, the tailings behind the proposed dam were assumed to have zero strength and a density of 100 lb/ft^3. For the dam and foundation materials, approximately 90% of the peak ultimate strength values were used in the analyses. The calculated minimum static safety factor of the proposed dam is 1.5.

In addition to the assumption of complete liquefaction of the tailings, a pseudo-static force of 10% of the vertical weight (0.1 g) was assumed to act horizontally on the center of gravity of each slice to simulate the earthquake loadings. For the critical slip circle, which was previously determined in the static analyses, the safety factor is slightly greater than 1.1.

Construction

Prior to starter dam construction, the surface of foundation's soils will be cleared of undesirable matter and properly compacted. Before mill operations begin, the starter dam will be constructed of on-site soils and clays. The dam will have a crest width of 3 ft and a crest elevation of 6,956 ft above mean sea level (MSL). The dam's height will range from 0 to 46 ft, with an average of 12 ft, and will be approximately 5,000 ft long. The dam will provide storage area for a 6 month's accumulation of tailings slurry and enough freeboard to contain the probable maximum flood, even if the intercept ditches along the southeast pond limit fail.

After mill operations begin, the starter dam will be periodically raised by the spreading and compaction of coarse tailings, 0.15 mm diameter and larger. The dam will be raised according to the centerline method of tailings dam construction, and the coarse tailings will be compacted to a minimum of 70% relative density. A filter blanket will be provided beneath the coarse tailings portion of the dam to lower the phreatic water level in the dam.

The tailings slurry from the mill will be routed to cyclones operating on the dam crest. The cyclone overflow, consisting of fine sands, slimes, and liquid, will be discharged into the pond. The underflow, coarse tailings, will be stockpiled near the crest of the dam for eventual use either in the dam itself or as backfill in the mine.

Table 3.4-1 presents the minimum required growth of the dam for storage of tailings. The minimum growth rate will be 7 ft/year for the first 3 years and 3 ft/year for the remaining 12 years. The actual growth rate will be somewhat greater so that dam construction and planting on the downstream face can be completed while the mill is operating.

TABLE 3.4-1

TAILINGS POND DAM GROWTH

Years from Startup	Accumulated Tailings[a] (Million ft^3)	Min Crest Elev (ft MSL)	Recommended Crest Elev for Early Planting (ft MSL)	Maximum[b] Surface Area (Million ft^2)
0	0	6956	6956	
0.5	15.6	6959.5	6959.5	1.9
1	24.7	6963	6963	2.2
1.5	33.8	6966.5	6966.5	2.9
2	42.9	6970	6970	3.3
3	90.8	6977	6977	4.3
4	116.5	6980	6982	4.6
5	138.4	6983	6987	4.9
6	162.1	6986	6992	5.2
7	184.0	6989	6997	5.4
8	205.9	6992	7002	5.6
9	227.8	6995	7007	5.8
10	249.7	6998	7012	6.0
11	273.3	7001	7014	6.2
12	295.2	7004		6.4
13	317.1	7007		6.6
14	339.0	7010		6.8
15	365.3	7014		7.0

(a) Includes tailings liquid and solids and storm water runoff.
(b) Based on minimum crest elevation.

The downstream face of the dam will be maintained at a 3 to 1 slope. Construction will consist of hauling, placing, spreading, and compacting coarse sands in successive lifts beginning at the downstream toe of the dam and ending at the upstream shoulder of the crest.

Construction of the upstream face of the dam will consist of (1) removal of excess stockpile underflow so that only a 5 ft depth of consolidated sand deposits remains on top of the previously compacted material, and (2) compaction of the remaining deposits. The tailings will be placed to form a 1 to 1 slope from dam crest to the pond surface. Construction will not take place during winter months when snow and ice might prevent adequate compaction of fill.

The completed tailings dam will have a maximum height of 100 ft and a crest elevation of 7014 ft above MSL. See Figure 3.4-1 and Appendix I for Design of Tailings Disposal Systems.

Instrumentation and Monitoring

To monitor the tailings dam stability, piezometers will be installed in the downstream face of the starter dam and in the tailings dam as the dam is raised. Settlement gages will not be necessary since the crest elevation of the dam will be continually raised.

Monitoring wells will be installed on the north and south sides of the pond. These wells will provide a means for regularly sampling ground water to detect possible seepage of tailings pond liquid. See Section 6.2.

Drainage Systems

Dam integrity and safety considerations require construction of a flood channel to control natural runoff crossing the property, intercept ditches to prevent runoff from entering the pond, and a system to collect runoff from the downstream face of the dam.

A 60 ft wide flood channel, with 2 to 1 side slopes, will collect runoff from the 18.7 sq mile watershed north of the property and direct it to the arroyo. This flood channel will parallel the existing main road 15 ft east of an El Paso Natural Gas Company easement, which contains two pipelines. The flood channel will have a capacity of 8,650 ft^3/sec and will be riprapped for erosion protection. See Section 2.6.

A diversion channel along the northeast side of the tailings dam will intercept drainage collected from a 580 acre watershed to the east of the property. This drainage will be diverted to the north by a diversion channel which will join the main flood channel at the north side of the property. Design capacity of the diversion channel will be 2500 ft^3/sec. In addition, the westerly bank of the diversion channel will be diked to further protect the tailings dam from east watershed runoff. Both the diversion channel and the east face of the dike will be riprapped.

The first intercept ditch along the southeast pond limit will be constructed at an elevation of approximately 6975 ft MSL. As the pond elevation increases, two more intercept ditches will be constructed outside the pond limit. The design flow for these ditches will be 630 ft^3/sec, based on a 96 acre watershed. See Section 2.6.

A runoff collection system for the downstream face of the tailings dam will also collect seepage through the dam and route the seepage to a retention basin. The seepage will be pumped from the retention basin back to the tailings pond.

Planting

As the proposed tailings dam is raised, the downstream face will be continually covered with compacted tailings. Soon after the final dam height is reached, the downstream face will be planted to prevent erosion. During the life of the mill, test beds of tailings will be prepared. Experimentation with different depths of soil cover and specimens of local flora will determine the depth of soil cover necessary to insure continued healthy growth without irrigation.

Tailings Pond Containment

The potential for tailings pond water to reach ground water is evaluated below. Also see Appendix B.

Since water-bearing alluvium is restricted to the valleys, only alluvium downstream from the mill site could be affected by Applicant's activities. Water pumped from the mine tends to recharge alluvium. Seepage from the proposed tailings pond will have the same effect, although the volumn will be much less. Permeability of approximately 0.01 ft/year is expected for liquid from the tailings pond. Total infiltration should be only a few gal/min per acre after the pond has been operating a few

years. Water movement, once in the alluvium, is expected to be very slow, a few inches per year, given the horizontal permeability of 3.8 ft/year discussed previously. Even if there were sufficient infiltration to produce surface flow in the arroyo below the pond, this surface water would rapidly re-enter the alluvium and move down gradient at a far slower rate. Due to low permeability, the isolated lenses of silty sands, and the sealing quality of tailing fines, no channeling of pond liquids into the ground is expected.

The sandstones that underlie the arroyo channel at the toe of the dam are probably part of the Dilco Coal Member and, if infiltration from the pond were significant, some water could move into them. However, the relatively low infiltration rate would preclude appreciable liquid from this source. The dip of the bedrock near the outcrop determines the direction of ground water movement. Surface drainage flows opposite the bedrock dip in Pipeline Canyon so little or no water could enter the Dilco from tailings water in the arroyo.

Beyond the influence of the ground water mound, created by infiltration from the tailings pond, ground water within the sandstones of the Dilco is expected to flow down at a rate determined by the dip of the rocks. The rather massive sandstone beds are not likely to be saturated very far downdip, and thus, artesian conditions probably would not be established.

Only one existing well could conceivably be reached by water from the tailings pond. This well, No. 17.15.30.341, is approximately 1.6 miles from the north boundary of the section containing the pond, Section 2, T.16 N., R.16 W. See Figure 2.6-1. This well taps the Gallup aquifer at a depth of 480 feet, and is cased through the Dilco sandstones and the upper part of the Gallup to a depth of 537 ft. Water from the tailings pond could only enter the well by flowing down between the casing and the soil.

Direct water entry from the tailings pond to the Gallup sandstone aquifer is unlikely because of the thick section of relatively impermeable material between the Dilco sandstones and the first unit of the Gallup aquifer. A remote possibility exists that water would enter the Gallup from the alluvium in Pipeline Canyon. If a significant amount of water were to enter the alluvium, it would recharge the Gallup at the point where the alluvium crosses the subcrop of the Gallup in the canyon floor. However, any water entering the lower, most-continuous Gallup sandstones would do so at least 0.5 mile southwest of the proposed tailings pond where the outcrop of this sandstone crosses the canyon floor.

Presumably, water in the lower Gallup sandstone beneath the tailings pond is under artesian conditions; thus, the aquifer would not be recharged.

Except for stock watering use near the southern rim of the San Juan Basin, the Dakota Sandstone is not an important aquifer. There is virtually no possibility of tailings water entering the Dakota from the pond. The only effect on the Dakota will be a lowering of piezometric surface by pumping from Applicant's mine. The Kerr-McGee mine also pumps from this aquifer.

A thick, relatively impermeable Mancos Shale overlies the Dakota and the Westwater Canyon Formations. For this reason and because of the heavy pumping from the Westwater Canyon, little or no possibility exists that water from Applicant's mine or proposed tailings pond will reach the Westwater Canyon aquifer.

Except for the San Andres-Glorieta system (see Section 2.6), none of the deeper aquifers are considered good aquifers within many miles of the proposed mill site. The possibility is remote that tailings pond water will enter any of these units because of the thick, impermeable rocks intervening.

3.5 SANITARY AND OTHER MILL WASTES

Sources and control of mill wastes that directly result from the mill processes are discussed in Section 3.3 and 3.4. Sanitary wastes, solid wastes other than tailings, storm water runoff, and boiler effluents are discussed below.

Sanitary Wastes

Sanitary wastes from the proposed mill will be treated by screening, aeration, secondary clarification, and chlorination in a package type, aerobic digestion treatment plant approved by the National Santiation Foundation. This plant will be located on the east edge of the mill area near the fuel oil storage tank. See Figure 3.1-1. The plant will be capable of 80% BOD reduction and will provide a secondary treatment type of effluent. The effluent will be sprinkled on vegetation around the mill's perimeter or in freezing weather will be discharged into the tailings pond. The mine sanitary waste system consists of a septic tank and a sanitary tile field.

Protective clothing worn for yellowcake handling operations will be laundered, and the wastes returned to the process for uranium reclamation or discharge to the tailings pond.

The small volume of wastes from the supporting chemical laboratory will be discharged into the tailings pond upstream of the sampler. This effluent will contain small amounts of laboratory reagents.

Solid Wastes

Solid wastes such as construction debris, office wastes, lunchroom wastes, and packaging materials will be disposed of in a public sanitary landfill about 10 miles south of the proposed site.

Before process machinery is discarded in the sanitary land fill, the machinery will be acid cleaned and surveyed for removal of radioactive material. The acid used in cleaning will be recycled to the mill process.

Stormwater Runoff

Rainwater runoff at the mill will be discharged to the arroyo in Pipeline Canyon, except for the small quantity trapped within tank impoundments. This water will either evaporate or percolate into the ground.

Boiler Effluents

Process steam and some building heat will be provided by two boilers fired by No.6 fuel oil. A single stack 57 inches in diameter and 70 ft tall, will serve both boilers. Applicable State air quality regulations are discussed in Section 5.4 for emissions summarized in Table 3.5-1.

Calculated from emission factors for similar equipment,[a] boiler emissions assume a maximum sulfur content of 0.5% for No. 6 fuel oil and a stack flow rate of 40,000 ft^3/min.

3.6 MINING ACTIVITIES

The Mine

The Applicant's mine is located in Section 35, Township 17 N., Range 16 W. See Figures 2.1-2 and 2.1-3. The ore is currently trucked approximately 85 miles to a uranium mill near Ambrosia Lake, New Mexico. With the operation of the proposed mill, the truck route will be reduced to approximately 0.5 mile each way.

(a) EPA, 1972.

TABLE 3.5-1 BOILER EMISSIONS

Substance	Maximum[a] Emission Rate, lb/hr	Anticipated[b] Emission 10^3 lb/yr	Annual[b] Avg Concn µg/liter	Ambient Air Quality Std
Particulates	11.2	46	268	60 µg/m^3 AGM[c]
Sulfur dioxide	38.1	157	1599	0.02 ppm AAM[d]
Sulfur trioxide	0.49	2	20.4	none
Carbon monoxide	0.10	0.4	4.1	none
Hydrocarbons as CH_4	1.5	6	61.1	none
Oxides of nitrogen as NO_2	38.8	160	1629	0.05 ppm AAM
Aldehydes as HCHO	0.49	2	20.4	none

(a) Based on 485 gal/hr maximum.
(b) Based on 2,000,000 gal/year.
(c) Annual geometric mean.
(d) Annual arithmetic mean.

The ore body lies in Sections 34 and 35 of Township 17 N. Range 16 W., and in Section 3 of Township 16 N. Range 16 W. The ore body occupies a portion of the Westwater Canyon Sandstone Formation, which is greater than 200 ft thick at the mine location. Horizon widths vary from 2400 ft to 50 ft and extend over 5700 ft in a northeast to southwest direction.

The mine is served by a three-compartment, concrete lined production shaft 1788 ft deep, and 14 ft in diameter. Currently, the 1500 ft level and the 1700 ft level are mined. A second production shaft is planned at the southwestern end of the mine.

Underground ventilation is provided by large ground-level exhaust fans which draw air down the main vertical shaft, through the working areas, and out two large vertical ventilation shafts. The ventilation provides mining personnel with fresh air and removes radon gas, radon daughter products, diesel exhaust fumes, and combustion gases from explosives.

A mechanical continuous miner transfers ore by conveyor to 10 ton capacity, rubber-tired trucks. Ore that is mined by blasting is loaded onto the trucks by 2 yd^3 front end loaders. The trucks haul the ore to strategically placed stope-ore passes. From the stope-ore passes the ore is hauled by diesel locomotives pulling 5-ton side-dump cars, which deliver the ore to measuring pockets at the shaft. The mine operates three shifts a day, 7 days a week.

For each ton of ore produced, an average of 0.033 ton of low-grade ore and 0.052 ton of waste are also produced. The low grade ore is segregated and stockpiled in anticipation of improved technology and economics. This low grade ore may be subsequently leached on site or processed through the mill for uranium removal.

The mine waste is presently used as fill to extend the level land area in the vicinity of the mine. After consolidation and revegetation, this land will become a permanent part of the landscape.

During the final retreat mining operations, portions of the mill tailings and mine wastes may be used as backfill in the mine.

Liquid Waste

Approximately 1400 gal/min of water is pumped from the mine to permit mining operations. This water flows through three settling

ponds and is discharged into the nearby arroyo. The proposed mill will use part of this water, which will then be discharged into the tailings basin. Mine water will also be used for sprinkling the exposed faces of the tailings dam, and for the mill's fire protection system.

Water discharged from the mine into the arroyo does not reach the Rio Puerco except during the rainy season. This discharge is sanctioned by an EPA discharge permit. See Section 12 and Appendix H.

Gaseous Effluents

The air exhausted through the mine ventilation shafts contains virtually all of the radon gas and combustion fumes generated by the mining activities. Dust is minimized by the natural high moisture content of the ore and exhausted air. No increase in environmental radioactivity resulting from mine activity is expected outside the immediate vicinity of the ventilation shafts.[a] See Section 2.9.

Other Mine Wastes

Sanitary wastes are discharged to a septic tank and sanitary tile field. Trash and other solid wastes are currently placed in a sanitary landfill adjacent to the mine surface operations. After completion of the proposed mill, mine waste will be disposed of in the county sanitary landfill, approximately 10 miles southwest.

(a) WASH-1248.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 4.0

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, MILL CONSTRUCTION, AND MINE OPENING

4.0 ENVIRONMENTAL EFFECTS OF SITE PREPARATION, MILL CONSTRUCTION, AND MINE OPENING

The effects of construction activities on land and water resources in the area are discussed in this section. The commitment of resources for mill construction are discussed in Section 5.6, along with commitment of resources anticipated for the entire life of the facility.

4.1 SITE PREPARATION PLANT CONSTRUCTION

The surface activities of the mine have disturbed approximately 60 acres. In addition, the proposed mill site will occupy approximately 20 acres and the tailings pond approximately 160 acres. Construction activity will be confined to these areas. Construction of the mill will require some grading on the mill site and earth-moving for the starter dike of the proposed tailings dam. Essentially all of the flora in these areas will be destroyed. Plant life will be re-established in the tailings pond area as a part of Applicant's restoration and reclamation efforts at the close of mill operation.

Approximately 1200 ft of road will be constructed in three segments. Approximately 400 ft will extend from State Highway 566 to the mill's parking area and administration building. A separate road from State Highway 566 to the ore truck receiving pad will be 200 ft. The third segment, approximately 600 ft long, will be from the highway to the tailings pond. The ore storage pad will occupy nearly 4 acres. Much of the remaining area around the mill will be surfaced for the operation of light trucks.

Construction activities and the consequent destruction of flora within these 20 acres will cause either the displacement or loss of local vertebrate and insect populations. Such disturbances should not affect the regional wildlife populations, for these populations are not limited to the site. Except for incidental use by local fauna, the proposed site is not known to be a nesting, breeding, or nursing area, or part of a migratory route.

The temporary environmental effects of construction activities will include environmental releases from diesel-powered construction equipment, noise, and dust. Noise and hydrocarbon emissions from construction equipment will have minimal impact on local fauna and area inhabitants. Except for the 43 individuals who will be relocated during the proposed mill's construction, the

nearest resident lives more than a mile away. The impact from noise and hydrocarbon emissions should be similar to, but less than that of the trucks presently hauling ore from Applicant's and Kerr-McGee's mines. Dust raised by construction activities will be minimized by sprinkling with mine water.

Impact upon or inconveniences to users of the road will be minimal, since traffic on the road is essentially limited to traffic to and from the Applicant's and Kerr-McGee's mines. State Highway 566 dead-ends at Applicant's mine less than 1 mile from the proposed mill site.

Forty-three people currently live in a trailer court adjacent to the mine surface facilities. This trailer court will be moved during construction to a new location designated as "the old Church Rock mine site" in Section 17, T.16 N, R.16 W. This new location, 10 acres or less, is approximately 4 miles from the proposed mill site and is closer to the recreational, educational, and shopping centers of Gallup.

Water is currently pumped from Applicant's mine at a rate of 1400 gal/min and discharged to an adjacent arroyo. A similar quantity of water from the nearby Kerr-McGee mine is also discharged to this arroyo. These combined discharges flow down Pipeline Canyon 2 to 5 miles before evaporating and/or seeping into the alluvium. Without these discharges the arroyo and canyon would normally be dry. By using only a small amount of the total mine water discharged into the arroyo for dust control, site preparation and construction activities will have minimal impact on wildlife. Evidence of aquatic life in the arroyo has not been observed. See Section 2.8.

Currently, drinking water is trucked to the area and mine water is used for other sanitary purposes. One or two wells will be drilled to supply sanitary water to the proposed mill and mine complex. The well withdrawal will be from the deeper confined aquifers and, consequently, will not affect the ground water table.

Portable chemical toilets will be used by the construction crews until the mill sewage treatment plant is in operation.

Trash, garbage, and other construction debris will be disposed of in the county sanitary landfill located approximately 10 miles southwest of the proposed site.

Three archaeological sites are located within the area. However, none of these sites will be disturbed by construction activities. See Section 5.5.

The proposed mill buildings will have a low profile and will be painted to harmonize with the terrain. Man-made cuts and embankments will be landscaped for aesthetic appeal as well as erosion control.

Explosives may be required for site preparation. However, Applicant and its designated contractors will be appropriately licensed and will adhere to state regulations for the use of explosives. A minimal environmental impact would be expected for the proposed site is isolated and Applicant has extensive experience in the proper use of explosives.

4.2 RESOURCES COMMITTED

The mine site, approximately 60 acres, and the proposed mill site, approximately 20 acres, are considered a short term commitment of land. The construction in these areas will result in destruction of flora and displacement or loss of fauna.

After all operations have terminated, the mill and visible structures will likely be dismantled, and the mine and mill areas will be revegetated. To assist natural reclamation of the land, Applicant will establish landscape and erosion protection by grading and stabilizing the exposed mine tailings and settling ponds, and finally, by replanting native vegetation.

Construction of the starter dam will disturb approximately 100 acres and will also result in the destruction of flora and displacement or loss of fauna. Additional information on resources committed is given in Section 5.6. See Section 9.0 for reclamation.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 5.0

ENVIRONMENTAL EFFECTS OF MILL AND MINE OPERATION

5.0 ENVIRONMENTAL EFFECTS OF MILL AND MINE OPERATIONS

Normal operation of Applicant's proposed mill and the existing mine will produce liquids, gases, and solids that contain small but measurable quantities of stable and/or radioactive chemicals. Equipment described in Section 3.4 will prevent or minimize such releases as far below the applicable standards, set by the State of New Mexico, as is practicable.

The Applicant's sampling program, described in Section 6.0, has been designed to determine the types and concentrations of stable and radioactive chemicals in mill and mine effluents. If, during the course of proposed mill operations, an abnormal increase in effluent concentrations is found, an investigative review of the release would be initiated. Should the observed increases be valid, corrective actions would be taken. In the unlikely event that release concentrations exceed the State of New Mexico standards, the source of the release will be determined and that portion of the mill operations will be suspended until necessary repairs are completed.

5.1 RADIOLOGICAL IMPACT ON BIOTA OTHER THAN MAN

This section covers the possible impact of radionuclide releases from plant operations on biota other than man. As discussed in Section 2.8, the mule deer is the single most important species known to live in this area. Because of its feeding habits and habitat, the mule deer has the highest potential for exposure to ionizing radiation.

5.1.1 Exposure Pathways

Figure 5.1-1 illustrates the various environmental exposure pathways by which biota may receive radionuclides released from the mill and mine. For mule deer, the principal exposure pathways are inhalation of radionuclides in air and consumption of contaminated foliage and water.

Airborne radionuclides will originate from mine tailings, from the mill ventilation stacks and vents, from piles of unprocessed ore, and from the tailings pond. Particulates and radon gas discharged in the mine ventilation air are comparatively minor sources of exposure, as discussed in subsequent sections. Airborne particulates released from the mill could settle out on vegetation that might be consumed by mule deer. Although the fences around

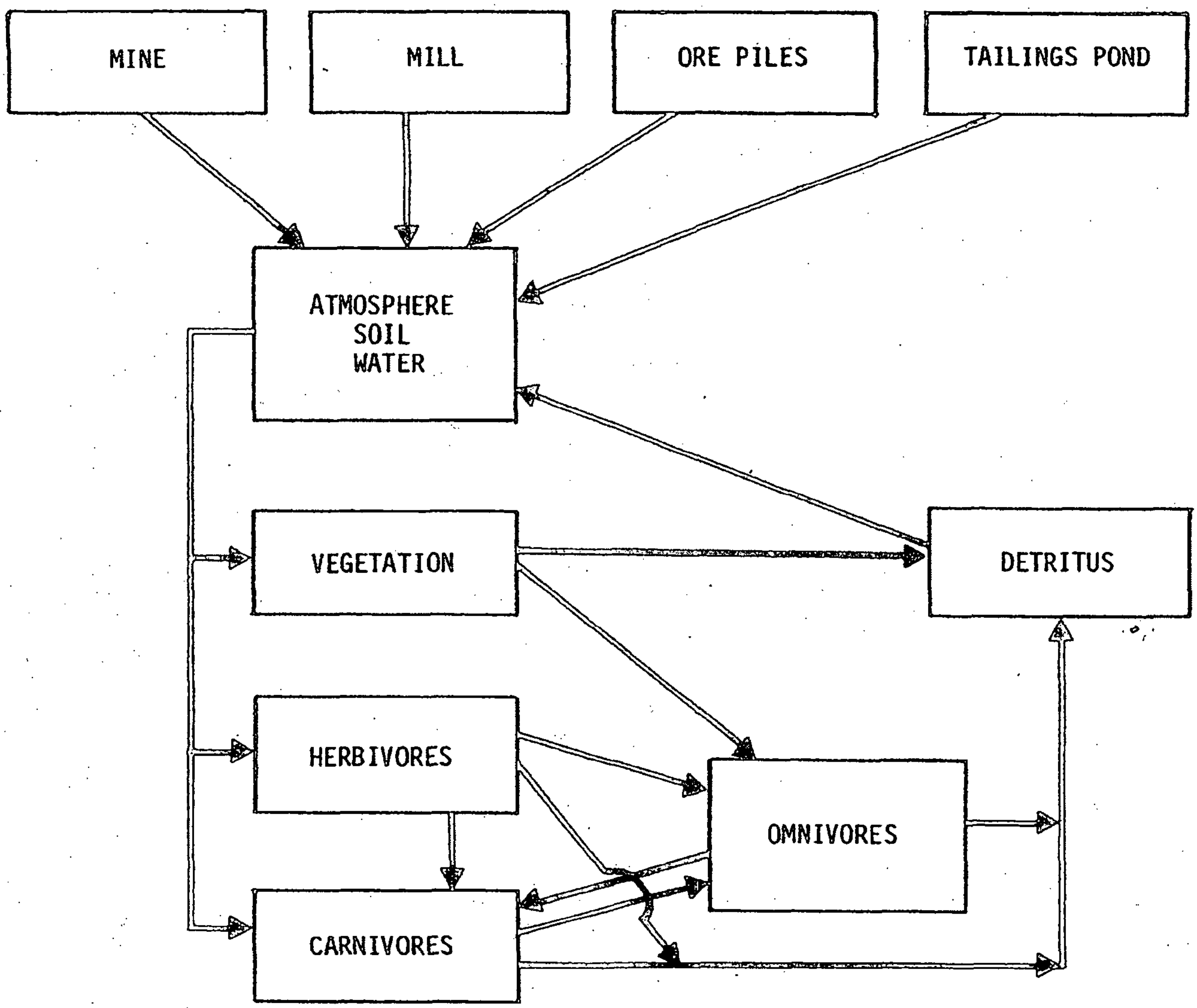


FIGURE 5.1-1 POTENTIAL EXPOSURE PATHWAYS TO BIOTA OTHER THAN MAN

the mill and land Section 2 are not expected to prevent access to vegetation around the mill, foraging by deer will be discouraged by milling activities once they begin. Vegetation around the mill will neither be extensive nor the sole source of food for deer in the area.

The water discharged from the mine into the arroyo draining into Pipeline Canyon may serve as a source of drinking water for mule deer (see Section 2.8) and is therefore a potential source of radionuclides. Algae and the limited plant life which grow in or near the mine water settling ponds and the arroyo provide little food for deer in the area. Consequently, these exposure pathways are of limited importance.

Mill liquid discharged to the tailings pond will be sufficiently unpalatable, pH 1.5-2.0, to prevent animals from using it as drinking water, especially when mine water is available in the arroyo. The chemical content of the tailings pond water is not known to be conducive to plant life, and few plants which might serve as an animal food source are expected to grow on the banks of the tailings pond.

Sprinkling mine water on the tailings pond dam for dust control may promote some plant growth, but this source of water will not contain radionuclides in levels higher than those that occur in the natural environment. Consequently, no significant exposure pathways from radionuclides contained in the tailings pond are anticipated.

5.1.2 Radioactivity in the Environment

Since 1969 water from Applicant's mine has been pumped into an unnamed arroyo. The concentrations of natural uranium, Th-230, and Ra-226 in the water vary considerably with the quality of ore through which the water passes and with the residence time of the water in the ore body. Average concentrations are measured in the mine water, in water flowing into and out of the mine water settling ponds, and at specified downstream locations as the water flows down the arroyo and interacts with the soil. Section 2.9 presents the data, and Section 6 describes the monitoring programs.

Current discharge rates from the mine are estimated at 1400 gal/min of which approximately 700 gal/min will be used by the proposed mill as a minimum requirement under full operation. The remaining 700 gal/min will discharge into the arroyo. The Kerr-McGee mine, located northeast of Applicant's mine, discharges approximately 1400 gal/min to the same arroyo. During the dry season, the total water discharged from both mines, 2800 gal/min, seeps into the ground before the arroyo joins the normally dry Rio Puerco, within an estimated 4 miles from Applicant's mill site. During the rainy season, however, the mine water may enter the Rio Puerco, which is not a potable water supply or a navigable water way, and then the water in an extremely diluted form may enter the Little Colorado.

As the mine water percolates into the soil underlying the arroyo, the fine particles of uranium ore and soluble radionuclides are removed by the soil.[a] Although the mine water may eventually reach the water table, this water has been partially stripped of the radionuclides present at the time of discharge into the arroyo. A buildup of radionuclides in the arroyo near the mine site results from the above process.

Natural uranium, Th-230, and Ra-226 are the radionuclides of potentia concern. The other radionuclides in the decay chain of U-238, the main component of natural uranium, are either too short-lived or are present in such low concentrations that they do not substantially accumulate in the environment.

Estimates of the maximum number of curies of each radionuclide introduced into the arroyo are obtained from the average concentrations observed in mine and surface water and from the anticipated flow rates before and during mill operation. The accumulation rates and the total number of curies introduced into the arroyo by the Applicant from 1969 through the estimated lifetime of the proposed mill, 1978-1993, are presented in Table 5.1-1. An estimated total of 45 curies will be dispersed downstream from the mine settling ponds and throughout the soil at the bottom of the arroyo. Plants grown in soil containing both uranium and radium incorporate but do not concentrate these radionuclides. The level of acquired radium in the plants is 1 to 2 orders of magnitude less than that which resides in the soil.[a]

(a) WASH-1248.

TABLE 5.1-1

ACCUMULATION OF LONG HALF-LIFE RADIONUCLIDES IN THE ENVIRONMENT FROM MINE AND MILL OPERATIONS

	Average Concentration pCi/Liter	Curies/Yr 1969-1977	Curies/Yr 1978[a] - 1993	Total Curies
Mine water discharged to arroyo[b]				
Natural uranium[c]	1426.	2.7	1.3	42.
Th-230	46.	0.1	0.1	2.
Ra-226	22.	0.1	<0.1	1.
Mill slurry discharged to tailings pond				
Natural uranium	800.	0.0	1.1	16.
Th-230	22000.	0.0	30.6	429.
Ra-226	350.	0.0	0.5	7.
Atmospheric releases[d]	μCi/sec			
Natural uranium	0.0072	0.0	0.2	3.
Th-230	0.0022	0.0	0.1	1.
Ra-226	0.0022	0.0	0.1	1.

(a) Estimated startup date for the proposed mill is June 1977, but initial operational systems shakedown needs will probably delay planned full scale operation until 1978.
(b) Average concentrations reported in Section 2.9.
(c) Specific activity of natural uranium is 6.77×10^{-7} Ci/g, 10 CFR 20.
(d) Reported values for an operating mill, EPA-520-9-73-3-B. See Section 5 Addendum.

Operation of the mill for 365 days/year will also release measurable concentrations of radionuclides into the immediate environs. For purposes of impact assessment, natural uranium, Th-230, Ra-226, and Rn-222 are the radionuclides of interest.

All of the liquid effluent, approximately 700 gal/min, from the milling process will be released to the tailings pond for solar evaporation. The projected rate of accumulation and total quantities of radionuclides in the tailings pond after the mill ceases operation are presented in Table 5.1-1.

A small quantity of the tailings pond water will leak through the tailings dam into a collection ditch around the base of the dam. This water will be pumped back into the pond. Another small quantity of the water is expected to seep into the soil underlying the pond.

Pond seepage into the soil and through the dam will result in some buildup of radionuclides in those areas. However, most of the estimated 452 curies discharged to the pond during the lifetime of the mill will remain in the pond bottom. After mill operations cease and the pond water has evaporated, this radioactivity will remain under the earth fill used for stabilization and restoration. See Section 5.3.

The Applicant's mine ventilation system controls the mine's atmospheric concentrations of Rn-222, radon daughter products, and diesel equipment exhausts. Because of the high relative humidity in the mine, the ventilation air contains very little dust and, consequently, very little Th-230 and Ra-226 associated with ore dusts.

"The BEIR report and the U. S. Environmental Protection Agency Report, Estimates of Ionizing Radiation Doses in the United States 1960-2000, both conclude that, while uranium mining activities increase the amount of surface uranium and its decay products, it does not cause measurable increases in environmental radioactivity outside the immediate vicinity of the mines."[a] Measurements taken of the radon daughter concentrations in mine ventilation air document the very low concentrations released, 0.4 WL and less. See Section 2.9.

Atmospheric releases of long-lived radionuclides from milling operations will include natural uranium, Th-230, and Ra-226. Other radionuclides in the U-238 decay chain have either such a short half-life or are present in such low concentrations that they do not substantially accumulate in the environment.

(a) WASH-1248.

The estimated atmospheric release rates of natural uranium, Th-230, and Ra-226 are based upon observed emissions from operating uranium mills and are adjusted for a 4000 tons/day capacity mill.[a] Anticipated release rates and the total quantity of radionuclides released from 1978 to the termination of proposed mill operation are presented in Table 5.1-1.

The atmospheric diffusion equation described in Section 5 Addendum was used to calculate long-term average concentrations for each source term. A source term quantitatively describes which radionuclides are released. The proximity of the sources allowed computation of atmospheric dispersions by assuming a ground level release from a single point midway between the tailings pond and the mill. To assume that all emissions occur at ground level is a conservative approach to the calculations and maximizes the dose rates calculated for yellowcake dust emissions from the yellowcake dryer stack. For Th-230, Ra-226, and Rn-222 the assumption of a ground level release represents actual conditions that will be present at the mill site.

Geometry factors in the diffusion equation account for differences between point source emissions of natural uranium from the stack and area source emissions from the tailings pond and ore piles of Th-230, Ra-226, and Rn-222. See Section 5 Addendum. The meteorological data used in the diffusion equation were available only for January 1973 to August 1974 for the Gallup, New Mexico, area. See Section 2.6. Since wind stability data were not available for the Gallup area, neutral wind stability Class D was used in the diffusion equation as recommended by Turner.[b]

The concentrations of radionuclides dispersed in the atmosphere, as a function of both the distance from the source and the average meteorological conditions, are presented in Tables 5.2-1 through 5.2-4 and discussed in Section 5.2.

Direct radiation exposures from gamma rays produced from radionuclides released to the environment by Applicant's activities will be low. Exposures exceeding a few mrem/hr will be rare, even at the surface of mill process vessels. Gamma rays from this source will not result in measurable radiation exposure to biota.[c]

(a) EPA-520-9-73-3-B and Section 5 Addendum.
(b) Turner, 1970.
(c) EPA-520-9-73-3-B.

TABLE 5.2-1
CONCENTRATIONS AND DOSE RATES AS A CONSEQUENCE
OF NATURAL URANIUM RELEASES

Source Term = 0.0072 μCi/sec[(a)]

Wind[(b)] Direction	f	$\bar{u}$	X_B	$(C_B)(10^{-14})$	D_B	X_R	$(C_R)(10^{-15})$	D_R
N	4.4	2.5	851	1.1	3.2	1824	0.3	0.9
NNE	3.7	2.4	910	0.9	2.6	2006	0.2	0.7
NE	3.5	2.2	760	1.2	3.5	1702	0.3	0.9
ENE	4.9	2.4	610	2.2	6.7	1884	0.3	1.0
E	3.8	2.4	610	1.7	5.2	7242	0.0	0.1
ESE	1.7	2.4	670	0.7	2.0	6080	0.0	0.1
SE	2.4	2.2	550	1.4	4.3	7000	0.0	0.1
SSE	2.5	2.5	456	2.3	6.9	1776	0.2	0.5
S	7.4	2.7	425	7.3	22.0	800	1.9	5.6
SSW	9.1	3.0	456	6.9	21.0	8045	0.0	0.1
SW	17.2	3.7	550	6.2	19.0	4800	0.4	0.7
WSW	18.7	3.7	912	2.8	8.4	3344	0.3	1.0
W	11.8	3.3	730	2.9	8.6	1824	0.6	1.8
WNW	5.1	3.0	790	1.2	3.6	3648	0.1	0.3
NW	2.5	3.0	851	0.5	1.5	2796	0.1	0.2
NNW	1.9	2.7	912	0.4	1.2	2736	0.1	0.2

f = Percentage of time wind blows in specified direction, including calms

$\bar{u}$ = Mean wind velocity in specified direction (m/sec)

X_B = Distance from center of site to site boundary (m)

C_B = Concentration at boundary (μCi/cc)

D_B = Dose rates to critical organ (lung) from continuous occupancy at site boundary (mrem/year)

X_R = Distance from center of site to nearest residence (m)

C_R = Concentration at nearest residence (μCi/cc)

D_R = Dose rates to critical organ (lung) from continuous occupancy at nearest residence (mrem/year)

(a) Source term is based on observed emissions from operating uranium mills, adjusted for 4000 tons/day ore input (EPA-520-73-3-B).

(b) Exposure locations are in opposite direction.

TABLE 5.2-2

CONCENTRATIONS AND DOSE RATES AS A CONSEQUENCE OF THORIUM-230 RELEASES

Source Term = 0.0022 μCi/sec[a]

Wind[b] Direction	f	$\bar{u}$	X_B	$(C_B)(10^{-14})$	D_B	X_R	$(C_R)(10^{-15})$	D_R
N	4.4	2.5	851	1.1	5.5	1824	0.5	2.3
NNE	3.7	2.4	910	0.9	4.4	2006	0.3	1.7
NE	3.5	2.2	760	1.2	6.0	1702	0.5	2.3
ENE	4.9	2.4	610	2.3	11.3	1884	0.5	2.5
E	3.8	2.4	610	1.8	8.8	7242	0.1	0.2
ESE	1.7	2.4	670	0.7	3.4	6080	0.0	0.1
SE	2.4	2.2	550	1.5	7.4	7000	0.0	0.1
SSE	2.5	2.5	456	2.3	11.7	1776	0.3	1.4
S	7.4	2.7	425	7.4	36.9	800	2.8	14.2
SSW	9.1	3.0	456	7.1	35.4	8045	0.1	0.3
SW	17.2	3.7	550	6.3	31.5	4800	0.6	1.7
WSW	18.7	3.7	912	2.8	14.2	3344	0.5	2.5
W	11.8	3.3	730	2.9	14.6	1824	0.9	4.7
WNW	5.1	3.0	790	1.2	6.2	3648	0.1	0.7
NW	2.5	3.0	851	0.5	2.6	2796	0.1	0.5
NNW	1.9	2.7	912	0.4	2.0	2736	0.1	0.5

f = Percentage of time wind blows in specified direction, including calms

$\bar{u}$ = Mean wind velocity in specified direction (m/sec)

X_B = Distance from center of site to site boundary (m)

C_B = Concentration at boundary (μCi/cc)

D_B = Dose rates to critical organ (lung) from continuous occupancy at site boundary (mrem/year)

X_R = Distance from center of site to nearest residence (m)

C_R = Concentration at nearest residence (μCi/cc)

D_R = Dose rates to critical organ (lung) from continuous occupancy at nearest residence (mrem/year)

(a) Source term is based on observed emissions from operating uranium mills, adjusted for 4000 tons/day ore input (EPA-520-73-3-B).

(b) Exposure locations are in opposite direction.

TABLE 5.2-3

CONCENTRATIONS AND DOSE RATES AS A CONSEQUENCE OF RADIUM-226 RELEASES

Source Term = 0.0022 μCi/sec[a]

Wind[b] Direction	f	$\bar{u}$	X_B	$(C_B)(10^{-14})$	D_B	X_R	$(C_R)(10^{-15})$	D_R
N	4.4	2.5	851	1.1	0.8	1824	0.5	0.3
NNE	3.7	2.4	910	0.9	0.7	2006	0.3	0.3
NE	3.5	2.2	760	1.2	0.9	1702	0.5	0.3
ENE	4.9	2.4	610	2.3	1.7	1884	0.5	0.4
E	3.8	2.4	610	1.8	1.3	7242	0.1	0.0
ESE	1.7	2.4	670	0.7	0.5	6080	0.0	0.0
SE	2.4	2.2	550	1.5	1.1	7000	0.0	0.0
SSE	2.5	2.5	456	2.3	1.8	1776	0.3	0.2
S	7.4	2.7	425	7.4	5.5	800	2.8	2.1
SSW	9.1	3.0	456	7.1	5.3	8045	0.1	0.0
SW	17.2	3.7	550	6.3	4.7	4800	0.6	0.3
WSW	18.7	3.7	912	2.8	2.1	3344	0.5	0.4
W	11.8	3.3	730	2.9	2.2	1824	0.9	0.7
WNW	5.1	3.0	790	1.2	0.9	3648	0.1	0.1
NW	2.5	3.0	851	0.5	0.4	2796	0.1	0.1
NNW	1.9	2.7	912	0.4	0.3	2736	0.1	0.1

f = Percentage of time wind blows in specified direction, including calms

$\bar{u}$ = Mean wind velocity in specified direction (m/sec)

X_B = Distance from center of site to site boundary (m)

C_B = Concentration at boundary (μCi/cc)

D_B = Dose rates to critical organ (lung) from continuous occupancy at site boundary (mrem/year)

X_R = Distance from center of site to nearest residence (m)

C_R = Concentration at nearest residence (μCi/cc)

D_R = Dose rates to critical organ (lung) from continuous occupancy at nearest residence (mrem/year)

(a) Source term is based on observed emissions from operating uranium mills, adjusted for 4000 tons/day ore input (EPA-520-73-3-B).

(b) Exposure locations are in opposite direction.

TABLE 5.2-4
CONCENTRATIONS AND DOSE RATES AS A CONSEQUENCE OF RADON-222 RELEASES

Source Term = 17.1 μCi/sec[(a)]

Wind[(b)] Direction	f	$\bar{u}$	X_B	$(C_B)(10^{-14})$	D_B	X_R	$(C_R)(10^{-15})$	D_R
N	4.4	2.5	851	0.6	0.3	1824	2.4	1.2
NNE	3.7	2.4	910	0.5	0.3	2006	1.8	0.9
NE	3.5	2.2	760	0.7	0.3	1702	2.4	1.2
ENE	4.9	2.4	610	1.3	0.7	1884	2.6	1.3
E	3.8	2.4	610	1.0	0.5	7242	0.3	0.1
ESE	1.7	2.4	670	0.4	0.2	6080	0.1	0.1
SE	2.4	2.2	550	0.9	0.4	7000	0.2	0.1
SSE	2.5	2.5	456	1.4	0.7	1776	1.4	0.7
S	7.4	2.7	425	4.3	2.2	800	14.7	7.3
SSW	9.1	3.0	456	4.1	2.1	8045	0.3	0.2
SW	17.2	3.7	550	3.7	1.8	4800	3.0	1.0
WSW	18.7	3.7	912	1.7	0.8	3344	2.5	1.3
W	11.8	3.3	730	1.7	0.9	1824	4.8	2.4
WNW	5.1	3.0	790	0.7	0.4	3648	0.7	0.4
NW	2.5	3.0	851	0.3	0.2	2796	0.6	0.3
NNW	1.9	2.7	912	0.2	0.1	2736	0.5	0.2

f = Percentage of time wind blows in specified direction, including calms

$\bar{u}$ = Mean wind velocity in specified direction (m/sec)

X_B = Distance from center of site to site boundary (m)

C_B = Concentration at boundary (μCi/cc)

D_B = Dose rates to critical organ (lung) from continuous occupancy at site boundary (mrem/year)

X_R = Distance from center of site to nearest residence (m)

C_R = Concentration at nearest residence (μCi/cc)

D_R = Dose rates to critical organ (lung) from continuous occupancy at nearest residence (mrem/year)

(a) Source term is based on observed emissions from operating uranium mills, adjusted for 4000 tons/day ore input (EPA-520-73-3-B).

(b) Exposure locations are in opposite direction.

In summary, mine water discharge and atmospheric dispersions from the mine will continue to be sources of radionuclides in the environment. After the mill begins operation, additional sources of radionuclides in the environment will be the mill, ore piles, and the tailings. Table 5.1-1 and Section 5 Addendum present summaries of the releases and the atmospheric diffusion equations respectively.

5.1.3 Dose Rate Estimates

For locations up to 5 miles from the proposed mill, atmospheric concentrations of natural uranium, Th-230, Ra-226, and Rn-222 are estimated from average annual meteorological data and observed emission rates from existing mills. The highest dose rates to mule deer will be to their respiratory tract from airborne radionuclides. The magnitude of these respiratory dose rates will be similar to those calculated for man. See Section 5.2.3. Exposure from ingestion of the airborne radionuclides deposited on forage and in water discharged into the arroyo is not expected to add sufficiently to the respiratory dose rates. The total dose rate will not result in a measurable risk to the mule deer.

5.2 RADIOLOGICAL IMPACT ON MAN

The radiological impact on man from mine and proposed mill operations and from transportation of radionuclides is evaluated in this section. The evaluations indicate that the radiological effects of mine and mill operations represent only a small fraction of the dose to man from natural background radioactivity. The dose rates are well within the dose guidelines and limits established for protection of the public.[a]

5.2.1 Exposure Pathways

During normal operation of the mine and the proposed mill, small quantities of natural uranium, Th-230, Ra-226, and Rn-222 will be released to the environment. The external gamma exposure from these radionuclides is low, rarely exceeding a few mrem/hr at the surface of process vessels,[b] but the radionuclides can be inhaled and cause an internal radiation exposure.

(a) NMEIA, 1973; 10 CFR 20.
(b) EPA-520-9-73-3-B.

Since the main exposure pathway is through the respiratory tract, dust that could be generated from the proposed activities is a primary concern. Dusts containing Th-230 and Ra-226 could originate from the piles of unprocessed ore and from the banks of the tailings pond. These potential sources of dust will be controlled by the use of sprinkler systems.

Rn-222 will originate from the tailings pond, from ore stored or being processed at the mill site, and from the mine ventilation shafts. Natural uranium will originate from the ventilation exhausts of the yellowcake handling areas of the proposed mill. Each of these sources is discussed in detail in Section 5 Addendum.

Presently, drinking water is transported to the site from an off-site location. In the future drinking water may be obtained locally from wells or from mine water. If necessary, drinking water from local sources will be treated to remove suspended and dissolved radionuclides. Thus, the intake of contaminated water is not considered a major exposure pathway for humans.

Since no edible crops are grown within 5 miles of the proposed mill site and none are anticipated, the transmission of natural uranium, Th-230, and Ra-226 from edible crops to man is not anticipated.

Deer that are foraging or passing through the immediate vicinity of the proposed mill are expected to ingest and/or inhale small but measurable quantities of Th-230 and Ra-226. Any dose to people consuming meat from such deer would be extremely small because:

1) Th-230 and Ra-226 tend to deposit in a deer's skeletal system, which is not consumed.
2) The affected vegetation area will be small, and deer are scarce and transient.
3) Hunting regulations and the scarcity of deer make it unlikely that an individual will consume a large quantity of meat from several deer.

Sections 5.3 and 5.5 of Applicant's application for a Radioactive Materials License address the problem of possible contamination of food in the proposed mill. Administrative controls will be used to limit this exposure pathway. The potential exposure pathways to man are illustrated in Figure 5.2-1.

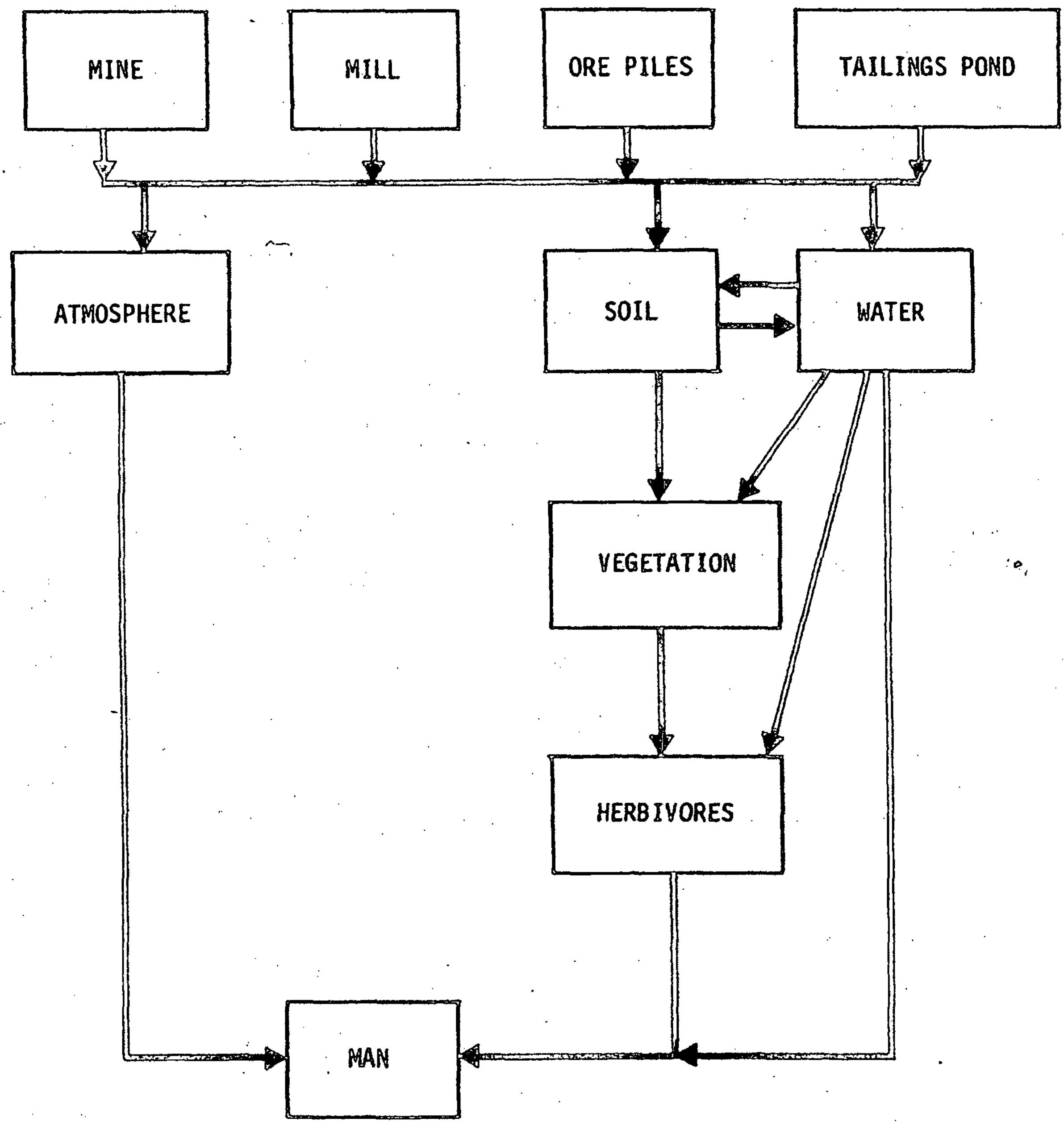


FIGURE 5.2-1 POTENTIAL EXPOSURE PATHWAYS TO MAN

The potential exposure pathway from ore dust during transportation from the mine to the mill has been evaluated as part of the ore dust potential at the site. All shipments of yellowcake will comply with the applicable Department of Transportation regulations for packaging and shipping[a] radioactive materials. An analysis of possible transportation accidents and the resultant environmental impact is presented in Section 7.2.

5.2.2 Liquid Effluents

Liquid effluents from the mine and from the proposed mill will contain natural uranium, Th-230, and Ra-226. The radionuclide concentrations in these effluents and the ultimate fate of both the liquid and the radionuclides are discussed in Section 5.1.2. Transmission of radionuclides to man directly from drinking water or through a food chain has been determined to be insignificant in comparison to the small but measurable exposures from gaseous effluents discussed below.

5.2.3 Gaseous Effluents

Computational methods and assumptions used to estimate long-term average concentrations of gaseous effluents in the lower layers of the atmosphere are presented in Section 5 Addendum. Dose calculations are derived from the maximum permissible concentrations in air (MPC_a) for insoluble radionuclides associated with ore dust and for radon gas. Dose rates for individuals are expressed in mrem/yr and for populations in man-rem/yr.

The concentrations of and corresponding doses from natural uranium, Th-230, Ra-226, and Rn-222 are presented in Tables 5.2-1 through 5.2-4. The concentrations and doses are listed for each of the 16 points of a compass and for the distances from the source to the site boundary and to the nearest resident. The concentrations and dose rates calculated from the atmospheric diffusion equation must be considered "best estimates" and correct within a factor of 2 or 3.[b]

The dose rate estimates presented in the tables are expressed to the nearest tenth of a unit to avoid the implication of zero

(a) 49 CFR 100-199.
(b) Turner, 1970.

dose rate at a given distance from the proposed mill. Consequently, the final digit signifies no more than a given value's relationship to a zero dose rate. The lung has been determined to be the critical organ, and the dose rates to the lung are calculated for continuous occupancy at the specified locations. External whole body dose rates have been shown to be close to zero[(a)] for individuals who might be exposed to effluents from mill operations.

Potential lung dose rate values for continual occupancy by an individual at the specified locations are presented in Table 5.2-5. In summary these values are:

1) 66.6 mrem/yr, the maximum ground level dose rate at the site boundary;

2) 25.5 mrem/yr, the dose rate at site boundary in the direction of the prevailing wind (WSW to ENE);

3) 66.6 mrem/yr, the dose rate at site boundary nearest the emission source, 425 meters;

4) 5.2 mrem/yr, the dose rate at nearest residence in the directio of the prevailing wind (WSW to ENE);

5) 29.2 mrem/yr, the maximum residential dose rate 800 meters from the emission source.

All dose rates were calculated using the equations presented in Section 5 Addendum and for a single ground level release point on the road midway between the proposed mill and the tailings pond. The dose rates are all well below the maximum allowable exposure of 1500 mrem/yr to the lung of an individual under 18 years of age.[(b)]

Food crops are not grown in the area, and radionuclide deposition on forage and grazeland is discussed in Section 5.1.

5.2.4 Exposure Pathways

The inhalation of airborne radionuclides released from the proposed mill will be the largest exposure pathway to man. Yet, even to the population living within 5 miles of the mill facilities, this pathway will result in low dose rates to the lungs. The calculated total dose rates for this pathway are presented in Table 5.2-5. The dose rate values are given as mrem/yr at the site boundary and nearest residences for each of the 16 wind directions.

(a) EPA-520-9-73-3-B.
(b) NMEIA, 1973, 10 CFR 20, 10 CFR 50.

TABLE 5.2-5

TOTAL DOSE RATE TO CRITICAL ORGAN (LUNG)

Wind[a] Direction	X_B	D_B	X_R	D_R
N	851	9.8	1824	4.7
NNE	910	8.0	2006	3.6
NE	760	12.1	1702	4.7
ENE	610	19.0	1884	5.2
E	610	15.8	7242	0.4
ESE	670	6.1	6080	0.3
SE	550	13.2	7000	0.3
SSE	456	21.1	1776	2.8
S	425	66.6	800	29.2
SSW	456	63.8	8045	0.6
SW	550	57.0	4800	3.7
WSW	912	25.5	3344	5.2
W	730	26.3	1824	9.6
WNW	790	11.1	3648	1.5
NW	851	4.7	2796	1.1
NNW	912	3.6	2736	1.0

X_B = Distance from center of site to site boundary (m)

D_B = Dose rates to critical organ (lung) from continuous occupancy at site boundary (mrem/yr)

X_R = Distance from center of site to nearest residence (m)

D_R = Dose rates to critical organ (lung) from continuous occupancy at nearest residence (mrem/yr)

(a) Exposure locations are in opposite direction.

The population dose rates from the airborne pathway for individuals within a 5 mile radius of the site are presented in Table 5.2-6. The population dose rate values are expressed as man-rem for:

1) Natural uranium, Th-230, Ra-226, and Rn-222, both individually and collectively, and
2) For each of the 16 wind directions.

For calculative purposes, dose rates less than 0.1 mrem/yr were equated to zero. See Section 5.2.3 for a discussion of the accuracy of dose rate estimates.

An estimated 1195 people reside within the 5 mile radius around the mine and proposed mill. These people receive (189 mrem/yr)/person from natural background radiation. Based upon a 4000 TPD dry uranium ore processing rate for the mill, an average dose rate of (2.2 mrem/yr)/person will be received by the same people. This would represent an increase in annual dose rate of less than 1.2% within the 5 mile radius.

5.2.5 Summary of Annual Radiation Doses

The total population dose rate for people continuously residing within a 5 mile radius of Applicant's mine and mill will be 2.7 man-rem/yr. This value represents the total population dose rate from all exposure pathways, recognizing that gaseous effluents are the only substantial pathway for exposures. The annual population whole body dose rate from natural background radiation, for the same people, is 226 man-rem/yr.

If the population remains constant, the 50-year dose commitment in the 5 mile radius would be the product of 2.7 man-rem/yr times 15 yr of operation, 40 man-rem. After operations cease in 1993, restoration and reclamation of the area will effectively eliminate all exposure pathways. Yellowcake will no longer be discharged to the atmosphere. The tailings pond will be dry and stabilized with soil and vegetation to prevent the formation of dust containing Th-230 and Ra-226. The soil will retard the diffusion of Rn-222 from the tailings to the atmosphere.

TABLE 5.2-6

POPULATION DOSE RATE DISTRIBUTION

WITHIN A 5 MILE RADIUS OF THE MILL SITE

(man-rem/year)

Wind Direction[(a)]	Uranium Natural	Thorium-230	Radium-226	Radon-222	Total
N	0.032	0.081	0.012	0.042	0.167
NNE	0.021	0.052	0.008	0.027	0.108
NE	0.010	0.026	0.004	0.014	0.054
ENE	0.012	0.029	0.005	0.015	0.061
E	0.004	0.007	0.0	0.004	0.015
ESE	0.002	0.002	0.0	0.002	0.006
SE	0.003	0.003	0.0	0.003	0.009
SSE	0.012	0.034	0.005	0.017	0.068
S	0.256	0.653	0.096	0.334	1.339
SSW	0.0	0.0	0.0	0.0	0.0
SW	0.049	0.119	0.021	0.070	0.259
WSW	0.075	0.075	0.012	0.039	0.201
W	0.031	0.081	0.012	0.042	0.166
WNW	0.021	0.051	0.008	0.027	0.107
NW	0.009	0.022	0.004	0.012	0.047
NNW	0.009	0.028	0.004	0.014	0.055
Total	0.546	1.263	0.191	0.662	2.662

(a) Exposure locations are in opposite direction.

Should the population of the area double in the next 50 years, the 50 yr dose commitment would be approximately 46 man-rem. See Table 2.2-2 for the projected population increases for the county.

5.3 EFFECTS OF CHEMICAL DISCHARGE

Due to the relatively remote location of the proposed site, the air quality is generally unaffected by industrial or municipal pollution sources. Ambient air quality measurements for pollutants, other than sulfur dioxide and total particulates, have not been made in the area. The State of New Mexico Environmental Improvement Agency data on total suspended particulates and on SO_2 concentrations in northwestern New Mexico are presented in Table 5.3-1.

SO_2 measurements were made at Farmington, north northeast of the proposed mill, and at Shiprock, north of the mill. In addition, SO_2 measurements were made in the northwest corner of the State at Beklabito, near the Four Corners area, an area of extensive fossile fuel use. The SO_2 concentrations in the area of the proposed mill are expected to be considerably lower than those in the northwest corner of the state.

Effect of Plant Emissions on Air Quality

Mining and proposed milling activities are not expected to contribute significantly to the dust problem in the area. Dust from mill construction and operation will be minimized by sprinkling graded surfaces, the tailings dam, and ore piles, and by keeping grinding operations wet. In addition, prevention of livestock grazing on Applicant's property will give ground cover vegetation an opportunity to grow, which should decrease the amount of dust from this previously overgrazed area.

Emissions from the two oil-fired boilers to be used in the proposed mill are discussed in Section 3.5 and 5.4.

Effect of Tailings Basin Seepage on Water Quality

The proposed mill facilities have been designed to discharge virtually all process wastes and any spilled or leaked process reagents into the tailings pond for long-term storage. See Section 3.3. However, minor amounts of the tailings basin liquid may seep into the underlying soil and rock strata. See Section 3.4.1.

TABLE 5.3-1

TOTAL SUSPENDED PARTICULATES AND SO_2 CONCENTRATIONS IN NORTHWESTERN NEW MEXICO

Location	Date	Distance (miles) and Direction from Applicant's Proposed Facility		Total Suspended Particulates Avg g/m^3	Total Suspended Particulates Max g/m^3	Number of Samples
Gallup	1971	15.6	SW	141.4	460.4	31
Sandstee	1972	51.0	NNW	127.4	556.0	37
Gallup	1972	15.6	SW	190.1	400.9	7
Gallup	1974	15.6	SW	119.0	228.4	22
Beklabito	1974	85.5	NNW	57.0	114.9	17
Grants	1974	48.0	SE	56.0	85.2	10
Tohatchi	1974	19.5	NW	24.7	85.8	10
				SO_2 Avg ppm	SO_2 Max ppm	
Beklabito	11/73	85.5	NNW	0.000	0.004	480
	1/74			0.001	0.074	656
	2/74			0.000	0.048	496
	3/74			0.000	0.033	564
	4/74			0.000	0.000	518
	5/74			0.000	0.001	493
	6/74			0.002	0.035	369
	7/74			0.001	0.018	92
Farmington	12/73	78.0	NNE	0.000	0.066	669
Shiprock	3/74	75.0	N	0.00	0.07	466
	4/74			0.00	0.02	506
	5/74			0.00	0.06	605
	6/74			0.00	0.08	628
	7/74			0.00	0.05	214

Adverse environmental impacts are not anticipated from tailings pond seepage for the following reasons:

1) The very fine or colloidal particulate composition of the tailings slurry provides an inherent sealing characteristic.

2) The fairly impermeable Mancos shale above the Dakota aquifer and underlying the tailings pond will retard seepage to a very low rate.

3) The seepage that does occur will have particulates and silt removed by filtration through or absorption on the soil prior to reaching the Dakota aquifer.

4) The soil and rock underlying the tailings pond will neutralize the acid in the seepage water. The extent of neutralization can be approximated by considering the quantity of acid that ultimately may reach the pond and by estimating the soil's neutralization capability. The proposed mill may use as much as 782 million lb of sulfuric acid during its operational lifetime. The ore in the leaching process will neutralize approximately 90% of this total, allowing 78 million lb of acid to reach the tailings pond. Assuming that the native soil and rock have a neutralization capacity equal to that of the ore, 50 lb of acid/ton, complete neutralization of all the acid in the pond would require 1.6 million tons of soil. This amount of soil represents a 3.1 ft thick layer over the bottom of the 160 acre pond area. Consequently, even though the low seepage rate may not be uniform, the availability of 1200 ft of soil between the pond floor and the Dakota aquifer precludes contamination of potable water.

5) Dissolved chemicals present in the tailings pond liquid will partially be removed by the soil through absorption and ion exchange processes.

Organic Materials in Tailings

Organic materials such as kerosene and amine from the proposed mill will be discharged in the tailings slurry to the tailings pond. The organic materials will emulsify in the tailings slurry so that separation of the organic from non-organic materials will not occur in the tailings pond. Some limited evaporation of volatile organic solvents, such as kerosene and isodecanol, may occur but is not expected to have

an adverse impact on local air quality. Seepage of organic materials into the water table is not expected for the reasons described above.

Organic compounds in the tailings are expected to decompose naturally. Degradation products and remaining organic materials will be buried when the tailings pond area is stabilized with soil. Consequently, environmental impacts from organic materials are not anticipated by Applicant.

5.4 EFFECTS OF SANITARY AND OTHER WASTE DISCHARGES

The mine and proposed mill waste management systems have been designed to discharge process wastes and effluents directly to the tailings pond. Sanitary sewage from toilets, sinks, and showers will be treated in a conventional sewage treatment plant with an 80% or greater BOD reduction. The treated effluent will be used to water plants around the mill site. However, during freezing weather, this effluent will be discharged to the tailings pond. No adverse environmental effect is anticipated from disposal to either location.

Effect of Stormwater Collection System

Areas of the proposed mill that contain chemical and radiological contaminants will be surrounded by earth and concrete dikes to impound stormwater and washdown water. In the areas of the barren organic holding tank, pregnant aqueous holding tanks, the raffinate tank, and thickeners, the impounded water will be pumped back into the process. Impounded water from the sodium chlorate, sulfuric acid, and fuel oil storage areas will evaporate or percolate into the ground.

Other stormwater runoff from areas within the mill will be diverted to the arroyo in Pipeline Canyon. Stormwater runoff at Applicant's mine will flow by gravity to natural drainage channels. No adverse environmental effects are anticipated from these runoffs.

Effect of Solid Waste Disposal

Solid waste consisting of garbage, trash, and packing material will be transported to a county sanitary land fill as discussed in Section 3.5. Minimal environmental effects are anticipated by the addition of Applicant's wastes to the county's wastes.

Effects of Combustion Products

The boilers for the proposed mill will consume an estimated 2 million gal/year of No. 6 fuel oil. See Section 3.5 for the analysis of boiler effluents. Air quality impact from this source is expected to be negligible. However, a permit from the state covering particulates, SO_2, and NO_2 discharges has been applied for and will be obtained prior to construction.[a] If required, registration certificates for other pollutants will be obtained within 180 days after startup of the proposed mill.

New Mexico Air Quality Standards and Regulations for oil-burning equipment apply to units having fuel inputs equivalent to or greater than 1,000,000 million BTU/year. The Applicant's two units each will have 225,000 million BTU/year input; therefore, these regulations are not applicable.

Nonradioactive gaseous effluents and applicable state air quality standards are listed in Table 3.3-1 of Section 3.3

5.5 OTHER EFFECTS

Three archeological sites, LA 11617, LA 11618, and an unrecorded Navajo site, are located within the area. Two of these sites will be disturbed by the tailings pond, and consequently, will be excavated under the direction of a professional archeologist prior to the beginning of mill operation. The third site will be excavated or protected as directed by the Museum of New Mexico.

Operation of the mine and proposed mill will generate noise that will be heard on site and in the surrounding vicinity. Noise sources will include mine-ventilation fans, hoist equipment, ore conveyor, ore trucks, front-end loaders, semi-autogenous grinder, boiler units, and various mill process units The proposed mill has been designed to maintain noise levels in the work areas to within the requirements set forth by occupational health and safety regulations. The Applicant anticipates that noise levels at times may exceed 95 db within 3 ft of individual pieces of process equipment. However,

(a) New Mexico Air Quality Standards.

noise levels outside the mill will not exceed 80 db. At the nearest residence the noise will be far below nuisance levels even when combined with the noise produced by the neighboring Kerr-McGee mine.

5.6 COMMITMENT OF RESOURCES

Natural and human resources committed by the construction and operation of the proposed mill will include ground water, uranium, land, fauna and flora, construction materials, chemicals, oil, man hours, and capital investments.

Ground water has been pumped by the Applicant from the water table since 1969 and will continue to be pumped until 1993. During that time interval, 11 billion gal of ground water will be pumped into the arroyo adjacent to the mine, and 515 million gal of ground water will be pumped to the tailings pond.

Approximately 20.4 million dry tons of uranium ore will yield approximately 46,000 tons of yellowcake from the proposed mill. The yellowcake will be shipped to other locations for further processing and eventual use as fuel for nuclear reactors. Most of the coarse tailings will be used to construct the tailings dam or to backfill the mine. The fine and liquid tailings will be dispersed in the tailings pond.

Approximately 200 acres of land will be utilized during the lifetime of the proposed operation. Assuming 30% of New Mexico is semiarid area, Applicant's land will occupy 0.006% of that semiarid area. This land is considered undesirable for agricultural use and is sparsely populated. However, Applicant's land does support indigenous flora and fauna. See Section 2.8. Restoration and reclamation measures will be instituted at the close of the proposed mill's operation. See Section 9.0.

The proposed tailings pond area, 160 acres, is considered a long term commitment of land. Prior to completion of the proposed mill's operation, the tailings dam will be raised to its final elevation, and the downstream face will be stabilized and planted with native vegetation. After mill operations cease, the tailings pond area will be covered with soil and a growth of native vegetation established.

The stabilized tailings pond area will require long term restriction that prohibits both habitation and the growth of food crops. Since the general area is sparsely populated

and poorly suited for farming, these restrictions are not expected to present significant human hardship. The displaced animal and insect life is expected to re-establish in this area.

Natural resources committed during construction of the proposed mill will include 1300 tons of construction steel plus that used in prefabricated items such as the grinding mill, tanks, and boilers. Construction will also utilize 129,000 yd^3 of concrete, 34,760 ft^2 of concrete blocks, assorted lumber, and roofing materials.

Construction of the proposed mill will take approximately 2 years. Direct labor cost to the construction contractor is estimated at $1.4 million, based on an average salary of $10/hr and 45% overhead; this corresponds to approximately 40 man-years. An additional $8.1 million is estimated for subcontracted work, much of which will be labor costs. The mill operation will require 117 people, and over the projected 15 year lifetime, 1755 man-years will be devoted to its operation. Given the above estimates, the proposed mill's construction and operation will commit, in terms of human resources, approximately 1810 man-years.

Operation of the proposed mill over the 15 year projected lifetime will utilize 420,000 tons of sulfuric acid, 11,000 tons of sodium chlorate, 4600 tons of ammonia, and lesser quantities of kerosene, isodecanol, amine, and polyacrylamide. The operation will also use 226 million kw-hr of electricity and 30 million gal of No. 6 fuel oil. Equivalent resources would be used by the mill currently processing the ore from Applicant's mine or by any other uranium mill.

Operation of the proposed mill will eliminate the need to truck ore 85 miles to another mill. After startup of the proposed mill, the ore will have to be trucked about 0.5 mile. This shorter distance will save an estimated 9 million gal of diesel truck fuel over the lifetime of Applicant's mill and will reduce road maintenance, highway noise, and air pollution.

The capital investment in the proposed project is estimated at $31.2 million for construction and $57 million for 15 years of operation. This financial investment will return 46,000 tons of yellowcake, a resource which will yield approximately 1.6 trillion kw-hr of electricity from nuclear power generation. To produce an equivalent amount of electrical power, a utility company would have to burn approximately 2.6 billion barrels of oil or 0.6 billion tons of coal.

SECTION 5 ADDENDUM

I. ATMOSPHERIC DIFFUSION CALCULATIONS

Diffusion in the lower layers of the atmosphere for long-term average concentrations is described by:[a]

$$C = \left(\frac{2}{\pi}\right)^{\frac{1}{2}} \frac{0.01 f Q' G}{\sigma_z \bar{U} \left(\frac{2\pi X}{n}\right)} \exp\left(\frac{-h^2}{2\sigma_z^2}\right)$$

where:

C = concentration of gas or particles less than 20 μ diameter ($\mu Ci/m^3$)

f = percentage of time wind blows in specified direction including percentage of calms

Q' = source term (μCi/sec)

σ_z = standard deviation of plume concentration distribution in the vertical plane

$\bar{U}$ = mean wind velocity in specified direction including percentage of calms (m/sec)

X = distance from source term to location where C is calculated (m)

n = number of sectors in wind rose

h = height of plume centerline when it becomes essentially level (m)

G = geometry factor

By combining constants, converting the units of C from $\frac{\mu Ci}{m^3}$ to $\frac{\mu Ci}{cc}$ and by setting n=16 and h=0, the equation simplifies to

$$C = 2.03 \times 10^{-8} \frac{f\ Q'G}{\sigma_z\ \bar{U}X}$$

(a) Shade, 1968.

Source terms are based on emissions from operating uranium mills.[a] Each value is adjusted for the anticipated 4000 tons/day ore input:

Radionuclide	Source Term in μCi/sec	Note
Natural uranium	0.0072	A
Th-230	0.0022	B
Ra-226	0.0022	B
Rn-222	17.1	C

A. The uranium source term assumes a 95% efficiency scrubber on the exhausts from the yellowcake handling areas of the proposed mill.

B. Dust containing both Th-230 and Ra-226 will originate from piles of unprocessed ore, transportation of ore from the mine to the mill, and from the banks of the tailings pond. Granular material discharged to the tailings pond will be kept wet by a sprinkler system, when the surfaces are not frozen, to minimize dust. The source terms for Th-230 and Ra-226 have consequently been reduced by a factor of 2 to adjust for the planned dust controls.

C. The maximum size of the tailings pond at the end of milling operations is estimated to be 160 acres which will release 13.5 μCi/sec, based on estimates from the referenced EPA report. Additionally, an estimated 10,000 tons of ore at any one time either will be passing through the mill or stored above ground in preparation for processing. These 10,000 tons of ore will release an estimated 3.6 μCi/sec for a total Rn-222 release rate of 17.1 μCi/sec.

Geometry factors were introduced into the atmospheric diffusion calculation to correct for the differences between a point source release, G=1, and a release from an area source.[a] For radium and thorium dust particles, a factor of 1/3 was assumed at the site boundary and a factor of 1/2 was assumed for concentrations at the nearest residence. For radon gas, a factor of 1/4 was used at the site boundary and 1/3 at the nearest residence. For uranium, a point source of exhaust air from the yellowcake handling area of the mill a factor of 1 was used.

(a) EPA-520-9-73-3-B.

Since stability wind rose information was not available the neutral wind rose stability Class D, as specified by Turner,[a] was used for atmospheric diffusion calculations.

II. DOSE RATE CALCULATIONS

Radiation dose rates were calculated from C, the concentration of gas or particles by:

$$D = \frac{C}{MPC_a} \quad (1500)$$

where:

D = dose rate $\left(\frac{mrem}{yr}\right)$

1500 = maximum permissible exposure/year to the lungs of individuals in the general population

MPC_a = maximum permissible concentrations in air from releases to unrestricted areas. Values were obtained from 10CFR20 Appendix B, Table II, Column I, for insoluble radionuclides associated with ore dusts or radon gas.

Radionuclide	MPC_a in μCi/cc Unrestricted Area
Natural uranium	5×10^{-12}
Th-230	3×10^{-13}
Ra-226	2×10^{-12}
Rn-222	3×10^{-9}

III. MAN-REM/YEAR CALCULATIONS

Population density in a 5 mile radius from the center of Applicant's proposed facility was presented in Section 2.2 as a circle containing 80 areas. The number of man-rem/year was calculated for each area by multiplying the population of each area by either (1) the dose rates to the lung from 24-hours/day occupancy at the nearest residence, or (2) the dose rates calculated for occupancy at the center of each area. A lower limit of 0.1 mrem/year was selected as the minimum dose rate; consequently, calculations involving lower dose rates were set equal to zero.

(a) Turner, 1970.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 6.0

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.0 EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

The methods for collecting baseline environmental data and Applicant's programs for monitoring the impacts of proposed activities on the environment are described in this section. Pre-existing site characteristics are those characteristics prevalent prior to any mine related activities. However, current mining activities by the Applicant preclude a comprehensive survey of these characteristics. Preoperational site characteristics are those characteristics prevalent on the Applicant's site prior to construction and operation of the proposed mill, and are descriptive of existing environmental conditions.

6.1 APPLICANT'S PREOPERATIONAL ENVIRONMENTAL PROGRAMS

The program for the collection of preoperational environmental data is described in the following subsections for surface waters, ground water, air, land, and radiological parameters of the area.

6.1.1 Surface Waters

A pre-existing characteristic of Applicant's mining and proposed milling sites is the nearly total absence of surface waters. Occasional storms cause runoff and erosion in the semiarid terrain, but these transient phenomena do not produce bodies of surface water that could be affected by Applicant's mining and milling activities.

During the development stages of Applicant's mine, 1967-1969, only a few gal/min of water were discharged from the mine into an unnamed arroyo draining through Pipeline Canyon to the Rio Puerco. Since the startup of the mine in 1969, approximately 1400 gal/min of water have been discharged from the mine into the arroyo. An adjacent mine owned by Kerr-McGee Corporation currently discharges water into the same arroyo at the same rate as the Applicant's mine.

Other than natural precipitation, the water discharged from the mines is the only source of surface water in the area. An authorization to discharge the water, a National Pollutant Discharge Elimination System permit, has been obtained from the U. S. Environmental Protection Agency.[a] In compliance with the EPA permit, the Applicant samples the discharge water and each calendar quarter forwards the analytic results to the EPA.

(a) EPA, 1974; see also Appendix H.

The sampling locations, parameters to be measured, sensitivities of measurements,[a] sampling frequencies, and sample size or type per sampling location are summarized in Table 6.1-1. The samples are collected in plastic jugs, labeled, and promptly shipped to a commercial laboratory for analysis of those parameters not measured at the sampling locations. Specific instrumentation and analytic procedures represent state of the art and will be updated as new and better techniques evolve. Thus, where possible, the sensitivity of each measurement technique, rather than lists of instruments and procedures, is presented in Table 6.1-1.

In addition to the effluent sampling program required by the EPA discharge permit, Applicant employs an environmental sampling program. This program for surface water discharged into the arroyo is presented in Table 6.1-1, with sampling locations designated in Figure 6.1-1. These water samples are collected at 6 month intervals and are analyzed to provide more detailed water quality data than is provided by samples obtained and analyzed for compliance with the EPA discharge permit.

If drinking water is supplied from the Applicant's site, samples will be analyzed for the radiological parameters specified in Table 6.1-1. State or federal public health regulations will govern the monitoring of other parameters.

6.1.2 Ground Water

Ground water samples will be pumped from two sampling wells to be drilled near the tailings pond prior to startup of the proposed mill. The samples are intended to detect seepage from the tailings pond. The location and depths of the wells will be as follows. See Figure 6.1-1.

1) 1000 ft south from north line, 600 ft west from east line of Section 2, depth 120 ft. Perforated casing will be used from 50 ft to 120 ft. This well will monitor water which might enter the Dilco Formation sandstones and be moving downdip.

(a) The analytical sensitivity of a specified parameter is the minimum detectable level of that parameter.

TABLE 6.1-1 (Page 1 of 2)

PREOPERATIONAL EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM

MEDIUM	SAMPLING LOCATIONS	PARAMETER MEASURED	SENSITIVITY	SAMPLING FREQUENCY	SAMPLE SIZE OR TYPE PER SAMPLING LOC.
Effluent Sampling					
Surface water	Discharge point of final mine water settling pond 1 site	Flow rate	223 gal/min	Continuous	Continuous
		Temperature	1 C	Weekly	Grab
		Total suspended solids	1.0 mg/liter	Weekly	24 hr composite, 1 gal
		Natural uranium	0.1 μg/liter	Monthly	24 hr composite, 1 gal
		Dissolved Ra-226	0.02 pCi/liter	Monthly	24 hr composite, 1 gal
		Total molybdenum	0.001 mg/liter	Monthly	24 hr composite, 1 gal
		Total selenium	0.1 mg/liter	Monthly	24 hr composite, 1 gal
		Total vanadium	0.01 mg/liter	Monthly	24 hr composite, 1 gal
Environmental Sampling					
Surface water	Arroyo adjacent to mine, see Figure 6.1-1 5 sites	Gross Alpha	1.0 pCi/liter	Semiannually	1 gal
		Gross Beta	0.5 pCi/liter		
		Th-230	0.02 pCi/liter		
		Ra-226	0.02 pCi/liter		
		Natural Uranium	0.1 μg/liter		
		Arsenic	0.01 mg/liter		
		Beryllium	0.001 mg/liter		
		Cadmium	0.001 mg/liter		
		Copper	0.0001 mg/liter		
		Lead	0.001 mg/liter		
		Magnesium	0.001 mg/liter		
		Mercury	0.001 mg/liter		
		Nitrate	0.1 mg/liter		
		Phosphate	0.003 mg/liter		
		Potassium	0.001 mg/liter		
		Selenium	0.1 mg/liter		
		Sodium	0.001 mg/liter		
		Sulfate	0.01 mg/liter		
		Total suspended solid	1.0 mg/liter		
		Zinc	0.001 mg/liter		
		pH	0.02		

TABLE 6.1-1 (Page 2 of 2)

PREOPERATIONAL EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM

Drinking water obtained from Applicant's Site	Applicant's Site	Gross Alpha Gross Beta Th-230 Ra-226 Natural Uranium	1.0 pCi/liter 0.5 pCi/liter 0.02 pCi/liter 0.02 pCi/liter 0.1 μg/liter	Semiannually	1 gal
Groundwater	See description Section 6.1.2 2 sites	Same as arroyo surface water	Same as arroyo surface water	Semiannually	1 gal
Air	See Figure 6.1-1 4 sites	Gross alpha Gross beta Th-230 Ra-226 Natural uranium	0.005 pCi/m^3 0.002 pCi/m^3 0.02 pCi/total vol. 0.01 pCi/total vol. 0.01 μg/total vol.	Semiannually	Approx 2 ft^3/min for 168 hr or high volum. air sample
Meteorology	See Figure 6.1-1 1 site	Wind speed Wind direction Temperature Humidity Precipitation	0.5 mph 22.5 degrees at 1 mph -25F to 125F 0-100% 0.01 inch	continuous	
Soils	See Figure 6.1-1 4 sites	Gross alpha Gross beta Th-230 Ra-226 Natural uranium	0.1 pCi/g(dry) 0.05 pCi/g(dry) 0.01 pCi/g(dry) 0.01 pCi/g(dry) 0.1 μg/g(dry)	Semiannually	1000 g for each soil layer: 0-2 inch 2-4 inch
Vegetation	See Figure 6.1-1 4 sites	Gross alpha Gross beta Th-230 Ra-226 Natural uranium	0.1 pCi/g(dry) 0.05 pCi/g(dry) 0.1 pCi/g(dry) 0.1 pCi/g(dry) 0.1 μg/g(dry)	Semiannually	2 liter compressed grasses + green leav from plants used for forage by mule deer.
Environmental Radiation	See Figure 6.1-1 4 sites	Environmental gamma dose rates	9 mrem over 90 day exposure	Semiannually	3-LiF dosimeters

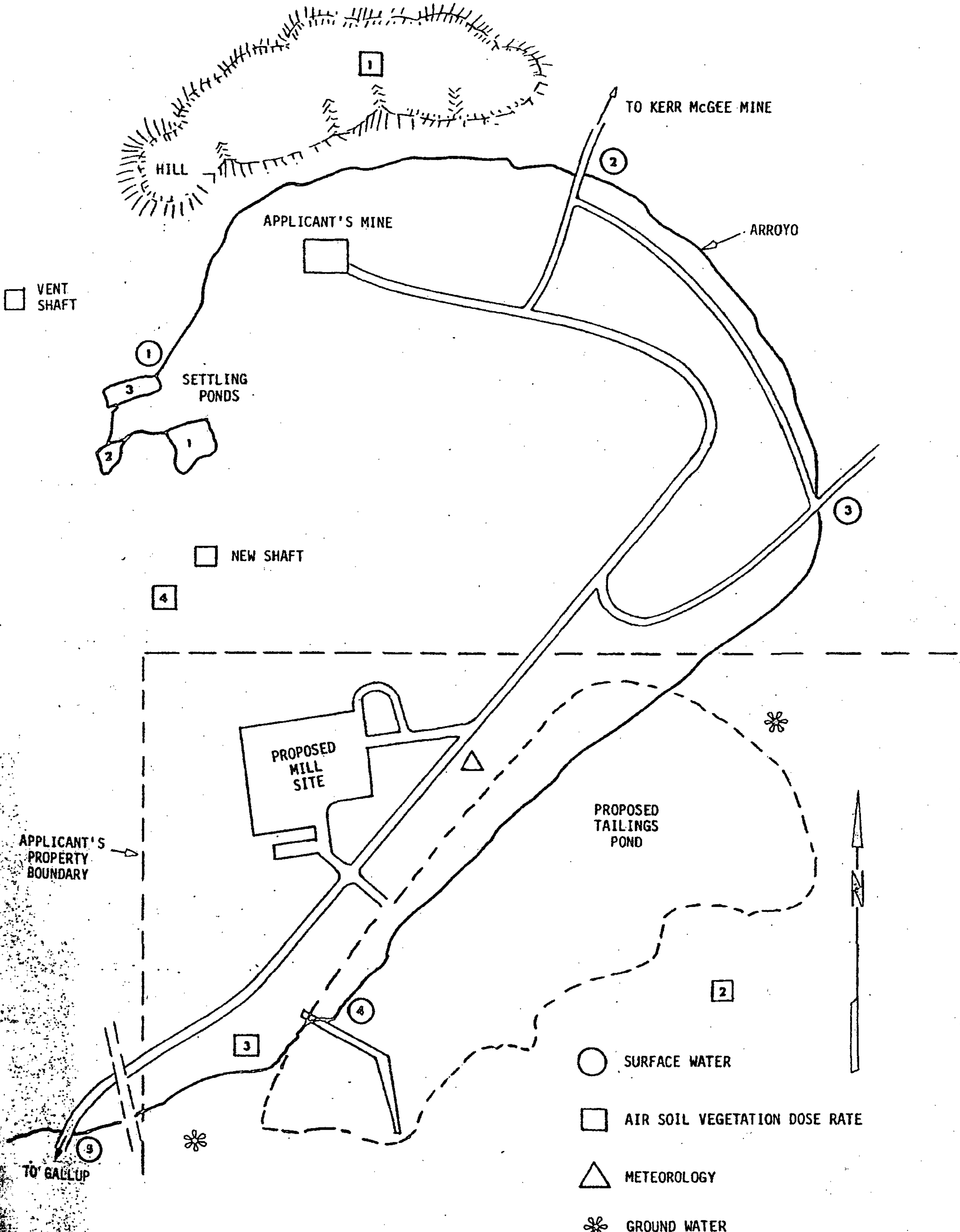


FIGURE 6.1-1 ENVIRONMENTAL SAMPLING SITES

2) 950 ft north from south line, 350 ft east from west line of Section 2, depth 150 ft. This well will monitor water which might enter the alluvium in Pipeline Canyon and subsequently enter the water-bearing strata. Measurements of water quality and possibly the gradient of the phreatic surface in the wells are planned. Perforations will be from approximately 60 ft to 950 ft. Some natural runoff may enter the well as bank storage dissipates after an exceptionally wet period. Portable, submersible pumps will be used to sample each well at 6 month intervals. The wells will be pumped until recharge of the well water sufficiently insures that fresh ground water is being sampled.

6.1.2.1 Physical and Chemical Parameters

The physical and chemical parameters to be measured and the sensitivities are shown in Table 6.1-1. Additional indications of ground water quality are obtained from the effluent sampling program for surface water.

6.1.2.2 Models

The Applicant's monitoring program for ground water is a comprehensive method of environmental assessment. Extensive models used to predict changes in ground water characteristics are not warranted at this time, for little change is predicted. See Sections 2.6.1, 3.4, 5.1.2, and 5.2.2.

6.1.3 Air

Preoperational air quality monitoring is conducted at 6 month intervals to establish background air quality data. Sampling locations are designated on Figure 6.1-1. The parameters measured and the respective sensitivities are presented in Table 6.1-1. The air samples are analyzed by a commercial laboratory. The methods for predicting the dispersion of effluents in the atmosphere are discussed in Section 5.2 and in Section 5 Addendum.

6.1.3.1 Meteorology

Summaries of meteorological data on temperature and precipitation in Gallup, New Mexico, were published for 1938-1960.[a] For 1961-1974, data supplied by the National Weather Service in Albuquerque, New Mexico, was reviewed and analyzed. Hourly surface wind observations for January 1973 through August 1974 for Gallup, New Mexico, were obtained from the National Climatic Center, Ashville, North Carolina and compiled by the Applicant. The Applicant is presently collecting meteorological data from a mechanical weather station[b] located near the proposed mill site. See Figure 6.1-1. The parameters measured and their respective sensitivities are presented in Table 6.1-1.

6.1.3.2 Models

Actual measurements of meteorological data have been used whenever possible to predict the diffusion of airborne effluents. Where measurements were not available, as in the case of wind stability categories, conservative assumptions were made as recommended by Turner.[c] See Section 5 Addendum. The diffusion equation used to calculate dose rates in Section 5 is published by the AEC.[d]

6.1.4 Land

Data collection programs for the terrestrial environment are discussed in the following sections on geology and soils, on land use and demography, and on ecology.

6.1.4.1 Geology and Soils

A complete geology, seismology, and stability analysis of the Applicant's proposed tailing dam is presented in Appendix A. Section 2.4 summarizes the geology of the region and Section 2.5 summarizes the seismology.

The tailings dam monitoring program will be instituted after construction of the tailings dam. The program will include the use of eight sets of piezometers installed 400 ft to 1000 ft apart in the downstream face. Each set will consist of two piezometers located 20 ft and 75 ft downstream from the centerline of the dam. The piezometers will measure the level of the phreatic surface in the downstream side of the dam, and all measurements

(a) Department of Commerce, 1972.
(b) Weather Measure Corporation, Sacramento, California, Mechanical Weather Station Model WS755.
(c) Turner, 1970.
(d) Shade, 1968.

will be recorded and plotted graphically for analysis of the dam's stability. The frequency of measurements will vary depending on the observed fluctuations of the phreatic surface.

Liquid seeping out of the tailings pond may alter the soil conditions under the tailings pond. The environmental ground water monitoring program, described in Section 6.1.2, will monitor two wells adjacent to the tailings pond and will indicate alterations of the soil conditions imposed by proposed operations.

Preoperational soil monitoring will continue to be conducted at 6 month intervals, with samples taken from the locations illustrated in Figure 6.1-1. The measured parameters and their respective sensitivities are presented in Table 6.1-1. Analyses are performed by a commercial laboratory. The samples are stratified into soil layers from 0-2 inches deep and from 2-4 inches deep. The quantity of effluent and its migration rate through the surface soils is then evaluated.

6.1.4.2 Land Use and Demographic Surveys

Land use information presented in Section 2.2 for the environs of the proposed mill was obtained from the Gallup, New Mexico, Chamber of Commerce. Although changes may occur as the mill is constructed and operated, no alterations are foreseen that would increase the environmental impact of the proposed mill.

Data on the demography of the region were obtained from the Bureau of Business Research at the University of New Mexico, from the Gallup Chamber of Commerce, from the Gallup-McKinley County School System, and from field and aerial surveys of the area. Estimates of the number of inhabitants within a 5 mile radius of the proposed mill site were compiled through use of the grid pattern illustrated in Figures 2.2-1 and 2.2-2. The number of inhabitants in each of the 80 areas of the grid pattern was calculated by multiplying the average number of people in each household[a] by the number of households in each area.[b] All other demographic information presented in Section 2.2 was compiled from sources referenced in Section 2.2.

6.1.4.3 Ecological Parameters

Assessments of the ecological characteristics of the proposed site have been completed by a consultant. The survey was conducted during the summer 1974 and provides a baseline for assessment of potential environmental stresses imposed by the

(a) Values obtained from University of New Mexico, 1972, or directly established in field surveys.
(b) Values obtained from USGS topographic maps or from aerial surveys.

construction and operation of the proposed mill. Fauna, flora, soil types, and vegetative productivity were surveyed by direct observation, observation of animal signs, trapping, and by vegetation line point sampling for aerial and botanical composition. Appendix C presents additional details of the sampling methods. Vegetation samples were collected in October 1974 and in June 1975. The samples were forwarded to a commercial laboratory for analysis of the parameters and sensitivities specified in Table 6.1-1. The vegetation samples taken from the locations designated in Figure 6.1-1 consist of grasses and green leafy material favored as food by mule deer, which are the most important species in the area. See Section 2.8. Subsequent sampling of vegetation will occur at 6 month intervals.

6.1.5 Radiological Surveys

Preoperational radiation levels in the environs of the proposed mill are surveyed at 6 month intervals using packets of thermoluminescent dosimeters (TLD) placed at locations identified in Figure 6.1-1. The TLDs are supplied and read by an analytic laboratory retained by Applicant. The parameters measured by the TLD and the analytic sensitivities are presented in Table 6.1-1. Analysis of radionuclides in surface water, ground water, air, soil, and vegetation is outlined in Table 6.1-1.

6.2 APPLICANT'S PROPOSED OPERATIONAL MONITORING PROGRAM

The operational monitoring program will be implemented after the proposed mill becomes operational. The data collected from the operational monitoring program will be compared to data from the preoperational monitoring program. Such a comparison will quantify any environmental impact caused by operation of Applicant's mill. The operational monitoring program consists of both an effluent sampling program and an environmental sampling program. Effluent sampling is designed to quantify significant mine and mill effluents for compliance with Federal and State regulations. The environmental sampling program will measure the impact of mill and mine operation on the local environs and will identify any unplanned adverse impacts to facilitate rapid correction.

The proposed operational sampling and monitoring program may be modified by Applicant after the first year of operation to more accurately characterize environmental releases and the resultant environmental impact.

6.2.1 Radiological Monitoring

Detailed description of the sources and release points for radioactive material from the mine and proposed mill are provided in Section 3.3. The effluent and environmental monitoring program is summarized in Table 6.2-1.

6.2.1.1 Mill Effluent Monitoring System

The primary source of airborne radioactive particulates is the stack from the yellowcake dryer. At monthly intervals Applicant will measure the flow rate and isokinetically sample the exhaust air as outlined in Table 6.2-1. Other airborne radionuclides released to the environment by the proposed mill will be evaluated in the environmental sampling program.

Within the mill, working zone breathing air samples will be taken according to the program specified in Table 6.2-1. Laboratory instrumentation used to determine alpha and/or beta radioactivity emitted from radionuclides collected on air filter samples will be selected and purchased by Applicant prior to startup of the proposed mill. A typical system would utilize a gas proportional counter with the following capabilities:

Counting Mode	Background, Counter	Efficiency	Sensitivity
Gross alpha	0.1 CPM	40%	1×10^{-7} μCi
Gross beta	20.0 CPM	40%	2×10^{-5} μCi

If air samples are collected by filtering 10 liters/min for 168 hr, with a collection efficiency of 95%, the sensitivities for a typical gas proportional counter would correspond to 1×10^{-15} μCi/ml for alpha emitting radionuclides and 2×10^{-13} μCi/ml for beta emitting radionuclides. These minimum detection levels are well below the MPC_a values specified by New Mexico[a] as presented below.

Radionuclide	MPC_a, Restricted Area, μCi/ml	MPC_a, Unrestricted Area, μCi/ml
Natural uranium	1×10^{-10}	5×10^{-12}
Th-230	2×10^{-12}	3×10^{-13}
Ra-226	5×10^{-11}	2×10^{-12}
Rn-222	1×10^{-7}	3×10^{-9}

(a) NMEIA, 1973.

TABLE 6.2-1

OPERATIONAL EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM

Medium	Sampling Location	Parameter Measured	Sensitivity[a]	Measuring or Sampling Frequency	Sample Size or Type per Sampling Location
EFFLUENT SAMPLING					
Air	Yellowcake dryer stack, 1 site	Gross alpha or	1×10^{-15} µCi/ml	Monthly	Continuous
		Gross beta	4×10^{-13} µCi/ml	Monthly	Continuous
		Ammonia	1 ppm	Monthly	Grab sample
		Flow rate	--	Monthly	--
Air	Work locations within proposed mill, various sites	Gross alpha	2×10^{-15} µCi/ml	Monthly on each shift	30 min sample
		Gross beta	4×10^{-13} µCi/ml		30 min sample
		Rn+daughters	0.1 WL[b]		30 min sample
		External gamma	5 mR/hr	Monthly on each shift	30 min sample
Air	Work location in mine, various sites	Rn+daughters	0.1 WL	Quarterly on each shift	Filter sample[c]
Water	Discharge to tailings pond, 1 site	pH	0.02	Continuous[c]	Continuous
		Natural U	(c)	Weekly[c]	grab sample
		Th-230	(c)	(c)	grab sample
		Ra-226	(c)	(c)	grab sample
Water	Discharge point from final mine water settling pond, 1 site	Same as preoperational effluent sampling program, see Table 6.1-1			
ENVRIONMENTAL SAMPLING AND MONITORING	Same as preoperational environmental sampling program, see Table 6.1-1.				

(a) Specified sensitivities are the minimum detectable levels of the parameter measured and are intended to be representative of commercially available instrumentation for use in uranium mills.

(b) WL - Working level is a unit that delineates the combined concentrations of short-lived radon daughter products in a liter of air.

(c) To be determined by operational needs.

Other sampling and counting systems may be selected by Applicant based on the best available technology, cost, reliability, and ease of use, but the system selected will be able to measure concentrations below MPC values for radionuclides specified above.

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

All liquid effluents from the proposed mill will be the discharge to the tailings pond. Numerous samples of process liquids will be taken in the mill for process control as well as to establish the inventory of radionculides discharged to the tailings pond.

6.2.1.2 Environmental Radiological Monitoring

The operational radiological monitoring program is an extension of the preoperational radiological monitoring program summarized in Table 6.1-1. See Table 6.2-1 for the Operational Monitoring Program.

The environmental monitoring program for surface water measures radiological and chemical parameters at five downstream locations in the arroyo that receives water discharged from the Applicant's mine. Prior to discharge to the arroyo, the water passes through three settling ponds and is sampled at the discharge weir of the final pond for the parameters specified in the EPA discharge permit. The Applicant's monitoring program is designed to complement the EPA effluent program by providing analysis for a greater number of chemicals at less frequent intervals.

All water samples are analyzed by a commercial laboratory for the parameters and the sensitivities listed in Table 6.1-1. The results of the effluent sampling program are forwarded to the EPA in accordance with their requirements. The surface water environmental sampling results will be evaluated by the Applicant and New Mexico State officials for compliance with the maximum permissible concentrations in water (MPC_w) as presented below:[a]

(a) NMEIA, 1973.

Radionuclide	MPC_w, Restricted Area, μCi/ml	MPC_w, Unrestricted Area, μCi/ml
Natural uranium	1×10^{-3}	3×10^{-5}
Th-230	5×10^{-5}	2×10^{-6}
Ra-226	4×10^{-7}	3×10^{-8}
Rn-222	--	--

If drinking water is supplied from the site, samples will be analyzed as specified in Tables 6.1-1 and 6.2-1.

The radiological monitoring of ground water from two proposed wells next to Applicant's tailing pond is designed to detect any seepage of tailings pond liquid into ground water. The well samples will be likewise analyzed by a commercial laboratory and the results evaluated by both Applicant and State officials for compliance with MPC_w criteria.

Environmental monitoring of air quality is designed to comply with MPC_a criteria for unrestricted areas. In addition, the soil and vegetation samples will be used by Applicant to ascertain the environmental impact of radionuclides that may enter the food chain of mule deer in the area. See Section 2.8.

6.2.2 Chemical Effluent Monitoring

The nonradioactive chemical effluent monitoring program proposed by Applicant is summarized in Table 6.2-1. Ammonia gas released from the yellowcake dryer will be monitored by monthly samples and flow rate determinations.

State and federal regulations do not address release rates of ammonia. However, the state requires that all facilities releasing more than 2000 lb/year be registered as an air pollution source. If adverse environmental effects result from the ammonia releases, Applicant will institute corrective actions to decrease the release rate.

The sampling of boiler emissions is not planned because releases can be calculated from the quantity and quality of fuel consumed. CO_2 formed in the reaction of sulfuric acid with the carbonates in the ore will not be monitored because CO_2 is neither toxic nor considered a pollutant or contaminant by New Mexico.

The use of kerosene in the proposed mill does not pose an occupational or health hazard that would necessitate an operational sampling program. Mill wastes discharged to the tailings pond will be monitored as described in Table 6.2-1.

Most other nonradioactive chemical effluents from the mill will be discharged with the tailings slurry to the tailings pond. These chemicals will include chlorates, chlorides, sulfates, residual sulfuric acid, flocculants, isodecanol, ammonia compounds, laboratory chemicals, lubricating oils including hydraulic fluid, organic amines, treated sanitary wastes during the winter, and all the nonextracted components of the ore. Since the quantity of chemicals permanently retained in the tailings pond can be evaluated from the amount of chemicals used, no sampling of the tailings pond slurry is planned beyond that required for operational control.

6.2.3 Meteorological Monitoring

The Applicant's environmental sampling program includes meteorological monitoring from a weather station located between the proposed mill and tailings pond. See Sections 6.1 and 6.2.

6.2.4 Ecological Monitoring

The environmental sampling program has been designed to evaluate the environmental impacts from Applicant's activities on mule deer. The analyses of water, vegetation, and soil samples will indicate the type and magnitude of environmental impact on the deer. Should these analyses indicate that the deer are being adversely affected by Applicant's activities, Applicant will determine the cause of the impact and take corrective action. Additional ecological surveillance will be instituted as necessary.

6.3 RELATED ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

The Applicant's site lies within a region where environmental measurements and/or monitoring programs are carried out by public agencies as specified below:

1) Demographic and land use data are continually being collected and updated by the U. S. Census Bureau, University of New Mexico Bureau of Business Research, and by the Gallup Chamber of Commerce.

2) Meteorological data are continuously being collected, analyzed, and summarized by the U. S. Department of Commerce, the National Weather Service in Albuquerque, and by the National Climatic Center in Ashville, North Carolina.

3) Air, water, and radiological data are analyzed by the New Mexico Environmental Improvement Agency.

The ongoing programs and data collected by the above agencies are available to the Applicant should the need become evident in the future. Likewise, the Applicant will be available for the exchange of environmental data with federal, state, and local public agencies.

CHURCH ROCK URANIUM MILL
ENVIRONMENTAL REPORT

SECTION 7.0
ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

The environmental consequences of selected accidents have been evaluated for the mine and proposed mill. Although potentially very serious in terms of loss of life and destruction of equipment, mine accidents are not expected to have off-site environmental impact. The accident potential during milling operations is comparable with that of other industrial operations, but the potential environmental consequences of accidents are lessened because of the facility's isolated location.

7.1 MILL ACCIDENTS

The types of accidents that have been considered include: flooding or collapse of mine walls, mine ventilation failure, release of mine drainage water from settling ponds, fire in the mine, leaks in mill piping, operator errors, scrubber failure, fire in the extraction solvent, ammonia release, utility loss, tailings release, and transportation accidents. Major catastrophic natural events and combinations of accidents which would far exceed the design capabilities of the proposed mill have not been considered, for they are highly improbable and would result in an environmental impact no more severe than that from other industrial or chemical processing facilities.

Except for radioactive shipments, no substantiated probability values have been published concerning accidents in uranium mining and milling facilities. Therefore, three accident categories have been established. These categories are listed in Table 7.1-1.

The storage of significant quantities of any chemicals or hazardous materials presents an accident potential. The maximum quantity of chemicals to be stored by the proposed mill, their use rates, and their environmental or toxicological data are listed in Table 7.1-2.

Category 1 Accidents (Expected)

Minor Leaks

A typical category 1 accident would be a leak in an uncovered pipeline resulting in the release of a few gallons of radiologically or chemically contaminated solution. Since a leak of this type would be visible inside the mill, it would be quickly detected, and corrective action, such as isolation of the leaking

TABLE 7.1-1

ACCIDENT CATEGORIES

Category	Definition	Cause Examples
		ON SITE
1	Expected to occur during facility life	Pipe leaks, operator errors, exhaust scrubber failure, minor spills, utility outages, pump failures.
2	Possible but not expected to occur during facility life	Bulk chemical storage container break, tailings pond breach, fire, explosion, loss of utilities, tornado, earthquake, collapse of mine wall, mine flooding.
		OFF SITE
3	Radioactive shipments	Vehicle accident

TABLE 7.1-2

CHEMICAL STORAGE

Chemical and Form	Storage Capacity	Daily Use Rate	Environmental or Toxicological Data
Ammonia (liquified)	15,000 gal	2400 lb	TLV (threshold limit value) 400-700 ppm in air; 1 hr exposures cause no serious effects.[a] Recommended TLV 50 ppm in air; 3 hr exposure.[b]
Kerosene (liquid)	13,200 gal	600 gal	LD50 rabbits (lethal dose to 50% of rabbit pop.) 28.350 mg/kg.[c] Moderate fire hazard.
Sodium chlorate (solution)	109,300 gal	5600 lb	Local irritation.[d]
Sulfuric acid (liquid)	109,300 gal each (2 tanks)	110 tons	TLV 1 mg/m^3 air.[b]
Fuel oil (liquid)	130,000 gal	5500 gal	Moderate fire hazard. Toxicity unknown.[d]
Chlorine, for water treatment (gas)	200 lb	0.4 lb	TLV 1 ppm air; 3 mg/m^3 air.[b]
Diesel oil, stored at the mine (liquid)	1800 gal	500 gal	LD50 rabbits 28.350 mg/kg.[c] Moderate fire hazard.[d]
Dynamite (solid)	6000 lb	2500 lb	Severe fire hazard; moderate to dangerous general explosion hazard.

(a) Manufacturing Chemist Data Sheet SD8.
(b) American Conference of Governmental and Industrial Hygienists, 1973.
(c) Merck Index, 1968.
(d) Sax, 1968.

line section, would be taken. If the spilled liquids were of value operationally, they would be returned to mill process streams. Otherwise they would be pumped to the tailings pond.

Oil and chemical spills too small to efficiently route to the tailings pond or back into mill circuits will be cleaned up using the most efficient and environmentally acceptable techniq available.

A leak in exposed piping outside the building would be quickly detected and corrected. Any spilled process liquids would be cleaned up, and no environmental releases would result.

The only buried line that will transport liquid other than wate will be the fuel oil supply line. Since the fuel will be No. 6 fuel oil, which must be heated in order to flow, a leak in this line would deposit oil in the immediate vicinity of the line but would not contaminate significant land areas or water supplies. Environmental consequences of such a leak are considered negligible.

Release of Uranium-bearing Material to Tailings Pond

Since all milling processes will be closely monitored, a signif cant release is unlikely. The quantity released would be accurately determined from the tailings sample and, if economic the uranium would be reclaimed from the tailing liquid. No off-site environmental releases would be expected, and the incre in radioactive material deposited in the tailings pond would neither significantly increase dose rates off site nor complica final restoration of the site.

Scrubber Failure

Partial failure of the wet venturi scrubber on the yellowcake dryer exhaust could result from a water pump failure, a clogged water line, or a loss of water supply. Even with a complete loss of water to the scrubber, partial removal of yellowcake would occur by impingement within the scrubber. However, maximum permissible concentrations of yellowcake in the stack exhaust would probably be exceeded for a short time during a complete scrubber failure.

Detection of the failure would probably be by direct observation of yellowcake dust, the smell of ammonia escaping, heating of ventilation equipment, or by the routine monitoring discussed in Section 6.2. Corrective actions would involve an immediate shut-down of the dryer and its exhaust until the necessary repairs or alterations are completed.

Monitoring of yellowcake contamination and cleanup following such an incident might be necessary. The environmental impact of a scrubber failure and subsequent yellowcake release would require evaluation but would be small. Ammonia would also be released during a failure of the scrubber. However, ammonia, at concentrations below the odor threshold, 50 ppm in air, is not toxic and for short periods of time can be tolerated with no deleterious effects to personnel at concentrations between 400 and 700 ppm for 1 hr.[a]

An analysis of Category 1 accidents has shown no conditions which would result in a significant environmental impact.

Category 2 Accidents (Possible but not expected)

Major Leaks

Because of Applicant's proposed detection and correction procedures, major leaks or tank ruptures occurring inside the buildings should not cause impact to the external environment. Rupture of outdoor storage tanks should likewise have minimal off-site impact because the tanks will be diked. The contained liquids would be reclaimed from the diked area for recycle to process systems or disposal to the tailings pond. The only potential environmental effect would be contamination of the soil immediately below the tanks.

Fire

An accidental mine fire involving large quantities of petroleum fuel is possible but unlikely because of industrial safety precautions. Such a fire could release combustion products, but radioactive material releases above normal operational levels should not result.

(a) Manufacturing Chemist Data Sheet SD-8.

Since kerosene and other flammables will be used in the proposed mill, careful attention will be given to fire prevention and protection. Kerosene will be stored above ground. Its use will be limited to the solvent extraction system that will be isolated from other facilities and will be equipped with a foam fire-fighting system.

The foam system will be composed of a main storage tank, containing approximately 2000 gal of high-protein foam, and a main header fed by the mill water system. The foam will be injected into a branching system of pipes with individual nozzles at the surface of areas where kerosene is used. The fire protection system will be activated by strategically placed heat-activated devices, which will automatically activate the necessary valves and pumps.

If the fire protection system were to fail and a large kerosene fire were to occur, the radiological environmental effects would be confined to within a few hundred feet of the building. Recovery of uranium scattered by burning uranium-bearing solvent would require a survey of the site and some limited removal of contaminated soil. Contaminated soil might be processed as ore; very slightly contaminated soil might be buried in place.

In 1968 two solvent extraction fires occurred in uranium mills. Between 2000 and 3000 lb of uranium were involved in each fire. Damages from the fires totaled $1 million. However, neither fire resulted in appreciable release of uranium to the unrestricted environment, and essentially complete recovery of the uranium was predicted.[a] Consequently, the impact from such an event at the Applicant's facility would be limited to (1) a small cleanup of contaminated soil, (2) replacement of destroyed mill components, and (3) a short duration release of nonradioactive combustion products to the atmosphere.

Ammonia Release

The probability of any accident releasing ammonia from the storage vessel is extremely low since the vessel will be pressure tested and isolated from other facilities. However, a failure of the relief valve or a fire around the vessel could result in an ammonia release. Assuming a 50% ammonia concentration in the release area and an aeolian dilution factor (X/Q) of 10^{-3} for a ground level release, the expected concentrations would be less than 500 ppm 100 meters from the source. Ammonia concentrations of 400 to 700 ppm for 1 hr ordinarily have no permanent effect on humans. Since the nearest inhabitant is at least 0.5

(a) WASH-1248.

mile from the tank, off-site consequences should be negligible.

Utility Loss

Complete loss of water or power to the mill could cause a scrubber failure, mine ventilation failure, or the pumping failure described earlier. Other, more serious environmental consequences are not anticipated.

A prolonged loss of electrical power at the mine is considered unlikely since two diesel generators supply emergency power to the pumps and exhaust fans. Failure of these generators during a prolonged power outage could leave the mine without ventilation or pumping of ground water. Resumption of mine ventilation after a power failure could result in a transient condition during which higher than normal concentrations of radon would be discharged to the atmosphere. Such an occurrence is not expected to affect measurably the off-site environment.

Wind Damage

Extremely strong winds are not common in New Mexico. In the 2 years for which data have been accumulated for the Gallup area, the highest recorded gust was 46 mph.

Winds of this magnitude are not expected to damage plant facilities or the environment. A much stronger wind would raise waves on the tailings pond, but they would be contained by the 5 ft freeboard.

High winds might cause some liquid to be spilled from the thickener tanks, but such a spill would be contained by the impoundment dike.

The most significant environmental impact from wind damage would occur in the case of sufficiently strong tornado picking up liquid from the tailings pond, thickeners or leach tanks, and dispersing it to the environment. The dispersed liquid would have a pH between 1.5 and 2.0 and contain some uranium, radium, and/or thorium. The liquid deposited in this manner should not harm plant or animal life. A slight increase in background radiation could result, but the increase would not exceed a few percent of natural background in the dispersal area.

Floods

During the summer months, New Mexico occasionally experiences short periods of heavy rainfall. Since the natural arroyo now present in the proposed tailings pond area will be diverted into a channel along the highway, flood waters will bypass the proposed mill and tailings pond without causing damage. Drainage from the mill site will flow through an existing culvert under the road into this channel.

During periods of heavy rainfall, a portable pump may be used to transfer storm runoff from the tank impoundment areas to the tailings pond. The only expected flood damage at the mill site could occur during the construction phase of the project. Heavy rainfall during construction could result in on-site erosion and could increase the turbidity of the runoff water in Pipeline Canyon. Erosion damage would be repaired by bulldozing, and no long-term damage is anticipated. After construction of the mill, embankments will be landscaped to minimize stormwater erosion.

A flood large enough to disrupt the mine water settling ponds is improbable. If such a flood occurred, the arroyo in Pipeline Canyon would receive the settling pond contents. These contents would be so diluted, however, that no drinking water standards would likely be exceeded should the settling pond contents reach potable water supplies.

Break of Tailings Dam

The tailings dam has been designed to withstand all meteorological and seismological conditions which are probable at the site. Section 3.4 discusses the structural and geological features which make a breach of the tailings dam highly improbable. Section 6.0 describes the seismic sensors which will be placed on the face of the tailings dam to detect slight shifts before serious cracking or loss of containment result. In spite of these precautions, a finite probability exists that some natural event or unforeseen accident might cause a break in the tailings dam.

Tailings dam failures are reported in the literature.[a] Of six tailings dam failures that occurred between 1959 and 1971, one was attributed to flooding conditions, one was the result of erosion from a break in a tailings pond slurry line, and the other four were apparently due to poor structural design. None

(a) WASH 1248.

of these failures resulted in measurable releases of radionuclides to natural waterways in excess of the Federal regulations.[a]

The Applicant's tailings retention system has been designed to withstand any flooding or earthquake conditions which are remotely possible in the area. A release of tailings pond liquid due to equipment malfunction or human error is not likely. In the event of a small release, the pond liquid would be deposited over a relatively short distance in Pipeline Canyon. An extremely large release might flow the 4 miles to the Rio Puerco before the spilled liquid was absorbed in the soil or evaporated. Both Pipeline Canyon and the Rio Puerco are dry most of the year, which would facilitate recovery of spilled tailings.

Mine Failures

Pump failures, flooding, or mine wall collapse could halt mining operations. During recovery, the required increased pumping rate might temporarily increase total suspended solids in the mine water. After passage through the third settling pond, however, the total suspended solids should be reduced to the concentrations observed during normal operations. Before the contaminated water would be discharged into the arroyo, the increased levels of natural uranium, Th-230, and Ra-226 would have to meet the discharge limitations set by the EPA.[b]

7.2 TRANSPORTATION ACCIDENTS

A serious traffic accident involving a yellowcake shipment presents a potential for release of yellowcake.

Yellowcake will be shipped in sealed drums built to withstand normal handling and minor accidents. Each drum will contain approximately 900 lb of product. Between 40 and 50 drums will be shipped in each closed van. The drums will be sealed and marked with the standard radioactivity symbol, and the trucks will be properly marked. Because most of the radioactive daughter products of uranium are removed in the extraction process and radioactive buildup of daughter products is extremely slow, yellowcake has a very low level of radioactivity and is, therefore, classified by the Department of Transportation as a low specific activity material.[c]

(a) 10 CFR 20
(b) See Appendix H.
(c) 49 CFR 173

The probability that a transportation accident will occur is about 10^{-6} per vehicle mile; the probability decreases to about 10^{-13} per vehicle mile for very severe accidents.[a]

The environmental impact of a transportation accident involving the product would be very small. Even in a severe accident, only a few drums would likely be breached, and since yellowcake has a very high density, approximately 4 g/cm^3, it would not easily disperse. More than likely, the drums and any released material would remain within the damaged vehicle.

Even if the yellowcake were to spill out of the vehicle, it could be detected easily by its distinctive color and by the use of survey equipment. Thus, the yellowcake could be reclaimed to prevent any significant environmental impact. At most, the cleanu operation would involve removing small amounts of topsoil and vegetation in the immediate area of the accident.

7.3 OTHER ACCIDENTS

Sections 7.1 and 7.2 include all postulated accidents for the Applicant's mine, proposed mill, or transportation associated with yellowcake. The potential for other accidents that would produce an environmental impact has not been identified.

(a) WASH 1248

CHURCH ROCK URANIUM MILL
ENVIRONMENTAL REPORT

SECTION 8.0
ECONOMIC AND SOCIAL EFFECTS OF MILL CONSTRUCTION AND OPERATION

Section 8.0 of the Church Rock Uranium Mill Environmental Report is not required by the New Mexico Environmental Improvement Agency.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 9.0

RECLAMATION AND RESTORATION

9.0 RECLAMATION AND RESTORATION

Current plans for reclamation and restoration of the tailings pond on termination of milling activity provide for stabilization and revegetation to prevent erosion, access restriction, periodic inspection, and monitoring. The pond area will be graded for aesthetic compatibility with the surrounding terrain. Mine tailings and/or topsoil will be used to cover and stabilize the graded tailings pond area. The stabilized surface will be planted with local vegetation. The choice of vegetation and the depth of soil will depend on results of experimental plantings conducted during mill operation. If necessary, irrigation water for the establishment of vegetation will be provided from either the mine or or a new well(s).

Diversion channels and intercept ditches constructed to protect the tailings pond will be maintained and riprapped as necessary to protect the stabilized tailings from erosion. See Figure 3.4-1.

The tailings pond area fence will be maintained and posted with appropriate warning signs to prevent public access to the tailings.

The land for the proposed mill operations is owned by Applicant who has no intention of selling. However, a description of the restricted use area, tailings pond, will be provided to the county land registrar for inclusion in the deed.

Periodic inspections and environmental measurements for radioactivity will be made of the terminated site. In addition, careful inspection of the site will be made following any unusual natural phenomenon such as floods or earthquakes. If needed, appropriate maintenance will be provided to keep the stabilized area intact.

A technical and feasibility assessment of methods and cost for stabilizing the tailings retention system was not made since the method described in this section is the practice currently accepted by both the industry and regulatory authorities.

The exact method of funding for the tailings pond stabilization and maintenance has not been finalized.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 10.0

ALTERNATIVES TO THE PROPOSED ACTION

10.0 ALTERNATIVES TO THE PROPOSED ACTION

The need for uranium to meet the electrical power generation requirements is well-documented in available literature, and the alternative of not operating Applicant's mine has not been considered.

Alternative Mill Sites

The first alternative for milling of Applicant's ore is to continue trucking the ore 85 miles to the Kerr-McGee mill in the Ambrosia Lake area. This mill uses the acid leach process, but will probably reach full capacity within the next few years. Although presently necessary, transportation by truck is both costly and a nuisance to other users of the road.

A second alternative is to resume trucking the ore 65 miles to the United Nuclear-Homestake Partners mill, also in the Ambrosia Lake area. The capacity of this mill is inadequate for the total output of Applicant's mine, and the mill uses a carbonate leach process, which is less efficient than the acid leach process of the proposed mill. Consequently, this alternative would result in less yellowcake extracted per ton of ore and less total uranium for electric power.

The third alternative is to construct a new mill immediately adjacent to Applicant's mine, but the need for a tailings storage location excludes this alternative.

The proposed site was selected for its general proximity to the mine, its isolation, its suitable area for tailings storage, and its accessibility by a paved road.

Alternative Mill Processes

A carbonate leach process was considered but rejected in favor of the more efficient acid leach and solvent extraction process. The construction cost of the acid leach type mill is higher; however, operation costs are lower and uranium recovery is higher.

CHURCH ROCK URANIUM MILL
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SECTION 11.0
BENEFIT-COST ANALYSIS

Section 11.0 of the Church Rock Uranium Mill Environmental Report is not required by the New Mexico Environmental Improvement Agency.

CHURCH ROCK URANIUM MILL

ENVIRONMENTAL REPORT

SECTION 12.0

ENVIRONMENTAL APPROVALS AND

CONSULTATIONS

12.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

Federal, state, and local authorities require specific licenses and/or permits for construction and operation of a uranium mill. The licenses and permits currently obtained and those to be obtained are outlined below.

An EPA permit, No. NM 0020401, has been issued effective from January 28, 1975, through January 27, 1980. The permit allows discharge of mine waters into an unnamed arroyo draining to the Rio Puerco. There will be no surface stream discharge from the proposed mill other than natural storm runoff.

The Applicant currently owns water rights for the property involved. The water rights exceed the quantities needed for mill operation.

Appropriate construction permits, including those for highway encroachment and the sewage plant, will be obtained by Applicant from local authorities before construction begins.

Individual construction contractors will be required to obtain their own contractor licenses and/or permits.

Licenses, permits, and/or registrations required for mill operation, such as a laboratory x-ray machine license, will be obtained after construction is completed. An application for an air pollution discharge permit was submitted in July 1975. See Sections 3.3, 3.4, and 5.4.

The Applicant is holder of Federal Tax No. 06-0765269 and New Mexico Tax No. 01-605170-00.

No meetings have been held with environmental or other citizen groups. No meetings or consultations concerning the economic development of the area have been held with state, regional, or local planning authorities. The license application posting and review period should provide ample opportunity for such meetings and/or consultations.

Consultations have been held with state licensing officials regarding the EPA discharge permit and requirements for the Radioactive Materials License. In addition, the Museum of New Mexico has been contacted and funded to excavate or direct the excavation of archaeological sites on Applicant's property.

CHURCH ROCK URANIUM MILL

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SECTION 13.0

REFERENCES

13.0 REFERENCES

References listed in this section are in alphabetical order by author or by organization if no author is identified. Documents identified by number are in numerical sequence following the alphabetical list.

AEC Regulatory Guide 3.8, 1973. Preparation of Environmental Reports for Uranium Mills. U. S. Atomic Energy Commission, Washington, D. C.

American Conference of Governmental and Industrial Hygienists, 1973. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Room Environment.

Beetle, A. A., 1970. Recommended Plant Names. Res. J.31. Agricultural Experimental Station, University of Wyoming.

Berggren, W. A., 1972. A Cenozoic Time-Scale--Some Implications for Regional Geology and Paleobiogeography. Lethaia 5(2):195-215.

Coffman & Von Hake, 1973. Earthquake History of the United States. U. S. Department of Commerce Publication 41-1.

Collier, John, F. R. Carpenter, L. C. Gray, H. H. Bennett and F. A. Silcox, 1937. Instructions for Range Surveys. Interagency Range Survey Committee. West Range Survey Conf. Mimeo.

Cooley, O. N. Hicks, et al, 1969. Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. U. S. Geological Survey Prof. Paper 521-A. 61p.

Davis, et al, 1963. Records of Ground-Water Supplies, pt. 1 of Geohydrologic Data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. Arizona Land Rept. Water Resources Department 12-A. 159p.

Department of Commerce, 1972. Climatology Summary for Gallup, New Mexico. Washington, D. C.

Department of Commerce. National Oceanic and Atmospheric Administration - Earthquake Epicenter Data 1853 to 1973. Washington, D. C.

EPA, 1972. Compilation of Air Pollutant Emission Factors. Document No. PB-209559. U. S. Environmental Protection Agency, Washington, D. C.

EPA, 1974. National Pollutant Discharge Elimination System Permit No. NM0020401. U. S. Environmental Protection Agency, Washington, D. C. See Appendix H.

EPA-520-9-73-3-B, 1973. Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply. U. S. Environmental Protection Agency, Washington, D. C.

Geological Society of London, 1964. The Phanerozok Time Scale, A Symposium. Geol. Soc. of Lond Quart. 120 (Suppl. p.222): 260-262.

Gould, W. L., V. W. Howard, and K. A. Valentine, 1972. Soil Characteristics, Biotic Composition and Vegetative Production of Areas Leased by Western Coal Company for Strip Mining near Fruitland, New Mexico. New Mexico State University Agr. Expt. Sta. Spec. Rep. No. 20.

Hale, Reiland, and Beverage, 1965. Technical Report No. 31 . Prepared for New Mexico State Engineer.

Heady, H. F., R. P. Gibbens, and R. W. Powell, 1959. A Comparison of the Charting, Line Intercept and Line Point Methods of Sampling Shrub Types of Vegetation. J. Range Manage. 12:180-189.

Kister, L. R., and J. L. Hatchett, 1963. Selected Chemical Analyses of the Ground Water. pt. 2 of Geohydrologic Data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. Arizona Land Dept. Water Resources Rept. 12-B. 58p.

League of Women Voters, 1974. The Gallup-McKinely County Public School Program. Gallup, New Mexico.

Longacre, J., 1973. Sixty-First Annual Report by the State Inspection of Mines to the Governor of the State of New Mexico. Santa Fe, New Mexico.

Manufacturing Chemist Data Sheet SD-8. Manufacturing Chemist Association, 1825 Connecticut Avenue, N. W., Washington, D. C.

McGavock, et al, 1966. Supplemental Records of Groundwater Supplies. pt. 1-A of Geohydrologic Data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. Arizona Land Dept. Water Resources Rept. 12 F. 55p.

Mercer, J. W., and J. B. Cooper, 1970. Availability of Ground Water in the Gallup-Tohatchi Area, McKinley County, New Mexico. U. S. Geol. Survey Open-File Report (Albuquerque, N. M.). 182p.

Merck Index, 1968. Encyclopedia of Chemicals and Drugs. Merck & Co., Rakeway, N. J.

Museum of New Mexico Archaeological Survey Catalog, Santa Fe, New Mexico.

New Mexico State Highway Department, 1970. General Highway Map, McKinley County, New Mexico.

New Mexico Air Quality Standards and Regulations. pt. 702. Permits and pt. 703 Regulations of Air Contaminant Sources. Santa Fe, New Mexico.

NMEIA, 1973. Regulations for Governing the Health and Environmental Aspects of Radiation, New Mexico Environmental Improvement Agency. Santa Fe, New Mexico.

Owensby, C. E., 1973. Modified Step-Point System for Botanical Composition and Basal Cover Estimates. J. Range Manage. 26:302-303.

Pickford, G. D., 1940. Range Survey Methods in Western United States. Herb Rev. 8:1-12.

Richter, C. F., 1958. Elementary Seismology. W. H. Freeman and Co., 353p.

Sax, N. Irving, 1968. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Co., New York, N. Y.

Shomaker, J. W., 1971. Water Resources of Fort Wingate Army Depot and Adjacent Areas, McKinley County, New Mexico. U. S. Geol. Survey Open-File Report (Albuquerque, N. M.). 230p.

Shomaker, J. W. Personal Communication, 3236 Candelaria, N. E. Albuquerque, New Mexico.

Shade, David H., 1969. Meteorology and Atomic Energy. Publication No. TID-24190. U. S. Atomic Energy Commission. Washington, D. C.

Turner, D. Bruce, 1970. Workbook of Atmospheric Dispersion Estimates. U. S. Public Health Service. Washington, D. C.

USGS, 1965 and 1969. Geologic Maps of Arizona and New Mexico. U. S. Geol. Survey. Washington, D. C.

USGS, 1972. Geographic Names Committee. U. S. Geol. Survey. Washington, D. C.

USGS, O.M. 158. Oil and Gas Investigation Map. U. S. Geol. Survey. Washington, D. C.

USGS, Riggs, E. A., 1960. Major Basins and Structural Features of the United States. U. S. Geol. Survey. The Geographical Press. Washington, D. C.

USGS, 1969. Tectonic Map of North America. U. S. Geol. Survey. Washington, D. C.

USGS, Topographic Maps (7.5 Minute Series) U. S. Geol. Survey. Washington, D. C. New Mexico Quadrangles: Pinedale, Church Rock, Big Rock, Hard Ground Flats, Oak Springs, Gallup East.

University of New Mexico, 1972. New Mexico Statistical Abstract. Bureau of Business Research, Institute for Social Research and Development, Albuquerque.

WASH 1248, April 1974. Environmental Survey of the Uranium Fuel Cycle. U. S. Atomic Energy Commission. Washington, D. C.

10 CFR 20, June 28, 1974. Standard for Protection Against Radiation (see Federal Register 29; No. 126). U. S. Atomic Energy Commission. Washington, D. C.

10 CFR 50, 1974. Licensing of Production and Utilization Facilities. U. S. Atomic Energy Commission. Washington, D. C.

49 CFR 100-199, 1974. Transportation, U. S. Department of Transportation. Washington, D. C.

49 CFR 173 (Sections 173.389c and 173.392), 1974. Shippers. U. S. Department ot Transportation, Washington, D. C.

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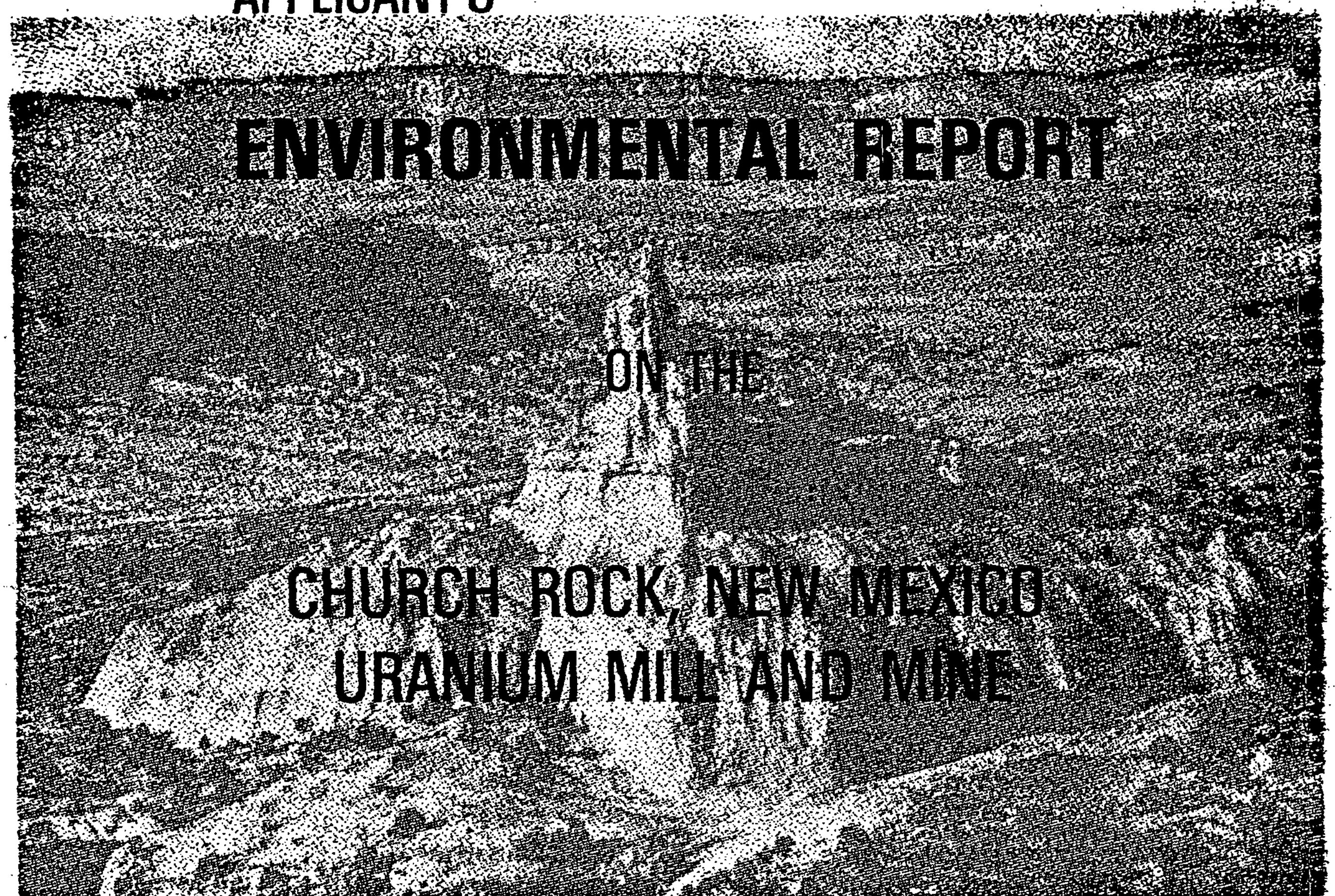
1975

APPLICANT'S ENVIRONMENTAL REPORT ON THE CHURCH ROCK, NEW MEXICO URANIUM MILL AND MINE



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UNITED NUCLEAR
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VOL II APP

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APPENDIX A

GEOLOGY, SEISMOLOGY AND STABILITY ANALYSIS
CHURCH ROCK URANIUM TAILINGS DAM
CHURCH ROCK, NEW MEXICO, FOR UNC

ROBERT WONG
EDGAR BECKER

GEOLOGY, SEISMOLOGY AND STABILITY ANALYSES
CHURCH ROCK URANIUM TAILINGS DAM
CHURCH ROCK, NEW MEXICO
FOR UNITED NUCLEAR CORPORATION
(JOB NO. 74131-100)

Prepared by
KAISER ENGINEERS

Robert T. Wong, Ph.D., P.E.
Principal Geotechnical Engineer

and
Edgar Becker, Ph.D., P.E.
Chief Geotechnical Engineer

October 2, 1974

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GEOLOGY, SEISMOLOGY AND STABILITY ANALYSES
CHURCH ROCK URANIUM TAILINGS DAM
CHURCH ROCK, NEW MEXICO
FOR UNITED NUCLEAR CORPORATION

I. INTRODUCTION

It is proposed to construct a tailings dam to retain the waste from uranium mining at Church Rock. The dam will be approximately 70 feet high and two miles long. The project site is situated at some 10 miles northwest of Gallup, New Mexico. The latitude and the longitude of the site are approximately 35° 35' N and 108° 35' W, respectively.

The tailings will have a production rate of about 4,000 tons per day (dry weight) for 20 years. The contents will consist of abount 10% larger than the #28 sieve, 30% passing #100 sieve and 18 to 20% passing the #200 sieve. The coarse portion of the tailings, that portion retained on #100 sieve, will be used for dam construction and mine backfilling. Separation of the -100 sieve size from the +100 sieve size will be by means of cyclones.

To assure continuous confinement of the uranium waste and to prevent their release to the environment, the U. S. Atomic Energy Commission has specified acceptable methods of analyzing the embankment stability and the minimum acceptable safety factors under both static and seismic conditions. Such analyses require the study of the geological and seismological characteristics of the site. The details are given in Regulating Guides 3.11, 3.8 and 3.5.

The purpose of this study is:

1. To collect and to compile the relevant historical earthquake data and, where possible, associate the seismic events with the tectonic and geologic features

2. To determine the vibratory ground motion for seismic analysis

3. To evaluate the potential of ground instability, including liquefaction, under static and seismic conditions

4. To provide design in-put for the tailings dam in compliance with the AEC's criteria

To assist in making the study, the following information was available:

1. A draft geology report dated June 6, 1974, prepared by M. MacRae of the United Nuclear Industries, Inc.

2. Two sets of boring and testing data dated August 6, 1974, and September 10, 1974, prepared by Sergent, Hanskins and Beckwith.

The study was performed under the supervision of Dr. H. B. Seed, the earthquake engineering consultant, and Dr. B. Bolt, the seismology consultant. A letter from Dr. B. A. Bolt dated September 17, 1974, is included in Appendix A as a reference.

II. REGIONAL PHYSIOGRAPHY & GEOLOGY

The site is situated in a general region located in the northwest corner of New Mexico and to the northwest of the Continental Divide. The region, which is situated on the San Juan Basin of the Colorado Plateau, is bounded at the north by the San Juan Mountains, at the east by Sierra Nacimiento (Nacimiento Uplift) and Rio Grande River (Rio Grande Depression), at the south by Zuni Mountains (Zuni Uplift) and at the west by Chuska Mountains and Defiance Plateau (Defiance Uplift). These regional features are shown on Plate I, "Major Basins and Structural Features." The regional topography and dam location is shown on Plate II, "Topographic and Dam Location Plan".

The basement rock units in the San Juan Basin are of Precambrian Era (some 600 million years old). The basement rock is generally covered by sedimentary deposits of Paleozonic (some 200 to 500 million years old) and younger eras.

The San Juan Mountains to the north and the Sierra Nacimiento to the east consist of terrestrial volcanic rocks of basically Tertiary Ages (some 2 to 63 million years old). In the area of the Rio Grande Depression, the rock units consist of thick sedimentary deposits of Late Tertiary Period and Quaternary Period (less than 2 million years old). The Rio Grande Depression is bounded to the east by Sangre De Cristo Uplift, which consists of basically Archean sedimentary and volcanic rocks of early Precambrian Era.

The Zuni Mountains to the south and the Defiance Plateau to the west consist of similar rock units as the San Juan Basin. However, in both Uplifts, there are sedimentary and volcanic rocks of early Precambrian Era.

There are numerous faults in the region. The faults are generally normal faults and are located along both the western and eastern boundaries of the Rio Grande Depression to the east, the Zuni Uplift to the south, and the Defiance Uplift to the west. The location of the faults and the regional tectonic structure are shown on Plate III, "Tectonic Map, Church Rock Uranium Mill".

III. SITE GEOLOGY

The geology of the site has been described in detail by M. MacRae in a report dated June 6, 1974. Basically, the site is located in Pipeline Valley, an incised valley system transecting the out crops of the southwestern rim of the San Juan Basin. The Valley, which consists of mainly Mancos Shale and Gallup Sandstone of Upper Cretaceous Period, is bounded to the north by Crevasse Canyon Formation of Mesa Verde Group in the Upper Cretaceous Period and to the south by Morrison Formation of Lower Cretaceous Period (some 135 million years ago). The valley floor is topped with alluvium soil, with the thickness varying for a few feet to more than one hundred feet. The alluvium soil in general consists of decomposed or degraded mixture of shale and sandstone. The various formations and their boundaries are given in Plate IV, "Geology Map, Church Rock Uranium Mill".

IV. REGIONAL & SITE SEISMOLOGY

The site and its general region is situated in Zone 2 on the Seismic Risk Map in the current Uniform Building Code, which means that the area has experienced in the past, and thus may experience in the future, moderate damage corresponding to Intensity VII of Modified Mercalli Intensity Scale.

Numerous earthquakes have occurred in the historical times. A computer search of all reported earthquakes from 1931 to 1973 within 200 miles of the site was made through a file from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration. Their catalogue consists of some 88,000 earthquake events throughout the world. In addition, the known earthquakes from 1852 to 1931 were compiled from a publication entitled, "Earthquake History of the United States", published by Jerry L. Coffman and Carl A. Von Hake. It may be noted that some of the data were described by magnitudes and some by intensity. To permit more quantitive analysis, the intensities of the historic earthquakes were converted to magnitudes using Richter's suggestion showing intensity as magnitude ("Elementary Seismology", 1958). The data were then plotted on Plate V, "Earthquake Epicenter Data (1883 to 1973)."

While the data shown on Plate V may not be complete, the data show strong correlation with the regional physiography, geology and structure. It may be seen that the majority of the earthquakes were closely related to the faults along the northeastern boundary of the San Juan Basin. These faults generally separate the San Juan Basin (with a rather old basement rock unit) from the uplift and depression of younger rock unit to the east.

The earthquakes on these faults have magnitudes up to 6 (Richter Scale) and have a maximum intensity of VIII.

Numerous other earthquakes fall on the tertiary volcanic units to the far southwest of the site in Arizona. These earthquakes have magnitudes up to 5.5 and a maximum intensity of VII. There are no earthquakes that are known to have occurred around the Defiance Uplift. However, there are two earthquakes that were noted near the Zuni Uplift where a normal fault of approximately 50 miles in length is present as shown on the tectonic map. These two earthquakes have magnitudes of 3.9 and 4.4, respectively. There are earthquakes that are noted to have occurred in other areas of the region. Their magnitude and intensity are not known.

In order to provide an estimate of intensity that might occur at the site, three cases for possible earthquake sources were evaluated as follows:

Case 1: An earthquake of magnitude 6.5 (or a maximum intensity of VIII) with an epicenter located on the fault system to the east (some 90 miles away if the shortest distance from this fault system to the site was used).

Case 2: An earthquake of magnitude 4.5 (or a maximum intensity of VI) centered locally near the site.

Case 3: An earthquake with a magnitude of 5.0 to 5.5 (or a maximum intensity of VII) centered along the normal fault around the Zuni Uplift (some 20 miles to the southeast of the site).

Since the tailings dam is considered more or less a permanent structure, the earthquake recurrence interval was not considered.

V. VIBRATORY GROUND MOTION

An assessment of the level of the vibratory ground motion is required for the design of the dam structure as well as for the evaluation of the seismic stability of both the tailings and the foundation soils. The probable surface ground motion and the rock motion for the three cases were thus analyzed. Based on the above data and some correlations by others, including the recommendations given by Dr. Bruce A. Bolt, it may be concluded that the maximum ground surface acceleration at the site would be on the order or 0.1g. The predominant period of the rock motion would be on the order of 0.2 to 0.3 sec. The duration of the earthquake could vary for 10 to 20 sec., with a bracketed duration of high intensities of less than 10 sec. The significant cycles of the earthquake would be less than 10, probably on the order of 5.

It may be pointed out that the 0.1g is also the minimum vibratory ground motion required by Atomic Energy Commission as the Design Basis Earthquake for Nuclear Power Plants.

VI. LIQUEFACTION POTENTIAL OF THE FOUNDATION SOILS AND THE TAILINGS

The subsurface conditions of the site and its vicinity were explored by 42 borings in July and August, 1974. The field exploration and the subsurface investigation was performed by Sergent, Hanskins & Beckwith. While the report is not yet currently available, preliminary results were given in the two sets of data dated August 6, 1974, and September 10, 1974, respectively.

The data indicate that the site is underlain by a layer of alluvium deposit, with thickness varying from a few feet to more than 100 feet. The deposit consists of inter-layers of medium-dense, fine-to-medium sand and silt, and medium-stiff clay. The underlying bedrock generally consists of moderately weathered sandstone. The ground water was encountered during drilling in a few borings at a depth ranging from 42 to 58 feet below the ground surface.

The relative density of the sand was evaluated based on the standard penetration blow count. It was found that the lower bound of the relative density of the sands varies from 80% to 45% above a depth of 20 feet. At depths greater than 20 feet, the relative density is approximately 45%.

When a saturated, fine, granular soil, such as sand, is subject to ground vibration, it tends to decrease in volume. Drainage through these materials is unable to occur in such a short time interval during an earthquake and the tendency to decrease in volume would result in an increase of the pore water pressure. When the pore water pressure builds up to a point where it is equal to the over-burden pressure, the soil loses all its strength and behaves like a liquid. Such phenomena have caused numerous failures in sands and soil-structures during earthquakes.

The liquefaction potential of the soil decreases with increased over-burden pressure and relative density. Further, liquefaction would only occur when the soil is saturated. The downstream portion of the dam will be made of compacted coarse tailings having a relative density of 70% or more. In addition, drainage is provided so the bulk of the structure will be in a non-saturated state. Under these conditions, potential for liquefaction and/or significant strain during an earthquake of 0.1g maximum ground acceleration and 10 or less significant cycles is very remote to non-existent. The liquefaction potential of the downstream toe area of the dam was evaluated because the soil there may become saturated at a shallow depth and the over-burden pressure is relatively small. The results indicate that liquefaction is unlikely to occur during an earthquake with the maximum ground acceleration not to exceed 0.1g and with the number of significant cycles of less than 10.

The foundation soils beneath the dam and the tailings would have much higher over-burden pressure and would, thus, have lower potential for liquefaction. The tailings in the pond will consist of mainly saturated, silty sand and sandy silt and the analysis indicates that the tailings in the storage area will very likely liquefy when subjected to the aforementioned earthquake. Thus, the dam must be constructed to retain the "heavy fluids" in the storage area during earthquake conditions.

VII. STABILITY ANALYSES OF THE DAM SECTION

For economic reasons, tailings are often employed for the construction of the tailings dams. There are basically three construction methods for tailings dams, namely, the Upstream Method, the Downstream Method and the Centerline Method. All methods begin with a starter dam to initially retain the tailings.

As filling of the pond progresses, the tailings dam is built on top of the beach-deposited tailings when using the Upstream Method. By this method, as the crest elevation increases, the crest of the dam moves further and further upstream over tailings deposited in earlier stages. The net result is a thick dam shell overlying the fine tailings. The starter dam by this method becomes the toe of the final dam. The Upstream Method is not selected for the project because of the high liquefaction potential of the tailings.

By the Downstream Method, the starter is the heel of the final dam and all subsequent dam building is done downstream of any tailings deposits. By the Downstream Method, all the sections of the dam will be compacted and the final dam will consequently be much more stable.

In the Centerline Method, the crest of the dam is maintained at the same horizontal position as the crest of the starter dam as the height of the dam is increased. The dam is raised by spreading and compacting additional coarse tailings on the top of the upstream shoulder and on the downstream slope. More than half of the final dam will consist of compacted material and the dam would also be more stable than the Upstream Method.

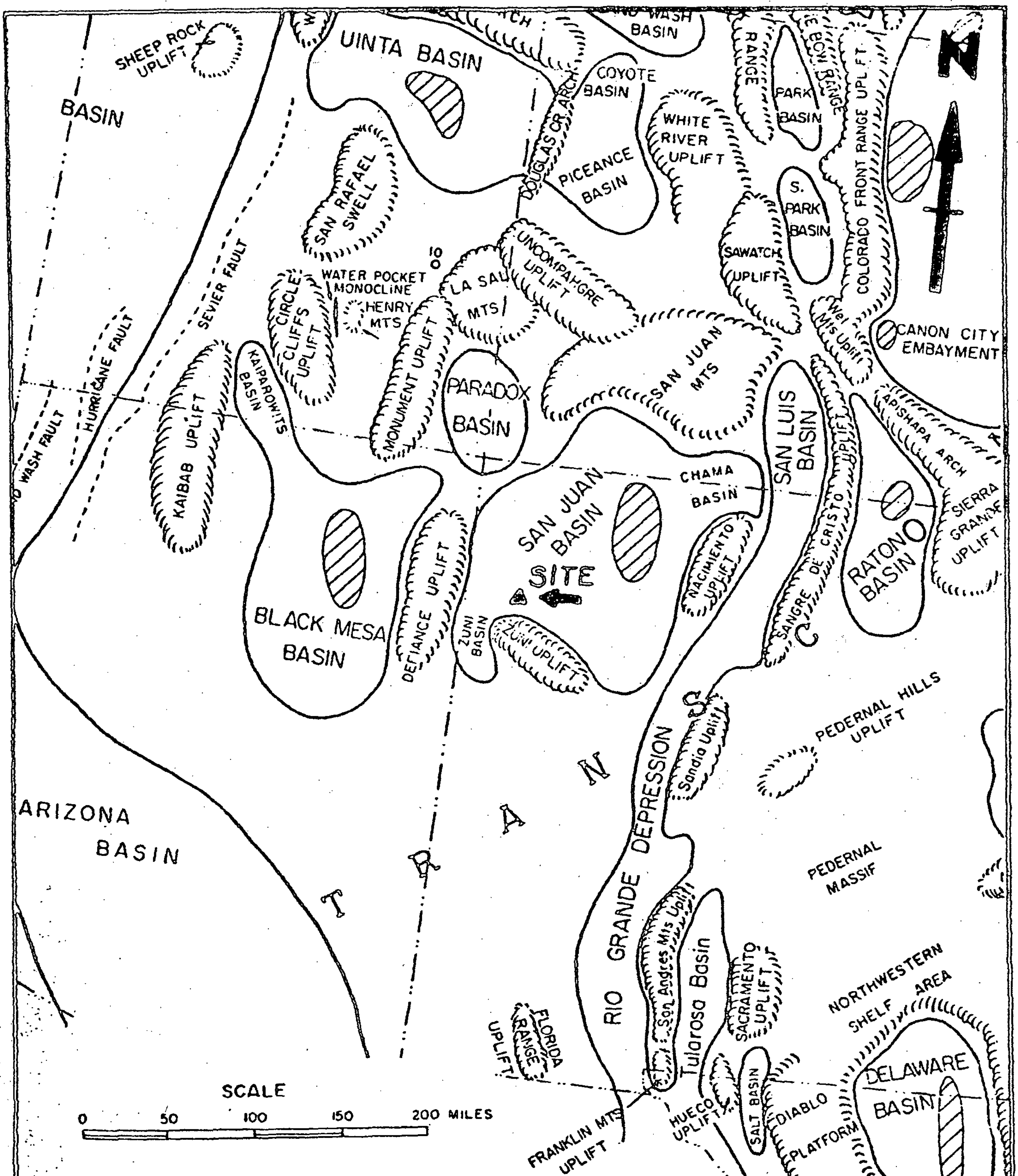
Due to stability and other considerations, the Centerline Method is selected for the project. The final dam will have a maximum height of approximately 90 feet. The dam will have a downstream slope of 3 to 1 (horizontal to

vertical) and an upstream slope of approximately 1 to 1, with tailings more or less filling the pond volume at all times. The dam section will be constructed of coarse tailings (retaining on #100 Sieve), compacted to a minimum of 70% relative density. A drainage blanket will be provided under the dam to lower the pheatic water level in the dam. The surface of foundation soils will be cleared of any deleterious matter and properly compacted prior to the dam construction.

Dam stability was analyzed by using Bishop's Modified Method and the Ordinary Methods of Slices using a computer program, STABR, developed at the University of California at Berkeley in 1971. This program is able to locate the critical slip surface and to calculate the minimum factor of safety. Due to the high potential of liquefaction during an earthquake, the tailings behind the dam were assumed to have zero strength but with a unit weight of 100 pounds per cubic foot. For the dam and foundation materials, approximately 90% of the peak ultimate strength values were used in the analyses. Under such conditions, the calculated minimum static safety factor of the dam is 1.5.

In addition to the assumption of complete liquefaction of the tailings, a pseudo-static force of 10% of the vertical weight (0.1g) was assumed to act horizontally on the center of gravity of each slice to simulate the earthquake loadings. For the critical slip circle, which was previously determined in the static analyses, the safety factor is slightly greater than 1.1.

It may be noted that the pseudo-static method which was used in the analyses is not necessarily the most sophisticated approach that could be used. Methods such as dynamic finite element analyses are often required for more complex studies. For this rather straight forward case, the site has been assumed to experience a maximum ground acceleration of 0.1g. The maximum acceleration, of course, would occur for only one or a few cycles, with other significant cycles having lower values of acceleration. It may be demonstrated that to assume a constant static force of .1g would be conservative. In addition, as stated earlier, the tailings behind the dam have been assumed to have zero strength due to complete liquefaction.

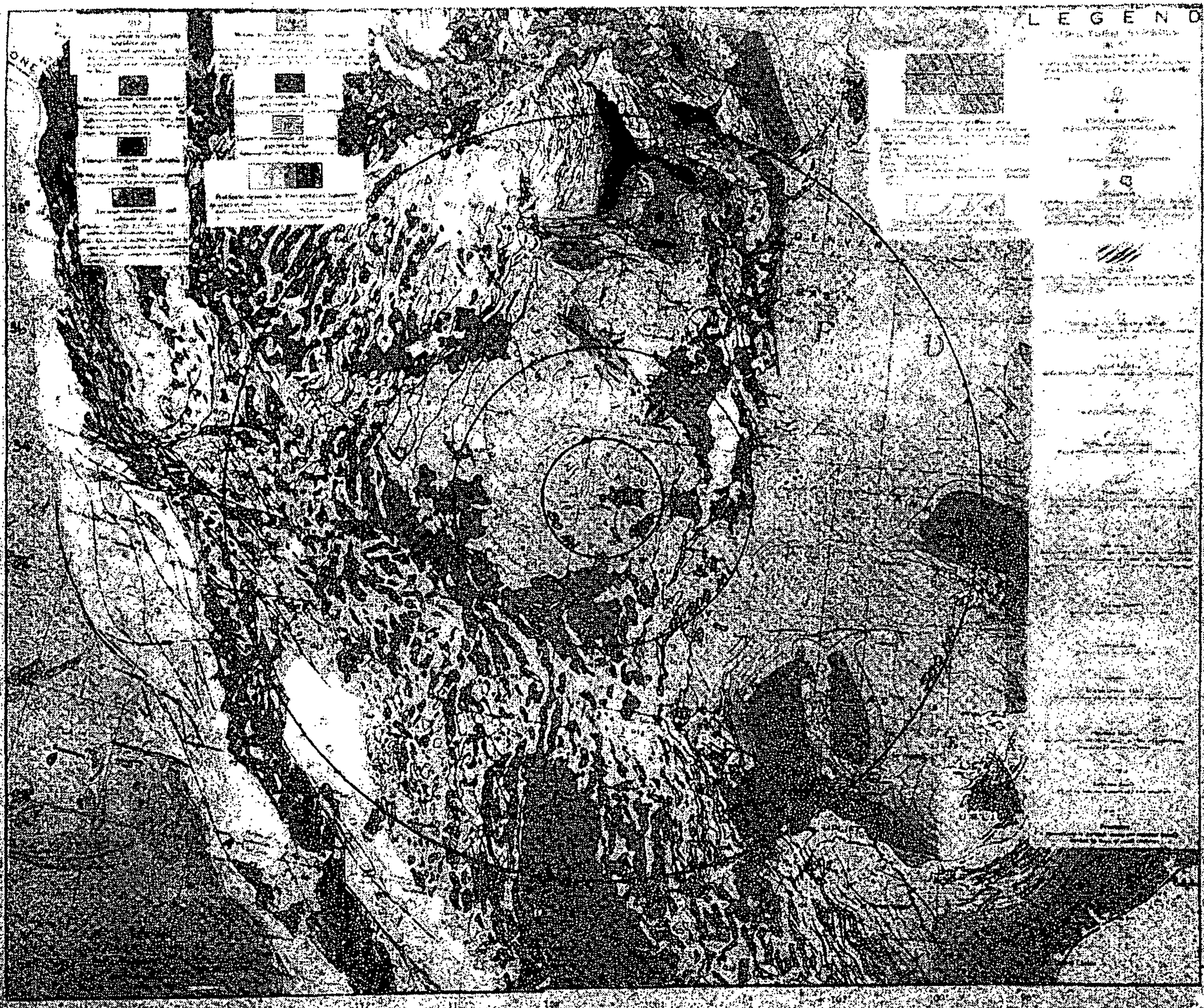


MAJOR BASINS AND STRUCTURAL FEATURES
(REFERENCE: RIGGS, E.A., 1960 "MAJOR BASINS AND STRUCTURAL FEATURES OF THE UNITED STATES" THE GEOGRAPHICAL PRESS)

PLATE I

TOPOGRAPHIC AND DAM
LOCATION PLAN
JOB NO.74131

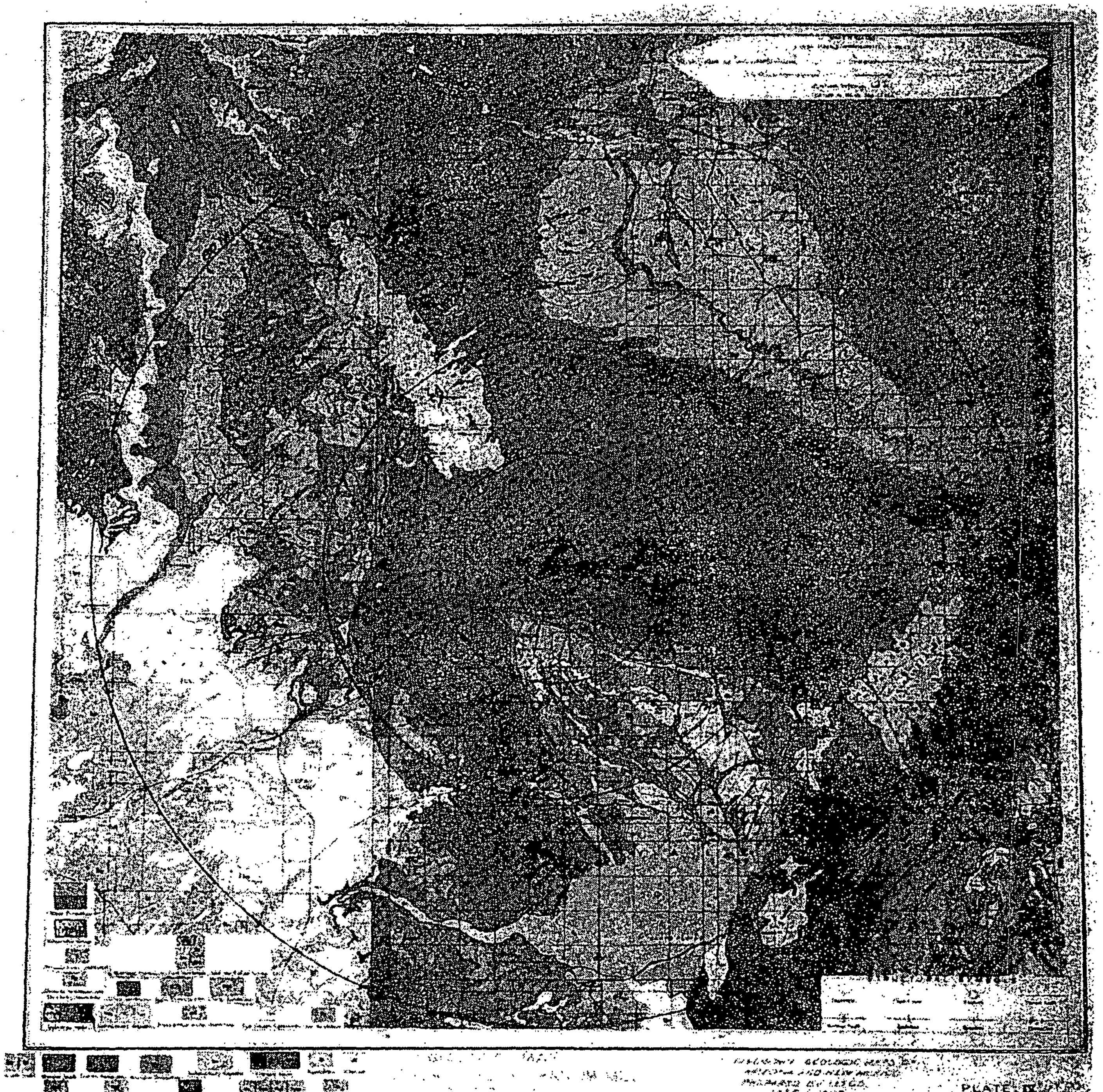
PLATE II



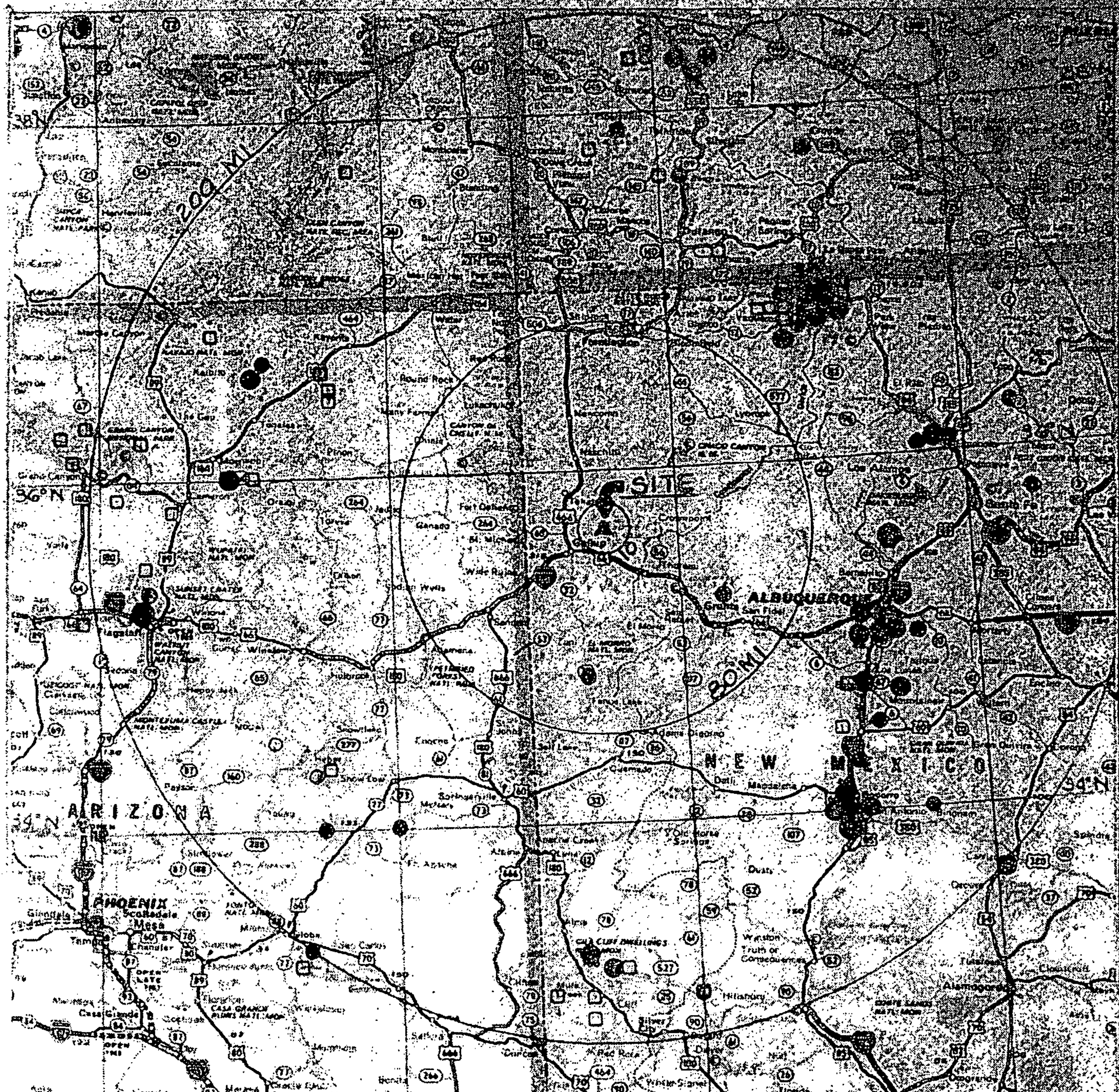
TECTONIC MAP
CHURCH ROCK URANIUM MILL
JOB NO. 74151

REFERENCE: TECTONIC MAP OF NORTH AMERICA PREPARED BY U.S.G.S. 1969

PLATE III



PLATE



MAGNITUDE

- ○ < 3.5
- ◐ 3.5 to 4.5
- ◑ 4.5 to 5.5
- ● > 5.5
- ⁝ UNCERTAIN

NOTE:

SOCORRO, N.MEX.
3.5 - 4.5 = 9
4.5 - 5.5 = 4
> 5.5 = 1

COL.-NEW MEX BORDER
< 3.5 = 1
3.5 - 4.5 = 15
4.5 - 5.5 = 6
UNCERTAIN = 51

CHURCH ROCK URANIUM MILL
EARTHQUAKE EPICENTER DATA
(1853 to 1975)

SOURCE: U.S. DEPT. OF COMMERCE
NATIONAL OCEANIC & ATMOS. ADMIN.
JOB NO. 74131 PLATE V

APPENDIX A

1508 Le Roy Avenue
Berkeley, California 94708

September 17, 1974

Dr. Robert Wong
Kaiser Engineers
300 Lakeside Drive
Oakland, California 94604

Church Rock (35° 50' 108° 31')
Uranium Mine Tailing Dam Project
(New Mexico)

Dear Dr. Wong,

As you requested I have considered the evidence of seismicity and geological structure which you provided.

In order to provide an estimate of intensity that might occur at the site I have taken three cases for possible earthquake sources. These cases are based on the recent recorded seismicity and general occurrence of faults. The estimates have been made on the side of caution both because the structure needs to remain effective over a long period of time, perhaps without maintenance, and because the expense of doing a very detailed field study to reduce perhaps the assumed levels is not warranted.

Case 1. Earthquake centered along the eastern active zone some 100-150 km away. Assume magnitude (M_s) 6.5.

I assess a peak horizontal acceleration of about 0.10g with a (bracketed) duration of 1-3 sec (Acc$\geq$0.05g, freq $\geq$ 2Hz).

This is similar to the Ferndale record of 1941 with peak acceleration 0.08g.

Case 2. Earthquake of sparse occurrence centered locally near the site. Assume M_s 4.5.

I calculate a peak acceleration of about 0.10g with duration (see above) of 2-5 sec.

The San Francisco records of 1957 give some guidance here.

Case 3. Earthquake centered along thrust faults mapped to south-east about 70 km away from site. Assume M_s from 5.5 to 6.0.

Again the attenuation estimates available suggest a peak acceleration of about 0.10g at the site. The duration

(as defined in Case 1) would again be likely to be 2-5 sec.

The El Centro record of 1934 is helpful for this case.

Yours sincerely,

Bruce A. Bolt

APPENDIX B

EPICENTER DATA FILE

HDF SEARCH 330-KM(200-MILE) RADIUS AROUND GALLUP, N.M. (35.5N, 108.8W) - 1880-73

DATA SOURCE	DATE GMT DAY	MO	YR	TIME GMT HR	MN	SEC	GEOGRAPHIC LOCATION LATITUDE	LONGITUDE	DEPTH KM	CGS BODY WAVE	CGS SURF WAVE	MAGNITUDES OTHER SOURCES	RICHTER / LOCAL	ASSOC PHENOMENA PHYSICAL (DIASTROPHISM / TSUNAMI / SEICHE / VOLCANISM / NONTECTONIC / OTHER)	MAN	INTENSITY MAX MM	ISO-SEISMAL MAP BY	QUALITY DEPTH CONTROL	RATING / AUTH	F-E GEO REG
CGS	05	02	38	04	44	00.0	35.100N	108.900W							DF	VI				496
CGS	17	04	38	12	38	00.0	34.000N	110.900W							F	V				495
CGS	29	07	38	08	40	00.0	35.000N	112.000W							F	V				042
CGS	18	12	35	05	33	39.0	36.700N	106.900W							DF	VI				496
CGS	19	12	35	01	57	33.0	36.700N	106.900W												496
CGS	06	11	36	11	30	00.0	33.300N	108.300W												496
SUTE	17	09	38	17	20	18.0	33.250N	108.750W				5.58 PAS			DF	VI				496
CGS	20	09	38	05	39	40.0	33.200N	108.600W							F	V				496
CGS	29	09	39	23	31	36.0	33.200N	108.500W												496
CGS	29	09	38	23	35	00.0	33.200N	109.600W							F	V				496
CGS	01	11	38	06	26	06.0	33.000N	108.700W												496
CGS	02	11	38	09	00	00.0	32.300N	108.700W												496
CGS	11	11	38	10	26	10.0	32.900N	108.700W												496
CGS	27	11	38	00	12	42.0	33.000N	109.000W												495
CGS	28	12	39	22	07	12.0	33.000N	109.000W												495
CGS	06	06	39	01	13	12.0	33.000N	109.000W												495
CGS	17	07	39	06	56	30.0	33.300N	109.000W												495
CGS	19	02	41	10	11	54.0	34.300N	111.000W												495
CGS	28	02	41	06	19	43.0	37.000N	113.500W												479
CGS	07	01	45	22	25	32.0	36.500N	111.000W				5.10 PAS			DF	VI				495
CGS	13	10	59	08	15	00.0	35.500N	111.500W				5.00 PAS			F	V				495
CGS	22	07	60	15	49	30.0	34.300N	105.500W							F	V				496
CGS	28	07	60	16	15	26.0	36.000N	106.500W							DF	V				496
CGS	11	10	60	06	05	30.5	38.300N	107.600W				5.50 BRK			DF	VI	USE			479
CGS-B	03	07	61	07	06	16.5	33.600N	105.300W	089						OF	VI				496
CGS-B	05	02	62	14	45	51.1	38.200N	107.600W	025						F	V		006		479
CGS-B	17	03	62	09	10	04.4	38.300N	108.100W	033									005		479
CGS-B	11	09	63	11	59	41.0	33.200N	110.700W	033	4.2					F			015		495
CGS-B	07	06	65	14	23	01.3	36.100N	112.200W	033									007		042
CGS-B	23	01	66	01	56	38.6	37.000N	107.900W	016	5.5					DF	VII	USE	082		479
CGS-B	23	01	66	02	03	34.5	37.000N	107.000W	005						F	III		008		479
CGS-B	23	01	66	02	13	13.5	36.900N	107.000W	005									009		496
CGS-B	23	01	66	04	50	14.1	36.300N	107.400W	005									005		496
CGS-B	23	01	66	05	19	47.6	37.000N	107.200W	005									005		479
CGS-B	23	01	66	06	14	15.6	36.900N	107.200W	005	4.2					F			009		496
CGS-B	23	01	66	07	10	41.2	36.300N	107.300W	005									005		496

CGS-8	23 01 66	07 55 0[illegible].1	36.900N	107.300W	005				0	496
CGS-8	23 01 66	07 44 35.7	36.900N	107.300W	005				005	496
CGS-8	23 01 66	10 53 10.6	36.900N	107.200W	005		F		006	496
CGS-8	23 01 66	11 01 07.1	36.900N	107.200W	005	4.3	F		011	496
CGS-8	23 01 66	12 14 30.0	37.000N	107.100W	005		F		006	479
CGS-8	23 01 66	15 43 19.7	36.900N	107.100W	005	4.5	F		010	496
CGS-8	23 01 66	20 42 18.5	36.900N	107.200W	005				007	496
CGS-8	23 01 66	22 45 12.8	36.900N	107.200W	005				005	496
CGS-8	23 01 66	23 49 04.1	36.900N	107.000W	005	4.6	F	V	021	496
CGS-8	24 01 66	01 31 26.7	36.900N	107.200W	005		F		005	496
CGS-8	24 01 66	09 00 30.3	37.000N	107.100W	005				005	479
CGS-8	24 01 66	22 06 50.0	36.900N	107.100W	005				006	496
CGS-8	25 01 66	07 50 54.8	36.900N	107.300W	005				007	496
CGS-8	25 01 66	10 33 05.0	36.900N	107.100W	005	6.0	F		011	496
CGS-8	25 01 66	15 32 48.5	36.800N	107.100W	005		F		006	496
CGS-8	25 01 66	19 53 12.0	37.200N	107.500W	005				005	479
CGS-8	27 01 66	00 49 59.1	37.000N	107.100W	005				005	479
CGS-8	27 01 66	03 53 32.2	36.900N	107.100W	005		F		005	496
CGS-8	27 01 66	07 48 28.7	36.900N	106.900W	005		F		006	496
CGS-8	27 01 66	09 29 00.6	36.900N	107.200W	005		F		005	496
CGS-8	29 01 66	05 32 20.7	36.900N	107.200W	005				005	496
CGS-8	29 01 66	06 55 30.6	36.800N	107.100W	005		F		005	496
CGS-8	28 01 66	14 53 03.0	36.900N	107.100W	005		F		005	496
CGS-8	29 01 66	11 21 51.3	37.000N	106.900W	005		F		008	479
CGS-8	29 01 66	18 38 48.0	37.000N	106.900W	005		F		005	479
CGS-8	29 01 66	19 25 05.8	37.300N	106.900W	005		F		005	479
CGS-8	29 01 66	20 01 53.7	36.900N	107.100W	005				005	496
CGS-8	30 01 66	02 39 53.2	36.900N	107.200W	005				005	496
CGS-8	31 01 66	15 43 52.3	37.000N	106.900W	005		F	IV	006	479
CGS-8	06 02 66	12 03 52.6	36.900N	107.100W	005				005	496
CGS-8	06 02 66	17 33 37.2	36.900N	107.200W	005				005	496
CGS-8	11 02 66	06 22 17.7	36.900N	106.900W	007		F		006	496
CGS-8	11 02 66	12 08 43.9	37.000N	107.000W	005		F		005	479
CGS-8	13 02 66	06 01 27.5	37.000N	106.900W	005		F		006	479
CGS-8	13 02 66	06 21 31.0	37.000N	106.900W	005		F		009	479
CGS-8	13 02 66	06 32 21.6	36.900N	106.900W	005		F		005	496
CGS-8	16 02 66	19 28 43.1	37.000N	106.900W	005				006	479
CGS-8	27 02 66	17 55 16.1	36.900N	106.900W	005				005	496
CGS-8	27 02 66	16 07 51.5	36.900N	107.000W	005				006	496
CGS-8	26 03 66	05 24 06.5	37.000N	107.100W	005				006	479
CGS-8	26 03 66	20 10 59.3	36.330N	139.300W	005				006	496
CGS-8	14 04 66	15 07 29.5	37.000N	107.000W	005				005	479
CGS-8	23 04 66	11 07 23.9	37.100N	107.100W	033				005	479
CGS-8	04 05 66	05 40 37.5	36.900N	107.100W	005	4.1			006	496
CGS-8	09 05 66	17 23 34.3	36.900N	107.000W	005	4.4			009	496
CGS-8	08 05 66	17 50 36.8	37.300N	107.000W	005	3.9			012	479
CGS-8	09 05 66	01 26 45.0	37.000N	106.900W	005				005	479
CGS-8	09 05 66	02 09 53.5	36.900N	107.000W	005	4.2			007	496
CGS-8	09 05 66	02 57 23.8	37.000N	106.900W	005	4.4			008	479
CGS-8	19 05 66	00 26 42.2	36.900N	107.000W	005	4.6	F		011	496
CGS-8	01 06 66	17 17 12.9	36.900N	107.000W	005				005	496
CGS-8	02 06 66	21 53 18.6	36.900N	107.000W	005	4.9			005	496
CGS-8	04 06 66	10 29 39.5	36.900N	107.000W	039	4.0			012	496
CGS-8	04 06 66	11 24 02.9	36.900N	107.100W	005				005	496
CGS-8	07 06 66	09 13 33.1	36.900N	107.200W	005				005	496
CGS-8	[illegible] 06 66	23 33 16.9	36.900N	107.100W	005				005	496
CGS-8	21 06 66	05 24 00.2	36.900N	107.100W	005	4.2			005	496
CGS-8	20 06 66	18 41 0[illegible].5	36.900N	107.200W	005				006	496
CGS-8	24 07 66	02 49 50.2	36.900N	107.000W	005	3.4			005	496
CGS-8	02 09 66	13 56 08.8	36.900N	107.200W	005				005	496
CGS-8	12 09 66	09 10 50.9	36.900N	107.200W	005				005	496
CGS-8	04 09 66	09 52 00.5	35.900N	107.300W	033	4.2			005	479
CGS-8	03 09 66	17 43 58.6	36.700N	105.300W	033				005	496
CGS-8	03 10 66	16 03 50.9	35.300N	111.500W	034				010	495
CGS-8	15 12 66	02 00 40.0	37.000N	107.300W	033	4.2			015	479
CGS-8	[illegible] 12 67	[illegible] 41 [illegible]	[illegible].432N	[illegible].365W	033	4.3		N	010	496

CGS-3	15 01 67	09 22 45.3	37.572N	107.360W	033	4.1					N 009	479
CGS-6	12 02 67	10 11 52.4	37.573N	109.002W	005						G 005	479
CGS-3	02 03 67	06 29 24.4	34.075N	110.964W	014	3.9					012	495
CGS-3	23 03 67	03 43 59.1	35.453N	111.732W	005						G 006 °	495
CGS-3	04 04 67	22 53 39.5	38.318N	107.754W	033	4.5					N 013	479
CGS-3	05 05 67	19 31 26.5	37.726N	110.238W	033						N 005 °	478
CGS-8	21 05 67	16 00 05.1	34.291N	110.565W	009	3.8					005	495
CGSPDE	20 07 67	13 51 10.4	36.300N	112.100W	033						005	042
CGSPDE	04 09 67	23 27 44.7	36.200N	111.700W	033						006	495
CGSPDE	10 12 67	19 30 00.1	36.700N	107.200W	000	5.1		E	'		077	496
CGS 15	30 01 69	05 17 37.5	34.291N	105.384W	008	4.1	3.60 ML SNM		F		007	496
CGS 48	04 07 69	14 43 34.0	36.378N	105.121W	010	4.4					G 003	496
CGS 65	23 06 69	21 41 54.2	34.846N	108.695W	033	3.9					N 005	496
CGS 85	25 12 69	12 43 10.1	33.362N	110.645W	015	4.4	5.10 ML CGS		F		G 022	495
CGS 16	03 02 70	05 59 35.5	37.918N	103.311W	033	4.0					N 005 °	479
CGS 61	03 08 70	19 24 17.8	34.318N	110.519W	000			E			G 005	495
NOS 34	24 11 70	10 47 50.0	36.357N	112.273W	006		3.00 ML NOS				007	042
NOS 30	25 11 70	07 40 11.6	35.028N	106.684W	009	4.5	3.80 ML NOS		OF	V	013	496
NOS 37	03 12 70	03 47 24.6	35.874N	111.306W	005		2.30 ML NOS				G 007 °	495
NOS 6	04 01 71	07 39 06.7	35.122N	106.591W	009	4.7			DF		013	496
NOS 22	12 02 71	11 26 13.7	36.222N	105.712W	005	3.7					G 005 °	496
NOS 27	14 03 71	16 14 12.2	36.478N	110.437W	005		2.20 ML NOS				G 005 °	495
NOS 33	24 04 71	11 36 52.7	35.794N	105.563W	005	4.0	3.00 ML ALQ				G 007 °	496
NOS 37	01 05 71	02 11 20.4	36.601N	110.481W	005		2.00 ML NOS				G 007	495
ERL 35	04 11 71	02 16 53.7	35.220N	112.168W	005		3.70 ML ERL		F		G 011	042
ERL 33	05 12 71	05 13 13.7	36.054N	105.321W	005	4.2	3.20 ML ERL		DF		G 012	496
ERL 95	15 12 71	12 58 14.5	36.731N	111.924W	005		3.00 ML ERL				G 008 °	495
ERL 30	20 04 72	13 25 16.3	35.311N	111.640W	005	3.7			F		G 013	495
ERL 13	09 02 73	17 38 37.0	36.430N	110.425W	005		3.20 ML ERL				G 006 °	495
ERL 30	17 03 73	07 43 05.5	36.037N	106.168W	006	4.5			F		008 °	496
GS 60	22 09 73	23 35 35.8	34.465N	106.352W	005		3.10 ML GS				G 006	496
GS 82	24 12 73	02 20 14.9	35.258N	107.739W	018	4.4	4.10 ML GS		DF		016	496

THIS RUN CONTAINS 134 HITS

PREPARED BY NATIONAL GEOPHYSICAL AND SOLAR-TERRESTRIAL DATA CENTER

HYPOCENTER DATA FILE

1900-1973: 88,100 events worldwide in total files.

Abbreviations used -

Magnitudes: BRK, Berkeley, California; CGS/NOS, Coast and Geodetic Survey/National Ocean Survey, GOL, Golden, Colorado; OXF, Oxford, Mississippi; PAL, Palisades, New York; PAS, Pasadena, California; SLM, St. Louis, Missouri; TUL, Tulsa, Oklahoma.

Non-tectonic phenomena: E, explosions (accidental or controlled) or suspected explosion; R, rockburst; C, coal bump or rockburst in coal mine.

Effects on man: C, casualties; D, damage; F, felt. Incomplete 1963-1967.

Isoseismal map by: USE, *United States Earthquakes;* EQN, *Earthquake Notes;* PDE, *Preliminary Determination of Epicenters.*

Depth control: D, restrained to agree with reported depth phases; G, restrained by geophysicist; N, restrained at normal depth (33 km) when data are not sensitive to depth for a shallow focus.

Quality: Authority A, U.S. Atomic Energy Commission; J, Jesuit Seismological Association (St. Louis); M, hypocenter based on macroseismic information; S, a special solution based on a local crustal model or use of dense local networks.

Intensity incomplete 1963-1967.

Quality Indicators, Column 72

* Indicates that the epicenter has been determined from incomplete or less reliable data so that it is not considered as accurate as the computed solution would seem to indicate (the absence of this or any other symbol is intended to indicate that inaccuracies in the hypocenter determination are thought to be due primarily to the travel-time curves, network bias and methods used rather than the quality of the data).

A Parameters of explosion supplied by U.S. Aromic Energy Commission (AEC).

E Some or all parameters of explosion (controlled or accidental) supplied by any group or individual other than AEC.

B Parameters of hypocenter supplied by University of California at Berkeley.

P Parameters of hypocenter supplied by California Institute of Technology.

G Parameters of hypocenter supplied by the U.S. Geological Survey (U.S.G.S.) for any area other than Island of Hawaii.

H Parameters of hypocenter supplied by the U.S.G.S. Hawaiian Volcano Observatory.

J Parameters of hypocenter supplied by St. Louis University.

M Hypocenter based on macroseismic information.

R Parameters of hypocenter supplied by University of Nevada.

S An NEIS solution based on use of dense local networks, a local crustal model, or other methods not routinely applied by NEIS.

W Parameters of hypocenter supplied by University of Washington.

APPENDIX B

HYDROLOGICAL CONDITIONS NEAR THE UNC MILLSITE

JOHN W. SHOMAKER

JOHN W. SHOMAKER
CONSULTING GEOLOGIST
3236 CANDELARIA, N.E.
ALBUQUERQUE, NEW MEXICO 87107

(505) 345-9648

November 7, 1974

Mr. Thomas E. Dabrowski
United Nuclear Industries, Inc.
P. O. Box 490
Richland, Washington 99352

Dear Mr. Dabrowski:

Attached is a copy of my report on hydrologic conditions near the Churchrock millsite. Please let me know if there are any questions about it, or if any parts need additional treatment.

Sincerely,

John W. Shomaker
John W. Shomaker
Consulting Geologist

JWS/nc
Encl.

HYDROLOGIC CONDITIONS NEAR THE UNITED NUCLEAR CORPORATION MILLSITE

by
John W. Shomaker
Consulting Geologist

prepared for
United Nuclear Industries, Inc.
Richland, Washington

November 1974

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TABLES

ILLUSTRATIONS

INTRODUCTION

This report was prepared at the request of United Nuclear Industries, Inc. who is in turn preparing an environmental report for the United Nuclear Corporation Churchrock Millsite. This report was prepared primarily to satisfy the Atomic Energy Commission Regulatory Guide 3.8 entitled, "Preparation of Environmental Reports for Uranium Mills", to recommend a monitoring well program suitable for determining any effects of infiltration by water from the tailing ponds and to determine the hydrologic suitability of the proposed pond sites.

Data for the report was taken from information in the writer's files, published material, information from the files of public agencies, and through field checking of water levels and on-site geology where appropriate.

GROUND WATER

Well Inventory

An effort was made to locate each water supply well in the vicinity of the millsite (see Fig. 1) and determine the aquifer tapped, the owner, the use, and other available information for each. Published information (Kister and Hatchett, 1963; Davis and others, 1963; McGavock and others, 1966; and Shomaker, 1971) was supplemented by field checking and examination of Navajo Tribal Water Development Department

records. The inventory is shown as Table 1 and chemical quality data are shown in Table 2.

Aquifers

Alluvium

Water-bearing alluvium is present in the principal drainages of the basin of the North Fork of the Puerco River. It is tapped by wells in a number of places (see Fig. 1 and Table 1) primarily for small quantities of domestic and stock water which are withdrawn by windmill or hand-operated pumps. Water quality is highly variable because recharge is derived from local storm flows in very small drainages, but is ordinarily good to fair with total dissolved solids ranging from less than 200 ppm to somewhat over 1,000 ppm.

Because water-bearing alluvium is restricted to the valleys, only alluvium downstream from the millsite could be affected by mine and mill activities. The principal potential effects are:

(a) Recharge to the alluvium of water pumped from the mine and consequent change in quality

(b) Recharge of water to alluvium through seepage from tailings and evaporation ponds, and

(c) Recharge of poor quality water released by accidental breaching of the tailings dam or evaporation pond dikes

Though mine waters are being pumped into the surface drainage at present (at a rate of some 1,400 gpm), it is anticipated that no water will be released after mill

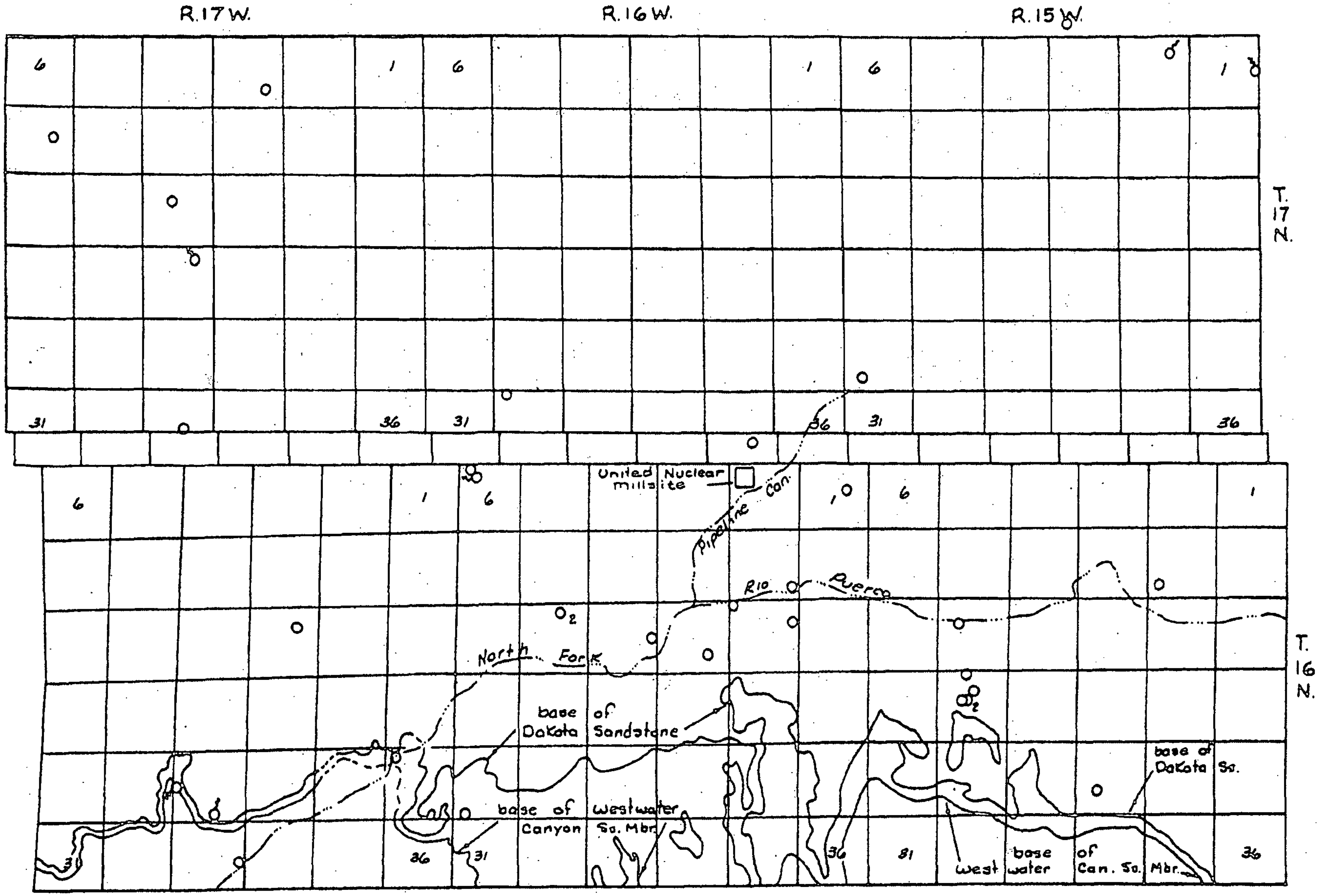


Figure 1. Locations of water wells near United Nuclear millsite

TABLE 1. Records of Wells and Springs in the Vicinity of United Nuclear Corp. Churchrock Millsite

Location number and name 1/	BIA Number	Elev.	Depth, ft.	Aquifer 2/	Water level, ft.,	date	Yield during test, gpm	Drawdown at yield shown, ft.	Use of water	Type of pump	Conductance, u mhos @ 25° C
16.15.11.331	16T-509	7015	953	Kd,Jmw	355	1960	8	25	D,S	W	1290
16.15.17.141	16T-348	6900	410	Kd	flow	1957	8	242	D,S	W	960
					87	1974					
16.15.20.121	16T-514	6975	496	Kd	63	1959	24	335	D		1600
20.143	16GS-105			Qal							
20.144	16GS-105			Qal							
20.231	16GS-105			Qal							
20.234 Pinedale TP	---			Km?							
16.15.27.323		7178									
16.16. 1.112	16K-319	7128	963	Kd	320	1948	7	490	D,S	W	1060 cased to 956
16.16. 6.112	14N-70	7010	---	Kcd	---	----	0.5	---	D,S		436
S 16.16. 6.121		7030									
16.16.11.442		6855		Qal							
16.16.14.111		6838		Qal							
16.16.14.242		6905	525	Jmw	54	1974			D,S	P	
16.16.15.432	16T-513	6875	318	Jmw	181	1959	33	20	D,S		1390
					257P	1974					
16.16.16.422		6799		Qal							
					144	1968					
16.16.17.214 Old Churchrock Mine		6808		Jmw	319	1974				N	
16.16.17.214	16T-532	6810	450	Kd							
16.16.30.343 Springstead TP		6870	505	Jmw,Jcs	211	1956	5				
16.17.15.232	16T-510	6818	680	Kd,Jmw	103	1960	26	240	D,S	W	1500
					253P	1974					
16.17.25.113	16K-340	6682	141	Qal	37	1954	23	68	D,S	W	1810
S 16.17.28.133		6860	---	Kd	---	----	--	---	U	-	
S 28.433		7010	---	Kd	---	----	--	---	U	-	
16.17.33.422	16K-336	6651	122	Qal	34	1955	15	28	D,S	W	1330
S 17.15. 1.244 Rock Spring		6920	---	Kpl	---	----		---			
S 17.15. 2.232 Oak Spring		6880	---	Kpl	---	----					
17.15.30.341	15T-303	7038	614	Kg	305	1952	23	50	D,S	W	3120 cased to 537
					318P	1974					
17.16.32.112	14K-313	7010	622	Kg	235	1953	20	128	D,S	W	1780
17.16.35.414 UNC water well		7180?	1650	Jmw-Kd?	900	1969	20		D	P	499

TABLE 1. Records of Wells and Springs in the Vicinity of United Nuclear Corp. Churchrock Millsite (continued)

Location number and name 1/	BIA Number	Elev.	Depth, ft.	Aquifer 2/	Water level, ft.,	date	Yield during test, gpm	Drawdown at yield shown, ft.	Use of water	Type of pump	Conductance, u mhos @ 25° C
17.17. 3.441	14T-320	6379	726	Kg?	434	1958	65	31	D,S	W	
17.17. 7.233	14A- 79	6240	873	Kcd	flow	1952	82 ('51) 30 ('55)		D,S,I		455
17.17.16.	14A- 14		7	Qal	6	1955	---		S		3370
S 17.17.21.221 Coal Mine Spring	14N- 57?	6470	---	Qal	---	----	0.5	--	D		
17.17.33.411	14T-321	7060	1082	Kmf-Kcc	flow 400	1960 1967	15	30	D,S	W	2700
18.15.34.323	15T-535	6760			211	1974			S	W	

1/ see explanation of numbering system in text

2/ Aquifers: Qal, alluvium; Kcc - Crevasse Canyon Formation; Kcd - Dalton Sandstone Mbr. of Crevasse Canyon Formation; Kmf - Menefee Formation; Kpl - Point Lookout Sandstone; Kg - Gallup Sandstone; Km - Mancos Shale; Kd - Dakota Sandstone; Jmw - Westwater Canyon Sandstone Mbr. of Morrison Formation; Jcs - Cow Springs Sandstone

TABLE 2. Selected Chemical Analyses of Ground Water in the Vicinity of United Nuclear Corp. Churchrock Millsite
(Constituents in parts per million unless otherwise noted)

Location number and name 1/	BIA Number	Aquifer 2/	Date Sampled	Silica SiO_2	Calcium Ca	Magnesium Mg	Sodium plus potassium Na + K	Bicarbonate HCO_3	Carbonate CO_3	Sulfate SO_4	Chloride Cl	Fluoride F	Nitrate NO_3	Total dissolved solids	Conductance u mhos @ 25° C
16.15.20.		Qal	8-1949	12	72	14	13	258	0	43	4	0.6	2.2	288	480
20.		Qal	5-1950	15	42	13	8	160	0	40	2	0.2	0.1	199	331
20.234 Pinedale TP		Km?	8-1949	12	170	55	161	359	0	590	50	0.4	24.0	1240	1710
16.16. 1.112	16K-319	Kd	6-1955	14	1.6	1.9	262	518	39	74	8	1.4	1.5	658	1060
16.16. 6.112	14N- 70	Kcd	5-1955	18	57	20	0.9	130	0	102	9	0.4	0.0	271	436
16.17.25.113	16K-340	Qal	6-1954	12	139	44	264	890	0	314	24	0.6	13.0	1250	1810
16.17.33.422	16K-336	Qal	9-1953	5.8	80	19	227	776	0	91	26	1.4	0.3	832	1330
17.15.30.341	15T-303	Kg	6-1955	15	157	89	504	297	0	1520	16	2.1	0.6	2450	3120
17.16.32.112	14K-313	Kg	5-1955	17	218	99	72	271	0	835	11	0.8	0.0	1390	1780
17.16.35. Kerr McGee Mine		Jmw	11-1973	17	11	8.4	131.6	220	21	110	3.6	0.3	---	412	663
17.17. 7.233	14A- 79	Kcd	6-1949	--	3	0.9	105	237	0	38	4	0.2	0.5	268	455
17.17.16	14A- 14	Qal	5-1955	--	--	--	---	409	0	---	32	1.2	0.3	530	3370
United Nuclear Churchrock Mine		Jmw	11-1973	17	2.2	0.3	121.4	215	31	45	5.2	0.2	---	329	550

1/ see explanation of numbering system in text

2/ Aquifers: Qal, alluvium; Kcc, Crevasse Canyon Formation; Kcd, Dalton Sandstone Mbr. of Crevasse Canyon Formation; Kmf, Menefee Formation; Kpl, Point Lookout Sandstone; Kg, Gallup Sandstone; Km, Mancos Shale; Kd, Dakota Sandstone; Jmw, Westwater Canyon Sandstone Mbr. of Morrison Formation; Jcs, Cow Springs Sandstone

operation begin. Some infiltration into alluvium will take place from the tailings and evaporation ponds because of the permeability of the material which will be introduced into the tailings. A monitoring well program will be suggested in a later section of this report to determine the effects brought about by infiltration from tailings.

The writer has been informed by Kaiser Engineers that a permeability of about 0.01 feet per year can be expected for the tailings which will be deposited in the pond. Using this value, it would appear that total infiltration would be only a few gpm per acre after the pond has been operating a few years. Rates of water movement within the alluvium are expected to be very slow, on the order of a few tenths of one foot per year, given the horizontal permeability of 4 feet per year determined by Kaiser.

Even if there were sufficient infiltration to result in some surface flow in the arroyo which borders the toe of the dam, it is expected that, after a short distance, this would re-enter the alluvium and move downgradient at the far slower rate.

The nearest well which withdraws water from the alluvium below the proposed tailings pond sites is along the east line of section 16 (well 16.16.16.442). It taps alluvium in the main stem of the North Fork of the Puerco about one-half mile below the confluence of Pipeline Canyon, and more than 2 miles below the proposed tailings dam site. It is equipped with a hand pump and water is used for domestic

and stock purposes.

Sandstones of the Crevasse Canyon Formation

The Dalton Sandstone Member of the Crevasse Canyon Formation forms the cliffs behind the millsite and lies above the water table throughout the vicinity of the mine and millsite; accordingly, only geologic units below the Dalton will be considered in the following discussion (Fig. 2). Several sandstones below the Dalton (but still within the Crevasse Canyon Formation) are potential minor aquifers. These are within the Dilco Coal Member and near the millsite they total less than 50 feet in thickness. Yields from the Dilco can be expected to be small--perhaps up to 20 gpm--and quality is probably quite variable but generally poor because of the close association with coal and carbonaceous shale.

The sandstones that underlie the arroyo channel adjoining the evaporation ponds are probably part of the Dilco and if infiltration from the ponds were significant, there could be some movement of water into them; however, the relatively low water movement rate seems to preclude serious contamination. The dip of the bedrock (and hence the general direction of movement of groundwater near the outcrop) and the direction of surface drainage are opposite. Thus little or no water is likely to enter the Dilco as a result of dike failure under flood conditions.

There is a possibility of water entering the Dilco from the evaporation ponds through infiltration from saturated

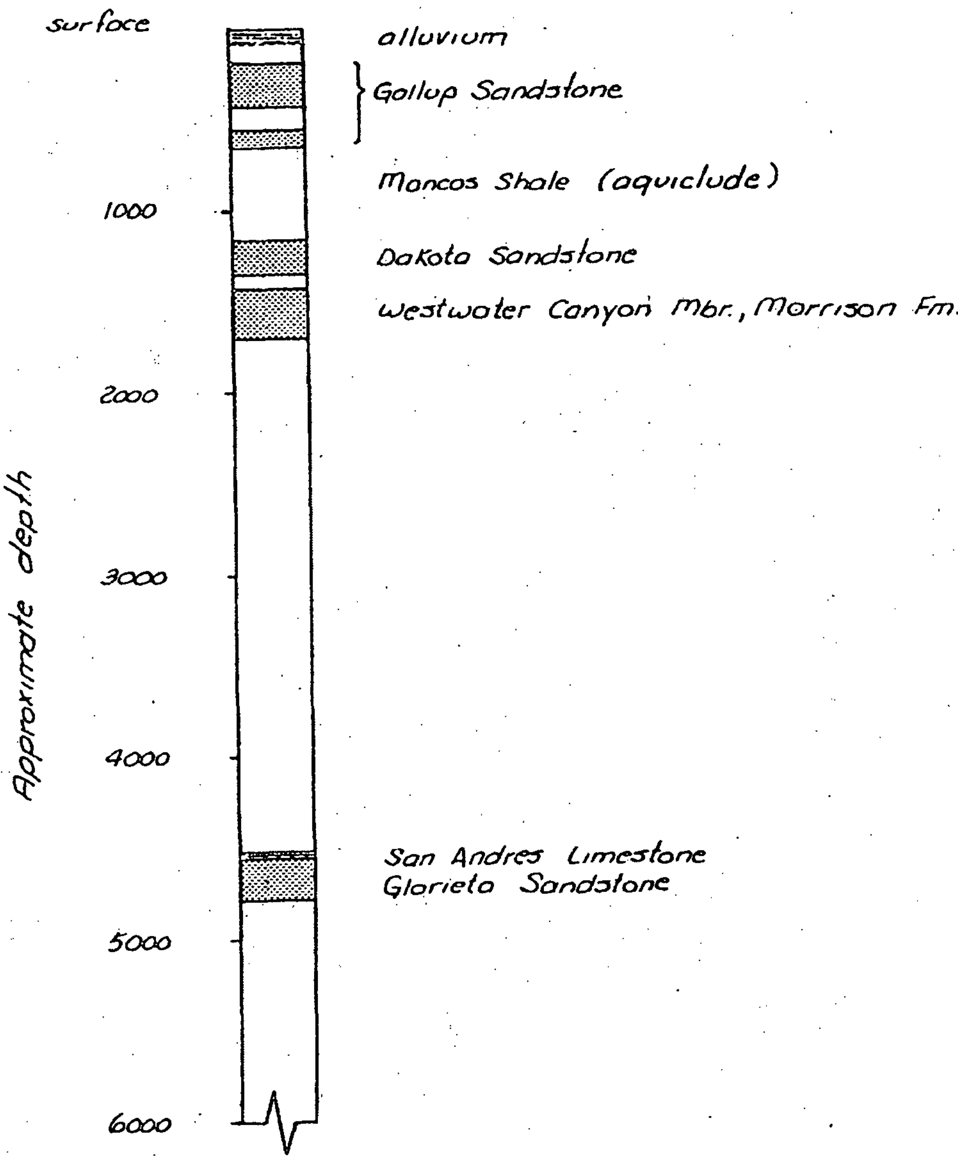


Figure 2. Principal aquifers and aquicludes beneath tailings pond area.

alluvium which overlies some part of the Dilco section below (downstream from) the evaporation ponds.

The permeability of the sandstone is typical of the rather massive beds in the Dilco at the millsite and has not been measured directly. The values used in this report are taken from field and laboratory measurements of permeability and transmissivity of similar rocks in the vicinity and must of course be considered only approximations.

Cooley and others (1969) list a range of values of 0.6 to 1.7 feet per day for laboratory-determined permeability of the "Crevasse Canyon Formation". Presumably the data applied to somewhat weathered outcrop samples of sandstones within the formation and may represent the situation just beneath the tailings ponds fairly well. Mercer and Cooper (1970) conducted aquifer tests in the Munoz-1A water well of the City of Gallup (in section 17, T. 16 N., R. 18 W.) and for a 267-foot screened section of Gallup Sandstone indicated a transmissivity on the order of 2,000 gpd per foot or somewhat less. The indicated permeability would have been around 1 foot per day; electric logs showed the Dilco sandstone units to be very similar to those of the Gallup.

Beyond the influence of the groundwater mound created by infiltration from the tailings pond, groundwater within the sandstones of the Dilco can be expected to move downdip at a rate commensurate with the gradient imposed by the dip of the rocks. It is not likely that the rather massive sandstone beds would be saturated very far downdip and thus

confined (artesian) conditions probably would not be established.

The structural dip in the area is northward at a rate averaging about 240 feet per mile, and that can be considered a maximum overall hydraulic gradient for practical purposes. Near the ponds, where water is being recharged from the source directly above the sandstones, the gradient would be steeper, but at any significant distance the gradient would flatten and probably almost coincide with the bedding planes.

Still further from the point of recharge beyond the points of saturation and confinement the gradient would be less steep. The artesian situation at well 17.15.30.341 (15T-303) in which the water level is at least 160 feet above the top of the aquifer (Gallup Sandstone) illustrates this point. Based upon a permeability of about 1.0 foot per day and at a gradient of 240 feet per mile, water movement would be 0.24 feet per day or about 88 feet per year downdip from the tailings pond in the zone above the point of confinement. Presumably the rate would be lower further downdip.

At present only one well exists that could conceivably be reached within many decades by water from the pond. It is well 17.15.30.341 which is about 1.6 miles from the north line of section 2 (T. 16 N., R. 16 W.) in which the pond is to be. That well produces from the Gallup Sandstone, which was reportedly reached at a depth of 480 feet; the well is cased through the Dilco sandstones and the upper part of the Gallup to a depth of 537 feet. Only if water from the

Dilco is entering the well by flowing downward between the casing and the hole could there be an opportunity for direct contamination.

Gallup Sandstone

At a depth of perhaps 180 feet below the tailings pond area occurs the first sandstone unit which may be part of the Gallup Sandstone aquifer (see Fig. 2). This sandstone underlies a section of approximately 110 feet of sandy and carbonaceous shales, very thin lenticular sandstones and coal which are below the "Dilco sands" and assigned to the Dilco Coal Member of the Crevasse Canyon Formation. The sandstones which comprise the Gallup Sandstone aquifer constitute a net thickness of about 210 feet in a total section of approximately 490 feet. The uppermost sand, about 35 feet thick, is probably correlative with the "stray" sandstone of some authors. It is referred to the Gallegos Member by geologists of United Nuclear Corporation. It is separated from the next major sandstone by a thickness of about 45 feet of sandy marine shale and interbedded thin sandstones. The second major sandstone, also about 45 feet thick, is considered the lower part of the Gallegos Member by United Nuclear Corporation geologists, and near the location at the millsite it rests directly on the "first Gallup Sandstone" which appears from electric logs to include about 85 feet of sandstone. The first Gallup rests upon approximately 130 feet of sandy marine shales and thin lenticular sandstones assigned to the Mancos Shale, which in turn rests upon the "second Gallup"

which is correlative with the "massive Gallup" that can be traced over a large area in the southern San Juan Basin. All of these sandstones are considered together as part of the "Gallup aquifer" because it is assumed that all are hydraulically connected, at least in some areas toward the southwest where the intervening marine shale tongues pinch out and the transgressive and regressive sands merge, and because in the logs of many wells drilled into the "Gallup" it is not possible to determine with assurance which particular sands are providing water to the well.

The upper sands described above are all variable in thickness, generally becoming thinner toward the northeast (i.e. depositionally seaward) direction. The two lowest beds (referred to as the first Gallup and second Gallup) are the most persistent but only the lower continues as a massive sandstone into the central part of the San Juan Basin. The upper sandstones of the "Gallup aquifer" are of irregular lithology and generally are composed of light-gray to buff, or pink, fine- to medium-grained sandstone sometimes with coarser-grained channel fillings. The upper units also contain a number of thin shale beds. The two lower sandstone beds are generally buff to light gray, fine-grained and silty, and the lowest (second Gallup) becomes gradually finer-grained towards the base merging with the rather thick transition zone which comprises the upper 100 feet or so of the underlying Mancos Shale.

Although drilling has indicated the Gallup is a good

aquifer throughout much of the area along the southern rim of the San Juan Basin, and the Gallup is the principle aquifer in a number of wells near Gallup including four supply wells at Window Rock Junction, the Gallup has not been extensively utilized as an aquifer in the area of the Churchrock Mine (see Table 1). Records show only two wells completed in the Gallup near the mine. These are well 17.16.32.112, about 3.5 miles north-northwest of the mine, and well 17.15.30.341 about 2.5 miles northeast of the mine in the valley of Pipeline Canyon. Neither of these wells penetrates more than a small part of the total thickness of the Gallup aquifer. Specific capacities of these two wells are 0.15 and 0.46 gpm per foot, respectively. Water quality is only fair, total dissolved solids being 1,390 and 2,450 ppm; water from both wells is high in sulphate (see Table 2).

It is not likely that any water from the tailings pond could enter the Gallup directly because of the thick section of relatively impermeable material between the Dilco sandstones and the first unit of the Gallup aquifer. There is a rather remote possibility of contamination entering the Gallup by way of the alluvium in Pipeline Canyon. If a significant amount of contaminated water were to enter the alluvium it would recharge the Gallup to some degree at the point where the alluvium crosses the subcrop of the Gallup in the canyon floor.

Any contaminated water which would enter the lowermost and most continuous of the Gallup aquifer sandstones

would do so at least one-half mile southwest of the proposed tailings pond at the point in the canyon where the outcrop of this sandstone crosses. Presumably water in the Gallup is under artesian conditions beneath the tailings pond and therefore there would be no recharge into the Gallup in that area.

Dakota Sandstone

The following discussion of the Dakota Sandstone follows the stratigraphic nomenclature of Marvin (1967). The top of the Dakota Sandstone is at a depth of about 1,160 feet below the tailings pond area (see Fig. 2). The Dakota is separated from the Gallup Sandstone by approximately 500 feet of Mancos Shale which is composed primarily of dark gray and greenish-gray shales with thin interbedded sandstones. The Mancos has very low relative permeability and for all practical purposes can be considered an aquiclude. The upper member of the Dakota Sandstone, termed the Two Wells Member, is approximately 61 feet thick and is composed of an upper massive sandstone unit approximately 47 feet thick, a lower fairly massive sandstone about 8 feet thick and an intermediate shale zone. The massive sandstone units are highly resistive and "clean" and can be assumed to contain water of relatively good quality. Below the Two Wells Member lies approximately 56 feet of shale, generally similar to the main body of the Mancos Shale lying above the Two Wells Member and referred to by Marvin as the Whitewater Arroyo Shale. The Whitewater Arroyo is a tongue of Mancos Shale which merges with the main body to the north-

eastward in the San Juan Basin. Like the main body of the Mancos Shale, the Whitewater Arroyo has very low permeability. Beneath it is an unnamed member of the Dakota approximately 66 feet thick which is made up of 6 ledges of clean, resistive sandstone separated by marine shale. The net thickness of resistive sandstone in this lower unit is approximately 38 feet.

Four wells in the vicinity of the Churchrock mine draw water from the Dakota. These are wells 16.15.17.141, well 16.15.20.121, well 16.16.1.112 and well 17.16.35.414. The last mentioned is the United Nuclear Corporation water well which probably is completed in both the Dakota and Westwater Canyon Sandstone Member of the Morrison Formation which lies below it. The first well mentioned is equipped with a windmill and pump jack and located about 1.5 miles north of Pinedale Trading Post and is used for domestic and stock water supplies. The second well mentioned is at the Pinedale Chapter House and is used primarily for domestic supplies. It is equipped with a submersible pump. The third well is about 1.5 miles east-southeast of the Churchrock mine and is equipped with a windmill and is used for domestic and stock water supplies.

Well 16.15.17.141 is open to only 10 feet of the aquifer and has a specific capacity of approximately 0.03 gpm/ft. Water quality is fair with a conductance of 160. Well 16.15.20.121 is open to approximately 85 feet of the Dakota Sandstone aquifer 55 feet of which is in the Two Wells Member

and approximately 35 feet of which is in the lower unnamed member of the Dakota. This well has a specific capacity of approximately 0.07 gpm/ft and water quality is somewhat poor with a conductance of 1,600. It may be that the poorer water quality is due to the fact that the well is completed in both the upper and lower zone. The "shaliness" of the lower zone probably contributes to the higher dissolved solids content. Well 16.16.1.112, a recompleted oil test, is open to only 7 feet of the aquifer, probably in the Two Wells Member, and it has a specific capacity of only 0.01 gpm/ft. Specific conductance of the water is 1,060. Though well 17.16.35.414, the United Nuclear Corporation water well, probably is drawing water from both the Dakota and the Westwater Canyon Member of the Morrison the similarity in quality between the water from the well and the water pumped from the mine indicates that most of the water being pumped from the well is being drawn from the Westwater Canyon Member.

The fact that water levels in all four of the wells mentioned above have declined in the past few years indicates that there is some hydraulic connection between the Dakota and the Westwater Canyon Member from which water is being pumped in the Churchrock mine. This phenomenon will be discussed at greater length in the consideration of the Westwater Canyon Member.

Except for stock water supplies near the southern rim of the San Juan Basin the Dakota Sandstone is not an important aquifer. There is virtually no possibility of contaminated

water entering the Dakota from the tailings pond and except for the lowering of piezometric surface with respect to water in the Dakota by pumping from the United Nuclear Churchrock mine and the Kerr-McGee mine there is little or no potential adverse affect on water supplies.

Westwater Canyon Sandstone Member

The Westwater Canyon Member of the Morrison Formation is probably the best aquifer beneath the tailings pond area (see Fig. 2). It lies at a depth of approximately 1,420 feet below the tailings pond and is separated from the base of the Dakota Sandstone by approximately 75 feet of green shales interbedded with sandstones assigned to the Brushy Basin Member of the Morrison Formation. It includes approximately 135 feet of what appears to be relatively "clean" resistive sandstone in a total thickness of approximately 280 feet. The sandstone is typically light gray to pale-yellowish brown with minor breaks of greenish-gray shale. The sandstone is generally poorly-sorted ranging from fine- to coarse-grained and often contain channel fillings, coarse-grained sand and conglomerate.

The coefficient of transmissivity for the Westwater Canyon Member generally falls in the range between 1,000 and 2,500 gpd/ft. for wells east of the Churchrock mine in the area of Crownpoint and Borrego Pass. Wells west of the Churchrock mine seem to indicate poorer transmissivity for the Westwater Canyon Member and in the City of Gallup Munoz-1A well there was very little difference between an

aquifer test of the entire well producing from the Westwater Canyon Member of the Dakota Sandstone, and the Gallup Sandstone and a test restricted to the Gallup Sandstone which indicated that neither the Westwater Canyon Member nor the Dakota contributed a significant amount of water to the well (Mercer and Cooper, 1970). To the north, toward the center of the San Juan Basin, the Morrison seems to have potential as an important aquifer, however. Strong water flows have been noted in uranium test drilling in a band from Coyote Canyon through Standing Rock and a point a few miles north of Crownpoint. An important well finished in the Westwater Canyon Member has recently been completed in T. 23 N., R. 14 W., and municipal water supplies are drawn from the Westwater Canyon at Crownpoint. The quality of water within the Westwater Canyon Member is typified by that pumped from the United Nuclear Corporation Churchrock mine (see Table 2). Quality is generally good with conductance less than 700 and total dissolved solids not much more than 400 ppm.

Because of the considerable thickness of relatively impermeable Mancos Shale which overlies the Dakota and the Westwater Canyon and because of heavy pumping from the Westwater Canyon there is little or no chance of contaminated water entering this aquifer because of activities at the Churchrock mine or mill; however, the pumping does produce an effect on the aquifer in the form of a decline of the piezometric surface.

Comparison of recent water level measurements with those taken before pumping from the United Nuclear mine began in 1968 (see Table 1), and examination of the water level data for the old Churchrock mine indicate that a very considerable cone of depression may be developing because of pumping in the United Nuclear and Kerr-McGee mines. The level in the old Churchrock mine, about 3.2 miles from the new mine, has dropped about 175 feet since pumping began, and the levels in four windmill wells tapping the Westwater Canyon also appear to have fallen. Well 16.16.15.432, about 2.6 miles from the new Churchrock mine, was measured in 1959 at which time the water level was 181 feet. In August 1974 the level was 257 feet. The latter measurement was made after the pump had operated a few strokes, but the storage tank was almost dry. Well 16.15.17.141 is about 4 miles from the new mine and was reported to be flowing about .25 gpm when finished in November 1957. Based upon the specific capacity reported when the well was bail tested at that time, the shut-in head should have been about 8 feet above land surface. A measurement in August 1974 indicated a level of 87 feet below land surface and there had been no pumping for at least 12 hours.

The new well drilled in 1968 (16.16.14.242) and pumped very little since being equipped with a pump jack rather than a windmill was measured in August 1974 and the water stood at 54 feet. That level seems somewhat higher than might be expected based on the two wells mentioned just previously

and it may be that the cone is developing irregularily or that pressure declines are considerably different in various zones of the Morrison and Dakota depending upon permeability.

Deeper Aquifers

Several stratigraphic units which yield water in other areas are present below the Westwater Canyon Member at the millsite (see Fig. 2); almost nothing is known of their water-bearing characteristics there, however. These units include, in descending order, the Bluff Sandstone, the Summerville Formation, the Todilto Limestone, and the Entrada Sandstone (all of Jurassic age), the Wingate Sandstone and several sandstone units in the Chinle Formation (of Triassic age), and the San Andres Limestone and Glorieta Sandstone of Permian age. None of these units are tapped near the millsite because adequate supplies have been available from shallower rocks.

Except for the San Andres-Glorieta system, none of the above-mentioned are considered good aquifers within many miles of the millsite. The possibility of any contaminant entering any of these units from the tailings pond is extremely remote because of the thickness of impermeable rocks intervening.

There is considerable likelihood that all of the Jurassic rocks mentioned above, and the Wingate Sandstone as well, are hydraulically connected to some degree with each other and with the Westwater Canyon Sandstone Member. Therefore it is probable that pumping from the United Nuclear and

Kerr-McGee mines will result in decrease of artesian pressure within these units. However, no water-users are likely to be affected.

SURFACE WATER

Characteristics of the Drainage System Near the Millsite

The millsite lies near Pipeline Canyon, which is tributary to the North Fork of the Rio Puerco in the drainage basin of the Little Colorado River (see Fig. 3). The North Fork of the Puerco drains some 281.3 square miles, of which 18.7 square miles comprise the drainage area of Pipeline Canyon above the millsite. All of the watercourses within the North Fork drainage are arroyos which are normally dry except for storm runoff, or carry only very small base flows in unconnected reaches. Except for storm flows the only significant surface flow is water pumped from the United Nuclear Churchrock mine and diverted into Pipeline Canyon and thence to the North Fork.

There are no surface water diversions or control structures below the millsite, and none above the millsite except for small impoundments for stock water and erosion control. Only one could exceed 10 acre-feet, and then only during a very wet period.

There are no downstream users of surface water for many miles, except in the sense that subflow in alluvium in the North Fork is tapped by several shallow wells. This water, technically groundwater, is derived from storm flows

passing down the arroyos, and is pumped for domestic and stock-watering use.

Flood Frequency and Duration, Pipeline Canyon

The peak discharge which might be expected in Pipeline Canyon is difficult to estimate except by comparison with similar drainages. In terms of "highest known discharge", regardless of record length or recurrence interval, recorded peaks can be plotted in terms of discharge per unit drainage area against drainage area. An "envelope curve" can then be drawn which defines the limit of peak discharges. Such a curve for the Puerco and its tributaries is shown as Figure 4. The curve is not well-defined, and does not take into account differences in the characteristics of the drainage basins. Used as an indication of the maximum flood, the curve would lead one to expect a discharge of perhaps 6,400 cfs (340 cfs/sq. mi.). Obviously, a larger number of stations and longer record periods would be required before the "envelope curve" could be considered even a moderately precise estimating tool. An "envelope curve" encompassing the highest known peaks for all stations in New Mexico in the Puerco, Zuni, San Francisco, and Gila drainages shows a peak of about 900 cfs/sq. mi. for an 18.7 sq. mi. drainage, or about 16,830 cfs. An estimated "average" or best fit curve yields a peak discharge near 220 cfs/sq. mi., or 4,120 cfs.

A commonly used "envelope curve" relation is $Q=2000\sqrt{A}$, which fits fairly well for streams in the Colorado drainage

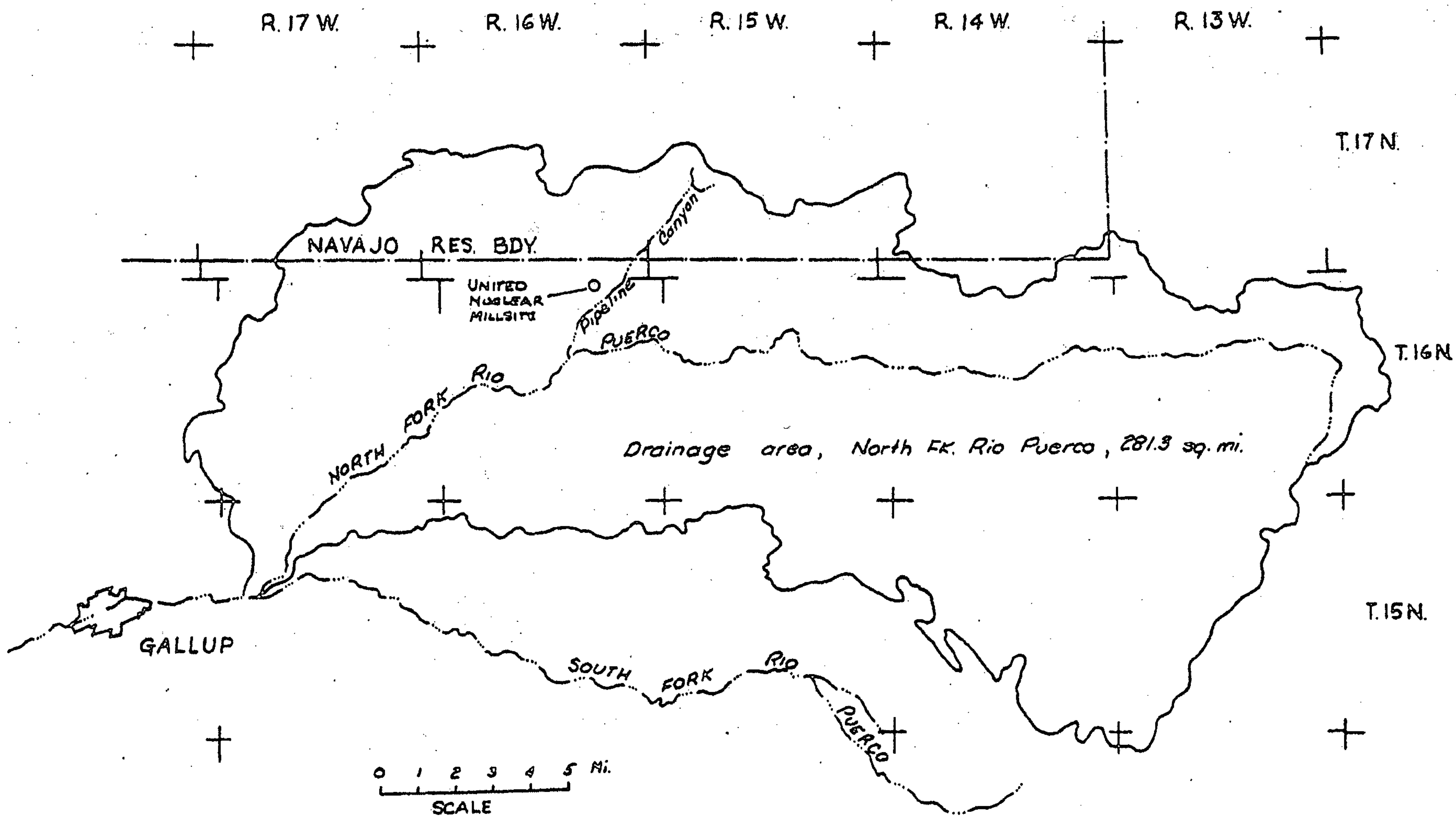


Figure 3. Drainage area of North Fork of Rio Puerco, McKinley County, N. Mex.

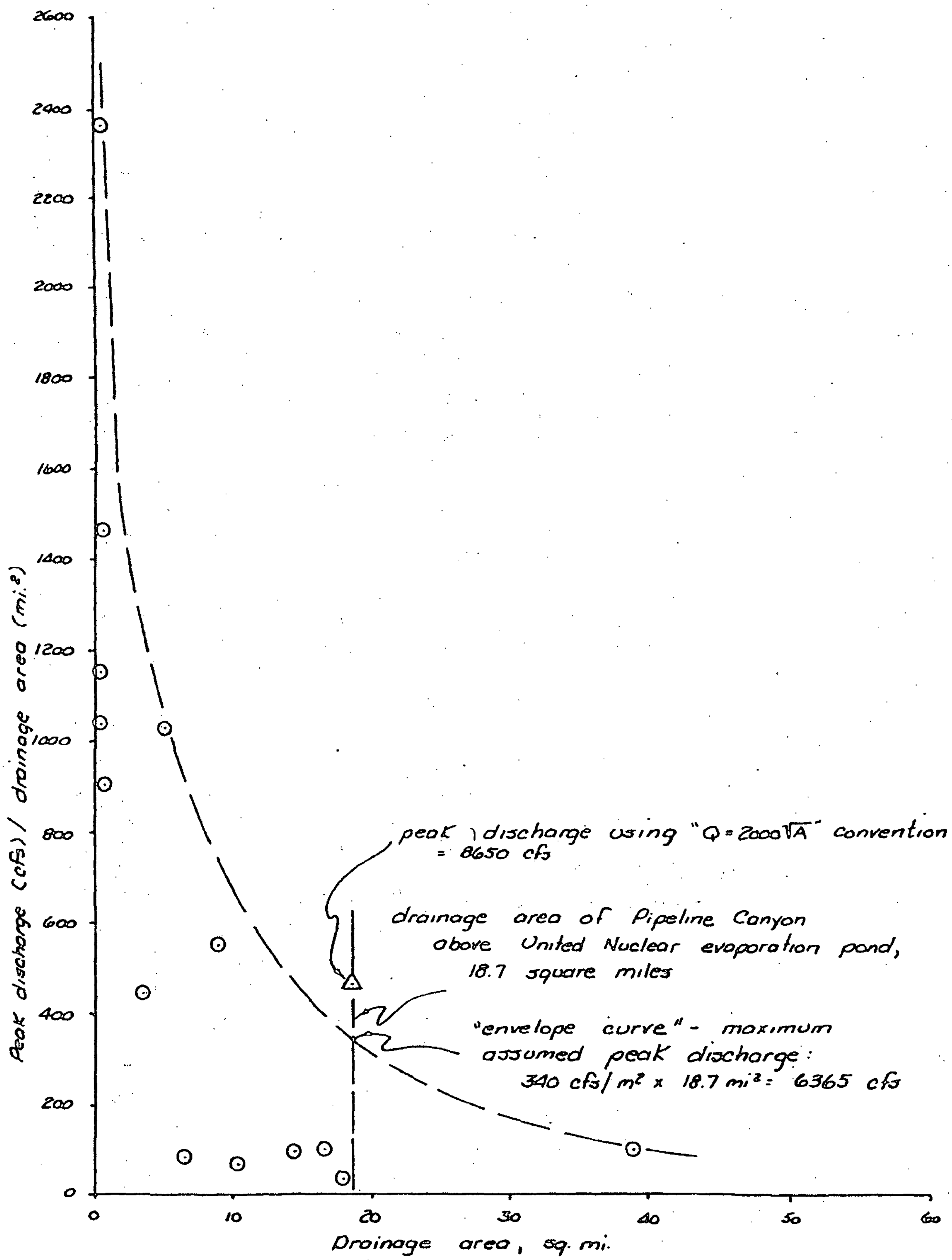


Figure 4. Comparison of peak discharge with drainage area for Rio Puerco and tributaries.

basin within New Mexico (Hale, Reiland, and Beverage, 1965). That relation yields a peak discharge of about 8,650 cfs for a stream draining 18.7 sq. mi.

A more refined approach is the regression analysis technique used by Scott (1971). In Scott's analysis, drainage area, slope, and mean minimum January temperature are empirically related to flood frequency and peak discharge. Application of that technique, and using a drainage area of 18.7 square miles, a channel slope of 44 feet per mile, and an interpolated temperature of 18.° F. yields the frequency curve shown in Figure 5. The "25-year flood" would peak at about 2,600 cfs, the "50-year" at 3,500.

All things considered, and giving some subjective weight to the rather low slope and the extraordinarily straight channel above the millsite, it would appear that the frequency curve (Fig. 5) may represent values somewhat below the truth.

A.E.C. Regulatory Guide 3.8, in part 2.6.2, refers to the "probable maximum flood (PMF), as defined by the Corps of Engineers", and indicates that the capability of facilities to pass or retain a PMF is to be considered in the environmental report. The writer understands the PMF to be the "500-year flood" for forecasting purposes.

In the absence of discharge data for Pipeline Canyon, and because of the great uncertainty involved in extrapolating the hypothetical frequency curve (Fig. 5), it might be best to use one of the "envelope curves" mentioned above to arrive at a guess as to the PMF. Some value in the range

between the 6,365 cfs arrived at in Figure 4 and the "$Q=2000\sqrt{A}$" result of 8,650 cfs might be near the mark.

SUGGESTED MONITOR-WELL PROGRAM

In order to help determine the rate of infiltration of water from the tailings pond into underlying materials, and to identify the chemical nature of such water after entering the underlying material, two groundwater monitoring wells are suggested. These are:

1) 1000' from north line, 600' from east line of section 2. Depth 120 feet. Perforated casing from 50 to 120 feet. The purpose of this well would be to monitor water which might enter the Dilco Formation sandstones and be moving down-dip in them.

2) 950' from south line, 350' from west line of section 2. Depth 150 feet, well into bedrock. The purpose of this well would be to monitor water which might enter the alluvial fill in Pipeline Canyon and subsequently enter the bedrock. It is recognized that much of such water may be intercepted by the deeply incised arroyo which borders the dam for nearly half its length, but it would be much better to measure both water quality and (possibly) the gradient of the phreatic surface in a well. Perforations should be from about 60 feet to total depth. It is anticipated that

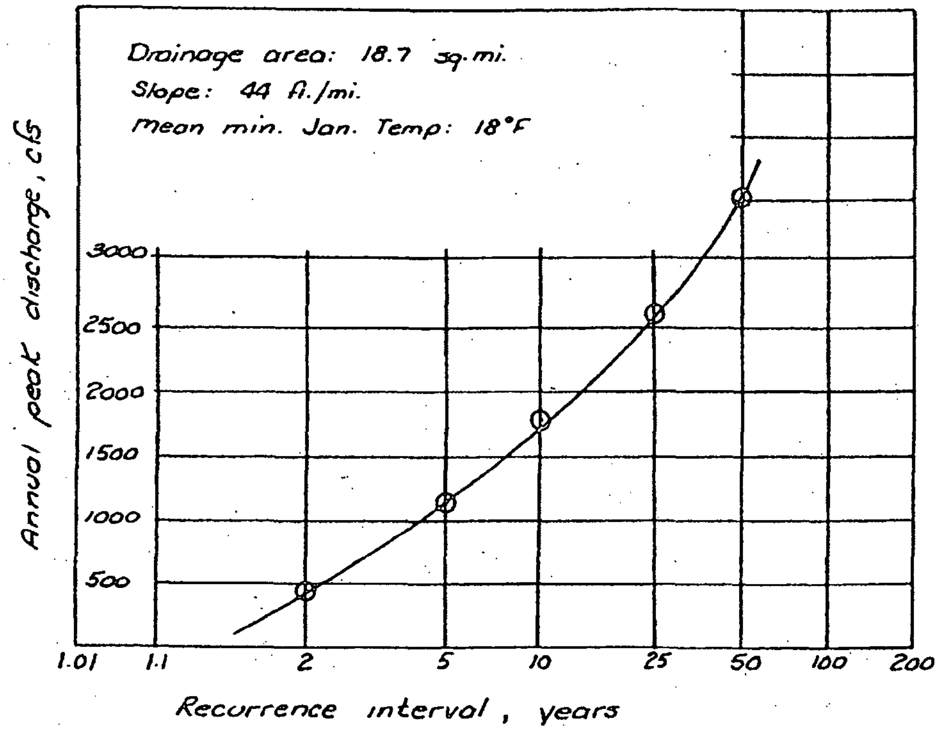


Figure 5. Projected frequency of annual peak discharge, Pipeline Canyon at United Nuclear millsite

some natural runoff will enter the well as bank storage dissipates after an exceptionally wet period, and that some perched water may be encountered. Thus an effort should be made to collect and analyze samples and measure the water level regularly so that the effects of the several influences can be interpreted.

It is intended that the monitor wells be rather close to the tailings pond so that the presence of water infiltering from the pond, if any, can be detected early. The position of the dam is assumed to be that shown on Kaiser Engineers drawing number CUM-SK-TD-3, revision R-O, dated August 12, 1974.

The constituents to be analyzed for should include those listed in the proposed New Mexico Water Quality Control Commission regulations for effluents which may enter groundwater.

Holes should be air-drilled, then allowed to stand 24 hours. Water level (if any water is present) should then be measured and water sampled by bailing. Hole should be filled with good-quality clear water and electric logs run to top, then rate of water level drop should be noted.

Each hole should be cased, preferably with a relatively inert material such as PVC. The casing should be perforated (1/8-inch holes would be satisfactory) as indi-

cated, and a makeshift cement basket placed just above the uppermost slots. The casing should then be cemented in from that point to surface to prevent surface infiltration from entering the well.

It would probably be wise to pour a substantial concrete collar around the well (see Fig. 6), with a stub of steel pipe cemented in around the PVC casing and provided with a lockable, raintight cover. This arrangement provides some protection from possible flood waters, and from vandalism.

John W. Shomaker
Consulting Geologist

JWS/nc

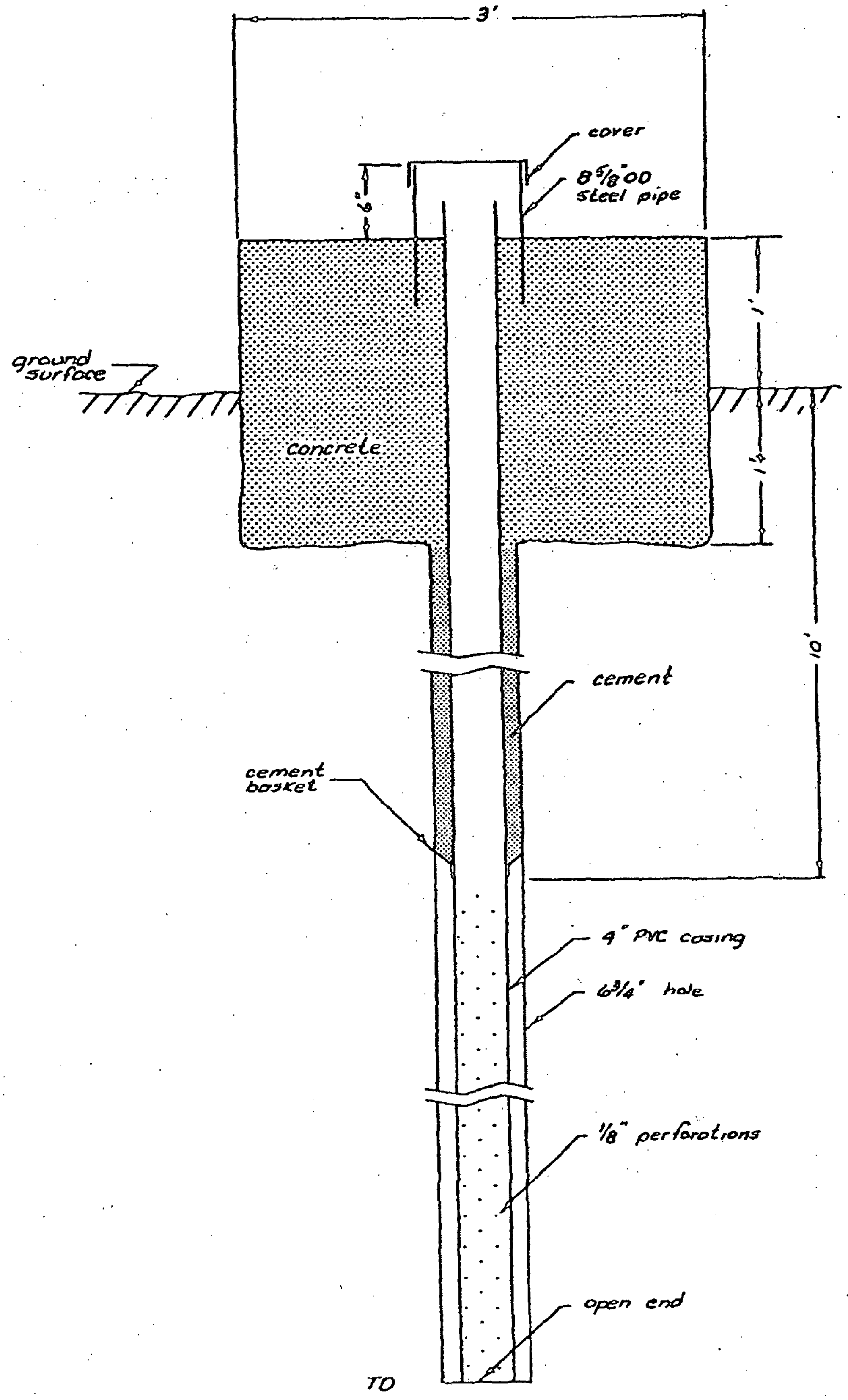


Figure 6. Suggested design for ground water monitoring wells.

REFERENCES CITED

Cooley and Others, 1969, Regional hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah, with a section on vegetation by O. N. Hicks: U.S. Geol. Survey Prof. Paper 521-A, 61 p., 5 pls.

Davis and Others, 1963, Records of ground-water supplies, pt. 1 of Geohydrologic data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: Arizona Land Dept. Water Resources Rept. 12-A, 159 p.

Hale, W. E.; Reiland, L. J.; and Beverage, J. P., 1965, Characteristics of the water supply in New Mexico: N.M. State Engineer, Tech. Rept. 31, 131 p.

Kister, L. R., and Hatchett, J. L., 1963, Selected chemical analyses of the ground water, pt. 2 of Geohydrologic data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: Arizona Land Dept. Water Resources Rept. 12-B, 58 p.

Marvin, R. G., 1967, Dakota Sandstone-Tres Hermanos relationship, southern San Juan Basin area: New Mexico Geol. Soc. 18th Field Conf. Guidebook, p. 170-172.

McGavock and Others, 1966, Supplemental records of ground-water supplies, pt. 1-A of Geohydrologic data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: Arizona Land Dept. Water Resources Rept. 12-E, 55 p.

Mercer, J. W., and Cooper, J. B., 1970, Availability of ground water in the Gallup-Tohatchi area, McKinley County, New Mexico: U.S. Geol. Survey open-file report (Albuquerque, N.M.), 182 p.

Scott, A. G., 1971, Preliminary flood-frequency relations and summary of maximum discharges in New Mexico: U.S. Geol. Survey open file report, 76 p.

Shomaker, J. W., 1971, Water resources of Fort Wingate Army Depot and adjacent areas, McKinley County, New Mexico: U.S. Geol. Survey open-file report (Albuquerque, N.M.), 230 p.

APPENDIX C

ECOLOGY OF THE UNC NE CHURCH ROCK NEW MEXICO PROPERTY

WALTER L. GOULD

1812 Imperial Ridge
Las Cruces, New Mexico 88001
September 13, 1974

Mr. R. D. Born
United Nuclear Industries, Inc.
1201 Jadwin Avenue
Richland, Washington 99352

Dear Mr. Born:

Enclosed please find a report on the plants and animals observed or showing sign on your Church Rock property in McKinley County, New Mexico. We did not make any statements concerning potential hazards of the water in the tailings disposal or evaporation ponds to migratory or resident animals because we feel you have consultants, or personnel, who are more informed on these problems than we are. We realize that the problem of a toxic level of molybdenum, mercury, lead or other ions in the water could develop, but we are not in a position to hypothesize on this.

The map in Figure 1 was drawn directly from the aerial photo mosaic you sent. You could probably develop a map of better scale by using the original photos that show detail more clearly.

I was assisted in the surveys, analyses and write-up by Dr. V. W. Howard, Associate Professor of Wildlife Science and Dr. Reldon Beck, Assistant Professor of Range Science. We can furnish vitae if you need them.

If you have any questions, please let me know.

Sincerely,

Walter L. Gould

W. L. Gould

ECOLOGY OF THE UNITED NUCLEAR CORPORATION'S

NE CHURCH ROCK, NEW MEXICO, PROPERTY

INTRODUCTION

This report pertains to the United Nuclear Corporation's North East Church Rock property located in Section 2, T16N R16W in McKinley County, New Mexico. The report presents an inventory of the present status of wildlife and vegetation present in the area. The occurrence and importance of any species in the report may change in the future as vegetation and animal populations are dynamic, and subject to change with changing environmental conditions. Only the current status of the floral and faunal populations found within the area has been included. The report does not intend to exclude the possibility of the occurrence of other species of plants or animals.

SOILS

Two major soil associations are found in the area. The Rock Land-Travessilla association is found on about two-thirds of the area, and the Lohmiller-San Mateo association makes up the remainder (Maker, et al. 1974). Characteristic features of the Rock Land-Travessilla association are the steep canyon walls and escarpments and the gentle to strongly sloping fans and valley floors below the canyon walls and escarpments. Outcrops of sandstone bedrock are found in the northwestern and southern part of the area. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges. The soils are generally shallow but small, isolated pockets of moderately deep to deep soils occur on the escarpments

where areas with a lesser slope have formed. The thin surface layer of soil is light brownish-gray or light brown, slightly calcareous fine sandy loam or stony, fine sandy loam. Subsoils vary from sandstone to clay. Pinyon, juniper and sagebrush are the prominent vegetation on this association.

The Lohmiller-San Mateo association makes up the central portion of the area and includes the alluvial valley and flood plains which are oriented in a northeast-southwesterly direction. The Lohmiller-like soils are deep and fine textured and occupy the level to very gently sloping flood plains and swales. San Mateo soils occur on gently sloping plains adjacent to intermittent drainages. The surface soils of this association are calcarceous loam or clay loam underlain to a depth of five feet or more by stratified loams, fine sandy loams and clay loams. The soils in this association are highly susceptible to erosion, and deep, vertically-walled gullies occur in the valley bottom. An erosion control dam built in about the middle of Section 2 has caused the gullies above the dam to fill with silt, but below the dam there is a deep erosion channel. Except in the intermittently flooded area above the dam, the area supports a fair to good stand of native grass and shrubs, including such species as blue grama, western wheatgrass, alkali sacaton, fourwing saltbush, rabbitbrush, snakeweed, and various annuals.

CURRENT STATUS OF WILDLIFE

An inventory of wildlife species, or signs of wildlife, was made on the site during August 23-26, 1974. This inventory does not assume to be a complete survey, nor does it assume that the fauna will remain static as wildlife populations are subject to many changing environmental conditions.

TRAPPING OF SMALL MAMMALS

Results of two nights of trapping for small mammals are presented in Table 1. Only the deer mouse appears to be present in fairly large numbers. All rodents were trapped in the flood plain and adjacent sagebrush, except the pinyon mice. This species was trapped only in the pinyon-juniper type.

OTHER WILDLIFE

The most important wildlife species in the area is the mule deer. Signs of these animals were observed in the pinyon-juniper type along the south and east side of the area. Some tracks were observed along the flood-control dam near the center of the area. The animals apparently were going to the arroyo for water.

Mourning doves were using the flood plain to feed and consume gravel. There was not a larger number of these birds present in the area. The availability of other gravel sources in the immediate locality should be adequate for the mourning dove population.

None of the rare or endangered avian predators were observed in the area. However, there could be periodic use along the steep bluffs by both bald and golden eagles. Since these areas probably will not be altered by the proposed development, there should be a minimal disturbance to these birds should they begin using the area.

None of the remaining species seen in the area are restricted to the habitat types of the area. Therefore, the proposed development should have little effect on the populations of these species outside the disturbed areas. A listing of animals or sign observed is presented in Appendix I.

Table 1. Results of rodent trapping effort on the United Nuclear Corporation NE Church Rock property.

Species	Night 1 (70 traps)	Night 2 (75 traps)	Total	Estimated density per section
Deer Mouse	19	10	29	728
Pinyon Mouse	1	0	1	26
Western Harvestmouse	1	0	1	26
Little Pocketmouse	2	0	2	52

VEGETATIONAL AND RANGE ANALYSIS

This report is based on field vegetation sampling conducted on the area on August 24-25, 1974.

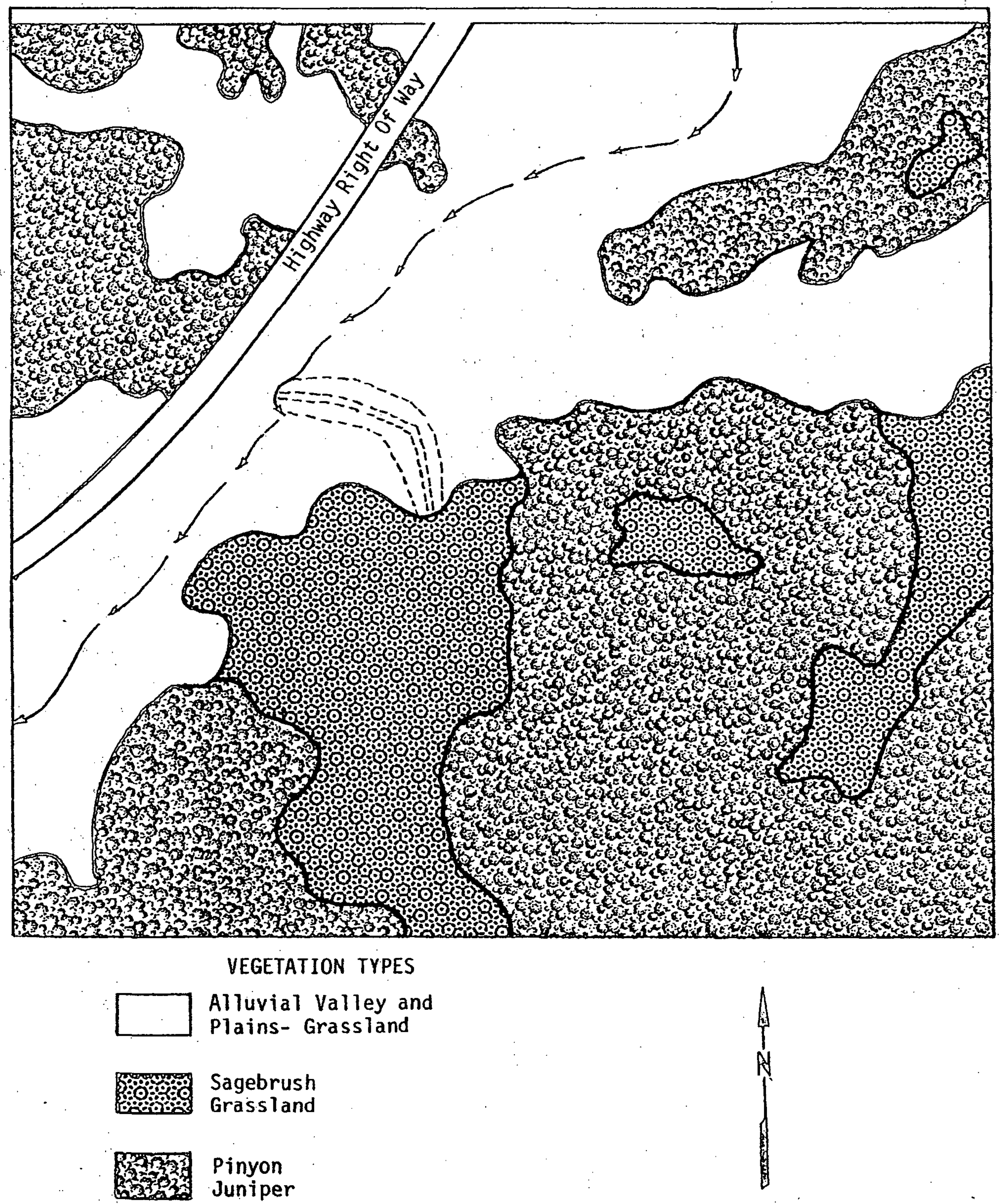
METHODS

Sampling locations were selected to give adequate coverage of the area and at the same time measure a representative cross section of the plant species growing on the area. The area was separated into three major vegetation types by general aspect: (1) alluvial valley and plains, (2) sagebrush-grass, and (3) pinyon-juniper. A total of 24 sampling locations were sampled in the area with ten located in the alluvial valley and plains, five in the sagebrush-grassland type and nine in the pinyon-juniper. A map showing vegetational types is shown in Figure 1.

The vegetation was sampled using line-point sampling (Heady, Gibbens and Powell, 1959, and Owensby, 1973) for aerial cover and botanical

FIGURE 1.

MAP SHOWING VEGETATION TYPES ON THE UNITED NUCLEAR CORPORATION N. E. CHURCH ROCK PROPERTY IN McKINLEY COUNTY, NEW MEXICO, AUGUST 1974



composition. At each sampling location a 100-foot steel tape was stretched between two points in a random direction. Readings were made at each foot mark along the tape. When a plant part occurred vertically above a "foot-mark" on the tape, the individual plant species was recorded as a "hit". If no plant part was within the vertical projection above a "footmark", then the plant species nearest to the point was recorded, but not as a "hit". A total of 2400 points were recorded in all three vegetation types. Only perennial vegetation was recorded; annual plants were recorded for species lists only. Percent cover was calculated by dividing the number of "hits" by the total number of points for each transect. Percent composition was calculated by dividing the total number of "hits" and "misses" by 100 for each species on each transect.

A grazing capacity estimate for livestock was made using the range survey technique (Pickford, 1940 and Collier, et al., 1937). For this area a forage acre requirement of 6.25 per animal-unit-year was used as derived by Gould, Howard and Valentine (1972). Proper use factors were taken from lists prepared by the New Mexico Interagency Range Committee in 1937 (Appendix II).

VEGETATION RESULTS

Alluvial valley and plains: Vegetation on the alluvial valley and plains area is dominated by grasses (Table 2). Blue grama (*Bouteloua gracilis*) and sand dropseed (*Sporobolus cryptandrus*) are nearly equal in dominance on the site, with western wheatgrass (*Agropyron smithii*) being

Table 2. Summary of plant composition and aerial cover of perennial vegetation for alluvial valley and plains, sagebrush grassland and pinyon-juniper vegetation types.

	Vegetation Types					
	Alluvial valley and plains		Sagebrush-grassland		Pinyon-juniper	
	% comp.	% cover	% comp.	% cover	% comp.	% cover
Understory						
Grass	82.3	17.1	50.2	9.6	39.0	4.2
Forbs	0.0	0.0	3.6	0.0	35.6	0.0
Shrubs	16.7	3.7	46.2	17.0	24.5	3.9
Total*	99.0	20.8	100.0	26.6	99.1	8.1
Overstory						
Oneseed juniper	---		---			3.9
Pinyon pine	---			1.2		11.5
Total				1.2		15.4

*May not add to 100 due to rounding.

Table 3. Plant composition and aerial cover on alluvial valley and plains, sagebrush-grassland and pinyon-juniper sites.

Common Names	Alluvial valley and plains		Sagebrush-grassland		Pinyon-juniper	
	% comp.	% cover	% comp.	% cover	% comp.	% cover
GRASSES						
Blue grama	35.5	9.9	31.4	8.2	20.8	2.8
Bottlebrush squirreltail	0.1		0.4		0.1	
Bristlegrass	X*					
False buffalograss	1.8	0.5				
Fescue			0.4		0.4	
Foxtail barley	X					
Galleta	0.1		0.8		10.1	1.2
Indian ricegrass	0.4		4.6		6.0	0.1
Inland saltgrass	0.7	0.5				
Muhly						0.1
Needle and thread			X			
Red muhly	X					
Sand dropseed	37.8	5.7	2.8	0.4	1.5	0.1
Sixweeks grama	X					
Subalpine needlegrass			X			
Western wheatgrass	5.9	0.5	9.8	1.0	X	
Total grasses	82.3	17.1	50.2	9.6	39.0	4.2
FORBS						
Aster					0.8	
Aster, babywhite			3.6		10.0	
Annual bursage	X					
Bladderpod			X			
Cholla					X	
Common dandelion	X					
Common ragweed	X					
Deer's tongue					2.5	
Desert baileya	X					
Eaton penstemon			X			
Fireweed summer cypress	X					
Fleabane	X					
Fleabane horseweed	X					
Four-o'clock					0.1	
Gianthyssop			X			
Gilia					4.5	
Globemallow	X					

Table 3 (cont'd.)

	Alluvial valley and plains		Sagebrush-grassland		Pinyon-juniper	
	% comp.	% cover	% comp.	% cover	% comp.	% cover
FORBS (cont'd.)						
Globemallow, scarlet					X	
Gumweed	X					
Hedgehog cactus					X	
King lupine					X	
Lambsquarter	X					
Lemonweed	X					
Mammillaria	X					
Mentzelia					0.4	
Milkvetch, groundcover			X			
Milkvetch, Rusby					0.9	
Pingue			X		10.6	
Prickly pear	X		X			
Purslane	X		X			
Redroot pigweed	X					
Rocky mountain beeplant	X		X			
Russian thistle	X		X			
Salsify					X	
Sand verbena	X					
Silverleaf nightshade	X					
Thistle	X					
White margin spurge					X	
White prairie clover			X		X	
Wholeleaf Indian paintbrush			X		X	
Wild buckwheat						
Wild buckwheat, James			X		3.1	
Wild lettuce	X				X	
Wild potato			X			
Wright deervetch					X	
Yucca, datil					X	
Yucca, soaptree					0.3	
Total forbs			3.6		35.6	
SHRUBS						
Big sagebrush	0.8	0.1	28.8	13.6	4.7	1.9
Black sagebrush			X		X	
Broom snakeweed	13.8	2.5	16.2	3.0	12.7	1.4
Condalia	X				X	
Fourwing saltbush	0.2	0.2	0.2	0.2		

Table 3 (cont'd.)

	Alluvial valley and plains		Sagebrush-grassland		Pinyon-juniper	
	% comp.	% cover	% comp.	% cover	% comp.	% cover
SHRUBS (cont'd.)						
Fringed sagewort	X		0.6		6.3	0.4
Gambel oak					X	
Gray horsebrush			X		X	
Mexican cliffrose					0.2	
Mountain mahogany					0.1	
Rubber rabbitbrush	1.6	0.9	0.2	0.2	0.2	0.1
Threadleaf groundsel			X			
Whitethorn acacia					X	
Wild buckwheat			X			
Winterfat	0.3		0.2		X	
Wright sagewort					0.3	0.1
Total shrubs	16.7	3.7	46.2	17.0	24.5	3.9
TREES						
Oneseed juniper			X			3.9
Pinyon pine				1.2		11.5
Ponderosa pine	X				X	
Total trees				1.2		15.4

*An "X" means the species was found growing in the vegetational site, but was not recorded on any transect. Generally these species are not common.

relatively low, but varies from areas void of plants (recently flooded areas) to areas having nearly 100% cover, an example being an area covered by red muhly (*Muhlenbergia repens*). Annual forbs are common in this type with Russian thistle (*Salsola kali*) being the most abundant. In some parts of the plain site broom snakeweed (*Gutierrezia sarothrae*) dominates the general aspect while rubber rabbitbrush (*Chrysothamnus naueosus*) is common.

Sagebrush-grassland: Over one-half of the plant composition in this type is grass, with an aerial cover of less than 10% (Table 2). Shrubs dominate the vegetative aspect and have 17% aerial cover. Many shrub species grow on the area, but big sagebrush (*Artemisia tridentata*) is the most abundant. Broom snakeweed is often found associated with big sagebrush. Blue grama is commonly found on the area with western wheatgrass being important in some areas. Trees are relatively uncommon on the area, however there is some invasion of pinyon pine (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*) into the sagebrush-grassland on the upper slopes.

Pinyon-juniper: Of the three vegetation types found in the study area, this vegetation type had the least understory cover (Table 2). The trees which dominate the aspect have over 15% aerial cover. Ground cover varies from sparse to fairly dense cover where broom snakeweed and sages are common. However, in some parts there is only bare ground and rocks under the trees. The grasses, the most common understory plants, are dominated by blue grama and galleta (*Hilaria jamesii*) over much of the area, with Indian ricegrass (*Oryzopsis hymenoides*) being common in part of the area.

Forbs comprise over one-third of the composition, but contribute very little to the aerial cover. Pingue (*Hymenoxys richardsoni*) and babywhite aster (*Aster leucelene*) both contribute over 10% to the total understory composition, while gilia (*Gilia* sp.) and James wild buckwheat (*Eriogonum jamesii*) are commonly found in parts of the pinyon-juniper vegetation.

A listing of all species found is presented in Appendix III.

VEGETATIVE PRODUCTIVITY

An estimate of grazing capacity for the three vegetation types is presented in Table 4. Excluding the highway right-of-way, the estimated grazing capacity is 4.5 animal unit years (AUY) for the area. An AUY is the forage requirement of a 1000-pound cow with calf for a year. This is low carrying capacity for this rainfall regime, but is due to the low vegetative productivity, caused by excessive livestock use in the past.

Except for the areas where vegetation will be destroyed by the location of the mill and the evaporation and settling ponds, the productivity and density of vegetation should increase with the exclusion of livestock. This should have favorable effects as increased vegetative cover will stabilize the soil and improve the habitat for many wildlife species.

Table 4. Grazing capacity and acreages of the alluvial valley and plains, sagebrush-grassland and pinyon-juniper types on the United Nuclear Corp. NE Church Rock property.

Type	Acres	Forage Acre Factor	Forage Acres	Animal unit years
Alluvial valley and plains	208	.0639	13.29	2.1
Sagebrush-grassland	135	.0665	8.98	1.4
Pinyon-juniper	277	.0225	6.23	1.0
Total	620*		28.50	4.5

*The highway right-of-way is not included in the above and is approximately 20 acres.

LITERATURE CITED

Collier, John, F. R. Carpenter, L. C. Gray, H. H. Bennett, and F. A. Silcox. 1937. Instructions for range surveys. Interagency Range Survey Committee. West Range Survey Conf. Mimeo.

Gould, W. L., V. W. Howard and K. A. Valentine. 1972. Soil characteristics, biotic composition, and vegetative production of areas leased by Western Coal Company for strip mining near Fruitland, New Mexico. New Mex. State Univ. Agr. Expt. Sta. Spec. Rep. No. 20.

Heady, H. F., R. P. Gibbens and R. W. Powell. 1959. A comparison of the charting, line intercept and line point methods of sampling shrub types of vegetation. J. Range Manage. 12:180-189.

Maker, H. J., H. E. Bullock and J. U. Anderson. 1974. Soil associations and land classification for irrigation, McKinley County. New Mex. Agric. Exper. Sta. Res. Prog. Rept. 262.

Owensby, C. E. 1973. Modified step-point system for botanical composition and basal cover estimates. J. Range Manage. 26:302-303.

Pickford, G. D. 1940. Range survey methods in western United States. Herb Rev. 8:1-12.

APPENDIX I

LIST OF FAUNA AND SIGN OBSERVED ON OR NEAR THE UNITED NUCLEAR CORPORATION'S NE CHURCH ROCK PROPERTY

MAMMALS

Black-tailed jackrabbit	*Lepus californicus*	2
Desert cottontail	*Sylvilagus auduboni*	3
Cliff chipmunk	*Eutamias dorsalis*	3
Deer mouse	*Peromyscus maniculatus*	29
Pinyon mouse	*Peromyscus truei*	1
Western harvest mouse	*Reithrodontomys megalotis*	1
Little pocketmouse	*Perognathus longimembris*	2

BIRDS

Red-tailed hawk	*Buteo jamaicensis*	1
Common raven	*Corvus corvax*	6
Sparrow hawk	*Falco sparverius*	2
Mourning dove	*Zenaidura macroura*	18
Pinyon jay	*Gymnorhinus cyanocephala*	numerous
Brewer's blackbird	*Euphagus cyanocephalus*	11
Red-shafted flicker	*Colaptes cafer*	1
Western kingbird	*Tyrannus verticulis*	7
Western bluebird	*Sialia mexicana*	11
Cliff swallow	*Petrochelidon pyrrhonota*	5
Chipping sparrow	*Spizella passerina*	8
Rock wren	*Salpinctes obsoletus*	5

REPTILES

Prairie lizard	*Sceloporus undulatus consobrinus*	1

SIGN NOTED

Mule deer	*Odocoileus hemionus*	6 sets tracks
Coyote	*Canis latranis*	1 set tracks
Porcupine	*Erethizon dorsatum*	numerous
Badger	*Taxidea taxus*	4 burrows
Woodrat	*Neotoma* sp.	3 dens

APPENDIX II

PROPER USE FACTORS FOR IMPORTANT FORAGE SPECIES ON UNITED NUCLEAR CORPORATION'S NE CHURCH ROCK PROPERTY

Species	Percent Proper Use*
Big sagebrush	20
Blue grama	40
Bladder pod	40
Bottlebrush squirreltail	30
Deer's tongue	50
Fescue	40
Fourwing saltbush	40
Fringed sagewort	30
Galleta	40
Indian ricegrass	40
Inland saltgrass	30
James wild buckwheat	10
Mexican cliffrose	20
Mountain mahogany	20
Sand dropseed	20
Western wheatgrass	40
Winterfat	30

Derived from the New Mexico Interagency Range Committee lists of 1938.

APPENDIX III

SPECIES LIST OF PLANTS FOUND ON UNITED NUCLEAR CORPORATION'S NE CHURCH ROCK PROPERTY

Scientific name	Common name*
Grasses	
Agropyron smithii	Western wheatgrass
Bouteloua barbata	Sixweeks grama
Bouteloua gracilis	Blue grama
Distichlis stricta	Inland saltgrass
Festuca sp.	Fescue
Hilaria jamesii	Galleta
Hordeim jubatum	Foxtail barley
Muhlenbergia repens	Red muhly
Muhlenbergia sp.	Muhly
Munroa squarrosa	False buffalograss
Oryzopsis hymenoides	Indian ricegrass
Setaria sp.	Bristlegrass
Sitanion hystrix	Bottlebrush squirreltail
Sporobolus cryptandrus	Sand dropseed
Stipa columbiana	Subalpine needlegrass
Stipa comata	Needle and thread
Forbs	
Abronia pumila	Sandverbena
Agastache sp.	Gianthyssop
Amaranthus retroflexus	Redroot pigweed
Ambrosia artemisiifolia	Common ragweed
Aster leucelene	Babywhite aster
Aster sp.	Aster
Astragalus humistratus	Groundcover milkvetch
Astragalus rusbyi	Rusby milkvetch
Baileya multiradiata	Desert baileya
Castelleja integra	Wholeleaf Indianpaintbrush
Chenopodium album	Lambsquarter
Cleome serrulata	Rocky mountain beeplant
Cirsium sp.	Thistle
Cryptantha crassisepala	Deer's tongue
Echino cactus	Hedgehog cactus
Erigeron canadensis	Horseweed Fleabane
Erigeron sp.	Fleabane
Erigonum jamesii	James wild buckwheat
Eriogonum sp.	Wild buckwheat
Euphorbia albomarginata	Whitemargin spurge

APPENDIX III

(cont'd.)

Scientific name	Common name
Franseria acanthicarpa	Annual bursage
Gilia sp.	Gilia
Grindelia aphanactis	Gumweed
Hymenoxys richardsoni	Pingue
Kochia scoparia	Fireweed summercypress
Lactuca sp.	Wild lettuce
Lesquerella sp.	Bladderpod
Lotus wrightii	Wright deervetch
Lupins kingii	King lupine
Mammillaria sp.	Mammillaria
Mentzelia sp.	Mentzelia
Mirablis sp.	Four-o'clock
Opuntia sp.	Cholla
Opuntia sp.	Prickly pear
Pectis papposa	Lemonweed
Penstemon eatoni	Eaton penstemon
Petalostemon candidum	White prarieclover
Portulaca olereca	Purslane
Salsola kali	Russian thistle
Solanium eleagnifolium	Silverleaf nightshade
Solanum jamesii	Wild potato
Sphaeralcea coccinea	Scarlet globemallow
Sphaeralcea sp.	Globemallow
Taraxacium officinale	Common dandelion
Tragapogon sp.	Salsify
Yucca baccata	Datil yucca
Yucca elata	Soaptree yucca
Shrubs	
Acacia constricta	Whitethorn acacia
Artemisia frigida	Fringed sagewort
Artemisia nova	Black sagebrush
Artemisia tridentata	Big sagebrush
Artemisia wrightii	Wright sagewort
Atriplex canescens	Fourwing saltbush
Cercocarpus montanus	Mountain mahogany
Chrysothamnus nauseosus	Rubber rabbitbrush
Condalia sp.	Condalia
Cowania mexicana	Mexican cliffrose

APPENDIX III

(cont'd.)

Scientific name	Common name
Eriogonum sp.	Wild buckwheat
Eurotia lanata	Winterfat
Gutierrezia sarathrae	Broom snakeweed
Quercus gambelii	Gambel oak
Senecio longilobus	Threadleaf groundsel
Tetradymia canescens	Gray horsebrush
Trees	
Juniperus monosperma	Oneseed juniper
Pinus edulis	Pinyon pine
Pinus ponderosa	Ponderosa pine

*Common names are mostly taken from A. A. Beetle, 1970. Recommended plant names. Res. J. 31. Agric. Exp. Sta. Univ. of Wyoming.

APPENDIX D

PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

ROBERT D. BOOTH

SERGENT, HAUSKINS & BECKWITH CONSULTING SOIL AND FOUNDATION ENGINEERS
APPLIED SOIL MECHANICS o ENGINEERING GEOLOGY o MATERIALS ENGINEERING

B. DWAINE SERGENT, P.E. | JOHN B. HAUSKINS, P.E. | GEORGE H. BECKWITH, P.E.
DALE V. BEDENKOP, P.E. | ROBERT D. BOOTH, P.E. | BRUCE J. LEISER, P.E.
JOHN J. MORAN, P.E. | DONALD C. METZGER, GEOL. | BUD WOODWARD

October 18, 1974

Kaiser Engineers
Kaiser Center
300 Lakeside Drive
Oakland, California 94604

Job No. E74-1072

Attention: Mr. Paul E. Stucker

Re: Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico

Gentlemen,

Our Preliminary Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes results of test drilling and laboratory analysis, along with our discussion and conclusions. The investigation was planned in collaboration with staff members of Kaiser Engineers and United Nuclear Corporation. Results of the test drilling were presented in rough form as data became available. Due to shipment delays, triaxial shear testing was not complete until October 11, 1974.

Should any questions arise concerning this report, we would be pleased to discuss them with you.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By [signature]
Robert D. Booth, P.E.

Reviewed by [signature]
George H. Beckwith, P.E.

REGISTERED PROFESSIONAL ENGINEER
GEORGE H. BECKWITH
4506
NEW MEXICO

Copies: Addressee (5)

REPLY TO: 2501 CANDELARIA ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87107

PHOENIX (602) 272-6848 | FLAGSTAFF (602) 774-4433 | EL PASO (915) 591-8188 | ALBUQUERQUE (505) 344-9940

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Job No. E74-1072

Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

INTRODUCTION

This report is submitted pursuant to a preliminary geotechnical investigation made by this firm of the proposed Tailings Dam for the Church Rock Uranium Mill located in Section 2, Township 16N, Range 16W north of Church Rock, New Mexico. The object of this investigation was to provide geotechnical data for design of the Tailings Dam. Included in the report are the results of subsurface exploration, field and laboratory tests, geologic cross-sections and our discussion and recommendations.

PROPOSED CONSTRUCTION

Preliminary details of the project were provided to us by the staff of Kaiser Engineers. It is understood that the starter dike will have a crest elevation of 6980 with a maximum height of approximately 50 feet. Total length of the starter dike will be approximately 5,300 feet. The ultimate crest elevation of the dam will be 7035 with a maximum height of approximately 105 feet and a length of approximately 8,000 feet.

INVESTIGATION

Field Investigation

Forty-two exploratory borings were drilled to depths varying between 8 and 81 feet below existing grade. Twenty of the borings were drilled using 6 5/8" O.D., 3¼" I.D., hollow stem auger with special carbide insert teeth in the drill bit. Standard

penetration testing and 3" O.D., 2.42" I.D., open-end drive sampling were performed at 5 foot intervals in these borings. The remaining borings were drilled with 4½" diameter continuous flight auger with a Colemaster bit and special carbide insert teeth.

The field investigation was supervised by staff engineers Gene Baker and Robert Crossley, of this firm, who continuously examined recovery and prepared the field boring logs. The results of the test drilling are presented in Appendix A which includes a brief description of test drilling equipment and procedures, a site plan showing boring locations and the logs of the test borings.

Field permeability tests were performed at three of the boring locations by the Bureau of Reclamation E-19 test procedure. The results of these tests are presented in Appendix B. In addition, three shallow seismic lines were investigated to aid in determining the depth of alluvium present in areas inaccessible with the drilling rig. This data is presented in Appendix B..

Laboratory Analysis

Moisture content determinations were made on selected tube samples recovered in standard penetration testing while dry densities were determined for the 2.42 inch diameter open-end drive samples. The results of these tests are shown on the boring logs.

Grain-size analysis and Atterberg Limits tests were performed on selected samples to aid in soil classification. Consolidation and direct shear tests were performed on selected drive samples obtained and also on two block samples obtained from the banks of the drainage located to the southwest of the property. Triaxial shear and permeability tests on samples of the tailings processed to simulate the cycloned material for the shell also were performed.

SITE CONDITIONS & SOIL PROFILE

The site is located in a tributary drainage to the Rio Puerco River to the south. The drainage runs generally from northeast to southwest of the site with a relatively broad floodplain on either side. Relatively steep sided slopes are present on each side of the floodplain extending upward in a northwest and southeast direction.

Gallup sandstone is the predominant geologic unit underlying the site which is intertongued to a small degree with the Mancus shale. The composition of Gallup sandstone is predominantly sandstone interbedded with some shale, carbonaceous shale and an occasional coal bed. The sandstone beds, in most places, form prominent cliffs or ledges which are separated by mostly thinner siltstone shale and friable silty sandstone beds.

Present vegetative cover within the floodplain at the site consists of a very sparse growth of brush and grass. The

slopes on either side of the floodplain have a light to moderate growth of grass and brush with numerous small juniper trees.

As indicated by the exploratory borings, the subsoils underlying the site consist predominantly of sandy and silty clays of medium plasticity with lesser amounts of sandy silts and silty sands. These soils extend to depths of 90 feet or more near the center of the present floodplain. Sandstones or shales are outcropped on either side of the floodplain. The soils are generally moderately firm, however, several soft zones were encountered. A geologic profile is presented in Appendix A which roughly parallels the axis of the proposed dam.

DISCUSSION & RECOMMENDATIONS

The consolidation and classification test data, plus general experience with the types of deposits involved, indicate that much of the alluvium present at the site would be substantially weakened by saturation. Under stresses that will be imposed, it is likely that relatively large settlements will occur. Based upon the consolidation test data, settlements on the order of 1.3 feet are estimated for the starter dike with settlements ranging to about 2.2 feet for the ultimate height of the dam. These figures are based upon 90.0 feet of compressible alluvium. Settlements in areas of shallow rock will be slight; thus, transition zones between areas of deep alluvium and

solid rock will be susceptible to relatively large differential settlements. As construction of the dam to its ultimate height will take place over a period of a number of years and the embankment foundation soils undoubtedly will be saturated during this period, the ultimate settlement does not appear excessive. However, the starter dike will be constructed during a period in which the embankment foundation soils are at their in situ moisture contents and saturation will not occur until after its completion. Thus, a major portion of settlement from the starter dike will occur fairly rapidly after saturation which could create some embankment cracking. This should be evaluated carefully, considering embankment stiffness.

The results of the exploratory drilling and research of available ground water data indicate that there is not a general ground water table within the alluvium at the site. The ground water encountered in some of the borings is believed to be perched on the underlying rock. This water level probably fluctuates considerably, depending upon the precipitation. It is quite probable, however, that the water contained in the alluvium is in direct communication with a permanent, general ground water table at some point downstream in the Rio Puerco drainage basin.

The tailings were processed into a mixture containing 4 percent passing the no. 200 sieve and 9 percent passing the no. 100 sieve to simulate the cycloned shell. The results of

the triaxial shear test performed on these materials at 70 percent relative density indicate that the angle of internal friction will be about 38.5 degrees at higher normal forces and probably at least somewhat higher under low normal forces. Thus, the use of 38.5 degrees in stability analysis would be a realistic lower value for the dam shell where a minimum of 70 percent of relative density is specified.

Shear strengths for the embankment foundation soils can be realistically evaluated on the basis of the direct shear test data. In our opinion, the shear strength of the mass of these soils under the rate of loading and moisture conditions involved is near the average of the direct shear tests performed and is controlled by the clayey soils. However, lenses of silty sands with rather large lateral extent could have shear strengths as low as about 30.0 degrees (zero cohesion).

Ample clayey material is available for borrow for the starter dike. When compacted to a minimum of 95 percent of ASTM D698 maximum density, a cohesion of 2,000 psf and an angle of internal friction of 23.0 degrees appears to be within the general range of shear strengths which would be achieved with the use of these materials.

A coefficient of permeability of 2,375 feet/year was determined for the cycloned shell material at about 70 percent of relative density. Thus, the shell can be expected to be

very free draining. Borehole permeability tests in the alluvium varied from coefficients of 3.8 to 27.0 feet/year with the higher value undoubtedly being created by stratifications of silty sands, thereby reflecting horizontal permeability. It is our evaluation that the mass vertical coefficient of permeability relative to downward seepage beneath the dam probably is less than the lower values. Additionally, we estimate that the coefficient of permeability of the compacted starter dike will be on the order of 1 foot/year or less.

APPENDIX A

OF

PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck mounted CME-55 drill rigs powered with 4 or 6 cylinder Ford Industrial Engines are used in advancing test borings. The 4 cylinder and 6 cylinder engines are capable of delivering about 4350 and 6500 ft. lbs. torque to the drill spindle, respectively. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6½" O.D. 3¼" I.D. hollow stem auger or 4½" continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NW rods using water or air as a drilling fluid.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedure. Two inch O.D. 1-3/8" I.D. samplers are used in many cases to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. Driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils driving resistance sometimes is recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX Diamond Core Drilling (ASTM D2113). The tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1-5/8" O.D. drill rods to provide clearance and minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487) with appropriate group symbols being shown on the logs.

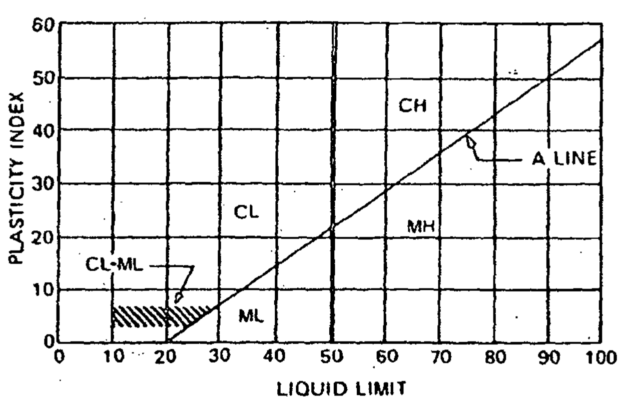
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS LIMITS PLOT BELOW "A" LINE & HATCHED ZONE ON PLASTICITY CHART	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS LIMITS PLOT ABOVE "A" LINE & HATCHED ZONE ON PLASTICITY CHART	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

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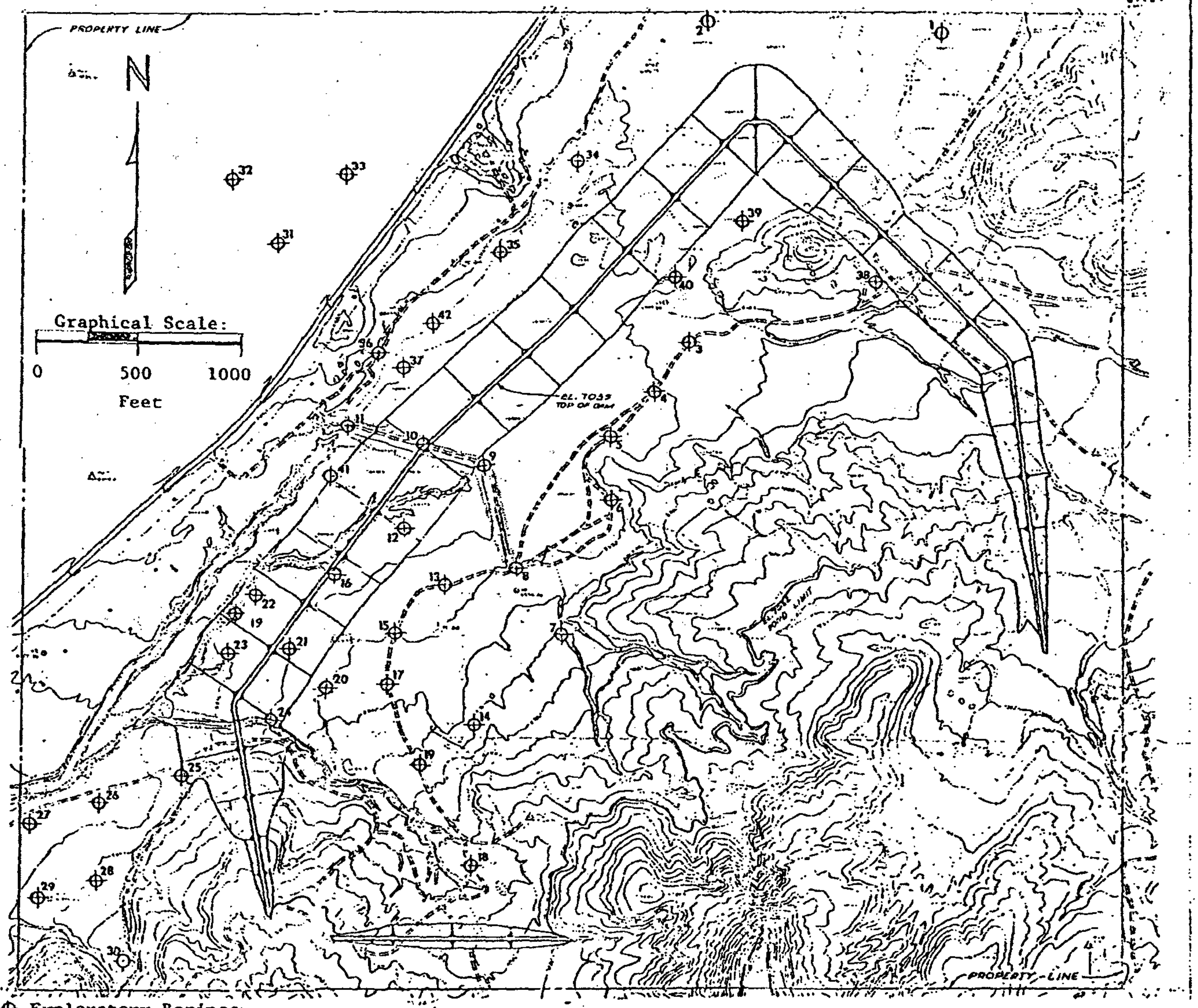
TERMINOLOGY FOR THE DESCRIPTION OF ROCK

General Property	Descriptive Term	Visual or Physical Properties
WEATHERING	VERY WEATHERED	Abundant fractures coated with oxides, carbonates, sulphates, mud, etc., thorough discoloration, rock disintegration, mineral decomposition
	MODERATELY WEATHERED	Some fracture coating, moderate or localized discoloration, little to no affect on cementation, slight mineral decomposition
	SLIGHTLY WEATHERED	A few stained fractures, slight discoloration, little to no affect or cementation, no mineral decomposition
	FRESH	Unaffected by weathering agents, no appreciable change with depth
FRACTURING	INTENSELY FRACTURED	less than 1" spacing
	VERY FRACTURED	1" to 6" spacing
	MODERATELY FRACTURED	6" to 12" spacing
	SLIGHTLY FRACTURED	12" to 36" spacing
	SOLID	36" spacing or greater
STRATIFICATION	THINLY LAMINATED	less than 1/10"
	LAMINATED	1/10" to 1/2"
	VERY THINLY BEDDED	1/2" to 2"
	THINLY BEDDED	2" to 2 feet
	THICKLY BEDDED	more than 2 feet
HARDNESS	SOFT	Can be dug by hand and crushed by fingers
	MODERATELY HARD	Friable, can be gouged deeply with knife and will crumble readily under light hammer blows
	HARD	Knife scratch leaves dust trace, will withstand a few hammer blows before breaking
	VERY HARD	Scratched with knife with difficulty, difficult to break with hammer blows

SITE PLAN

SHOWING LOCATIONS OF TEST BORINGS



⊕ Exploratory Borings

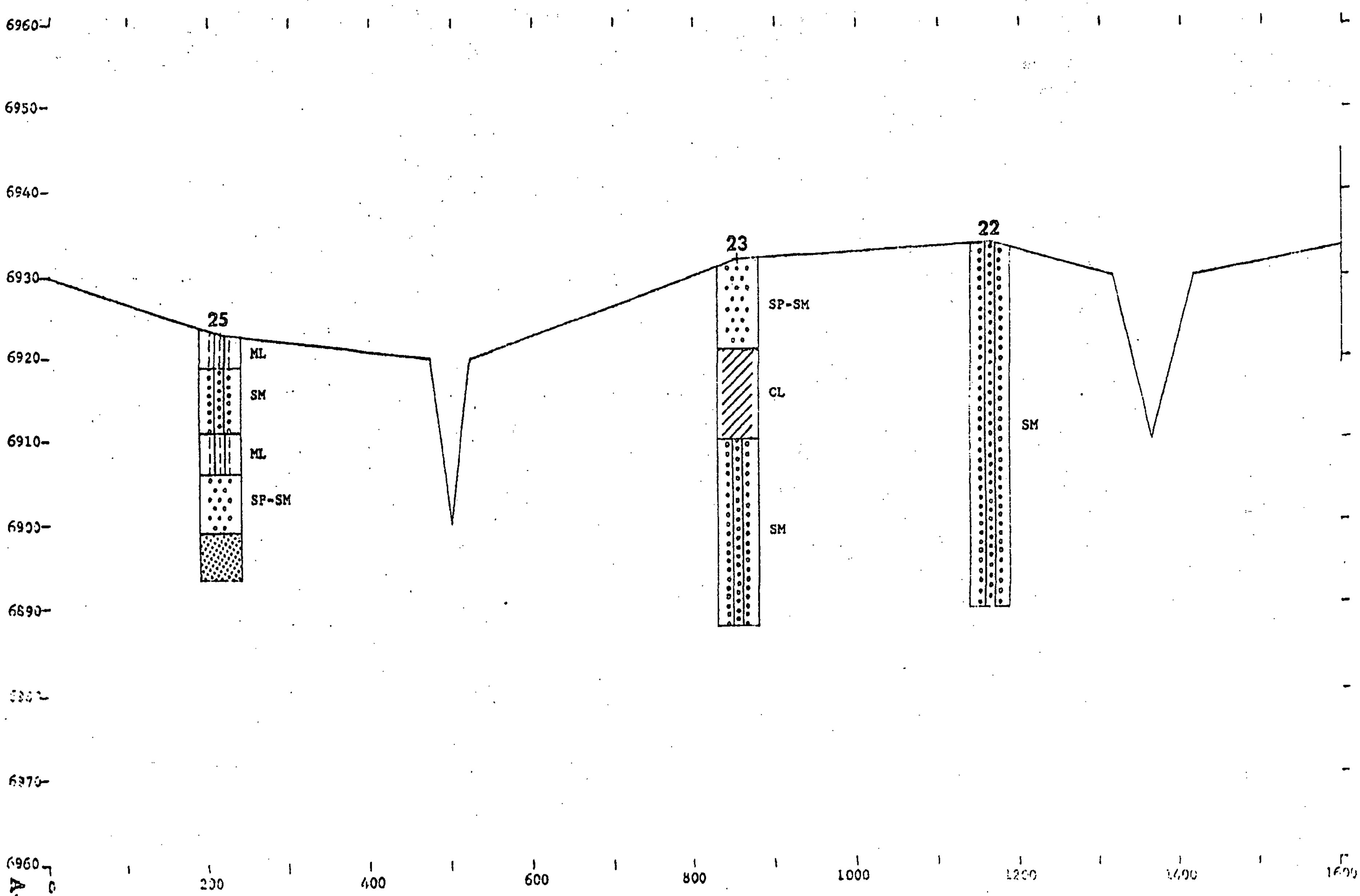
⊕ Block Samples

SERGENT, HAUSKINS & BECKWITH

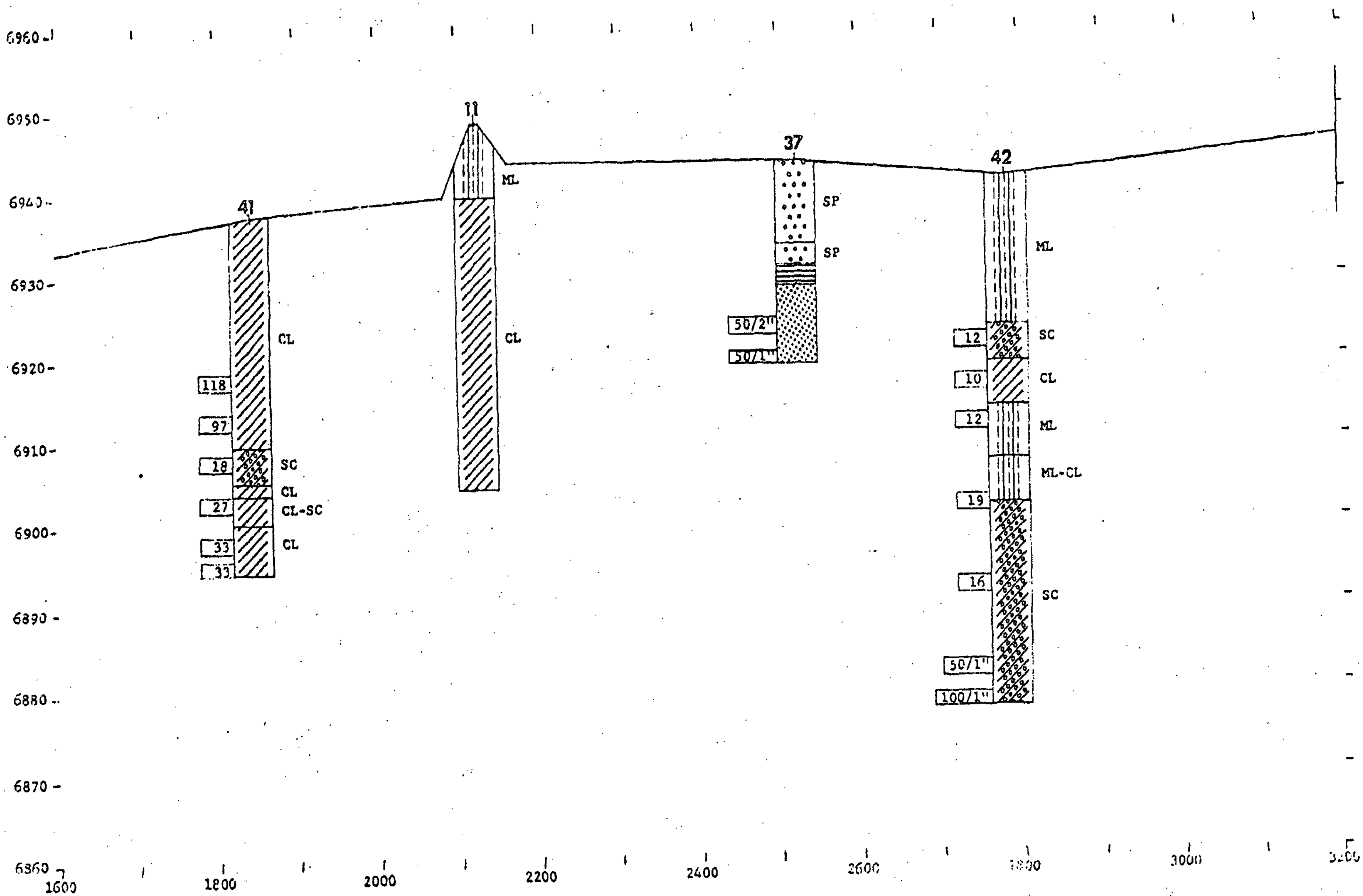
A-4

Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

GEOLOGIC PROFILE



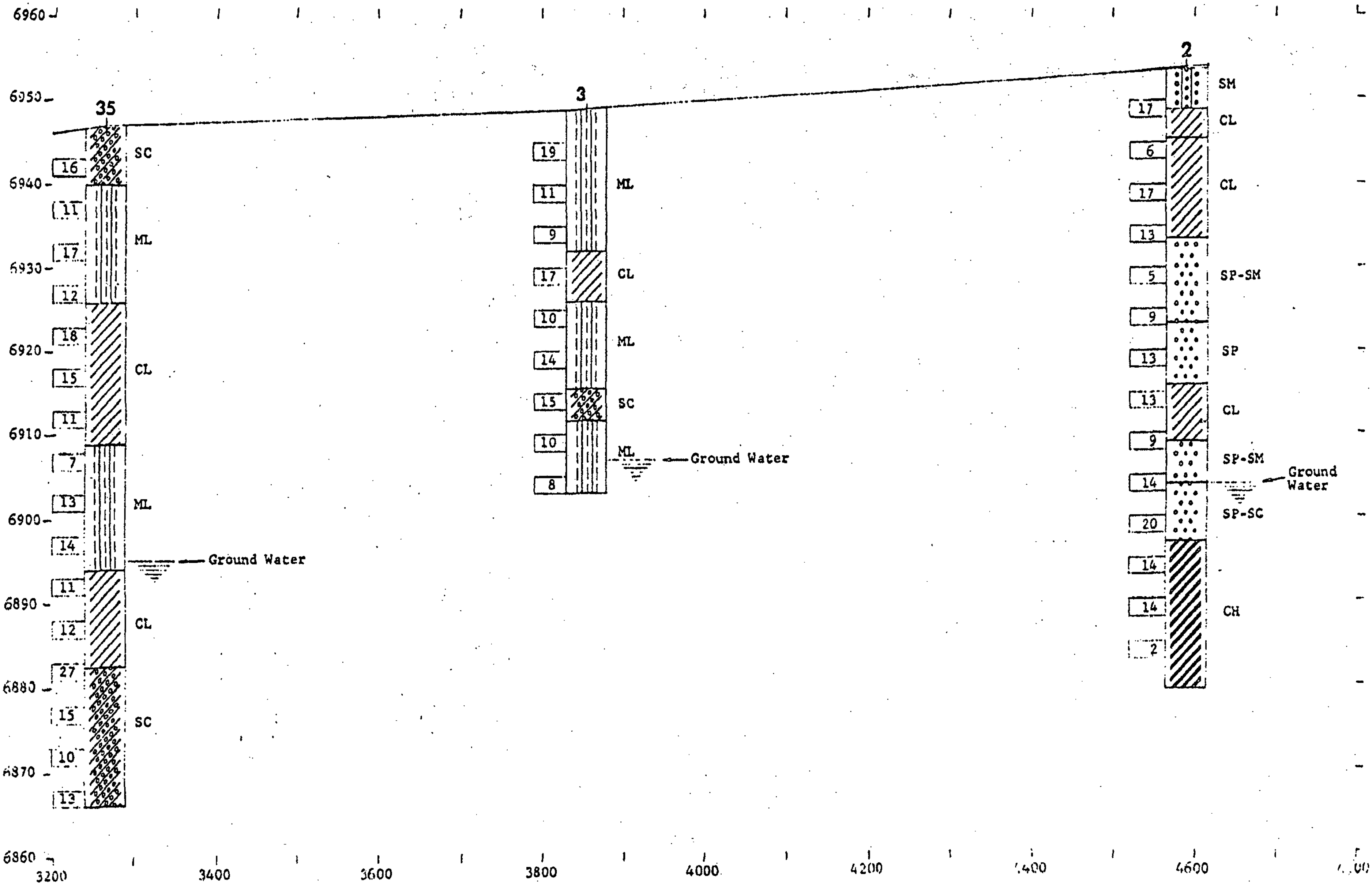
GEOLOGIC PROFILE



Legend: [112] - Blows/foot with 2" O.D. drive sampler ASTM D1586-64T

Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

GEOLOGIC PROFILE



Legend: 112 - Blows/foot with 2" O.D. drive sampler ASTM D1586-64T

PROJECT Church Rock Uranium Mill

JOB NO. E74-1072 DATE 7-30-74

LOG OF TEST BORING NO. 1

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" Flight Auger

SURFACE ELEV. 6952.0'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–13								SM		SILTY SAND, PREDOMINANTLY FINE, LOW PLASTICITY, BROWN
13–34.5								CH		CLAY, TRACE OF SAND, MEDIUM TO HIGH PLASTICITY, DARK BROWN
35										STOPPED AUGER AT 34'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

SERGENT, HAUSKINS & BECKWITH

CONSULTING SOIL AND FOUNDATION ENGINEERS
PHOENIX • FLAGSTAFF • ALBUQUERQUE • EL PASO

PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 7-30-74

LOG OF TEST BORING NO. 2

RIG TYPE CME-55

BORING TYPE 6½" HOLLOW STEM AUGER

SURFACE ELEV. 6954.0'

DATUM TOPO

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, TRACE OF GRAVEL, PREDOMINANTLY FINE, LOW PLASTICITY TO NONPLASTIC, LIGHT BROWN
5			X	S	17		10	CL	MODERATELY FIRM	SILTY CLAY, TRACE OF SAND, MEDIUM PLASTICITY, DARK BROWN
10			X	S	6		18		SOFT TO MODERATELY FIRM	CLAY, TRACE OF SAND, MEDIUM TO HIGH PLASTICITY, DARK BROWN
15			X	S	17		20	CL		
20			X	S	13		20			
25			X	S	5		16	SP-SM	LOOSE	SAND, SOME SILT, PREDOMINANTLY FINE TO MEDIUM, LOW PLASTICITY, BROWN NOTE: OCCASIONAL LAYER OF SILT & CLAYEY SAND
30			X	S	9		11			
35			X	S	13		11	SP	MEDIUM DENSE	SAND, CLEAN, POORLY GRADED, PREDOMINANTLY FINE TO MEDIUM, LIGHT BROWN
40			X	S	13		21	CL	MODERATELY FIRM	CLAY, SOME SAND, MEDIUM PLASTICITY, BROWN
45			X	S	9		14	SP-SM	LOOSE	SAND, SOME SILT, PREDOMINANTLY FINE TO MEDIUM, BROWN NOTE: SOME THIN CLAY LAYERS
50			X							

GROUND WATER

DEPTH	HOUR	DATE
50'	11:00 A.M.	7-30

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 2

PROJECT: CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 7-30-74

RIG TYPE: CME-55

BORING TYPE: 6½" HOLLOW STEM AUGER

SURFACE ELEV.: 6954.0'

DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			X	S	14		25	SP-SC	MODERATELY FIRM	SAND, SOME CLAY, TRACES OF CARBON CONTENT, PREDOMINANTLY FINE TO MEDIUM
55			X	S	20		16			
60			X	S	14		20	CH	MODERATELY FIRM TO VERY SOFT	CLAY, TRACE OF SAND, HIGH PLASTICITY, DARK BROWN
65			X	S	14		30			
70			X	S	2		28			
75										STOPPED AUGER AT 74'6"

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT: CHURCH ROCK URANIUM

JOB NO. E74-1072 DATE 7-30-74

LOG OF TEST BORING NO. 3

RIG TYPE: CME-55
BORING TYPE: $6\frac{1}{2}$" HOLLOW STEM AUGER
SURFACE ELEV.: 6953.5'
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0							ML		SANDY SILT, LOW PLASTICITY, BROWN
5		X	S	18		6	CH	MODERATELY FIRM	SANDY CLAY, WEAKLY CEMENTED, HIGH PLASTICITY, BROWN
							SP-SM		SAND, SOME SILT, FINE TO MEDIUM, WEAKLY CEMENTED, BROWN
10		X	S	46		10	CL	VERY FIRM	SANDY CLAY, MODERATELY LIME CEMENTED, MEDIUM PLASTICITY
15		X	S	20		8		MODERATELY FIRM TO FIRM	SANDY SILT, PREDOMINANTLY FINE, WEAKLY TO MODERATELY LIME CEMENTED, LOW PLASTICITY, BROWN
20		X	S	16		4			
25		X	S	23		3			
30		X	S	25			CL-ML		
35		X	S	28					
40		X	S	30					
45		X	S	50					
50									

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 3

PROJECT: CHURCH ROCK URANIUM MILL
JOB NO. E74-1072 DATE 7-30-74

RIG TYPE: CME-55
BORING TYPE: 6½" HOLLOW STEM AUGER
SURFACE ELEV.: 6953.5'
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50		////	X	S	37					
55		////	X	S	23			CL-ML		
58 (water level)		////								
60		////	X	S	20					
65										STOPPED AUGER AT 59'6" STOPPED SAMPLER AT 61'

GROUND WATER

DEPTH	HOUR	DATE
58'	6:30	7-30
	P.M.	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT: CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 4

JOB NO. E74-1072 DATE 7-31-74

RIG TYPE: CME-55
BORING TYPE: $6\frac{1}{2}$" HOLLOW STEM AUGER
SURFACE ELEV.: 6948.5'
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–8								ML	SOFT	SANDY SILT, PREDOMINANTLY FINE, NONPLASTIC, BROWN
5			X	S	8		5			
8–17								CL	VERY FIRM	CLAY, WEAKLY LIME CEMENTED, MEDIUM PLASTICITY, BROWN
10			X	U	56	104	12			
15			X	U	45	104	14			
17–31								SC	MODERATELY FIRM	CLAYEY SAND, PREDOMINANTLY FINE, LOW TO MEDIUM PLASTICITY, BROWN
20			X	S	11		5			
25			X	S	15		5			
30			X	S	15		4			
35										STOPPED AUGER AT 29'6" STOPPED SAMPLER AT 31'

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT: CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 5

JOB NO. E74-1072 DATE 7-31-74

RIG TYPE: CME-55
BORING TYPE: 6½" HOLLOW STEM AUGER
SURFACE ELEV.: 6946.0'
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	Remarks	Visual Classification
0									MODERATELY FIRM	SILTY SAND, PREDOMINANTLY FINE, WEAKLY TO MODERATELY CEMENTED, NONPLASTIC TO LOW PLASTICITY, BROWN
5			X	U	15	91	6	SM		
10			X	U	24	105	10			
									FIRM TO VERY FIRM	SANDY SILT, PREDOMINANTLY FINE TO MEDIUM, OCCASIONAL SANDSTONE, FINE, WEAKLY TO MODERATELY CEMENTED, NONPLASTIC, YELLOWISH-BROWN
15			X	S	34		8	ML		
20			X	S	40		5		VERY SOFT	SANDSTONE, FINE, WEATHERED, YELLOWISH-BROWN
25			X	S	24		10			
30			X	S	28		13			
35										STOPPED AUGER AT 29'6" STOPPED SAMPLER AT 31'

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Church Rock Uranium Mill

JOB NO. E74-1072 DATE 7-31-74

LOG OF TEST BORING NO. 6

RIG TYPE CME-55

BORING TYPE 4½" Flight Auger

SURFACE ELEV. 6946.0'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–12								SM		SILTY SAND, predominantly fine, low plasticity, brown
12–14									SOFT	MUDSTONE, weathered, medium plasticity, brown
14–19.5									SOFT	SANDSTONE, fine, yellowish-brown
20										Stopped auger at 19'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 7

JOB NO. E74-1072 DATE 7-31-74

RIG TYPE CME-55
BORING TYPE 6½" HOLLOW STEM AUGER
SURFACE ELEV. 6969.0'
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, SOME GRAVEL, PREDOMINANTLY FINE, LOW PLASTICITY, LIGHT BROWN
5			X	S	14		7	CL	MODERATELY FIRM TO FIRM	SANDY CLAY, OCCASIONAL SANDSTONE FRAGMENTS, MEDIUM PLASTICITY, BROWN
10			X	S	26		5			
15				U	100/2"		13	CL	HARD	SILTY CLAY, (WEATHERED SHALE), LOW TO MEDIUM PLASTICITY, BLACK
				S	50/0"				SOFT	SANDSTONE, FINE, YELLOWISH-BROWN
20										STOPPED AUGER AT 19'6" SAMPLER REFUSED AT 19'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 8

JOB NO. E74-1072 DATE 7-30-74

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6951.5'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–5								SM		SILTY SAND, PREDOMINANTLY FINE, LOW TO MEDIUM PLASTICITY, BROWNISH-GRAY
5–25									SOFT	SANDSTONE, FINE, WEATHERED, YELLOWISH-BROWN
25										STOPPED AUGER AT 24'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 9

JOB NO. E74-1072 DATE 7-31-74

RIG TYPE CME-55
BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER
SURFACE ELEV. 6949.5'
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								ML		CLAYEY SILT, TRACE OF SAND, LOW TO MEDIUM PLASTICITY, BROWN
5										CLAY, HIGH PLASTICITY, DARK BROWN
10										
15										
20										
25								CH		
30										
35										
40										
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 7-31-74

LOG OF TEST BORING NO. 10

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6949.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–7								ML		CLAYEY SILT, TRACE OF SAND, LOW TO MEDIUM PLASTICITY, BROWN
7–44.5								CL		CLAY, MEDIUM TO HIGH PLASTICITY, DARK BROWN
44.5										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 11

JOB NO. E74-1072 DATE 7-31-74

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER

SURFACE ELEV. 6948.5'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0 – 9								ML		CLAYEY SILT, LOW TO MEDIUM PLASTICITY, BROWN
9 – 44'6"								CL		CLAY, SOME SILT, SOME HARD SANDSTONE FRAGMENTS, MEDIUM PLASTICITY, BROWN
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Church Rock Uranium Mill

JOB NO. E74-1072 DATE 7-31-74

LOG OF TEST BORING NO. 12

RIG TYPE CME-55

BORING TYPE 4½" Flight Auger

SURFACE ELEV. 6937.5'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–11								SM		SILTY SAND, some gravel, predominantly fine, non-plastic, light brown
11–20								CL		SANDY CLAY, medium plasticity, gray
20–32								CH		CLAY, some sand, medium plasticity, gray
32–44.5								SM		SILTY SAND, some clay, predominantly fine, low plasticity, brown
45										Stopped auger at 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO.

PROJECT: CHURCH ROCK URANIUM MILL
JOB NO.: E74-1072 DATE: 8-1-74

RIG TYPE: CME-55
BORING TYPE: 6½" HOLLOW STEM AUGER
SURFACE ELEV.: 6945.0'
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–8								SM		SILTY SAND, SOME CLAY, OCCASIONAL SANDSTONE FRAGMENTS, PREDOMINANTLY FINE, LOW PLASTICITY, LIGHT BROWN
8–23.5								SM		SILTY SAND, TRACE OF CLAY, PREDOMINANTLY FINE, NONPLASTIC, LIGHT BROWN
23.5–32.5								SM		SILTY SAND, OCCASIONAL SANDSTONE FRAGMENTS, PREDOMINANTLY FINE, NONPLASTIC, MOTTLED YELLOWISH-GRAY
32.5–44.5								SM		SILTY SAND, OCCASIONAL SANDSTONE FRAGMENTS, PREDOMINANTLY FINE, NONPLASTIC, MOTTLED YELLOWISH-GRAY
44.5–50								CH		SANDY CLAY, HIGH PLASTICITY, DARK GRAY

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJEC
JOB NO.
Depth in Feet
0
5
10
15
2

PROJECT: CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 13

RIG TYPE: CME-55

BORING TYPE: 6½" HOLLOW STEM AUGER

SURFACE ELEV.: 6945.0'

DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50										
55								CH		
60										STOPPED AUGER AT 59'6"

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 14

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER

SURFACE ELEV. 6970.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, OCCASIONAL SANDSTONE FRAGMENTS, MOTTLED YELLOW & GRAY
5			X	U	23				FIRM	SAND, SOME SILT, SOME SANDSTONE FRAGMENTS, PREDOMINANTLY FINE, MOTTLED RUST, YELLOW & BROWN
10			X	S	19		3	SP-SM		
15			X	S	25		3			
									VERY FIRM	SILTY CLAY, SOME SAND, MODERATELY CEMENTED, MEDIUM PLASTICITY, DARK BROWN
20			X	S	38		10	CL		
25			X	S	54		8		FIRM	SILTY SAND, SOME CLAY, OCCASIONAL SANDSTONE FRAGMENTS, MOTTLED YELLOW & LIGHT BROWN
30			X	S	28			SM		
35			X	S	14				MEDIUM DENSE	SAND, SOME SANDSTONE FRAGMENTS, VERY FINE, NONPLASTIC, TAN
40			X	S	23			SP		
									HARD	CLAYEY SILT, SOME SAND, LOW PLASTICITY, DARK BROWN
45			X	S	50			ML		
50										STOPPED AUGER AT 44'6" STOPPED SAMPLER AT 46'

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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A-24

PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 7-31-74

LOG OF TEST BORING NO. 15

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6950.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–16								SM		SILTY SAND, SOME SANDSTONE FRAGMENTS, NON-PLASTIC, LIGHT BROWN
16–19.5										SANDSTONE, FINE, WEATHERED, YELLOWISH-BROWN
20										STOPPED AUGER AT 19'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 16

JOB NO. E74-1072 DATE 8-1-74

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER

SURFACE ELEV. 6936.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–12								SM		SILTY SAND, VERY FINE, LOW PLASTICITY, BROWN
12–23								SM		SILTY SAND, CONSIDERABLE GRAVEL, SUBROUNDED, LOW PLASTICITY, BROWN
23–44.5								SC		CLAYEY SAND, SOME GRAVEL, SUBROUNDED, MEDIUM PLASTICITY, BROWN
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 7-31-74

LOG OF TEST BORING NO. 17

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" Flight Auger

SURFACE ELEV. 6957.0'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	Remarks	Visual Classification
0–28								SM		SILTY SAND, predominantly fine, nonplastic, brown
28–34.5										SANDSTONE, fine, slightly weathered, yellowish-brown
35										Stopped auger at 34'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 18

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" Flight Auger

SURFACE ELEV. 6999.0'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SP		SAND, SOME SILT, VERY FINE, NONPLASTIC, DARK BROWN
5										SANDSTONE, FINE, MODERATELY WEATHERED, YELLOWISH-BROWN
10										STOPPED AUGER AT 9'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 19

RIG TYPE CME-55

BORING TYPE 4½" Flight Auger

SURFACE ELEV. 6974.0'

DATUM Topo

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0 – 5								SM		SILTY SAND, PREDOMINANTLY FINE, SUBANGULAR, NONPLASTIC, MOTTLED YELLOW, BROWN & BLACK
10 – 15								SM		SILTY SAND, SOME CLAY, PREDOMINANTLY FINE, SUBANGULAR, LOW PLASTICITY, MOTTLED YELLOW, BROWN & BLACK
20								SM		SILTY SAND, VERY FINE, NONPLASTIC, BROWN
25								SP		SAND, OCCASIONAL SANDSTONE FRAGMENTS, NONPLASTIC, MOTTLED BROWN, YELLOW & GRAY
30 – 35								SM		SILTY SAND, VERY FINE, NONPLASTIC, GRAYISH
40								SM		SILTY SAND, OCCASIONAL SANDSTONE FRAGMENTS, MOTTLED YELLOWISH-GRAY
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 20

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6949.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–12								SM		SILTY SAND, FINE, LOW PLASTICITY, DARK BROWN
12–18								SM		SILTY SAND, CONSIDERABLE GRAVEL, FINE, LOW PLASTICITY, DARK BROWN
18–25								ML		CLAYEY SILT, SOME GRAVEL & SAND, SOME SANDSTONE FRAGMENTS, FINE, MEDIUM PLASTICITY, DARK BROWN
25–29.5								SP		SAND, VERY FINE, NON-PLASTIC, BROWN
29.5–36								CL		SILTY CLAY, MEDIUM PLASTICITY, BROWN
36–39.5										SANDSTONE, FINE, YELLOWISH-BROWN
40										STOPPED AUGER AT 39'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 21

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6940.5'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–17								SP-SM		SAND, SOME GRAVEL & SILT, FINE, NONPLASTIC, BROWN
17–36								SM		SILTY SAND, SOME GRAVEL, FINE, NONPLASTIC, BROWN
36–44.5								SP-SM		SAND, SOME SILT, VERY FINE, NONPLASTIC, BROWN
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 22

RIG TYPE CME-55
BORING TYPE 4½" FLIGHT AUGER
SURFACE ELEV. 6934.0'
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0										SILTY SAND, TRACE OF GRAVEL, VERY FINE, NON-PLASTIC TO LOW PLASTICITY, BROWN
5										
10										
15										
20								SM		
25										
30										
35										
40										
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-1-74

LOG OF TEST BORING NO. 23

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6931.5'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–11								SP-SM		SAND, SOME SILT, VERY FINE, NONPLASTIC, TAN TO BROWN
11–22								CL		CLAY, MEDIUM TO HIGH PLASTICITY, BROWN
22–44.5								SM		SILTY SAND, VERY FINE, NONPLASTIC, TAN TO BROWN
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 24

JOB NO. E74-1072 DATE 8-1-74

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER

SURFACE ELEV. 6940.5'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–22								SM		SILTY SAND, TRACE OF GRAVEL, FINE, LOW PLASTICITY, BROWN
22–37								CL		SILTY CLAY, TRACE OF SAND, FINE, MEDIUM PLASTICITY, BROWN
37–44.5								SP		SAND, FINE, NONPLASTIC, YELLOWISH-BROWN
44.5										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 25

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6923.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								ML		CLAYEY SILT, LOW TO MEDIUM PLASTICITY, BROWN
5								SM		SILTY SAND, VERY FINE, NONPLASTIC, BROWN
10										
15								ML		SANDY SILT, LOW PLASTICITY, BROWN
20								SP-SM		SAND, TRACE OF SILT, NONPLASTIC, YELLOWISH-BROWN
25										SANDSTONE, FINE, YELLOWISH-BROWN
30										STOPPED AUGER AT 29'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 26

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER

SURFACE ELEV. 6917.0'

DATUM TOPO

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0 – 5								ML		CLAYEY SILT, MEDIUM PLASTICITY, BROWN
10 – 20								CH		CLAY, MEDIUM TO HIGH PLASTICITY, BROWN
25 – 30								SM		SILTY SAND, VERY FINE, NONPLASTIC, TAN TO GRAY
35 – 40								CL		CLAY, MEDIUM TO HIGH PLASTICITY, BROWN
45										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 27

RIG TYPE: CME-55

BORING TYPE: 4½" FLIGHT AUGER

SURFACE ELEV.: 6913.0'

DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–45								SM		SILTY SAND, VERY FINE, NONPLASTIC TO LOW PLASTICITY, BROWN NOTE: SOME SANDSTONE AT 8' TO 9'
45										STOPPED AUGER AT 44'6"

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 28

RIG TYPE CME-55

BORING TYPE 4½" FLIGHT AUGER

SURFACE ELEV. 6931.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, FINE, LOW PLASTICITY, BROWN
28								CL		CLAY, SOME SILT, MEDIUM TO HIGH PLASTICITY, BROWN
44'6"										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 29

RIG TYPE CME-55

BORING TYPE $4\frac{1}{2}$" FLIGHT AUGER

SURFACE ELEV. 6925.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–4.5								ML		CLAYEY SILT, SOME SAND, FINE, MEDIUM PLASTICITY, BROWN
4.5–26								SM		SILTY SAND, VERY FINE, NONPLASTIC, TAN TO BROWN
26–44.5								CL		CLAY, TRACE OF SILT, SOME SAND, MEDIUM TO HIGH PLASTICITY, BROWN
44.5										STOPPED AUGER AT 44'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 30

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER

SURFACE ELEV. 6957.0'

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SP		SAND, FINE, YELLOWISH-BROWN
5			X	S	11		4	SM	MODERATELY FIRM	SILTY SAND, TRACE OF CLAY, FINE, LOW PLASTICITY, BROWN
10			X	S	20		3		FIRM	SAND, TRACE OF SILT, SOME HARD SANDSTONE FRAGMENTS, PREDOMINANTLY FINE, NONPLASTIC, BROWN
15			X	S	20		5	SP-SM		
20			X	S	28		6			
25			X	S	30		3		SOFT	SANDSTONE, FINE, WEATHERED, YELLOWISH-BROWN
30										STOPPED AUGER AT 24'6" STOPPED SAMPLER AT 26'

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 31

RIG TYPE CME-55

BORING TYPE 6½" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	70				SOFT	SILTSTONE, MODERATELY WEATHERED, GRAY
5			☒	S	50/4½"		7		SOFT	SANDSTONE, HIGHLY WEATHERED, GRAYISH-YELLOW
10			☒	S	50/4"		8		SOFT	CARBONACEOUS MUDSTONE, FINE, BLACK
15				S	50/1"		7		SOFT	SANDSTONE, MODERATELY WEATHERED, GRAYISH-YELLOW

STOPPED AUGER AT 14'6"
SAMPLER REFUSED AT 14'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 32

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									MODERATELY FIRM TO FIRM	SANDY SILT, LOW PLASTICITY, TAN
5			X	S	15		8			
10			X	S	25		7	ML		
15			X	S	28		8			
20			X	S	19		8			
				S	50/0"				MODERATELY HARD	SANDSTONE, FINE, MODERATELY WEATHERED, YELLOWISH-BROWN
25										

STOPPED AUGER AT 24'6"
SAMPLER REFUSED AT 24'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-2-74

LOG OF TEST BORING NO. 33

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									MODERATELY FIRM TO FIRM	SILTY SAND, FINE, NON-PLASTIC, BROWN
5			X	S	18		4			
								SM		
10			X	S	24		5			
15			X	S	105		4			
									MODERATELY HARD	SANDSTONE, FINE, MODERATELY WEATHERED, YELLOWISH-BROWN
				S	50/0"					
20										STOPPED AUGER AT 19'6" SAMPLER REFUSED AT 19'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 8-14-74

LOG OF TEST BORING NO. 34

RIG TYPE CME-55

BORING TYPE 6½" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									MODERATELY FIRM TO SOFT	CLAYEY SILT, CONSIDERABLE SAND, FINE, LOW TO MEDIUM PLASTICITY, DARK BROWN
5			X	S	19					
								ML		
10			X	S	11					
15			X	S	9					
									MODERATELY FIRM	CLAY, MEDIUM PLASTICITY, VERY DARK BROWN
20			X	S	17			CL		
										CLAYEY SILT, SOME SAND, MEDIUM PLASTICITY, VERY DARK BROWN
25			X	S	10					
								ML		
30			X	S	14					
									MODERATELY FIRM	CLAYEY SAND, LOW PLASTICITY, BROWN
35			X	S	15			SC		
									SOFT	SANDY SILT, SOME CLAY, TRACES OF CHARCOAL, LOW PLASTICITY, BROWN
40			X	S	10					
								ML		
45			X	S	8					
50										STOPPED AUGER AT 44'6" STOPPED SAMPLER AT 46'

GROUND WATER

DEPTH	HOUR	DATE
42'	6:00 P.M.	8-14

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E74-1072 DATE 8-15-74

LOG OF TEST BORING NO. 35

RIG TYPE CME-55
BORING TYPE 6½" HOLLOW STEM AUGER
SURFACE ELEV.
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									MODERATELY FIRM	CLAYEY SAND, LOW PLASTICITY, LIGHT BROWN
								SC		
5			☒	S	16					
									MODERATELY FIRM.	SANDY SILT, SOME CLAY, LOW PLASTICITY, LIGHT BROWN
10			☒	S	11					
								ML		
15			☒	S	17					
20			☒	S	12					
									MODERATELY FIRM	SILTY CLAY, TRACE OF ORGANIC MATERIAL, LOW TO MEDIUM PLASTICITY, BROWN
25			☒	S	18					
30			☒	S	15			CL		
35			☒	S	11					
									SOFT TO MODERATELY FIRM	SILT, CONSIDERABLE SAND, LOW PLASTICITY, DARK BROWN
40			☒	S	7					
								ML		
45			☒	S	13					
50			☒							

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 35

JOB NO. E74-1072 DATE 8-15-74

RIG TYPE CME-55
BORING TYPE 6½" HOLLOW STEM AUGER
SURFACE ELEV.
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			X	S	14			ML		
55			X	S	11			CL	STIFF	CLAY, MEDIUM PLASTICITY, DARK BROWN
60			X	S	12					
65			X	S	27			SC	MODERATELY FIRM	CLAYEY SAND, PREDOMINANTLY FINE, LOW PLASTICITY, BROWN
70			X	S	15					
75			X	S	10					
80			X	S	13					
85										STOPPED AUGER AT 79'6" STOPPED SAMPLER AT 81'

GROUND WATER

DEPTH	HOUR	DATE
52'		8-15

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 8-15-74

LOG OF TEST BORING NO. 36

RIG TYPE CME-55

BORING TYPE 6½" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								ML	VERY FIRM	SANDY SILT, SOME CLAY, LOW PLASTICITY, YELLOW
5			X	S	50/3"					
5									SOFT TO MODERATELY HARD	SANDSTONE, FINE, VERY WEATHERED, YELLOW TO DARK GRAY
10				S	50/0"					
15			X	S	119					
				S	50/1"					
15									SOFT TO MODERATELY HARD	CARBONACEOUS MUDSTONE, SOME COAL, BLACK
20										AUGER REFUSED AT 15'9" ON SANDSTONE SAMPLER REFUSED AT 15'10"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 37

JOB NO. E74-1072 DATE 8-15-74

RIG TYPE CME-55

BORING TYPE 6½" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0										SAND, PREDOMINANTLY FINE, NONPLASTIC, YELLOW
5								SP		
10								SP		SAND, PREDOMINANTLY FINE, NONPLASTIC, BROWN
										CARBONACEOUS MUDSTONE, VERY WEATHERED, BLACK
15									SOFT TO MODERATELY HARD	SANDSTONE, VERY WEATHERED, OCCASIONAL THIN SEAM OF MUDSTONE, GRAY
20				S	50/2"					
				S	50/1"					
25										AUGER REFUSED AT 24'6" SAMPLER REFUSED AT 24'7"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 38

JOB NO. E74-1072 DATE 8-16-74

RIG TYPE CME-55
BORING TYPE 6½" HOLLOW STEM AUGER
SURFACE ELEV.
DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									VERY HARD	CLAY, MEDIUM PLASTICITY, YELLOW & BROWN
5			X	S	87			CL		
10			X	S	31			CL	FIRM	CLAY, MEDIUM TO LOW PLASTICITY, BROWN
15			X	S	33			ML	FIRM	CLAYEY SILT, LOW PLASTICITY, GRAYIS-BROWN
20				S	50/5"				SOFT TO MODERATELY HARD	SANDSTONE, VERY WEATHERED, OCCASIONAL THIN MUDSTONE SEAM, YELLOW
25				S	50/1" (NO RECOVERY)				SOFT	CARBONACEOUS MUDSTONE, VERY WEATHERED, BLACK

AUGER REFUSED AT 24'6" ON SANDSTONE
SAMPLER REFUSED AT 24'7"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 39

JOB NO. E74-1072 DATE 8-16-74

RIG TYPE CME-55
BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER
SURFACE ELEV.
DATUM TOPO

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC	VERY FIRM TO HARD	CLAYEY SAND, LOW PLASTICITY, GRAY, YELLOW & BROWN
5			X	S	38					
				S	50/1"					
10										AUGER REFUSED AT 8'2" ON SANDSTONE SAMPLER REFUSED AT 8'3"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 40

PROJECT: CHURCH ROCK URANIUM MILL
JOB NO. E74-1072 DATE 8-16-74

RIG TYPE: CME-55
BORING TYPE: $6\frac{1}{2}$" HOLLOW STEM AUGER
SURFACE ELEV.:
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–6.5								ML	MODERATELY FIRM	SILT, CONSIDERABLE CLAY, LOW PLASTICITY, BROWN
5			X	S	14					
6.5–15								CL	MODERATELY FIRM	SILTY CLAY, LOW TO MEDIUM PLASTICITY, DARK BROWN
10			X	S	15					
15			X	S	8					
15–22								SC	SOFT	CLAYEY SAND, OCCASIONAL LENSE OF SILTY CLAY, LOW PLASTICITY, BROWN
20			X	S	6					
22–33								CH	SOFT	CLAY, MEDIUM TO HIGH PLASTICITY, DARK BROWN
25			X	S	9					
30			X	S	8					
33–43								CL	SOFT TO MODERATELY FIRM	CLAY, SOME SAND, FINE, LOW TO MEDIUM PLASTICITY, DARK BROWN
35			X	S	9					
40			X	S	12					
43–50								ML	MODERATELY FIRM	CLAYEY SILT, LOW PLASTICITY, BROWN
45			X	S	12					
50										

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 40

PROJECT: CHURCH ROCK URANIUM MILL
JOB NO. E74-1072 DATE 8-16-74

RIG TYPE: CME-55
BORING TYPE: 6½" HOLLOW STEM AUGER
SURFACE ELEV.:
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			X	S	12			SC		CLAYEY SAND, PREDOMINANTLY FINE, LOW PLASTICITY, GRAY
55				S	50/2"				SOFT TO MODERATELY FIRM	CARBONACEOUS MUDSTONE, VERY WEATHERED, BLACK
				S	100/2"				MODERATELY HARD	SANDSTONE, FINE, MODERATELY WEATHERED, WHITE
60										AUGER REFUSED AT 57'4" SAMPLER REFUSED AT 57'6" ON SANDSTONE

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT CHURCH ROCK URANIUM MILL

JOB NO. E74-1072 DATE 8-19-74

LOG OF TEST BORING NO. 41

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" HOLLOW STEM AUGER

SURFACE ELEV.

DATUM TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									FIRM TO HARD	SILTY CLAY, LOW TO MEDIUM PLASTICITY, GRAYISH-BROWN
5										
10										
								CL		
15										
20			☒	S	118					
25			☒	S	97					
30			☒	S	18			SC	FIRM	CLAYEY SAND, LOW PLASTICITY, LIGHT BROWN
								CL		CLAY, MEDIUM PLASTICITY, DARK BROWN
35			☒	S	27			CL	FIRM	ALTERNATING LAYERS OF CLAY & CLAYEY SAND, LOW TO MEDIUM PLASTICITY, BROWN
40			☒	S	33			CL	HARD	SANDY CLAY, OCCASIONAL THIN LENSES OF SAND, FINE, MEDIUM PLASTICITY, BROWN
			☒	S	33					
45										AUGER REFUSED AT 42' POSSIBLE IN WEATHERED SHALE STOPPED SAMPLER AT 43'6"

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT: CHURCH ROCK URANIUM MILL

LOG OF TEST BORING NO. 42

JOB NO. E74-1072 DATE 8-19-74

RIG TYPE: CME-55
BORING TYPE: $6\frac{1}{2}$" HOLLOW STEM AUGER
SURFACE ELEV.:
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0–18								ML	MODERATELY FIRM	CLAYEY SILT, LOW PLASTICITY, BROWN
18–22 (sample at 20)			X	S	12			SC	MODERATELY FIRM	CLAYEY SAND, CONSIDERABLE SILT, PREDOMINANTLY FINE, LOW PLASTICITY, LIGHT BROWN
22–28 (sample at 25)			X	S	10			CL	MODERATELY FIRM	SANDY CLAY, LOW TO MEDIUM PLASTICITY, LIGHT BROWN
28–35 (sample at 30)			X	S	12			ML	MODERATELY FIRM	CLAYEY SILT, LOW PLASTICITY, LIGHT BROWN
35–40								ML-CL		SILTY CLAY, MEDIUM PLASTICITY, BROWN
40–50 (sample at 40)			X	S	19			SC		CLAYEY SAND, PREDOMINANTLY FINE, LOW PLASTICITY, YELLOWISH-BROWN

GROUND WATER

DEPTH	HOUR	DATE
	NONE	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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LOG OF TEST BORING NO. 42

PROJECT: CHURCH ROCK URANIUM MILL
JOB NO. E74-1072 DATE 8-19-74

RIG TYPE: CME-55
BORING TYPE: 6½" HOLLOW STEM AUGER
SURFACE ELEV.:
DATUM: TOPO

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			X	S	16					
55										
								SC		
				S	50/1"					
60										
				S	100/1"					
65										STOPPED AUGER AT 64'6" SAMPLER REFUSED AT 64'7" ON WEATHERED SANDSTONE

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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APPENDIX B

OF

PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

LABORATORY TESTING PROCEDURES

Consolidation Tests. Soiltest or Clockhouse apparatus of the "floating-ring" type are employed for the one-dimensional consolidation tests. They are designed to receive one inch high 2.5 inch O.D. brass liner rings with soil specimens as secured in the field. Procedures for the tests generally are those outlined in ASTM D2435-65T. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. For soils which are essentially saturated, each increment of load is maintained until the deformation versus log of time curve indicates completion of primary consolidation. For partially saturated soils, each increment of load is maintained until the rate of deformation is equal or less than 1/10,000 inch per hour. Applied loads are such that each new increment is equal to the total previously applied loading. Porous stones are placed in contact with the top and bottom of the specimens to permit free addition or expulsion of water. For partially saturated soils, the tests are normally performed at in situ moisture conditions until consolidation is complete under stresses approximately equal to those which will be imposed by the combined overburden and foundation loads. The samples are then submerged to show the effect of moisture increase and the tests continued under higher loadings. Generally the tests are continued to about twice the anticipated stress due to overburden and structural loads with a rebound curve then being established by releasing loads.

Expansion Tests. The same type of consolidometer apparatus described above is used in expansion testing. Undisturbed samples contained in brass liner rings are placed in the consolidometers, subjected to appropriate surcharge loads and submerged. The loads are maintained until the expansion versus log of time curve indicates completion of "primary swell".

Direct Shear Tests. Direct Shear Tests are run using a Clockhouse or Soiltest apparatus of the strain-control type. Shearing forces are applied at a rate deformation of approximately 0.05 inches per minute. The machine is designed to receive one of the one inch high 2.42 inch diameter specimens obtained by tube sampling. Generally, each sample is sheared under a normal load equivalent to the effective overburden pressure at the point of sampling. In some instances, samples are sheared at several normal loads to obtain the cohesion and angle of internal friction. When necessary, samples are saturated and/or consolidated before shearing in order to approximate the anticipated controlling field loading conditions.

APPENDIX E

CORRESPONDENCE
CONCERNING
ARCHAEOLOGY

MUSEUM OF NEW MEXICO. P.O. BOX 2087. SANTA FE. NEW MEXICO 87501

June 6, 1974

Dr. Leland J. Abel
Archaeologist
Bureau of Indian Affairs
P. O. Box 8327
~~Santa Fe~~, New Mexico 87108
Albuquerque

Dear Lee

Mr. Paul Grigg, of our archaeological survey staff, conducted an archaeological clearance survey of:

All Section 2 Township 16 North Range 16 West N.M.P.M.

in McKinley County, New Mexico, at the request of the United Nuclear Corporation which plans to construct a uranium processing mill on that piece of land.

Mr. Grigg encountered two archaeological sites as shown on the accompanyin g maps and described in the attached survey forms. The sites have been entered as LA 11617 and LA 11618 in the Museum of New Mexico Archaeological Survey Catalog.

The first site apparently is a one-room field house with very little associated pottery. The sherds present do indicate repeated use of the structure. Without an area-wide survey, it is difficult to judge the significance of the site. At this point, its location and ceramic assemblage are likely to be the principal bits of information to be derived from it. I would question the need for a salvage excavation, though very few field houses have been excavated and their contents studied.

The second site; though less well defined, is the more interesting of the two. Mr. Grigg could not find any architecture to go along with the pottery, but the latter's association with a coal deposit, plus the tendency toward a yellowish color for the utility pottery, suggests the use of coal for pottery-firing, as the Hopi did in the past. I would think that some additional field work would be worthwhile at this site.

PALACE OF THE GOVERNORS, FINE ARTS BUILDING, MUSEUM OF INTERNATIONAL FOLK ART, LABORATORY OF ANTHROPOLOGY, AND STATE MONUMENTS

Job No. E74-1072

Date

TABULATION OF TEST RESULTS

Client:

Project Church Rock Uranium Mill

Church Rock, New Mexico

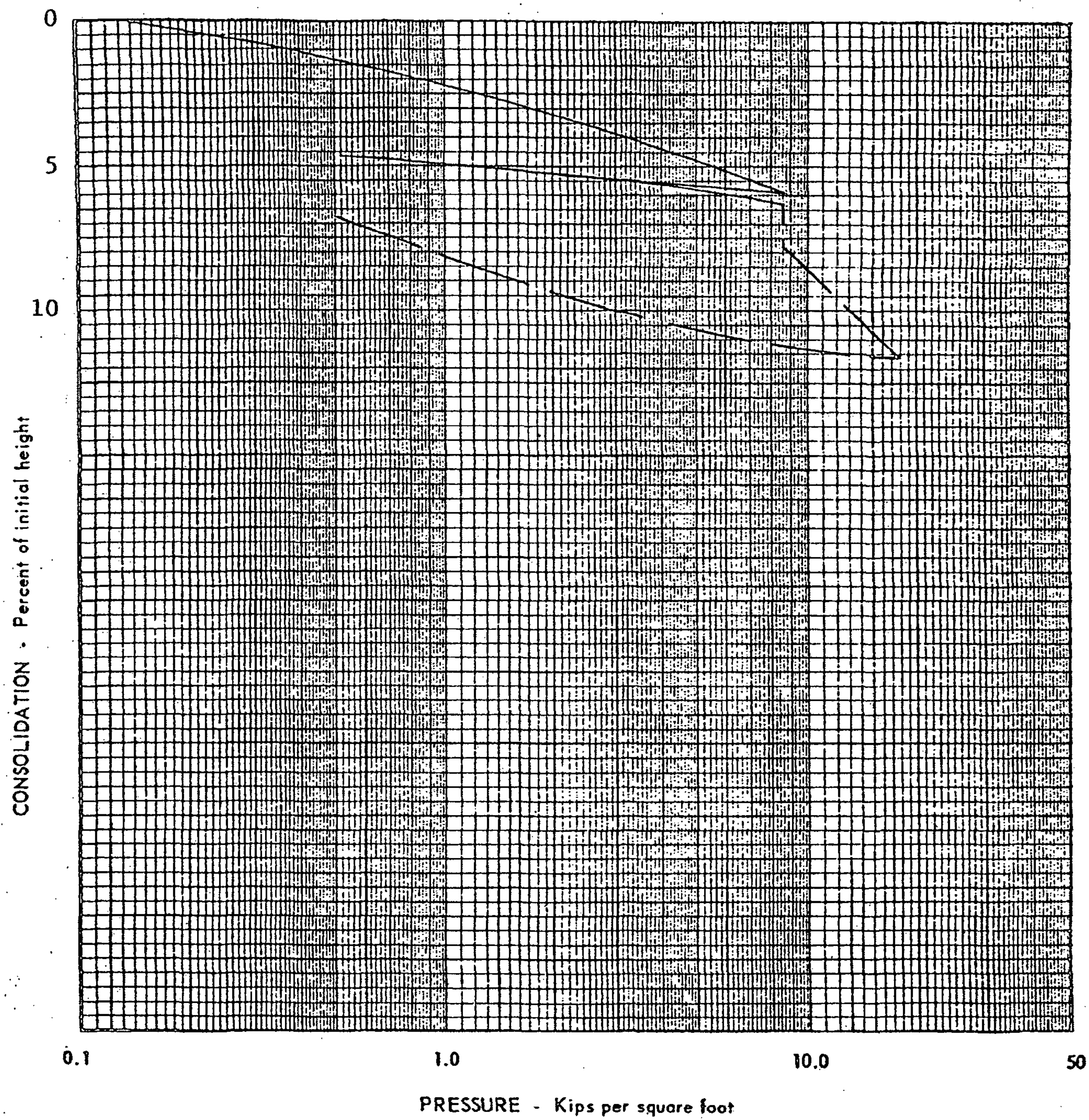
Material

Source

HOLE NO.	LOCATION	DEPTH	UNIFIED CLASS.	LL	PI	SIEVE ANALYSIS – ACCUM. % PASSING												LAB. NO.
						200	100	40	16	10	4	¼	⅜	¾	1	1½	2	
2	See Site Plan	10'	CL	38	20	92	98	99	99	99	100							1072-2
3	See Site Plan	5'	CH	62	45	70	87	99	99	99	100							1072-15
3	See Site Plan	10'	CL	44	27	77	93	99	99	99	100							1072-16
3	See Site Plan	15'	CL-ML	21	4	70	93	100										1072-17
4	See Site Plan	5'	ML		NP	55	82	96	98	99	99	100						1072-27
4	See Site Plan	10'	CL	46	29	98	99	99	100									1072-28
4	See Site Plan	20'	SC	29	11	39	79	99	99	99	100							1072-30
5	See Site Plan	15'	CL-ML	23	4	53	83	97	97	97	100							1072-90
7	See Site Plan	5'	CL	33	15	75	91	96	96	98	98	98	100					1072-41
	Block Sample #19		CL	33	18	84	95	99	100									1072-75
	Block Sample #118		CL	42	27	98	99	100										1072-76
	Mine Tailings					18	30	74	97	99	100							1072-77
	Composite Gradation																	
	+#100 = 485 gms -#100 = 15 gms					4	9	64	91	94	98	99	100					1072-80

SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT		UNIFIED SOIL CLASSIFICATION
			INITIAL	FINAL	
A	Boring #4 @ 10'	104.28	12.4	20.6	CL

SOIL MOISTURE CONDITION

———— INSITU

– – – – SUBMERGED

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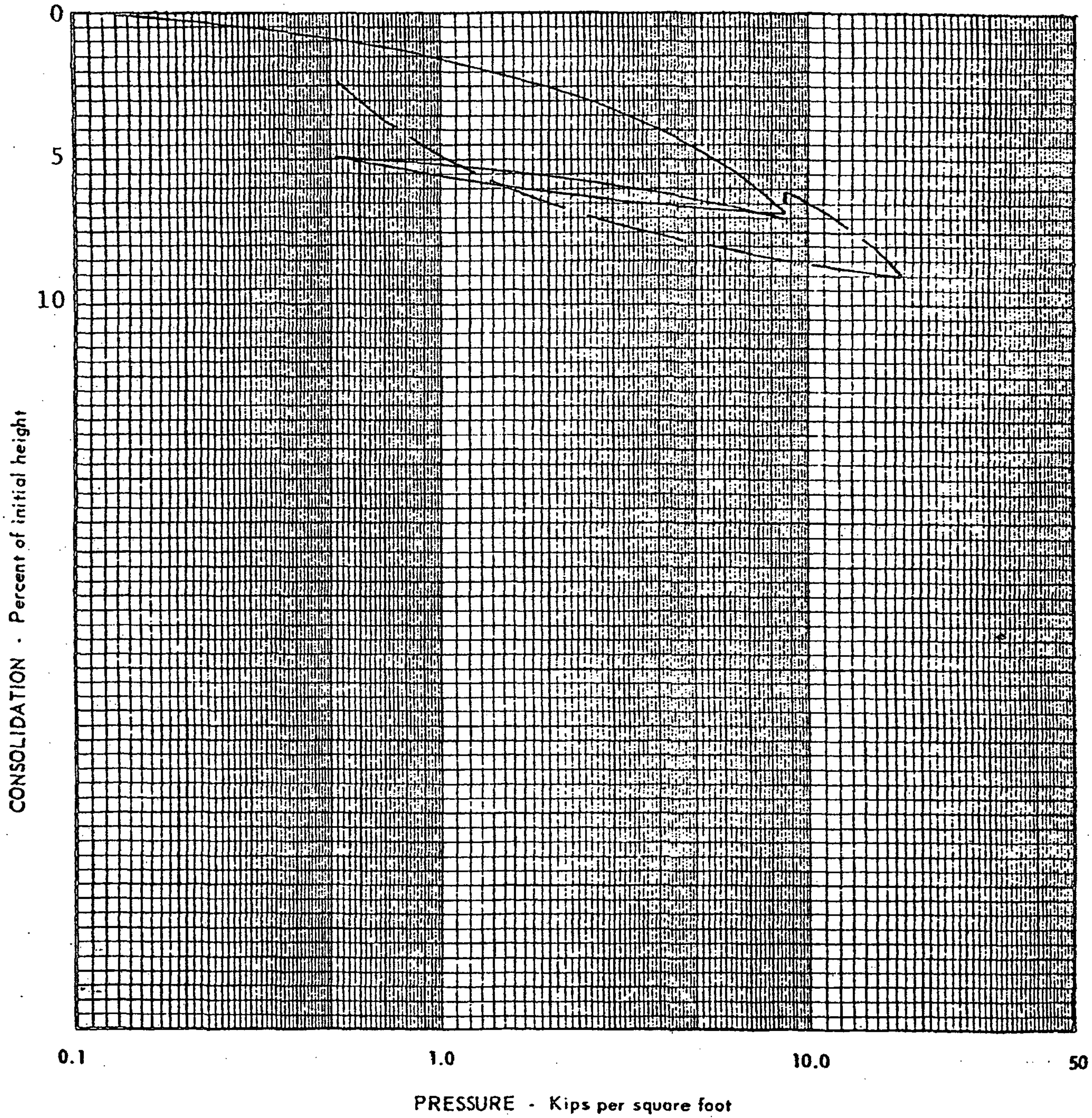
SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT INITIAL	MOISTURE CONTENT % DRY WEIGHT FINAL	UNIFIED SOIL CLASSIFICATION
B	Boring #4 @ 15'	104.3	13.8	22.6	CL

SOIL MOISTURE CONDITION

——— INSITU
– – – – SUBMERGED

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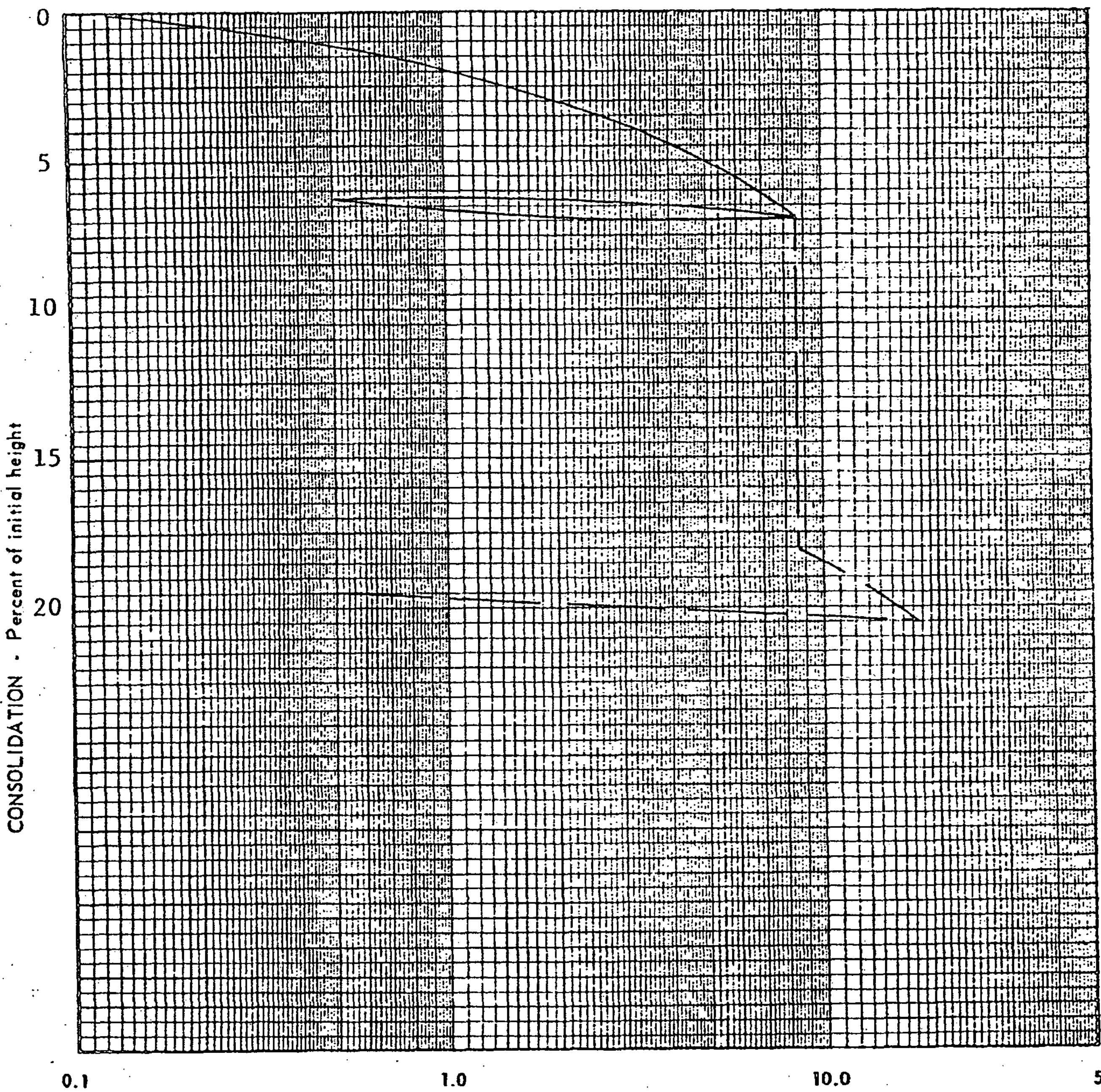
SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT		UNIFIED SOIL CLASSIFICATION
			INITIAL	FINAL	
C	Boring #5 @ 5'	91.1	5.6	17.1	SM

SOIL MOISTURE CONDITION

——— INSITU

– – – – SUBMERGED

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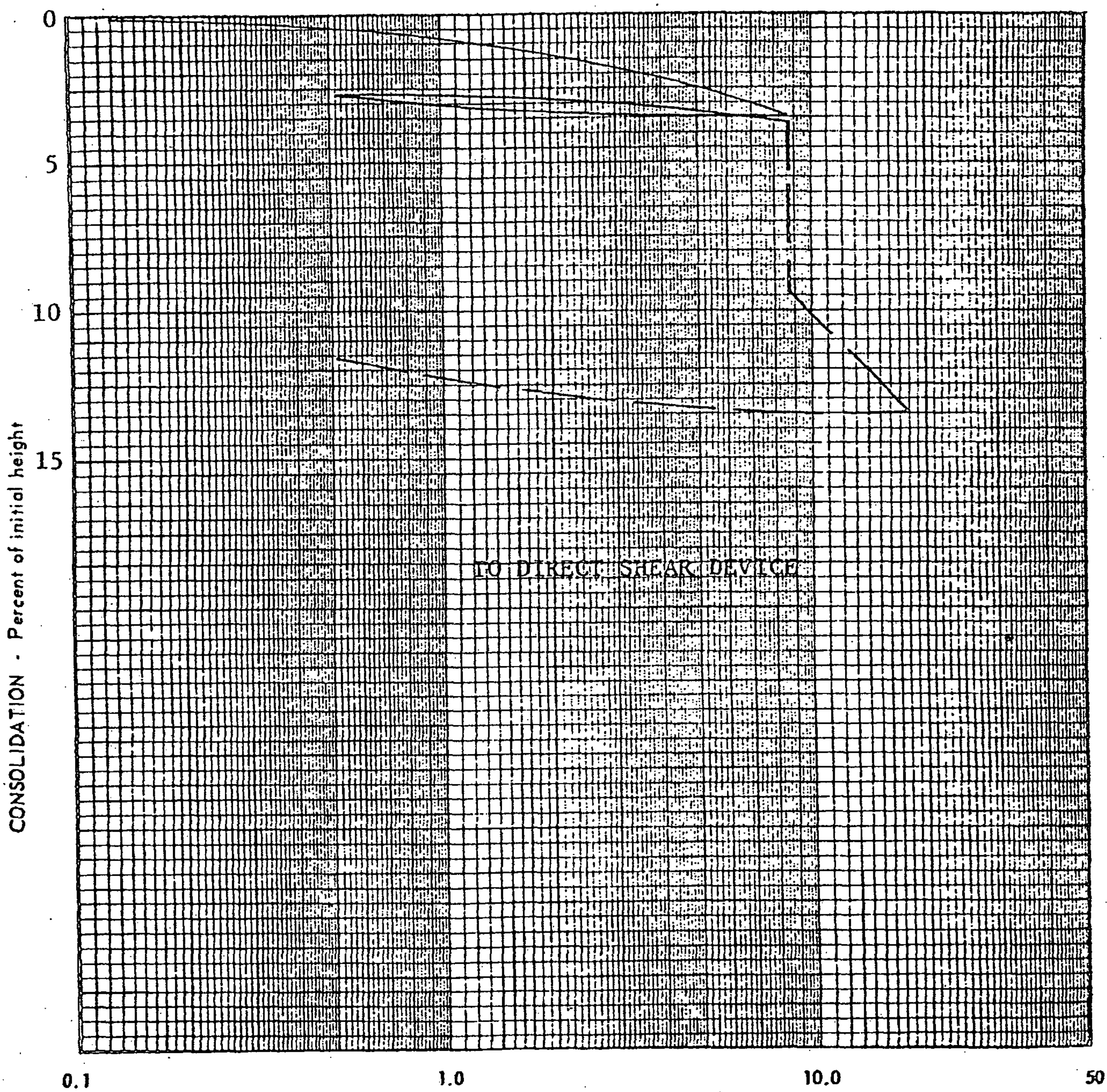
SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT INITIAL	MOISTURE CONTENT % DRY WEIGHT FINAL	UNIFIED SOIL CLASSIFICATION
D	Boring #5 @ 10'	104.6	10.4	16.7	SM

SOIL MOISTURE CONDITION

——— INSITU

– – – – SUBMERGED

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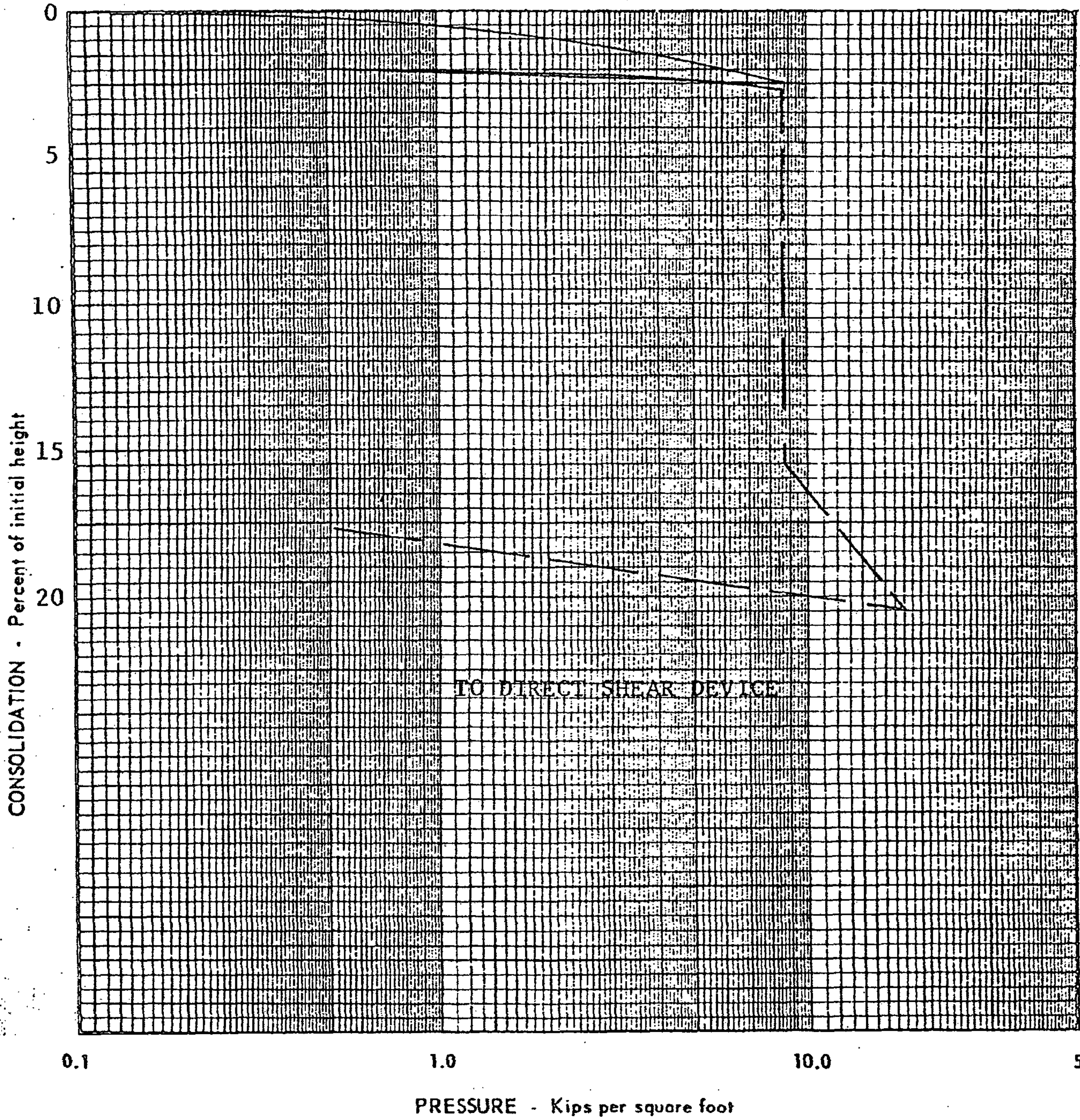
SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT		UNIFIED SOIL CLASSIFICATION
			INITIAL	FINAL	
E	Block Sample #19	87.3	12.7	23.3	

SOIL MOISTURE CONDITION

——— INSITU

– – – – SUBMERGED

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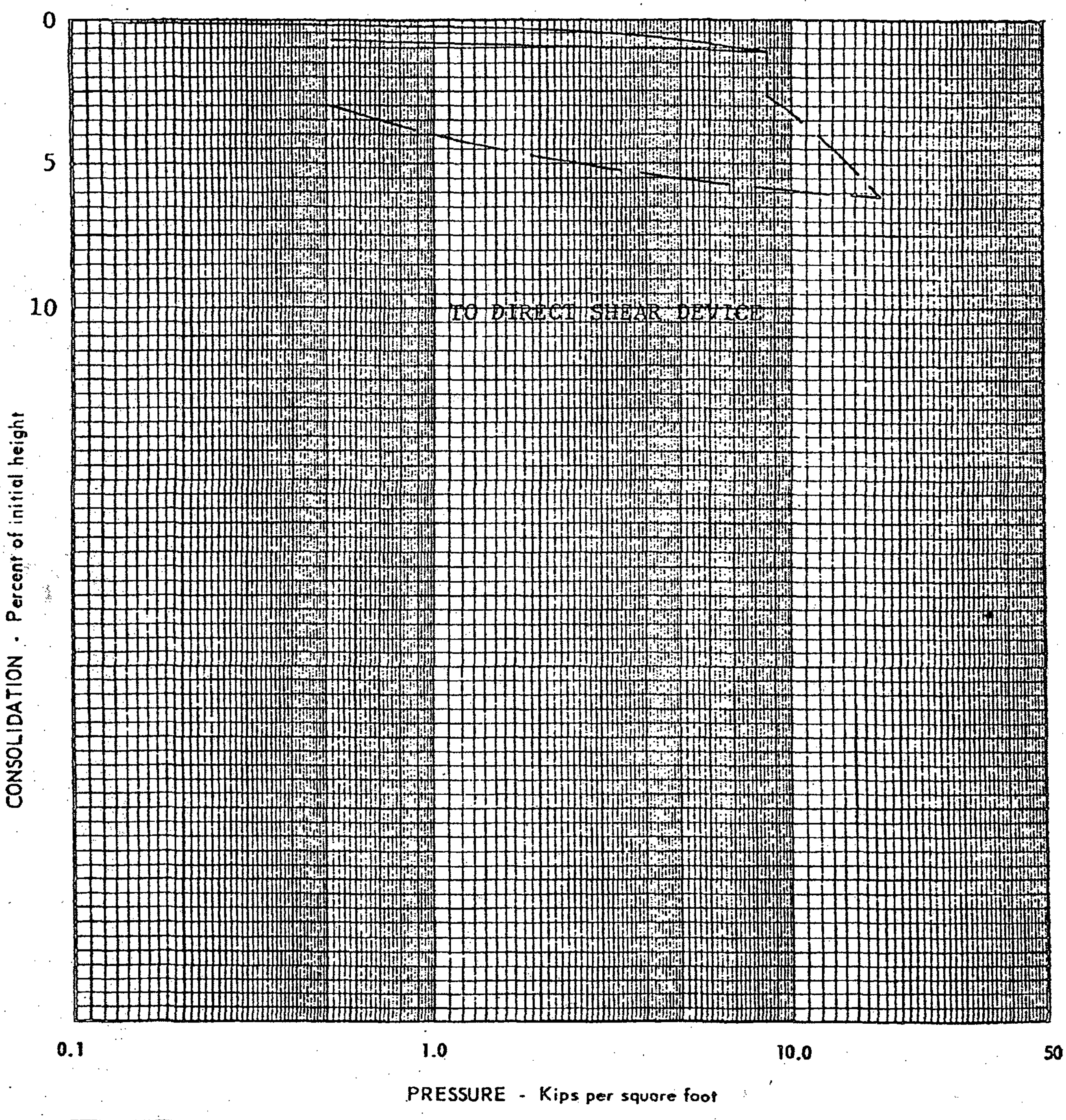
SUMMARY OF CONSOLIDATION TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT INITIAL	MOISTURE CONTENT % DRY WEIGHT FINAL	UNIFIED SOIL CLASSIFICATION
F	Block Sample #118	102.6	6.2	19.5	

SOIL MOISTURE CONDITION

——— INSITU
– – – – SUBMERGED

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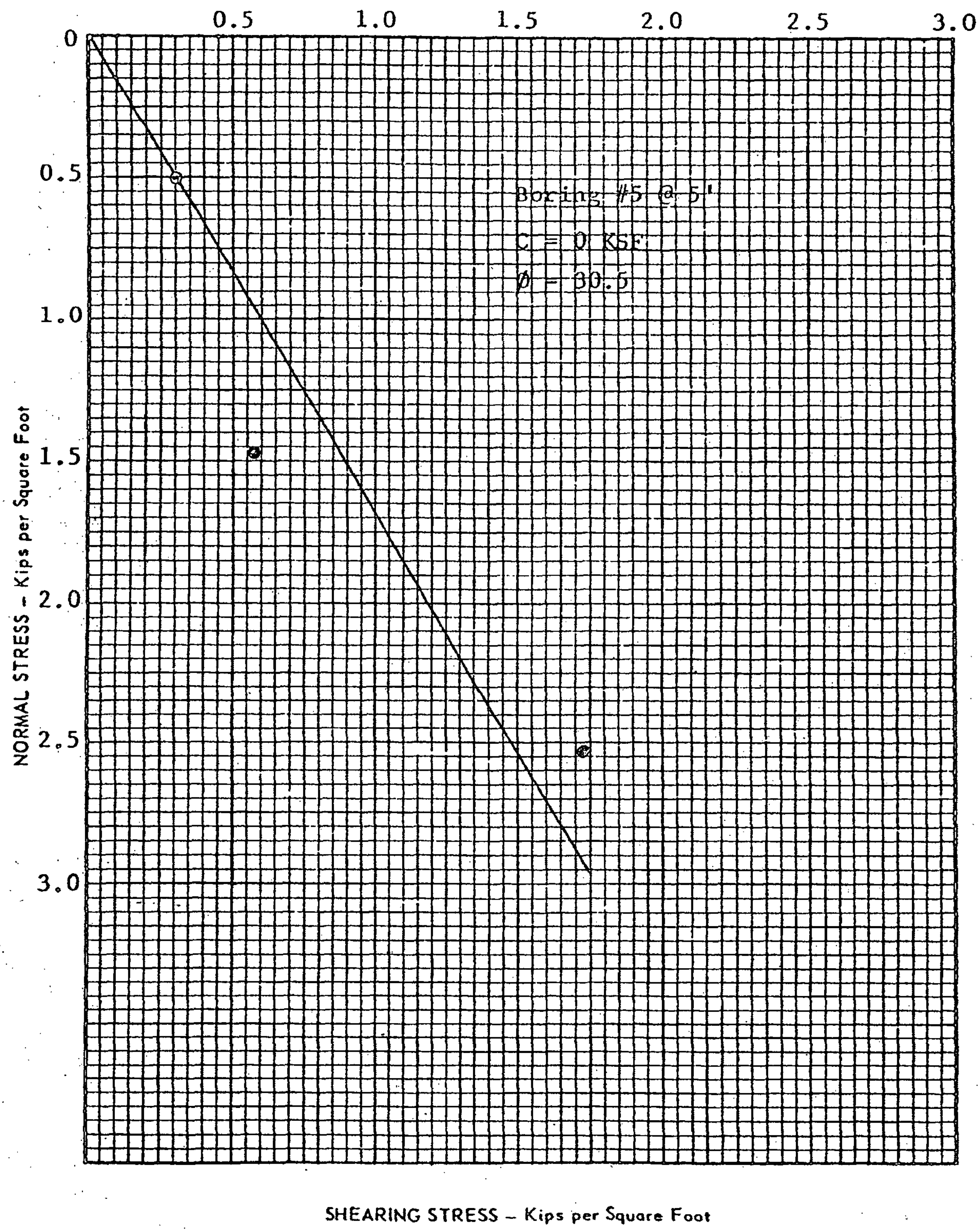
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO E74-1072



SOIL MOISTURE CONDITION

o – INSITU

⊗ – SUBMERGED

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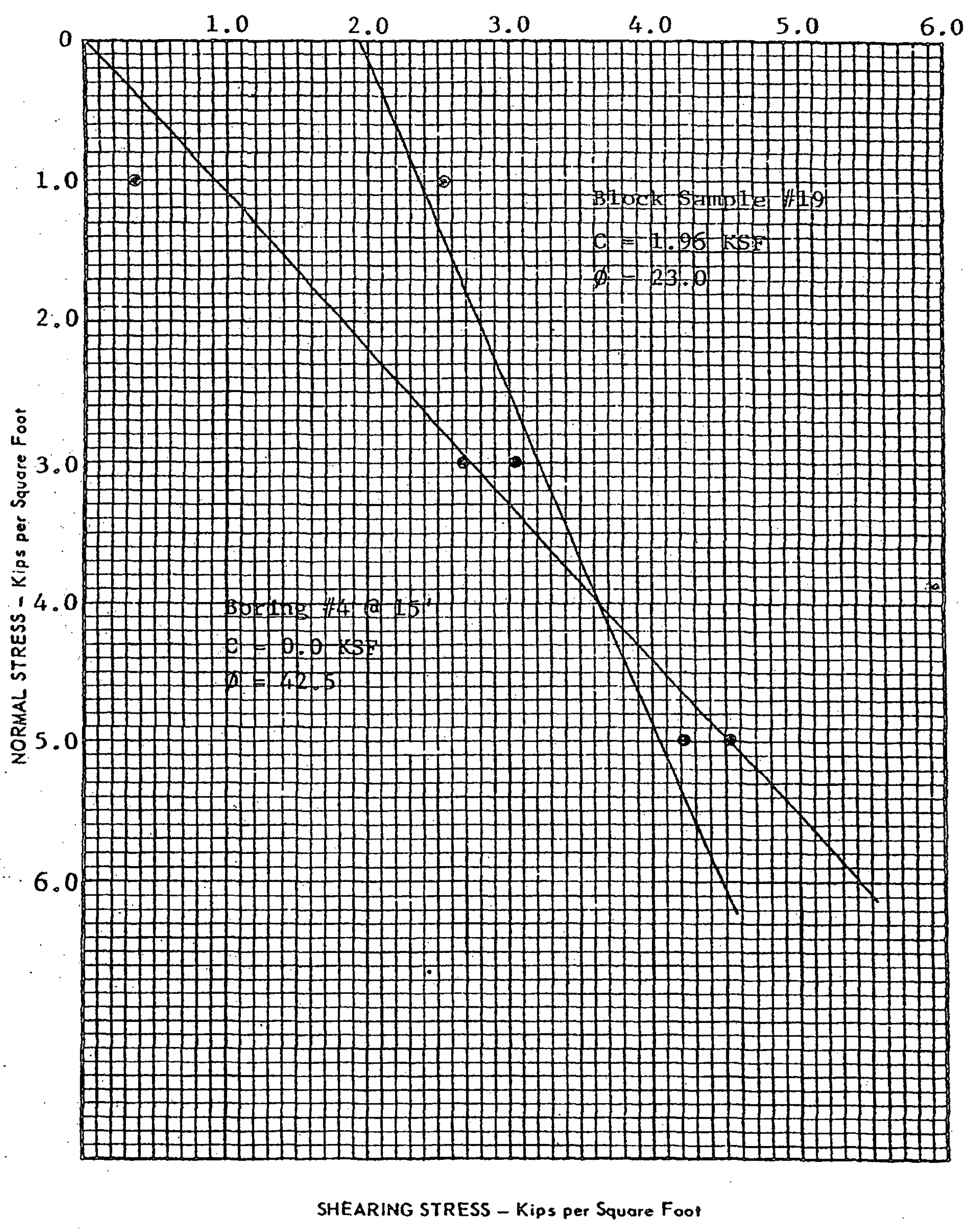
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



SOIL MOISTURE CONDITION
O - INSITU
⊗ - SUBMERGED

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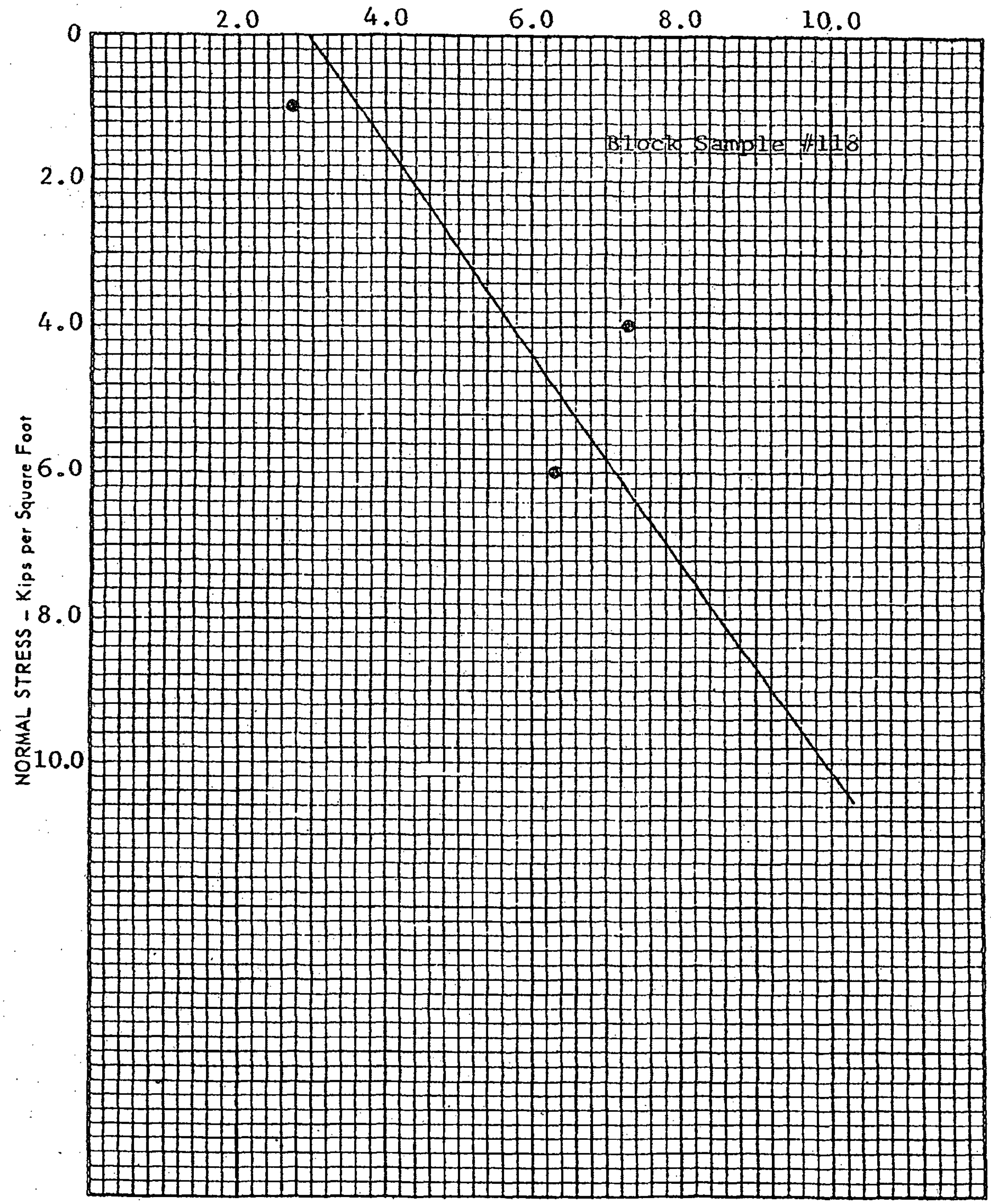
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



SOIL MOISTURE CONDITION

o – INSITU
⊗ – SUBMERGED

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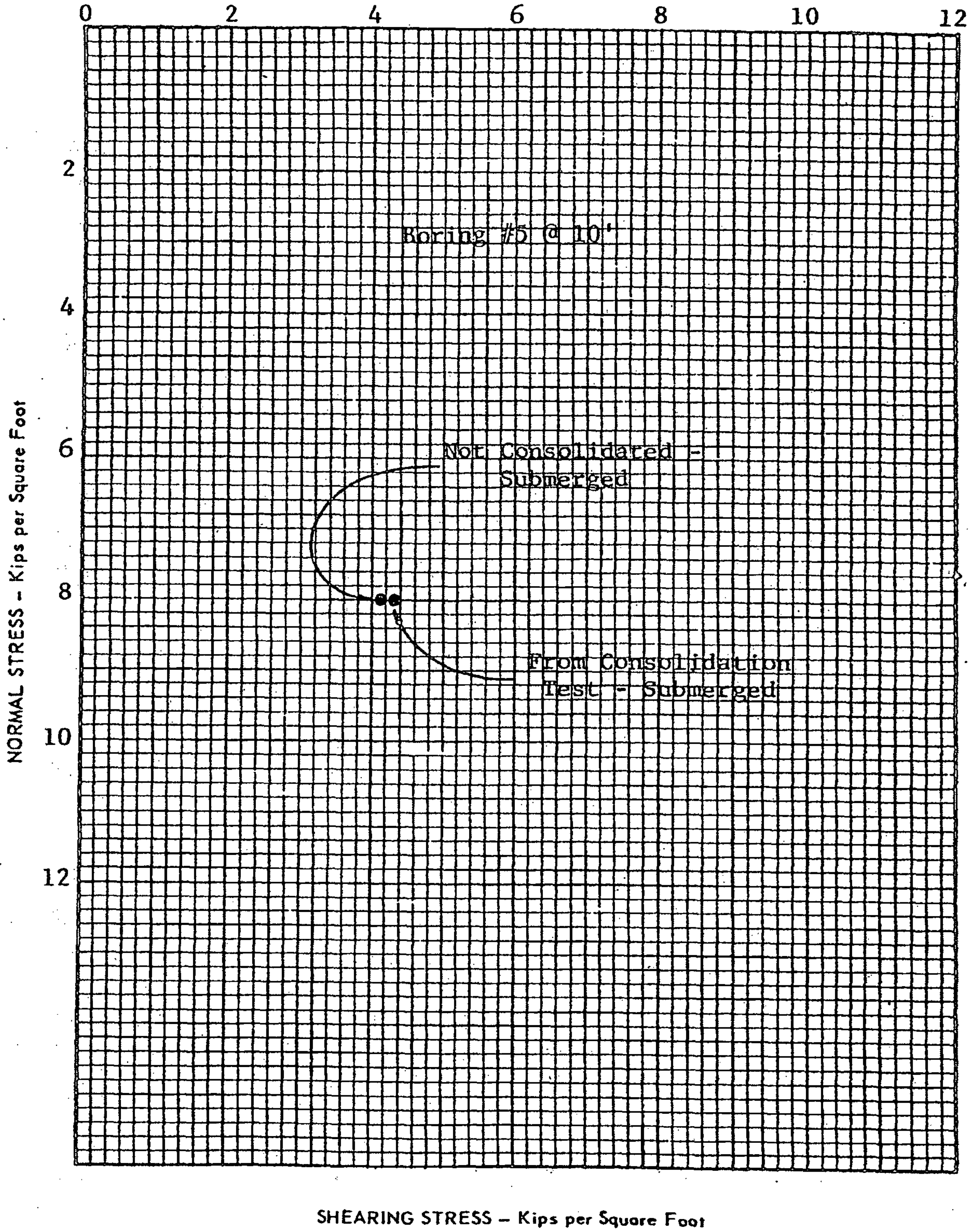
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



SOIL MOISTURE CONDITION

o – INSITU
⊗ – SUBMERGED

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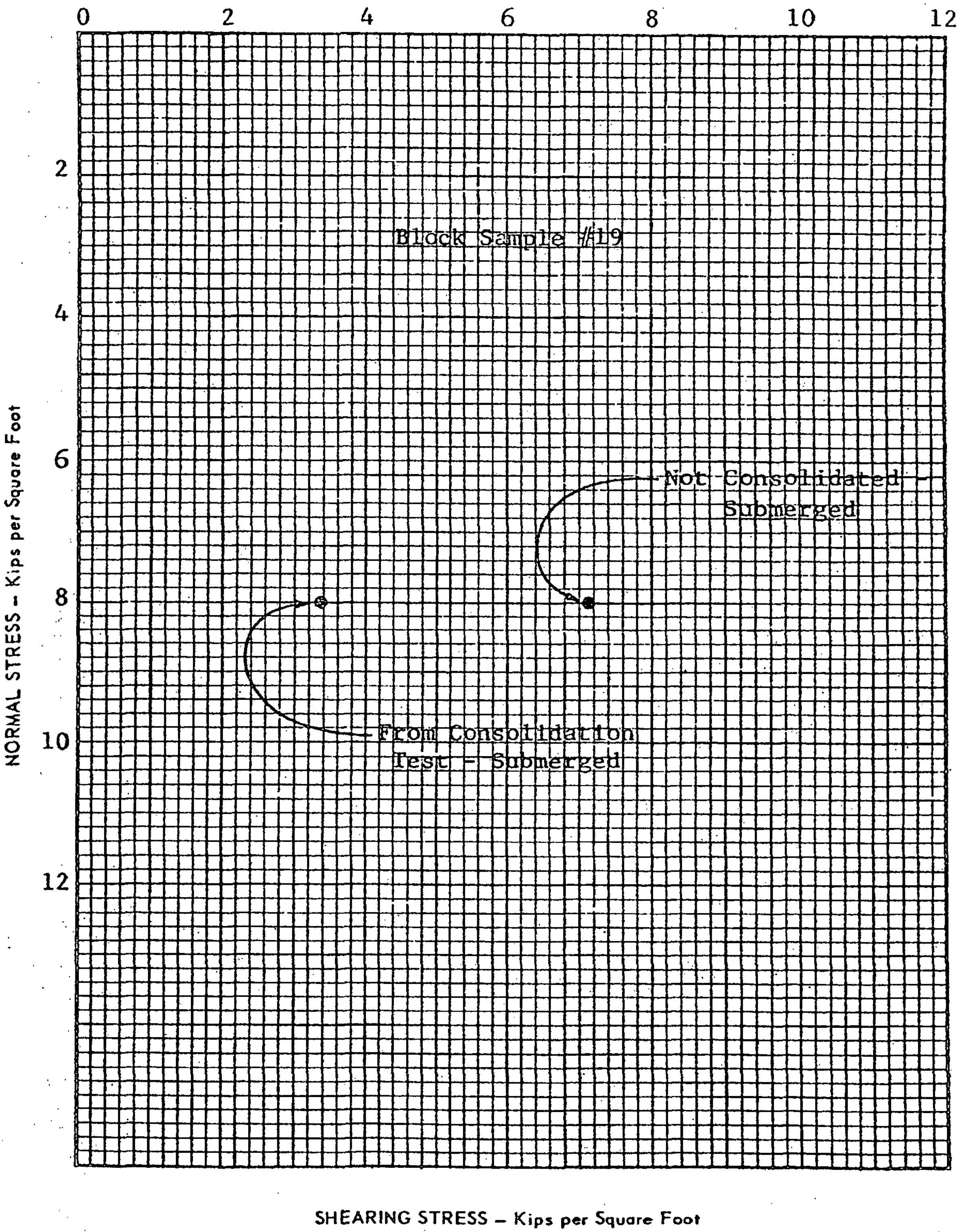
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



SOIL MOISTURE CONDITION

O - INSITU
⊗ - SUBMERGED

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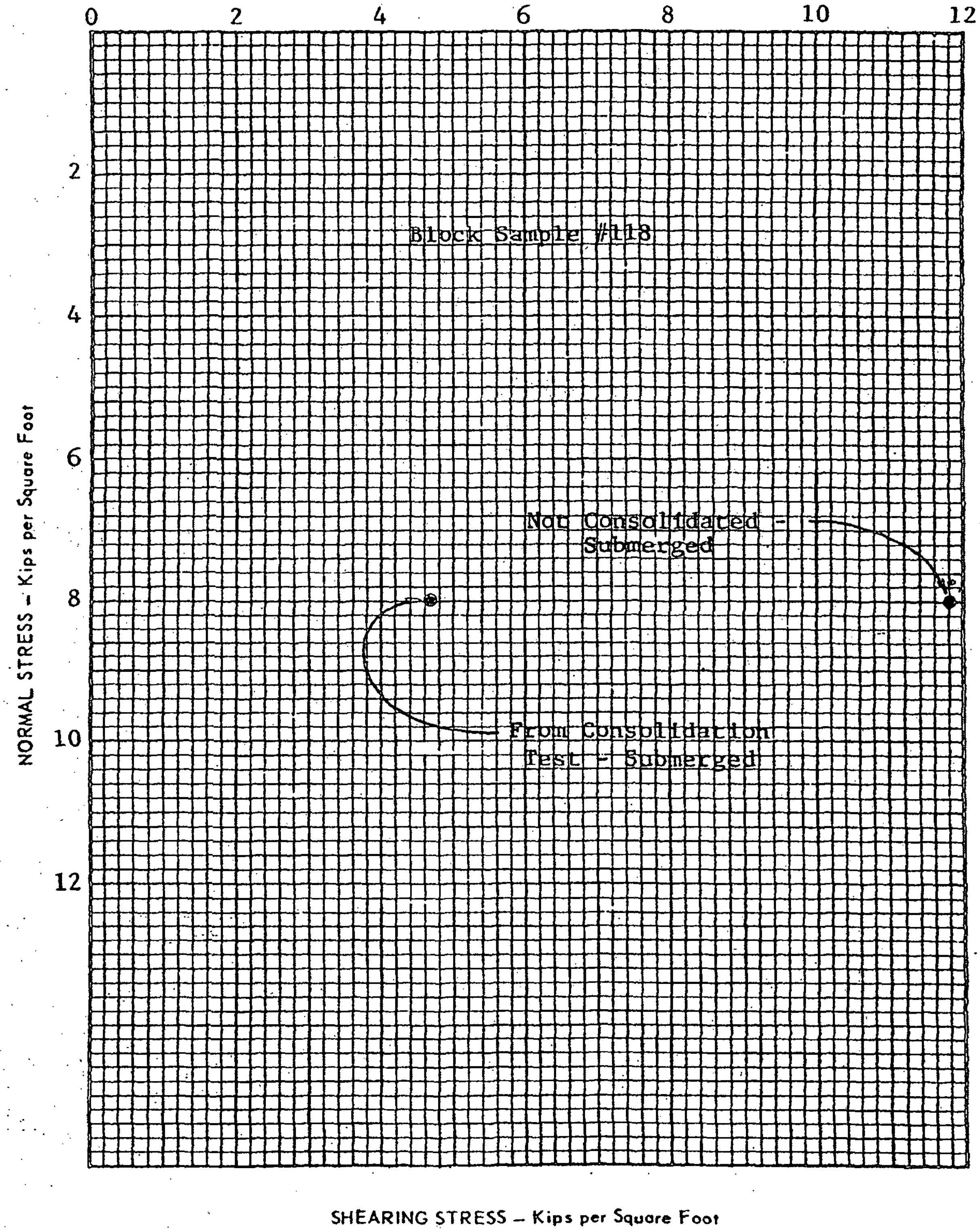
SUMMARY OF DIRECT SHEAR TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



SOIL MOISTURE CONDITION

O – INSITU
⊛ – SUBMERGED

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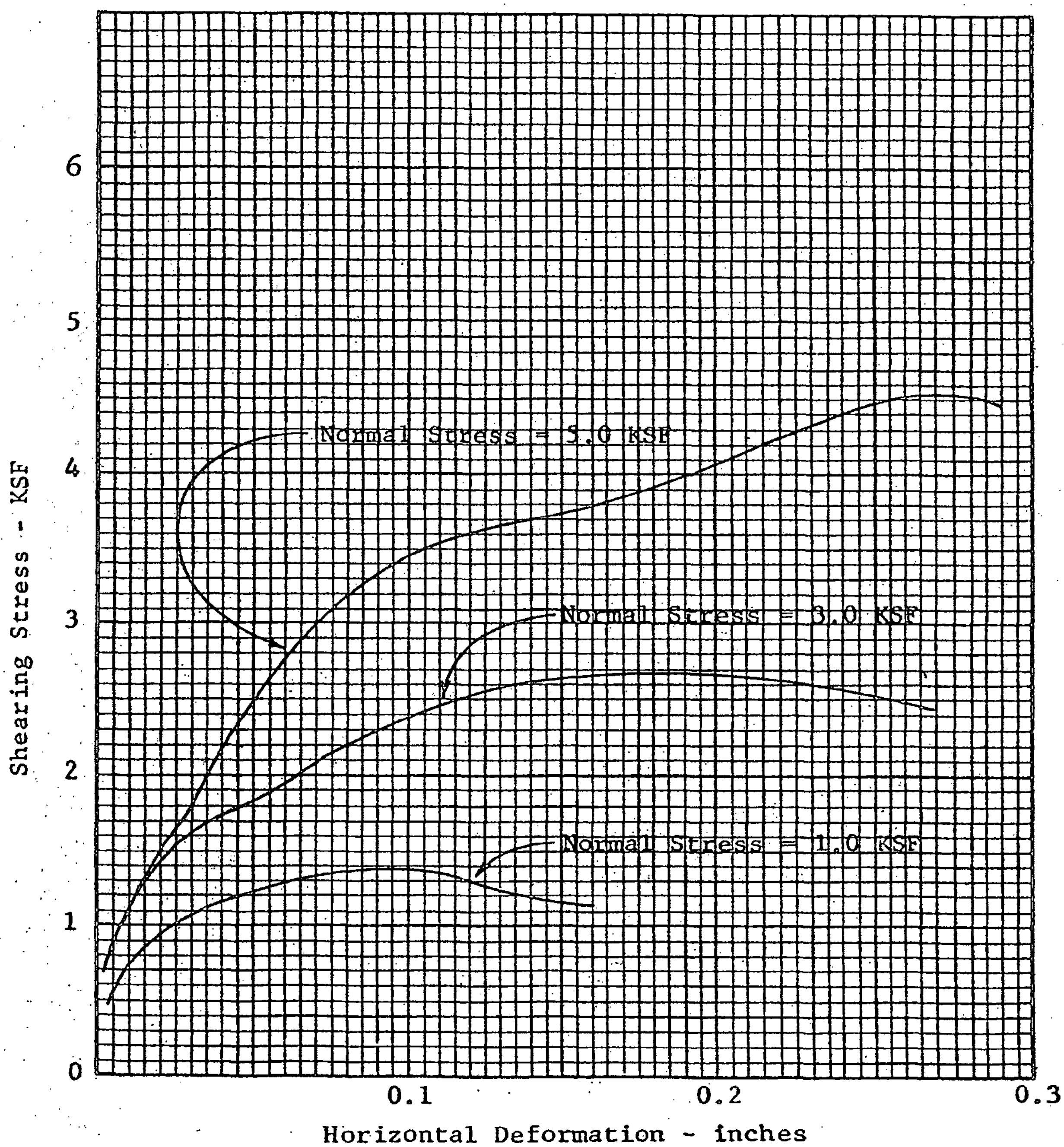
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

STRESS DEFORMATION CURVES
from Direct Shear Tests

Boring #4 @ 15'



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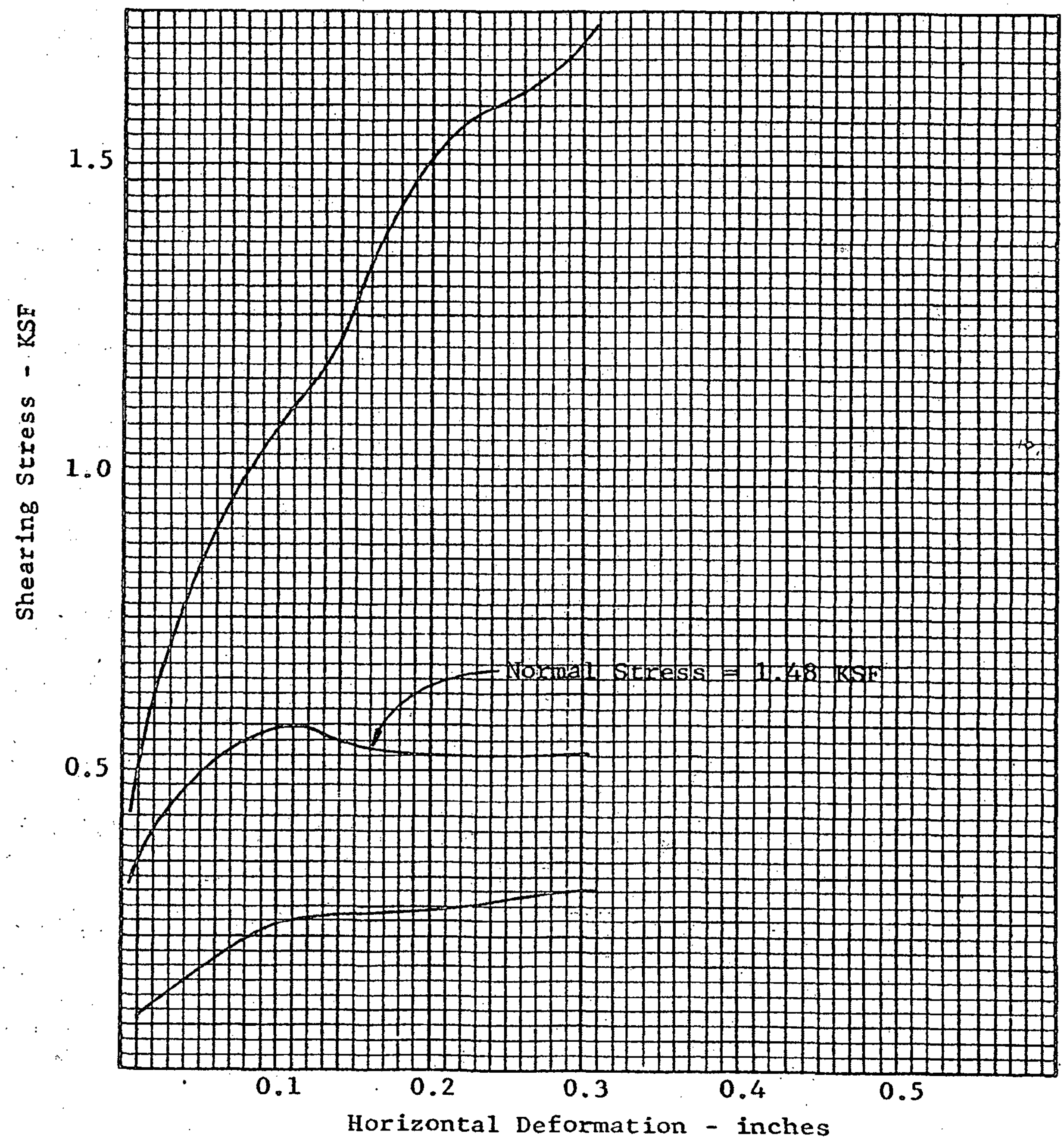
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

STRESS DEFORMATION CURVES
from Direct Shear Tests

Boring #5 @ 5'



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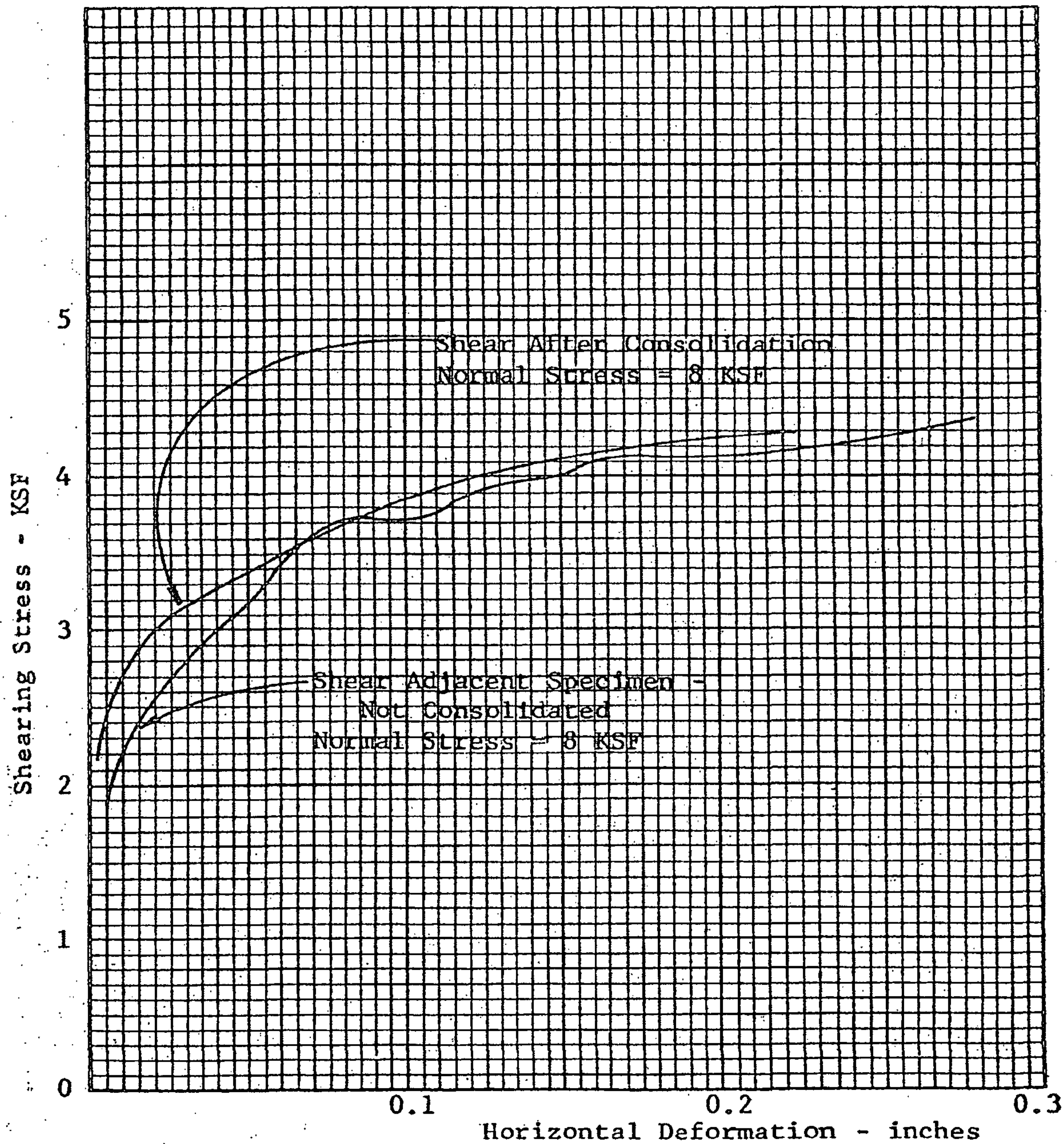
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

STRESS DEFORMATION CURVES
from Direct Shear Tests

Boring #5 @ 10'



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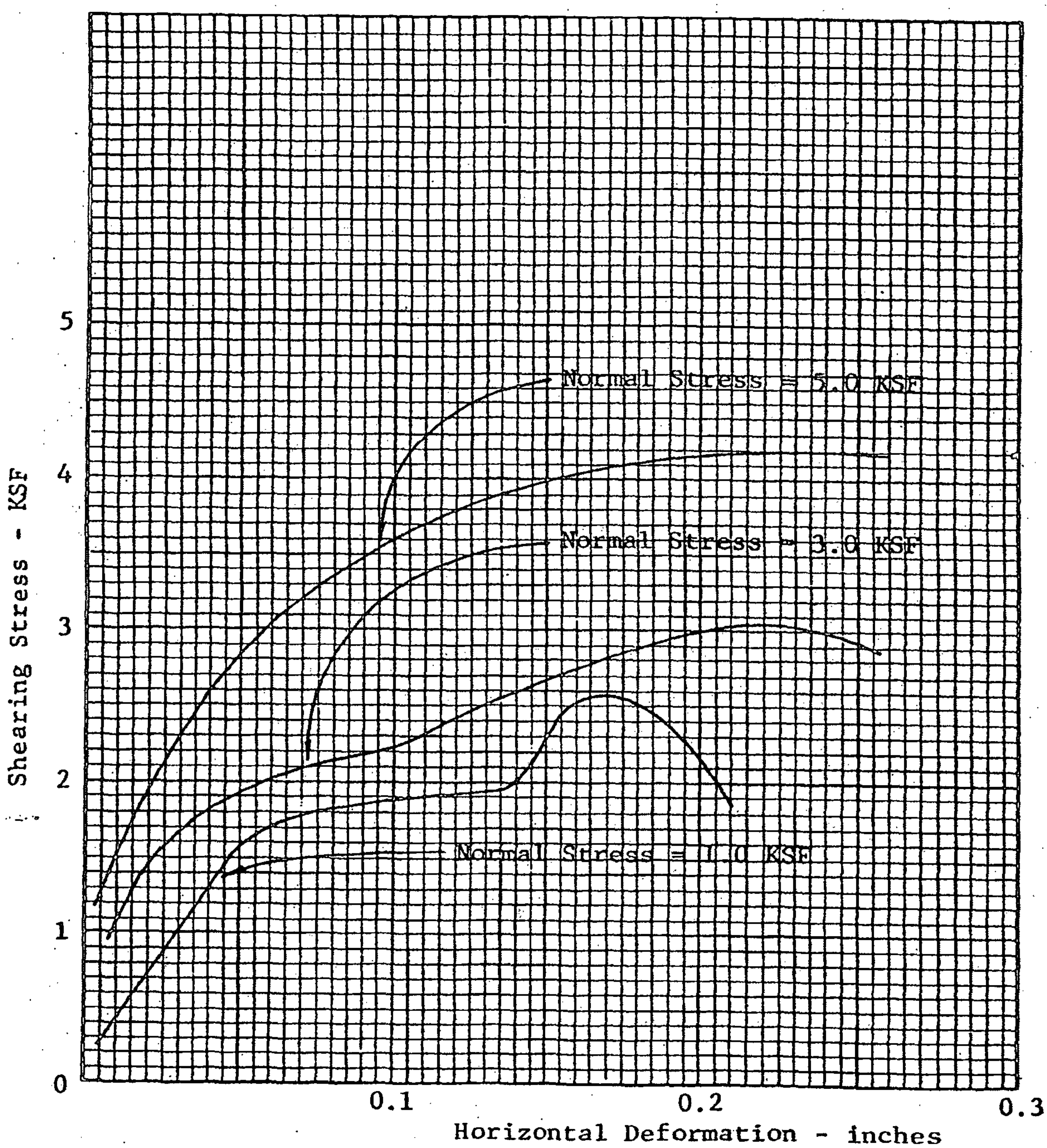
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

STRESS DEFORMATION CURVES
from Direct Shear Tests

Block Sample #19



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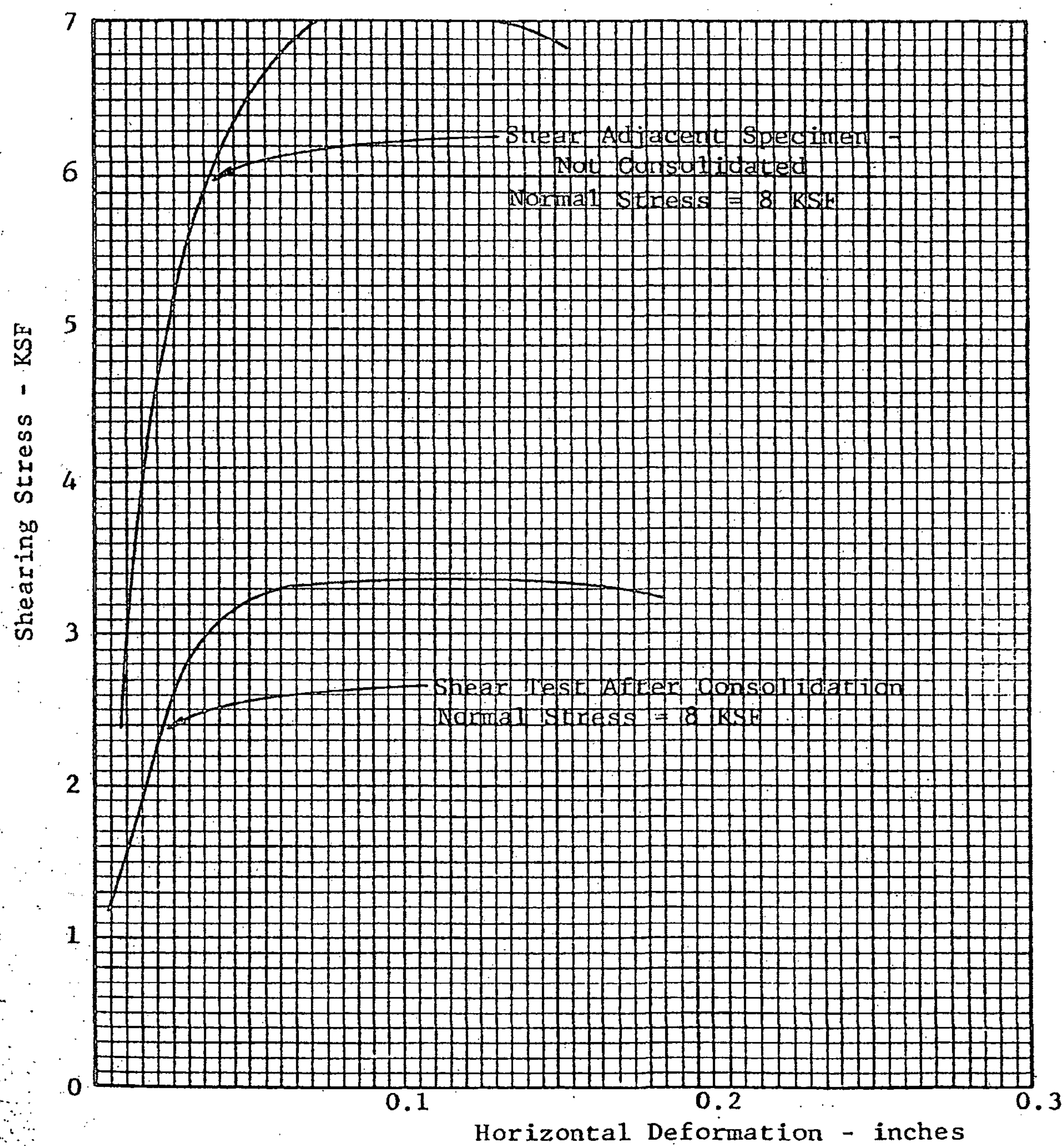
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

STRESS DEFORMATION CURVES
from Direct Shear Tests

Block Sample #19



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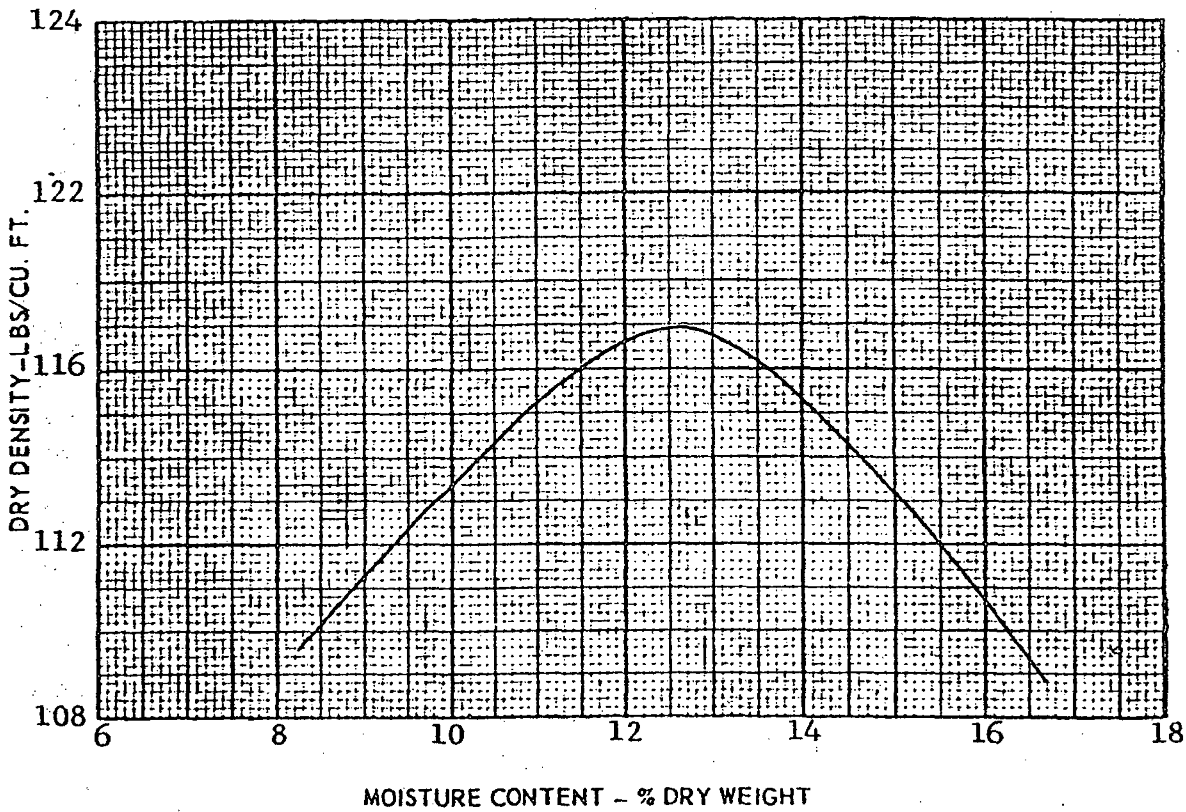
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Church Rock Uranium Mill JOB NO. E74-1072



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	Block Sample #19	12.5	116.0	ASTM D1557	C	4-1072-86

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHO T99-61 and ASTM D 698-66T (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHO T180-61 and ASTM 1557-66T (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	4"	4.58"	5	25	10.0 LBS.	18"	56,260
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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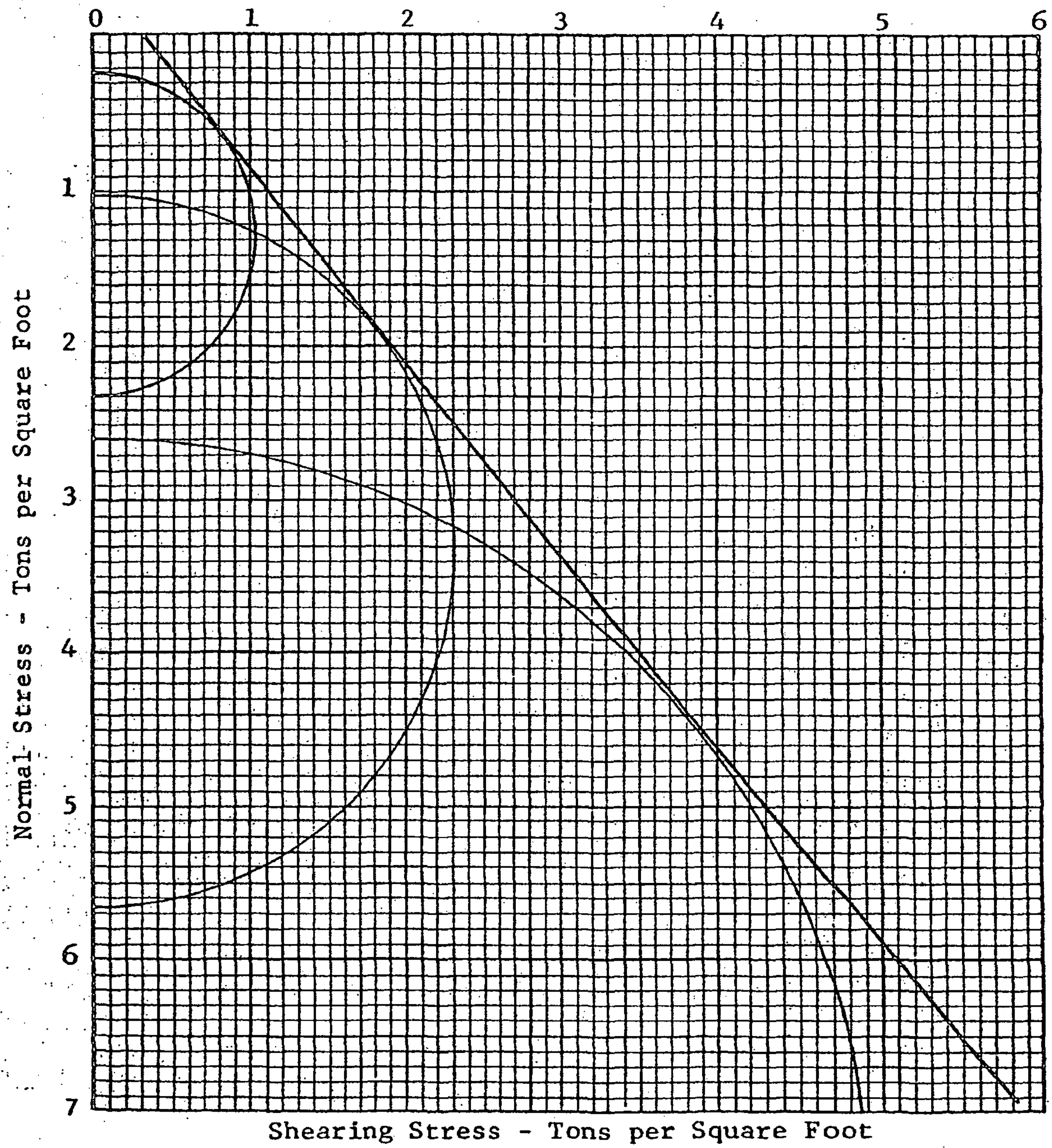
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

SUMMARY OF TRIAXIAL SHEAR TESTS



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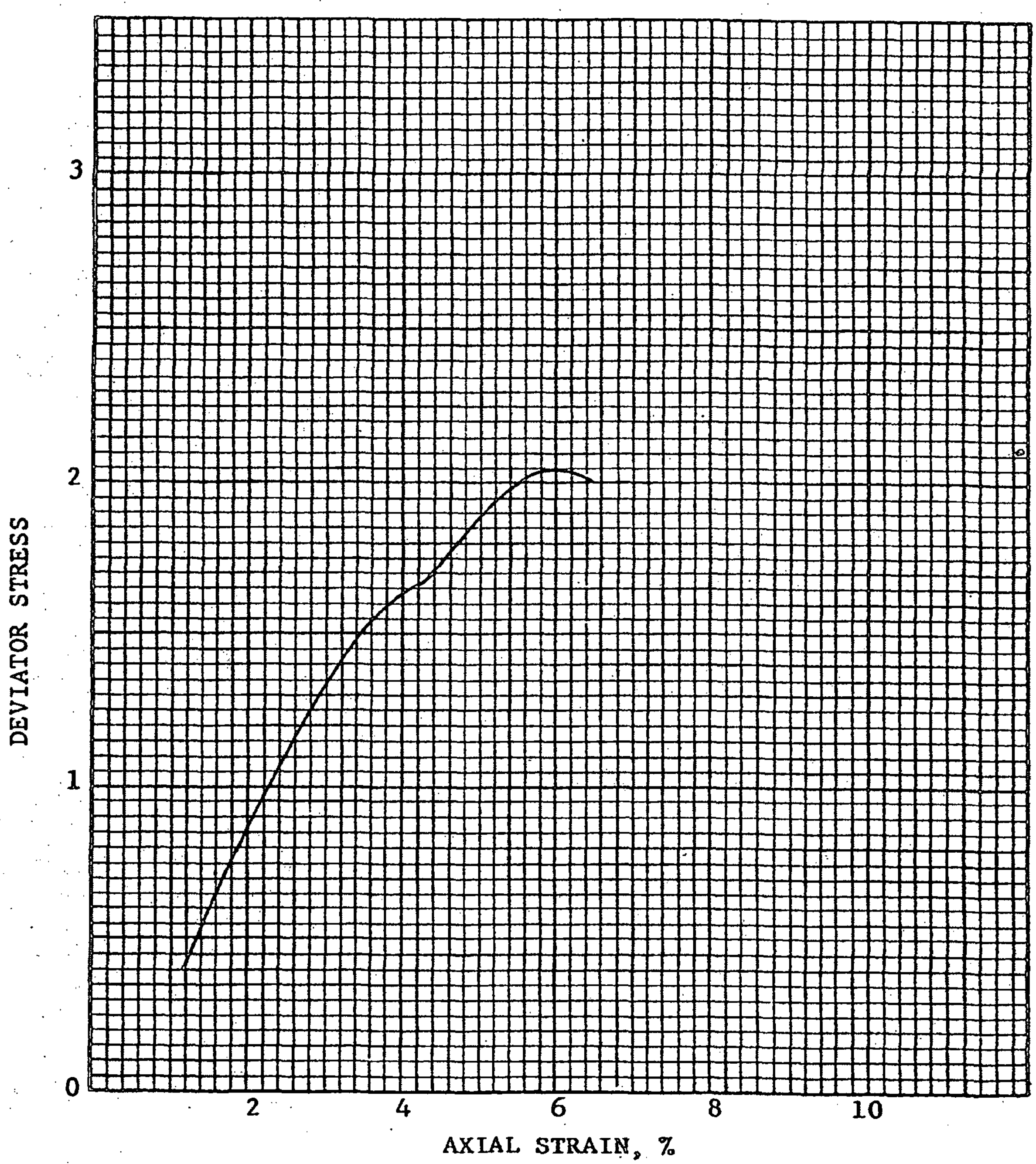
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

Sample No. 1-83

TRIAXIAL STRESS-STRAIN CURVE

CONFINING STRESS @ 3.5 PSI
0.25 TSF



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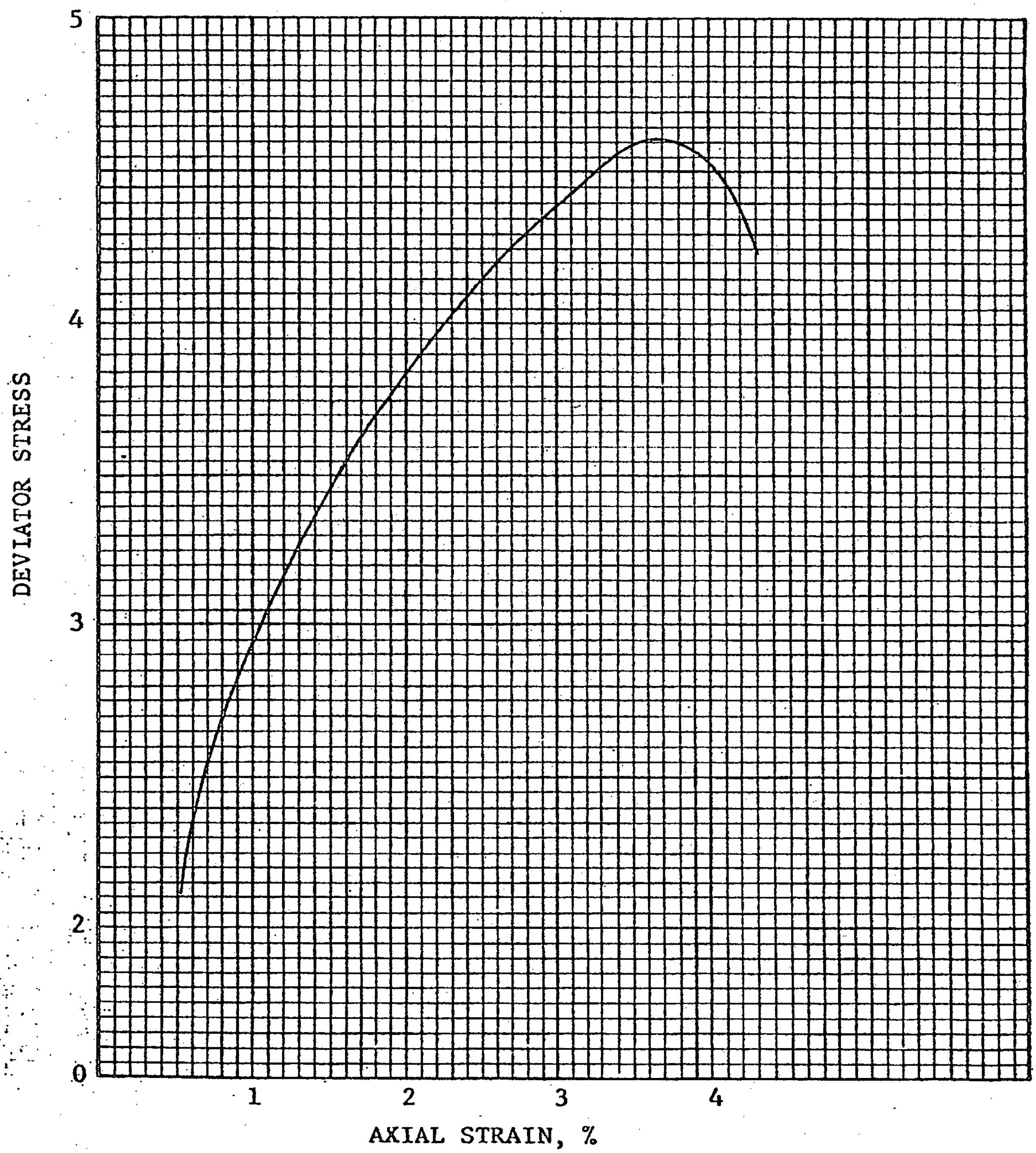
PROJECT Church Rock Uranium Mill JOB NO. E74-1072

Sample No. 2-83

TRIAXIAL STRESS-STRAIN CURVE

CONFINING STRESS @ 14.0 PSI
1.01 TSF



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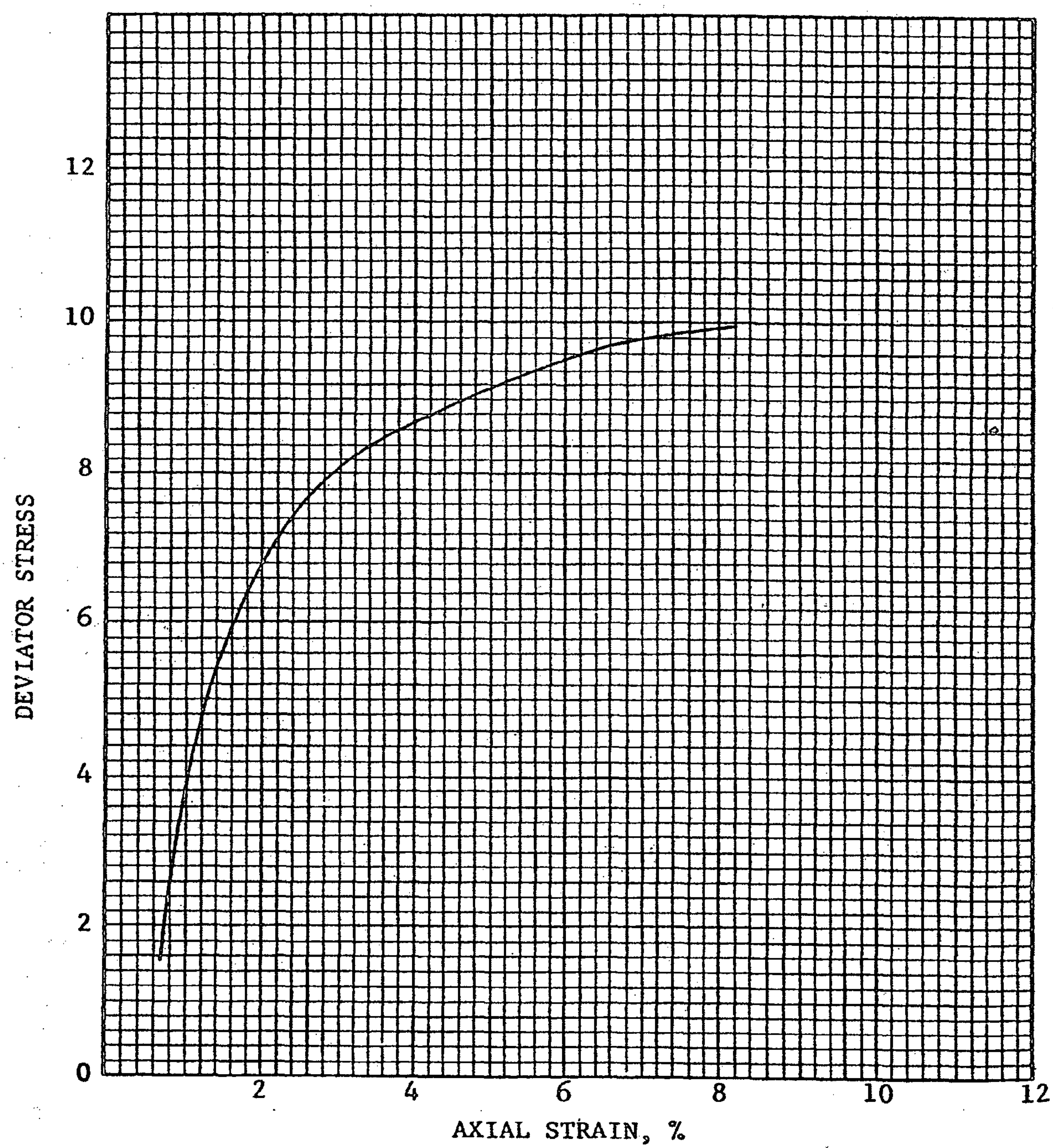
PROJECT Church Rock Uranium Mill JOB NO. E74-1072
Sample No. 3-83

TRIAXIAL STRESS-STRAIN CURVE

CONFINING STRESS @ 35.0 PSI
2.52 TSF



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MATERIALS TESTING ENGINEERS
ENGINEERING ANALYSIS • PHYSICAL TESTING • QUALITY CONTROL • FIELD EXPLORATION

REPORT ON LABORATORY TESTS

DATE

PROJECT Church Rock Uranium Mill JOB NO. E74-1072

LOCATION Church Rock, New Mexico LAB NO. 4-1072-82

CLIENT ADDRESS

SOURCE OF SAMPLE No. 4-1072

MATERIAL SAMPLED BY

SUBMITTED BY REQUESTED BY

TESTED ASTM D2434-68 DATE RECEIVED

TEST RESULTS

REMOLDED PERMEABILITY

*Maximum Dry Density (Wet Method)	102.8 pcf
70% of Maximum Relative Density	98.5 pcf
Initial Dry Density at 70% of Relative Density	98.5 pcf
Initial Moisture Content	19.0%
Percent of Maximum Density	70.0%
Percent Saturation	87.7%
Head	6.04 ft.
Volume of Sample	2080 cc
Coefficient of Permeability	2.29×10^{-3} cm/sec.
Specific Gravity	2.562
Coefficient of Permeability	2375 ft/yr.

Note: *Relative Density per ASTM D2049 (Lab No. 4-1072-81).
Specimen Remolded to 70% of Maximum Relative Density.

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ENGINEERING ANALYSIS • PHYSICAL TESTING • QUALITY CONTROL • FIELD EXPLORATION

REPORT ON LABORATORY TESTS

DATE ____________

PROJECT Church Rock Uranium Mill JOB NO. E74-1072

LOCATION Church Rock, New Mexico LAB NO. 4-1072-83

TRIAXIAL COMPRESSION TEST
(SPECIMEN DATA)

Specimen No.	1	2	3
INITIAL			
Diameter, cm.	7.112	7.112	7.112
Height, cm.	15.187	15.187	15.187
Water Content, %	19.3	19.3	19.0
Dry Density, PCF	97.7	98.2	97.9
Saturation, %	77.8	78.7	77.1
Void Ratio	0.64	0.63	0.63
AFTER SHEAR			
Specific Gravity	2.562	2.562	2.562
Saturation, %	91.9	93.8	99.3
Confining Stress, PSI	3.5	14	35
Maximum Deviator Stress, TSF	2.05	4.60	9.90
Time to Maximum Deviator Stress, Minutes	27	19	56
Type of Test & Controlled Loading	Consolidated-drained, strain controlled		
Sample Identification Lab No.	4-1072-83		

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REPORT ON LABORATORY TESTS

DATE ______

PROJECT Church Rock Uranium Mill JOB NO. E74-1072

LOCATION Church Rock, New Mexico LAB NO. 4-1072-83

TRIAXIAL COMPRESSION TEST
(SPECIMEN DATA)

Specimen No.	1	2	3
INITIAL			
Diameter, cm.	7.112	7.112	7.112
Height, cm.	15.187	15.187	15.187
Water Content, %	19.3	19.3	19.0
Dry Density, PCF	97.7	98.2	97.9
Saturation, %	77.8	78.7	77.1
Void Ratio	0.64	0.63	0.63
AFTER SHEAR			
Specific Gravity	2.562	2.562	2.562
Saturation, %	91.9	93.8	99.3
Confining Stress, PSI	3.5	14	35
Maximum Deviator Stress, TSF	2.05	4.60	9.90
Time to Maximum Deviator Stress, Minutes	27	19	56
Type of Test & Controlled Loading	Consolidated-drained, strain controlled		
Sample Identification Lab No.	4-1072-83		

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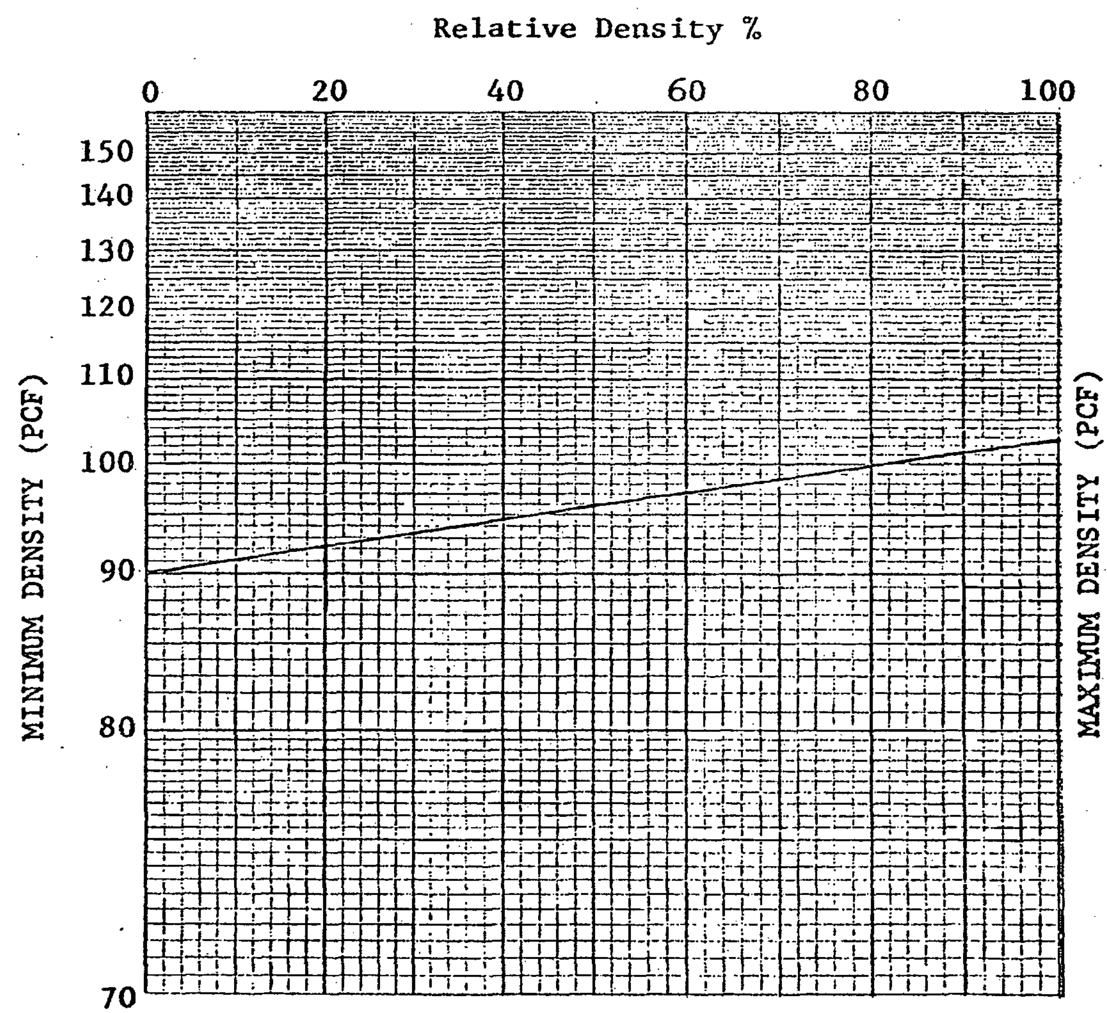
Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

RELATIVE DENSITY

Minimum Density - PCF 90.17

Maximum Density - PCF 102.80

Preparation Method - Wet



Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

RESULTS OF FIELD PERMEABILITY TESTS (E-19)*

Location	Depth	Coefficient of Permeability
Boring No. 4	10.0'	4.0 feet/year
Boring No. 12	10.0'	3.8 feet/year
Boring No. 15	10.0'	27.0 feet/year

* The tests were performed by the E-19 permeability test method (U. S. Bureau of Reclamation, 1963) in 6½" diameter borings.

Tailings Dam
Church Rock Uranium Mill
United Nuclear Corporation
Church Rock, New Mexico
Job No. E74-1072

RESULTS OF SEISMIC SURVEY

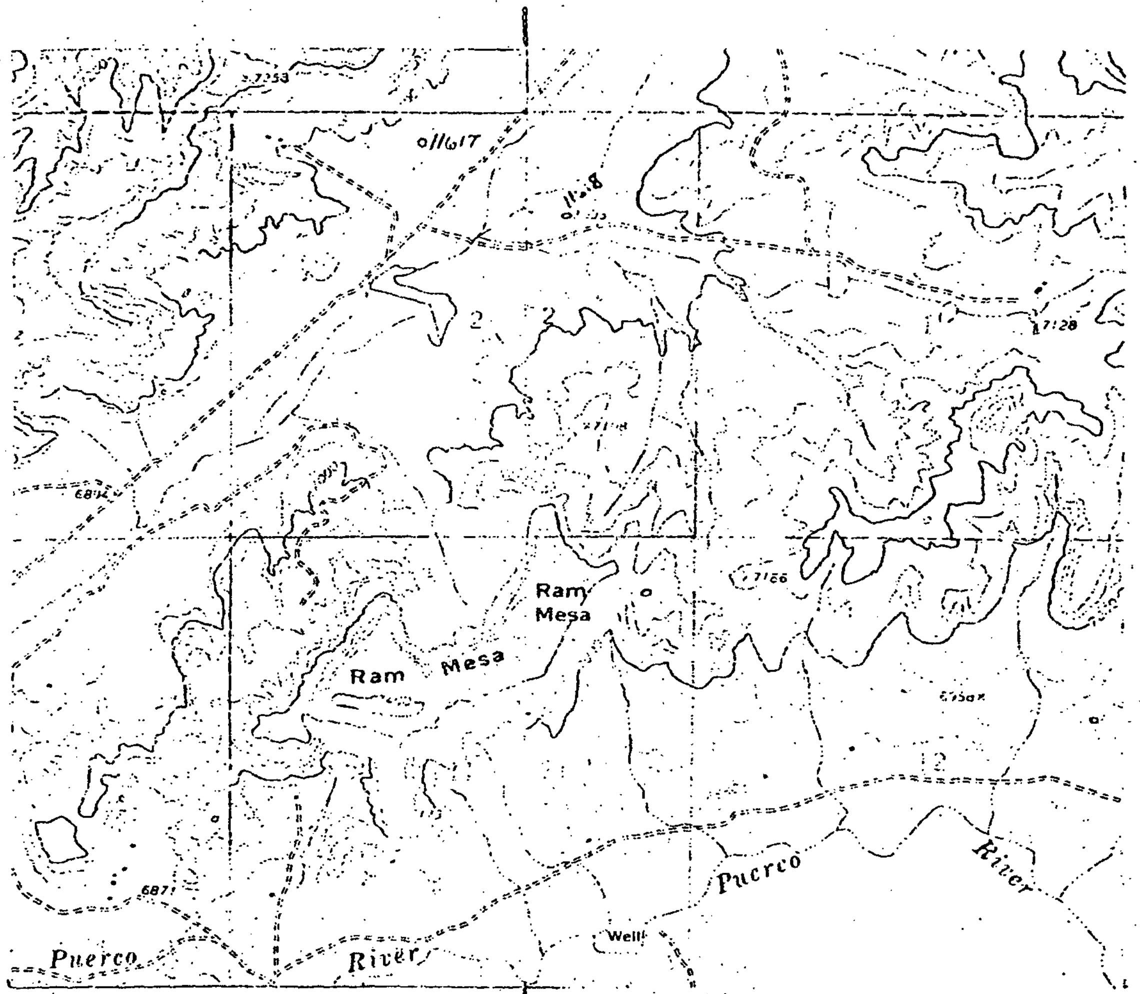
Location	Depth	Velocity
Line #1	0-53'	630 ft./sec.
	53'+	1780 ft./sec.
Line #2	0-55'	780 ft./sec.
	55'+	1800 ft./sec.
Line #3	0-94'	1080 ft./sec.
	94'+	1000 ft./sec.

In view of the presences of these two sites, I would recommend that archaeological clearance be withheld until there is an opportunity for a qualified archaeologist to investigate LA 11618 further, and perhaps LA 11617, as well.

Sincerely

Stewart L. Peckham
Curator-in-Charge
Division of Anthropology

Enclosures



HARD GROUND FLATS QUADRANGLE | OAK SPRING QUADRANGLE

UNITED NUCLEAR LEASE--All of Section 2, Township
16 North, Range 16 W., N.M.P.M.,
McKinley County, New Mexico.

Showing locations of archaeological sites LA 11617 and LA 11618 (Museum of New Mexico Archaeological Survey Catalog).

Archaeological survey conducted April 15-16, 1974

MUSEUM OF NEW MEXICO ARCHAEOLOGICAL SURVEY United Nuclear Project SITE NO.: L.A. 11617

Site name -- Quad no. NM G : 5 Field No. 16-16-2-1

Map source USGS 7.5' Quad.-Hard Ground Flats Accessibility: foot X sedan X 4-wh. dr. X backhoe X

NE ¼ of the NE ¼ of the NW ¼, Sec. 2, T. 16 N., R. 16 E., County McKinley State N.M.

Location About 30 meters west of paved highway and 100 meters north of turn-off for houses in Section 2. Elevation 6990

Stake location (MNM, Other)

Site is in what nearest named drainage? Puerco River Nearest town Church Rock Nearest highway NM 546

Ownership Navajo Tribe--owner United Nuclear Corp.--lessee Informant

FEATURES (indicate number): Pit houses ___ Kivas ___ Surface rooms: Slab/Jacal ___ Masonry 1 Adobe ___ Other ___

Refuse area (direction) ___ Hearths ___ Burials ___ Sherd/Chipping area ___ Grids/Dams/Terraces/Borders ___ Petroglyphs/Pictographs ___

Trails/Steps/Toeholds ___ Other Scattered refuse

PLAN (check ✓): 1-room ✓ Arc ___ Linear ___ L-shaped ___ C-shaped ___ F-shaped ___ E-shaped ___ ( )-shaped ___

Enclosed plaza: by a wall ___ by rooms ___ Scattered dwelling units ___ Indeterminate ___ Other ___

Single-tier ___ Double-tier ___ ( )-tiers ___ Part double-tier ___ Part ( )-tiers ___ Orientation - Exposure 360°

Modern structures on site N/A

Nature and depth of fill sand and sandstone; depth undetermined Area of site 10 x 5 meters

Condition: Undisturbed ___ Eroded X Pot-hunted ___ Pottery/Artifact abundance: 0, (10's), 100's, 1000's Multiple component site? NO

SITUATION (check ✓): Valley bottom ___ Bench/Terrace ___ Slope ___ Ridge X Mesa top ___ Cliff edge ___ Overhang ___ Cave ___

Dune ___ Other ___

Terrain: Level X Broken ___ Slopes to (direction) E Surface deposits: Alluvium ___ Colluvium ___ Aeolian X Talus ___ Residual ___

Soil: Rocky ___ Gravelly ___ Sandy X Clayey ___ Other ___ Local outcrops: Sandstone X Shale ___ Limestone ___

Basalt ___ Tuff ___ Caliche ___ Other ___ Arable land (type, distance & direction) valley bottom; 100m E.

Water (distance & direction): River ___ Arroyo 300m ESE Stream confluence ___

Spring/Seep ___ Bedrock pool ___ Local vegetation patterns Pinyon-juniper

Field remarks Very little pottery on surface. Should have been surveyed for N.M. 546.

Excavation requirements: Labor ___ Time ___ Registered site? National no State no

CULTURE Anasazi (component 1) / Anasazi (component 2) Phase or Date P-I/P-II (component 1) / P-III (component 2)

Zone ___ Locality ___ Photo: B/W ___ Color ___

Lab remarks Apparently a field house re-used over a considerable period.

Sherd analysis on reverse

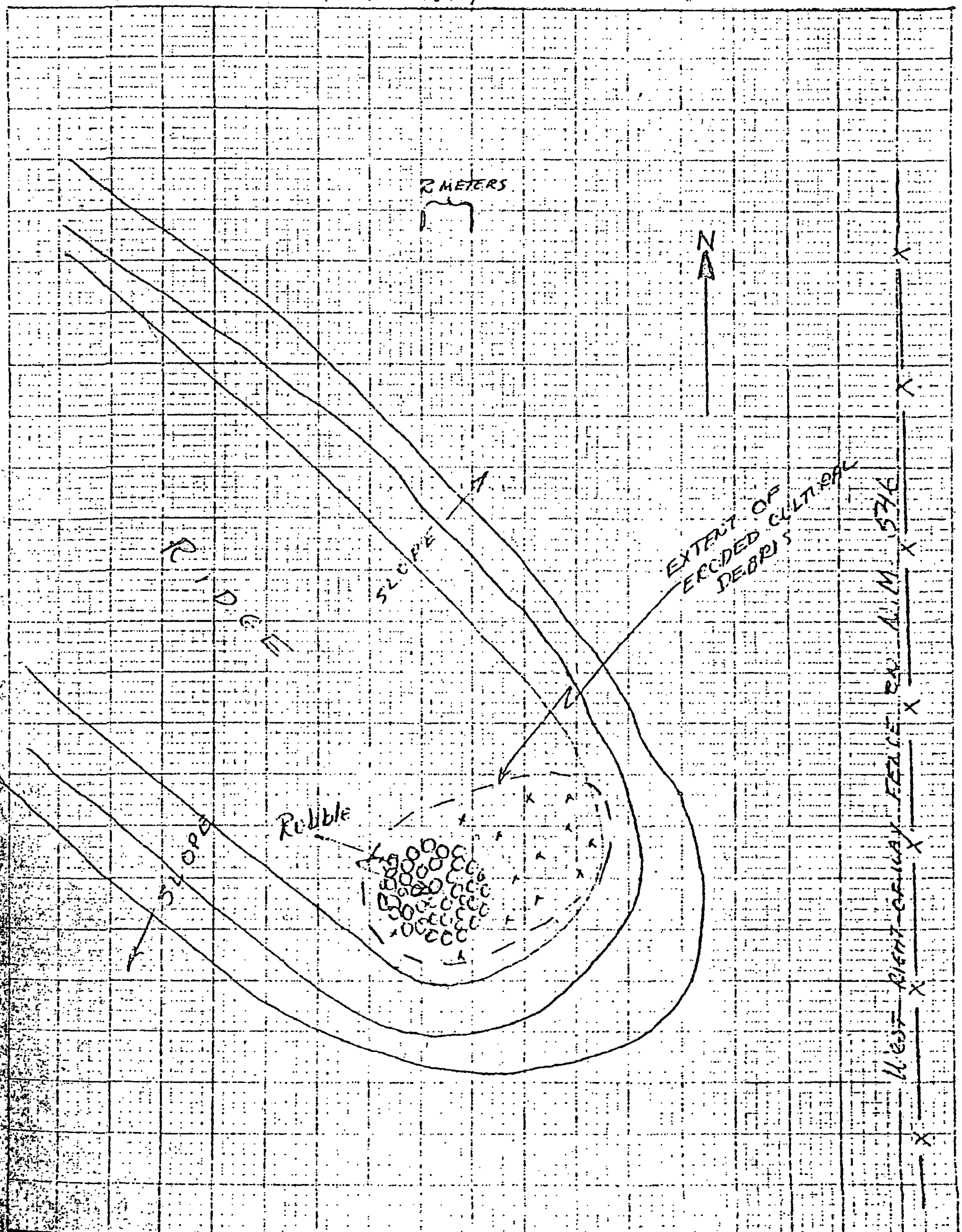
Field recorder Paul S. Grigg Date April 15, 1974 Survey collections storage: Survey cabinet ___ Drawer ___

Lab recorder ___ Date ___ Bulk cabinet ___ Drawer ___

4-1-73

MUSEUM OF NEW MEXICO CONTINUATION SHEET

PROJECT: United Nuclear SITE: LA 11617 FEATURE: C SHEET NO: 1



LA 11617

Sherd analysis

Red Mesa B/W	1		
Escavada B/W	3		
Gallup B/W	3		
Chaco-McElmo B/W	1		8
? Grey neckbanded			
Sand temper, P II Plain Corrugated		2	
Sand temper, P II Indented Corrugated		2	
Sand temper gray		1	
White ware		1	6
		Total sherds	14

MUSEUM OF NEW MEXICO ARCHAEOLOGICAL SURVEY United Nuclear Project SITE NO.: L.A. 11618

Site name ______ Quad no. NM G : 5 Field No. 16-16-2-1

Map source USGS 7.5' Quad--Oak Spring Accessibility: 4-wh. dr. X backhoe X foot X sedan X

SE¼ of SE ¼ of the NW ¼ of the NE ¼, Sec. 2, T. 16 N., R. 16 E., County McKinley State N.M.

Location East side of large arroyo paralleling N.M. 546 about 200 meters north of an old corral Elevation 7000

Stake location (MNM, Other) ______

Site is in what nearest named drainage? Puerco River Nearest town Churchrock Nearest highway NM 546

Ownership Navajo Tribe--owner United Nuclear--lessee Informant ______

FEATURES *(indicate number)*: Pit houses -- Kivas -- Surface rooms: Slab/Jacal -- Masonry -- Adobe -- Other None

Refuse area *(direction)* -- Hearths -- Burials -- Sherd/Lithic area X Grids/Dams/Terraces/Borders ______ Petroglyphs/Pictographs ______

Trails/Steps/Toeholds ______ Other ______

PLAN *(check ✓)*: 1-room ___ Arc ___ Linear ___ L-shaped ___ [-shaped ___ F-shaped ___ E-shaped ___ ( )-shaped ___

Enclosed plaza: by a wall ___ by rooms ___ Scattered dwelling units ___ Indeterminate X Other ___

Single-tier ___ Double-tier ___ ( )-tiers ___ Part double-tier ___ Part ( )-tiers ___ Orientation -- Exposure S. and E

Modern structures on site small road to top of knoll

Nature and depth of fill N/A Area of site 70 x 40 meters

Condition: Undisturbed ___ Eroded X Pot-hunted ___ Pottery/Artifact abundance: 0, 10's, (100's), 1000's Multiple component site? Poss.

SITUATION *(check ✓)*: Valley bottom ___ Bench/Terrace ___ Slope ___ Ridge ___ Mesa top ___ Cliff edge ___ Overhang ___ Cave ___ Dune ___ Other knoll

Terrain: Level ___ Broken ___ Slopes to *(direction)* 360° Surface deposits: Alluvium ___ Colluvium ___ Aeolian ___ Talus ___ Residual X

Soil: Rocky X Gravelly ___ Sandy ___ Clayey ___ Other ___ Local outcrops: Sandstone X Shale ___ Limestone ___

Basalt ___ Tuff ___ Caliche ___ Other Coal Arable land *(type, distance & direction)* ______

Water *(distance & direction)*: River ______ Arroyo 100m W. Stream confluence ______

Spring/Seep ______ Bedrock pool ______ Local vegetation patterns Pinyon-juniper

Field remarks Knoll appears to steep for habitation and top was small and had no cultural material on it. There is an abundance of pottery up to the coal deposits on the slope. Several large sandstone slabs apparently were removed and tossed to one side to get to the underlying coal deposit. This was the only good coal deposit I found in the section.

Sherd analysis on reverse.

Excavation requirements: Labor ______ Time ______ Registered site? National no State no

CULTURE Anasazi (component 1) / Anasazi (component 2) Phase or Date P-II (component 1) / P-III (component 2)

Zone ______ Locality ______ Photo: B/W ______ Color ______

Lab remarks Culinary pottery has been fired quite yellowish--like that produced in the Hopi area where coal was used for firing. The site should be investigated further to verify the relationship of the pottery to the coal deposit, i.e., does it represent aboriginal use of coal.

Sherd analysis on reverse.

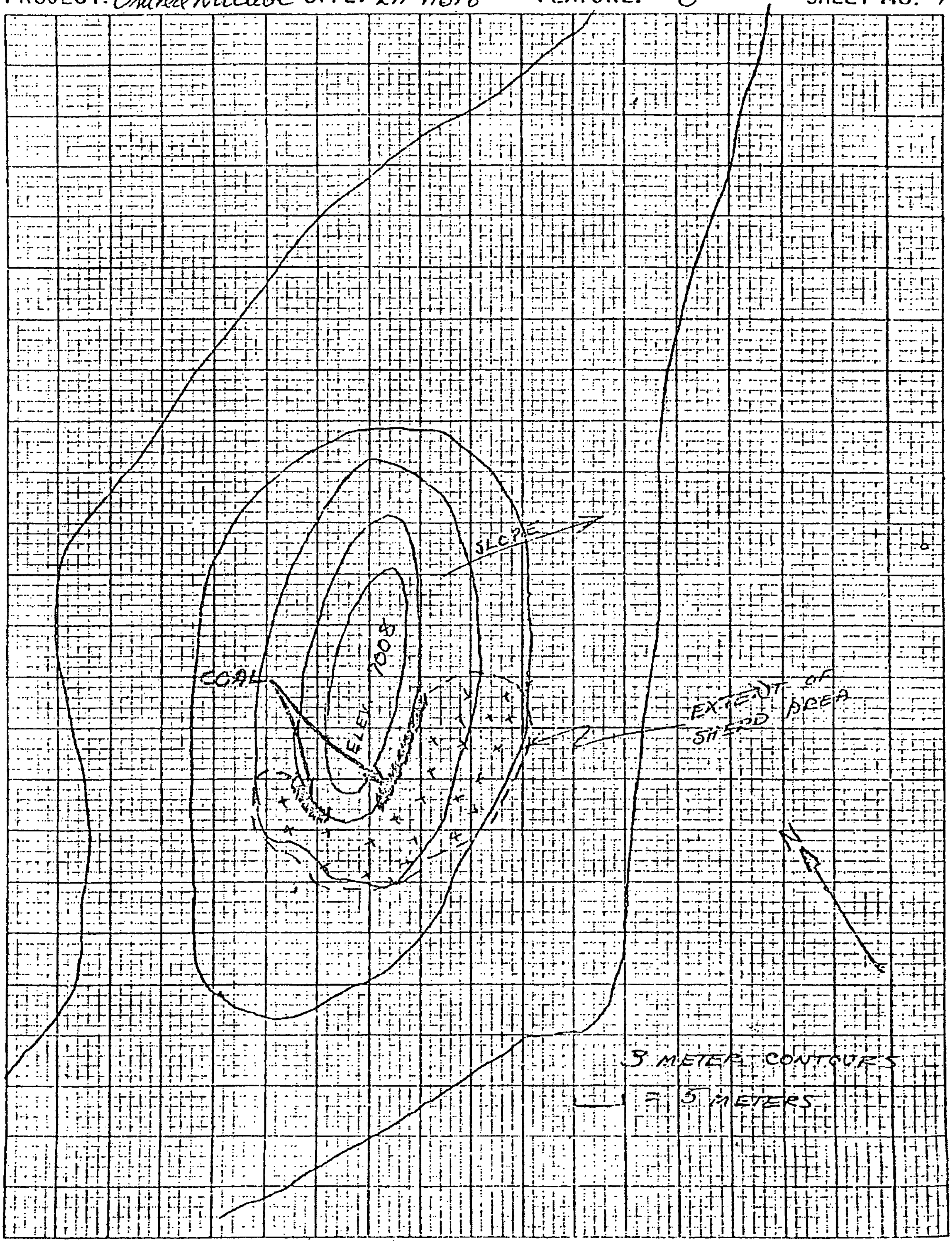
Field recorder Paul S. Grigg Date April 16, 1974 Survey collections storage: Survey cabinet ______ Drawer ______

Lab recorder Grigg & Peckham Date ______ Bulk cabinet ______ Drawer ______

4-1-73

MUSEUM OF NEW MEXICO CONTINUATION SHEET

PROJECT: *United Nuclear* SITE: *LA 11618* FEATURE: *0* SHEET NO: *1*



LA 11618

Sherd analysis

Red Mesa B/W	2		
Escavada B/W	3		
Gallup B/W	14		
Chaco-McElmo B/W	2		23
Sand temper, P II Indented Corrugated		12	
Sand temper, PII-III Plain Corrugated		1	
Sand temper, P III Indented Corrugated		1	
Lino Gray		1	15
		Total sherds	38

MUSEUM OF NEW MEXICO, P.O. BOX 2087, SANTA FE, NEW MEXICO 87501

23 October 1974

United Nuclear Corporation, Ambrosia Lake Operation
Attn. Mr. Greenslade
P.O. Box 199
Grants, New Mexico 87020

Dear Mr. Greenslade:

Please find enclosed a budget estimate for the excavation of archaeological sites LA 11617 and 11618. The sites, located in Section 2, T. 16 N., R. 16 W., N.M.P.M., McKinley County, New Mexico, are endangered by the construction and operation of the proposed Church Rock Uranium Mill.

In addition to the two surveyed sites, a third site was located while I was enroute to LA 11618 to make the budget estimate. As this third site is quite small, test excavations can be carried on simultaneously with those at LA 11618, and time for that purpose has been alloted in the LA 11618 estimate.

As mentioned in our phone conversation of October 11, 1974, the proposed budget is believed to cover accurately any anticipated costs of excavation, analysis, and publication. However, it has been common experience of investigators in the Gallup area that the surface indications of archaeological sites are quite often misleading. That is, once excavations were underway, it was found that the extent of many sites was greater than was inferred from surface indications. Consequently, more time and expense was required to complete the excavations. For this reason, the budget covers any situation which we feel might arise. There is the very remote possibility, however, that more funds might be required. In that event, you will be duly notified. As usual, the Museum will bill for only those costs actually incurred on the project.

A brief explanation of some of the line items is in order. The excavation crew will consist of one archaeologist and three laborers (utility workers). Since the geologist and botanist we normally contract with are not on our staff, their fees are flat daily rates established over several years. Both of their specializations are archaeologically oriented. Each has accrued several years of experience in the correlation of geological and botanical phenomena with cultural phenomena, integrations which are vital to archaeological interpretations within an ecological framework. For instance, the geologist will not only make a study of the local geology, she will search for sources of lithics, minerals, and other materials which might have been used by the Indians. In the

laboratory, she will do much of the petrographic analysis of the pottery to help answer questions concerning the constituents and origins of the various wares. The botanist will ascertain the kinds and locations of economically important plants. In addition, she will be called on to identify any archaeological plant remains of both macroscopic and microscopic nature.

Vehicle fees call for the use of a Museum truck at 10¢ per mile. Gasoline cost estimates are based on the estimated number of miles to be driven on the project (including travel to and from Santa Fe on weekends) and are figured on 10 miles to the gallon at 60¢ per gallon. Oil is figured at one quart per 750 miles at $1.00 per quart. In-state meals and lodging (per diem) for the archaeologist is $20.00 per day.

Field, office, and laboratory supplies are calculated on flat percentages of the non-contractual salaries (1% each for office and laboratory and 3% for field). The publication costs are also a flat fee projected from paper, photographic, and other supplies costs.

The 16.6 % administrative expense is the rate which the Museum established this year in consultation with representatives of the U.S. General Accounting Office.

We will be most happy to further explain or clarify any questions you may have regarding this budget or our procedures.

Sincerely,

Regge N. Wiseman

Regge N. Wiseman
Staff Archaeologist

Attachment

PROPOSED BUDGET FOR THE
UNITED NUCLEAR PROJECT
(LA 11617 and LA 11618)

Field Phase	Laboratory Phase	Line Items
$830.40	$2076.00	Archaeologist (1)
277.94	651.45	Benefits
6.64	16.61	Personnel Assessment
1108.80	554.00	Utility Workers (3 field, 1 lab)
90.04	45.02	Benefits
8.87	4.43	Personnel Assessment
	145.20	Secretary
	45.56	Benefits
	1.16	Personnel Assessment
		Contractual:
600.00	900.00	Geologist
500.00	750.00	Botanist
	160.00	Draftsman
	500.00	Samples Analysis
	30.00	Photographic Processing
250.00		Vehicle
154.00		Gas and Oil
		Supplies:
58.18		Field
19.39	27.75	Office
	27.75	Laboratory
6.30		Photographic
	250.00	Publication
400.00		In-State Meals & Lodging
$4310.56	$6184.93	Actual Field & Lab Costs
715.55	1026.70	Administrative Expense
$5026.11	$7211.63	Total Field & Lab Costs
$12,237.74		Total Project Costs

MUSEUM OF NEW MEXICO, P.O. BOX 2087, SANTA FE, NEW MEXICO 87501

March 17, 1975

Mr. J. G. Greenslade
United Nuclear Corporation
P. O. Box 199
Grants, New Mexico 87020

Dear Mr. Greenslade:

As you can see on the enclosed maps, the two archaeological sites (LA 11617 and 11618) and an unrecorded Navajo site are all located peripherally to your planned uranium mill and waste disposal facilities north of Church Rock, N.M. Judging by the information at hand, only one site, LA 11617, may be directly impacted. The source of potential impact is the access road from the highway to the mill parking lot. If the access road can be shifted south in order to avoid the small hill on which the site lies, excavation will not be necessary. The hill should be left intact in order to prevent accelerated erosion which would provide an additional hazard to the ruin.

In the cases of LA 11618 and the unrecorded Navajo site (possibly the location of a ceremony which would be remembered by the participating Navajos) as well as LA 11617, if it is not excavated, the immediate and long range concern is indirect impact. Off-road vehicle travel, casual pedestrians who are out "looking around", and vandals who dispoil ruins for personal gain are all sources of destruction made more likely through increased human activity in the area. Additionally, the Navajo site and LA 11618 are situated on hills which might be used as overlooks for the operation. All of these potentials for destruction should be avoided and can best be handled through employee education and restrictions on vehicle movements. If United Nuclear can give these assurances, then excavation of the sites is not necessary.

Sincerely,

Regge N. Wiseman

Regge N. Wiseman
Staff Archaeologist

MUSEUM OF NEW MEXICO. P.O. BOX 2087. SANTA FE. NEW MEXICO 87501

June 19, 1975

United Nuclear Corporation
Ambrosia Lake Operation
P. O. Box 199
Grants, New Mexico 87020

Attn: Mr. Greenslade

Dear Mr. Greenslade:

Enclosed is our budget of anticipated expenditures for the excavation of LA 11618, located in Sec. 2, T-16N., R-16W., McKinley County, New Mexico. LA 11618 is a site which contains three discrete occupation units within an area of less than 1/2 acre which, I understand, will be disturbed during operations planned by United Nuclear in the near future. I believe that Mr. Reggie Wiseman has explained the need for excavating these units to preserve the scientific and cultural information they contain.

Mr. Wiseman informs me that, after consultation with United Nuclear officials, excavation of nearby LA 11617 is no longer considered necessary, and I have made the appropriate budget adjustments to exclude this work. The difference of approximately $800 between Mr. Wiseman's budget and the one enclosed here reflects the anticipated time needed to excavate three, rather than two archaeological units. Please let me know if I am correct in assuming that LA 11617 has been eliminated from consideration. I understand also from Mr. Wiseman, that United Nuclear would like to have this project completed, or underway at any rate, by September. We would prefer, if at all possible, to have the three units excavated by September because of the press of other projects. Please let me know as soon as possible if the enclosed budget is an acceptable one, and whether we might plan to initiate work in the coming weeks.

Sincerely,

David H. Snow

David H. Snow
Curator of Archaeology

United Nuclear: LA 11618 etc. (Revised 6/12/75)

Personal Services	
Proj Supervisor, 5 days @$1025.00/ mo.	$237.00
Site Supervisor, Archaeo. 120 days @ $690.00/ mo.	3821.00
Ass't. Archaeo., 20 days @ $575.00/ mo.	532.00
Archaeo/Recorder 20 days @ $420.00/ mo.	388.00
Proj. Secretary 10 days @ $480.00/ mo.	222.00
Utility Workers (4), field, 20 days @ $4.00/ mo.	1479.00
Utility Worker (1) Lab., 10 days @ $400.00/ mo.	185.00
Draftsman @ $630.00/ mo, 5 days	146.00
	$7010.00
Employee Benefits	
Field @ 33.47%	$2223.00
Lab. @ 31.38%	116.00
Labor @ 0.812%	136.00
	$2475.00
Travel-Per-diem	
2500 miles @ 12¢ per mile	$300.00
Per diem, 20 days, (3 persons) @ $20.00/ day	1200.00
	$1500.00
Supplies: @ 75¢ per day	90.00
Contractual Services	
Photo & Zeroxing	50.00
Communications	15.00
	$65.00
Personnel Assessment @ 0.8% of salaries	$57.00
TOTAL DIRECT COSTS:	$11197.00
+ 16.6% Overhead	1859.00
TOTAL PROJECT COSTS (est.)	$13056.00

UNITED NUCLEAR CORPORATION

LA Freytag
JW Riches
~~NF Savignac~~

MINING AND MILLING DIVISION
AMBROSIA LAKE OPERATION

P. O. BOX 199
TELEPHONE 876-2217
GRANTS, NEW MEXICO 87020

June 24, 1975

David H. Snow
Curator of Archaeology
Museum of New Mexico
P. O. Box 2087
Santa Fe, New Mexico 87501

Dear Mr. Snow:

Please be advised that United Nuclear Corporation approves your budget for the excavation of the three archaeological sites located in Sec. 2, T-16N., R-16W, McKinley County, New Mexico.

We would like you to procede with the project as soon as possible. As it states in your letter of June 19, 1975, it will not be necessary for you to excavate LA 11617.

Thank you very much for your prompt attention to this project.

Sincerely,

UNITED NUCLEAR CORPORATION

J. O. Greenslade

J. O. Greenslade
Manager of Operations

JOG:gk

xc: G. A. Swanquist w/attch.
Linda Freytag "
C. Milliken "

APPENDIX F

CORRESPONDENCE
CONCERNING
HISTORIC, SCENIC, CULTURAL,
AND
NATURAL LANDMARKS

STATE OF NEW MEXICO

STATE PLANNING OFFICE

DAVID W. KING
STATE PLANNING OFFICER

EXECUTIVE — LEGISLATIVE BUILDING
SANTA FE 87503

PETER C. PENCE
DEPUTY STATE PLANNING OFFICER

BRUCE KING
GOVERNOR

December 10, 1974

Mr. John Dorian
United Nuclear Industries
1101 N Building
P. O. Box 490
Richland, Washington 99352

Dear Mr. Dorian:

This is with reference to our telephone conversation of the afternoon of Friday, December 6, 1974, in regard to sites in McKinley County eligible for inclusion in the National Register. Chaco Canyon is of course on the Register; Manuelito Complex is a National Historic Landmark. Other properties presently regarded as eligible by our Cultural Properties Review Committee are Heshotauthla Ruin, Zuni Pueblo, the restored Zuni Mission Church, Soldado Ruin, Tohatchi Village, Yellow House Ruin, Kwakima, Kechipawan, Kyakima, Matsaki, and the Village of the Great Kivas.

The enclosed USGS maps show the above properties and sites. I should add that this letter is in no sense a clearance or determination of effect. More precise information can be obtained from Stewart Peckham, Chief Archeologist, Museum of New Mexico, P.O. Box 2087, Santa Fe, New Mexico 87501. Both Mr. Peckham and I should be informed of the exact nature and scope of any land-modifying activity.

Sincerely,

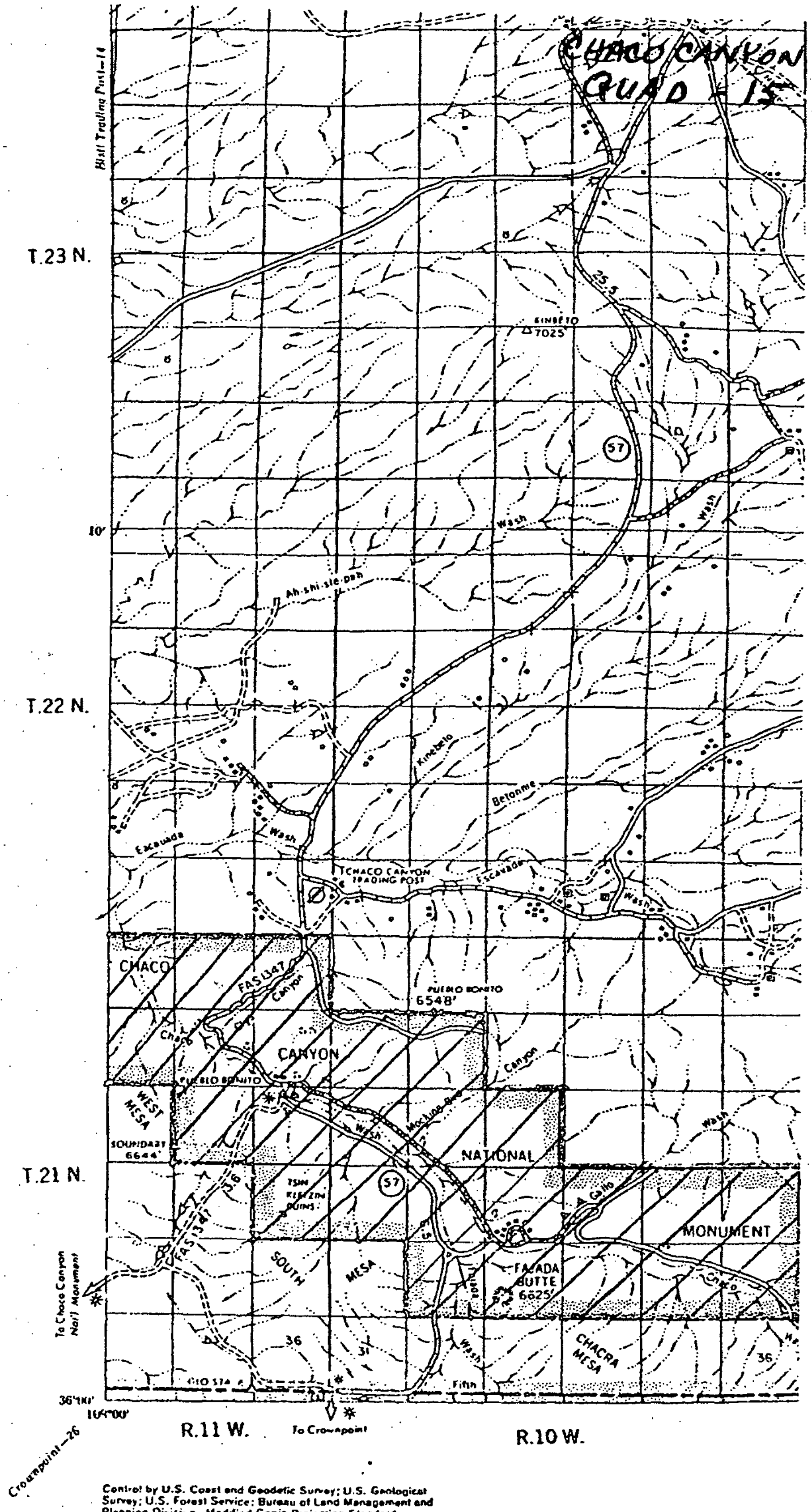
DAVID W. KING
State Planning Officer

by: Thomas W. Merlan

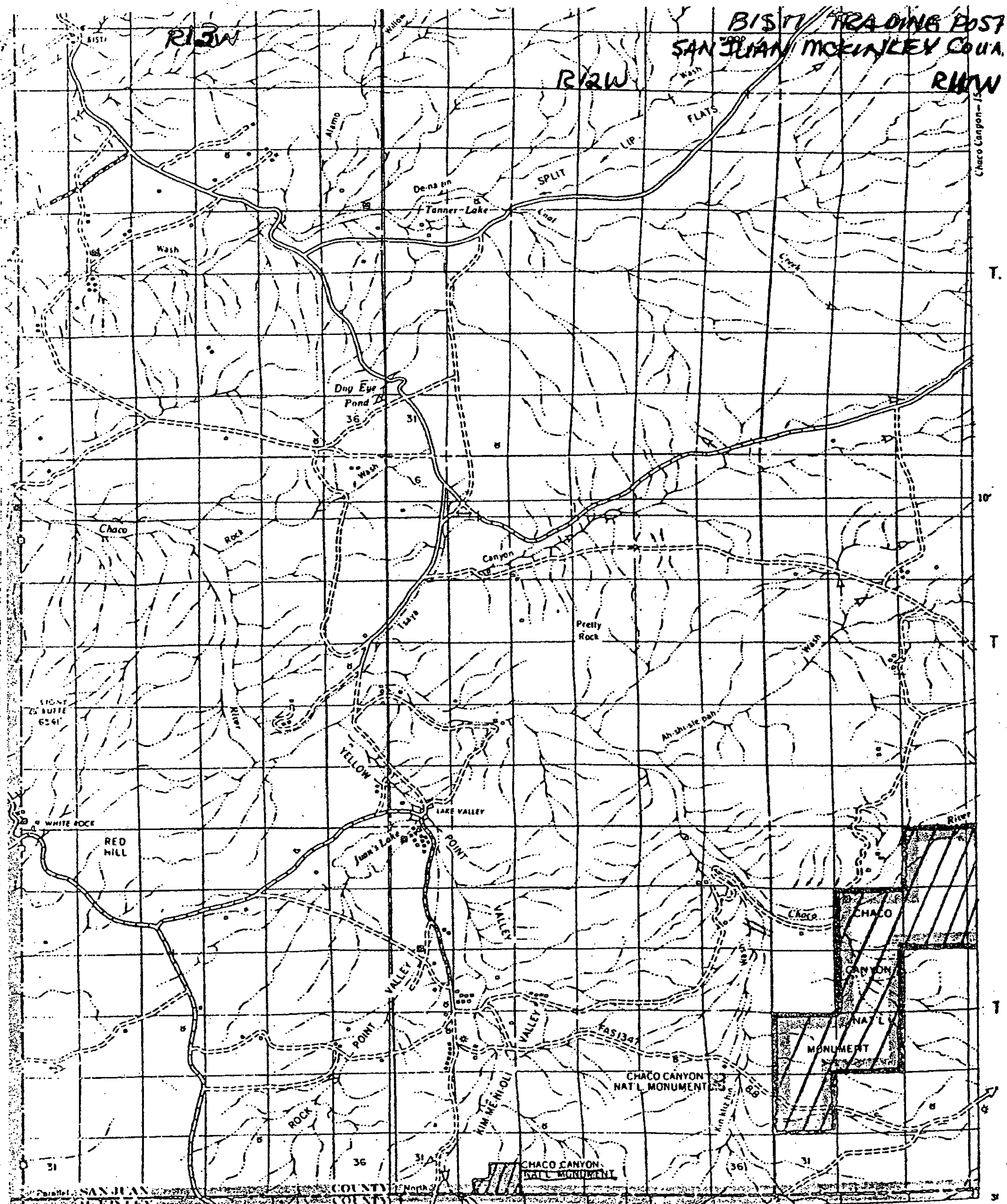
Thomas W. Merlan, Deputy Director
Recreation and Historic Preservation

DWK:TWM:dm

Enclosures



Control by U.S. Coast and Geodetic Survey; U.S. Geological Survey; U.S. Forest Service; Bureau of Land Management and Planning Division—Modified Conic Projection Standard Parallel 34½° North American Datum



R.13 W. R.12 W. R.11 W.

Longitude West from Greenwich

Scale $\frac{1}{126720}$ or 1 Inch = 2 Miles

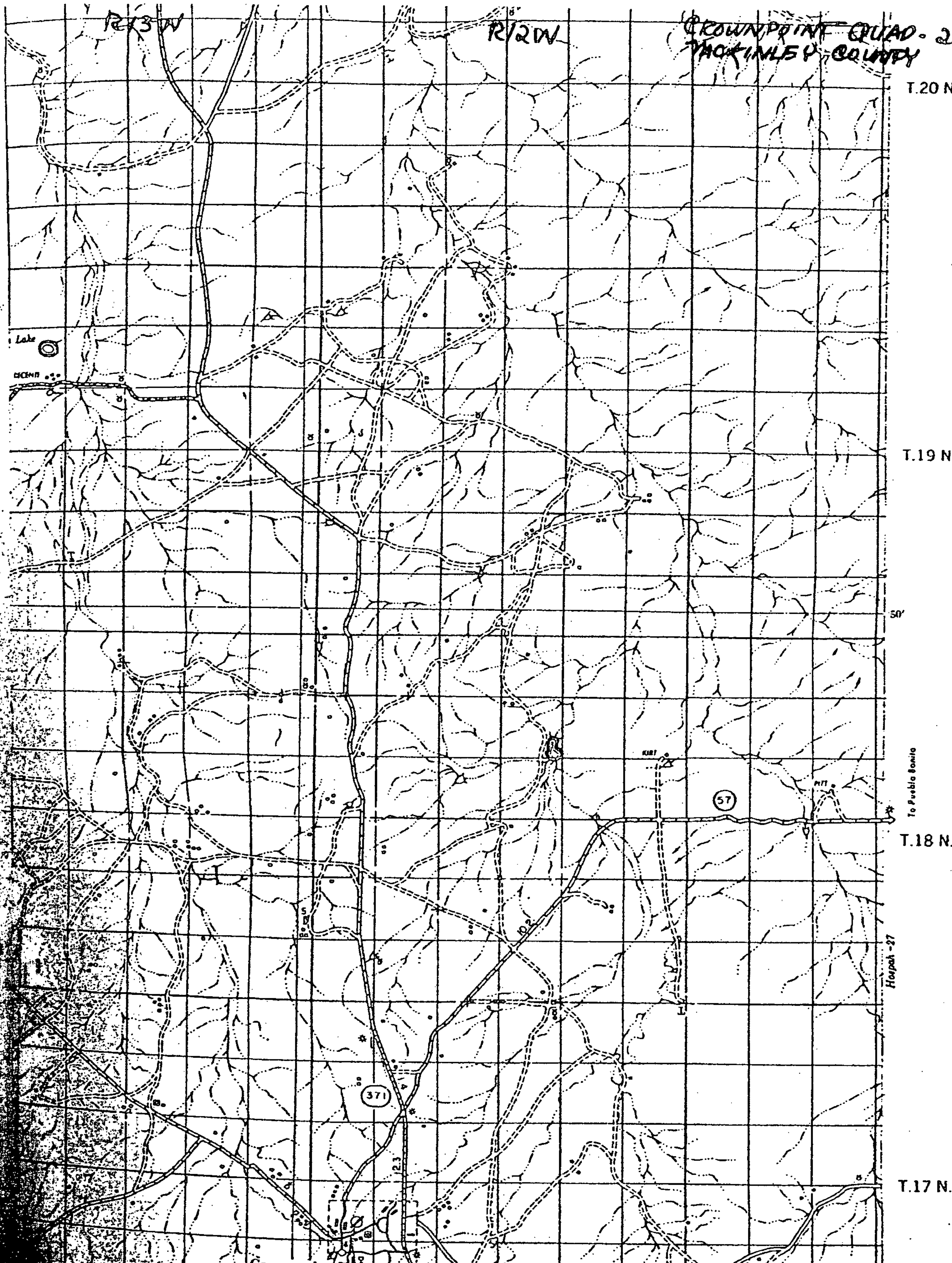
1 2 3 4

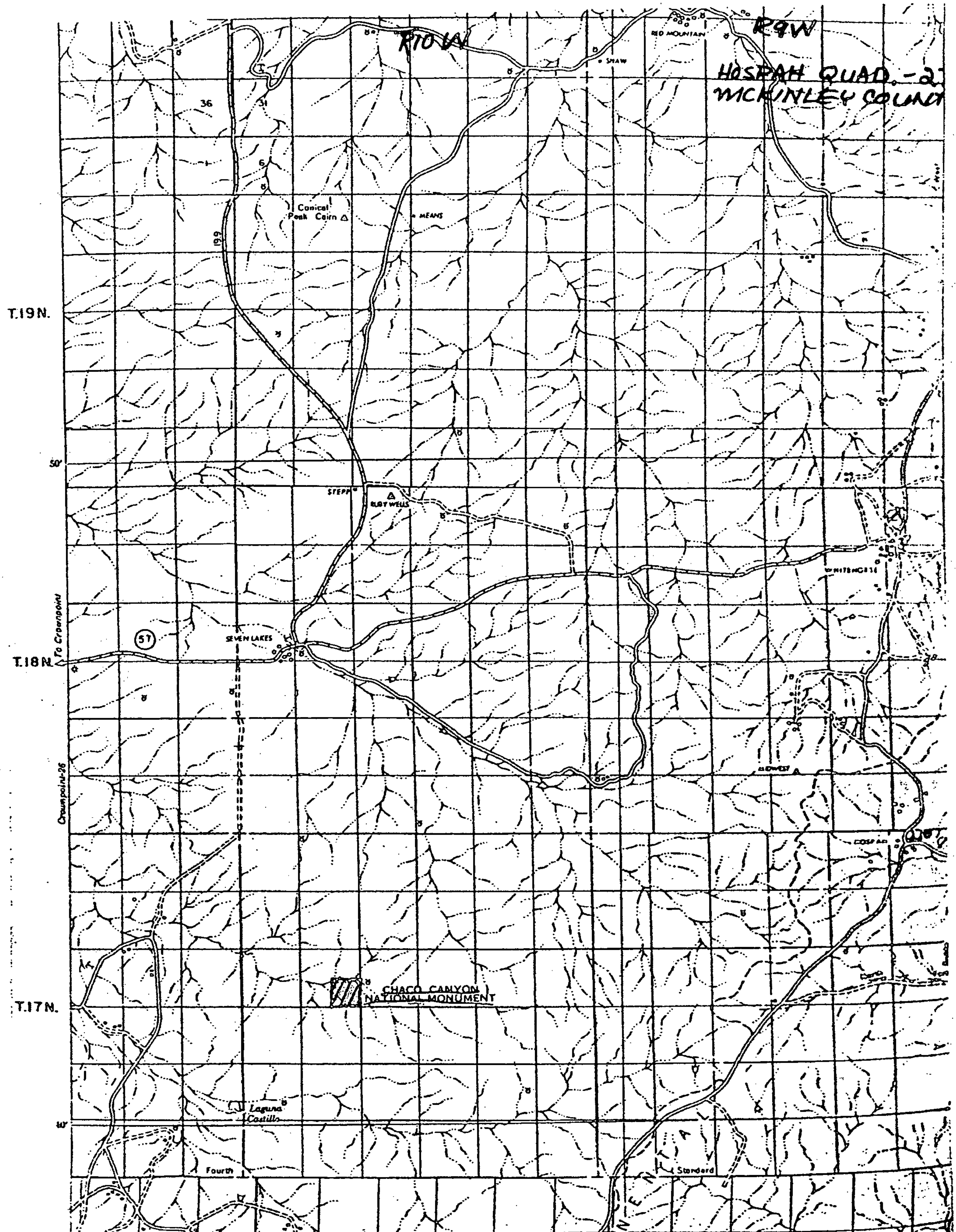
STATUTE MILES

DATE OF INVENTORY
SAN JUAN COUNTY 1967
McKINLEY COUNTY 1964

BISTI TRADING POST QUADRANGLE

14

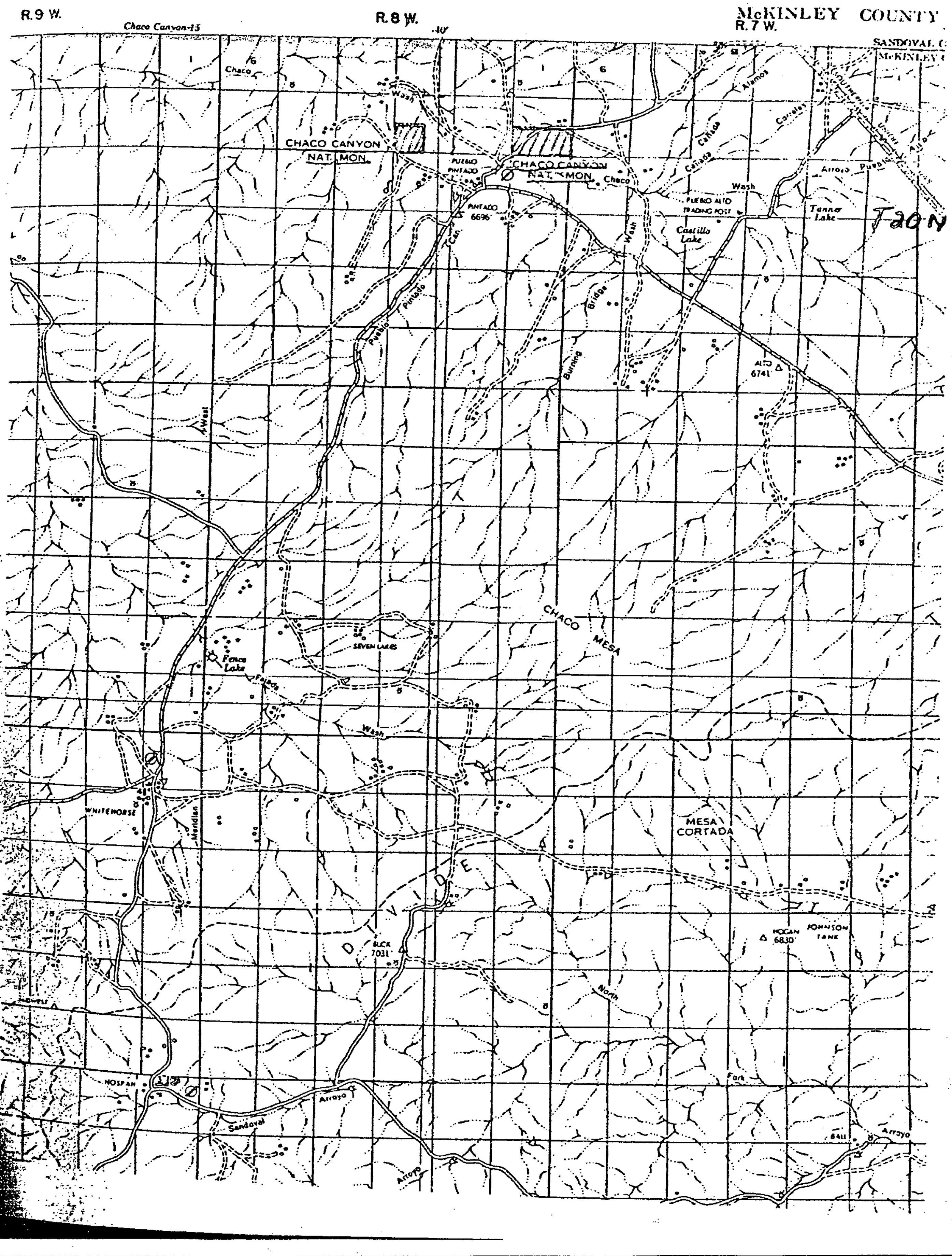

R13W
R12W
CROWNPOINT QUAD - 26
McKINLEY COUNTY
T.20 N.
T.19 N.
T.18 N.
T.17 N.
50'
40'
Lake
57
To Pueblo Bonito
Hospah -27
371
Crownpoint
CHACO CANYON
NATL. MON.



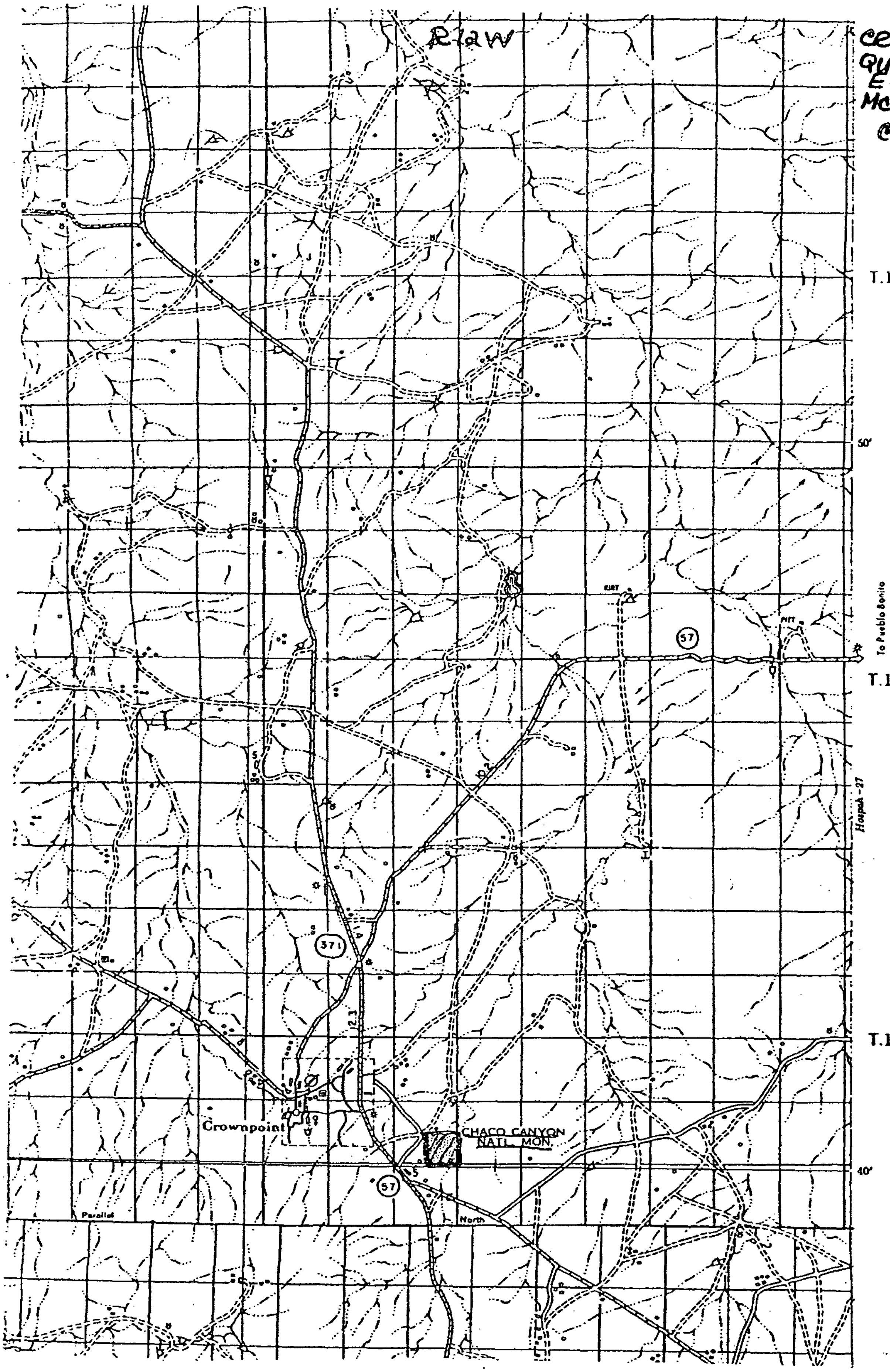
R10W
R9W
RED MOUNTAIN
SHAW
HOSPAH QUAD. -2
MCKINLEY COUN
36
31
6
Conical Peak Cairn
MEANS
199
T.19N.
50'
STEPP
RUBY WELLS
WHITEHORSE
To Crownpoint
57
SEVEN LAKES
T.18N.
Crownpoint-26
CHACO CANYON NATIONAL MONUMENT
T.17N.
Laguna Castillo
30'
Fourth
Standard

HOSPAH QUADRANGL

McKINLEY COUNTY



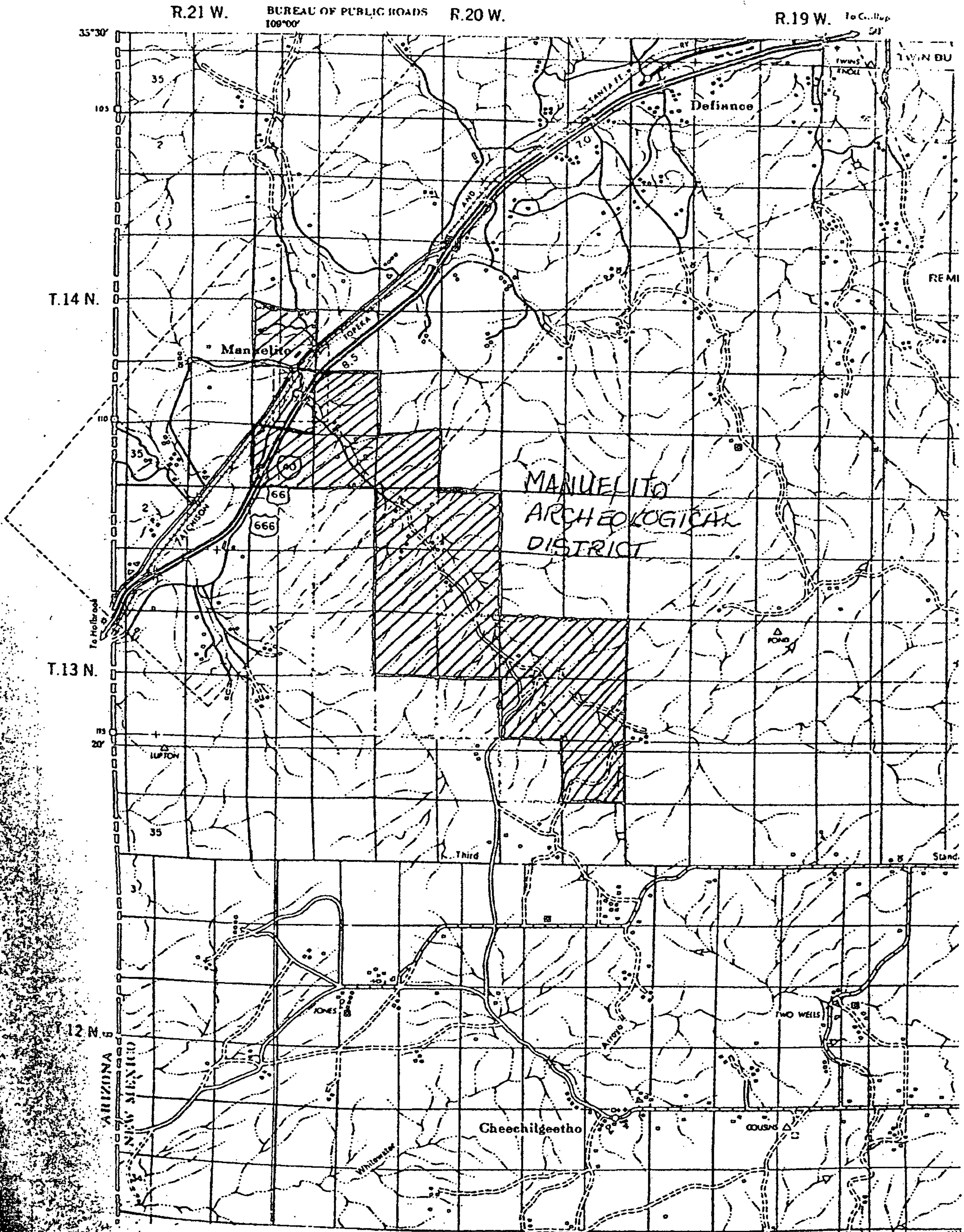
CROWNPOINT QUADRANGLE
E-26
McKINLEY COUNTY



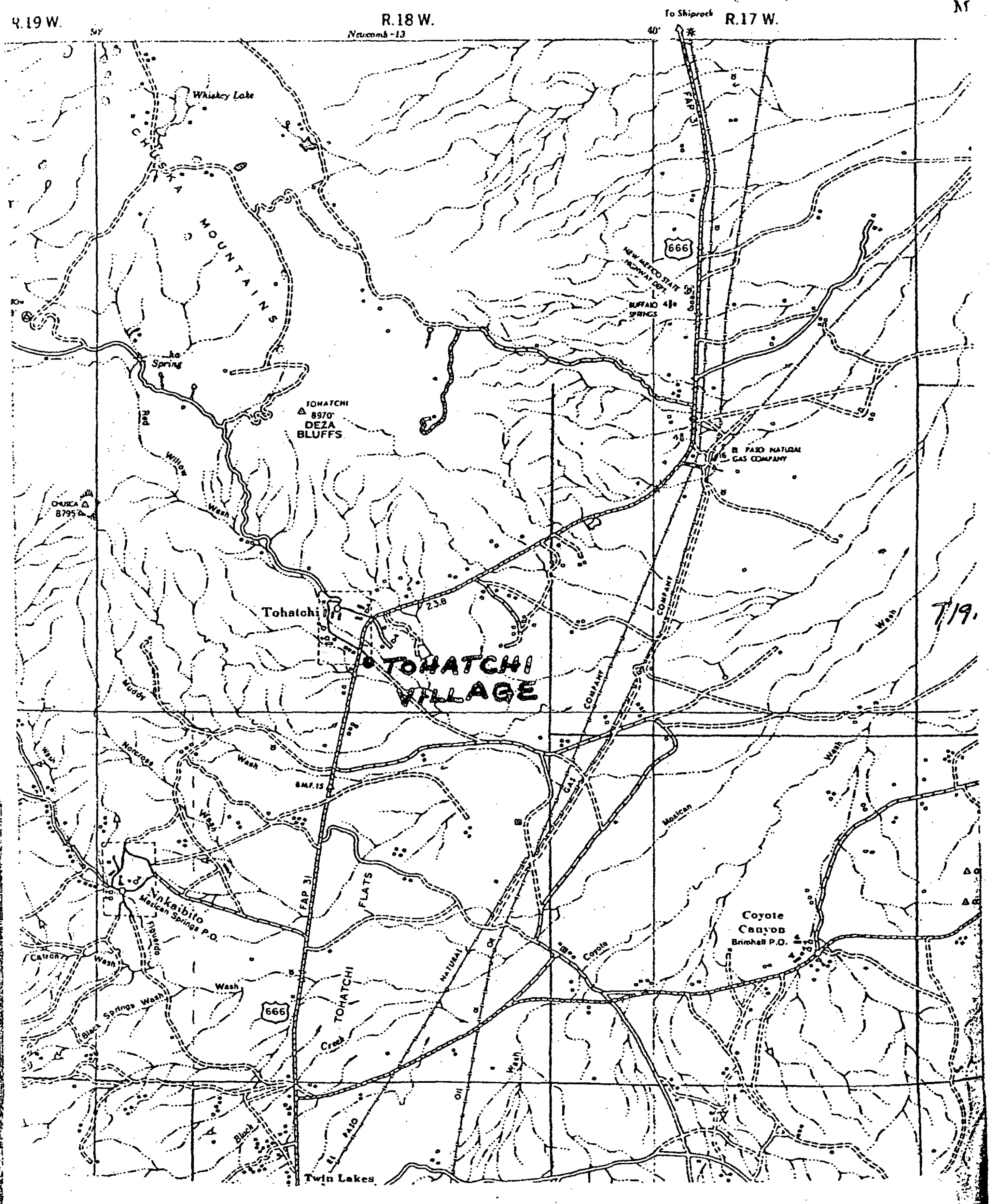
NEW MEXICO STATE HIGHWAY DEPARTMENT

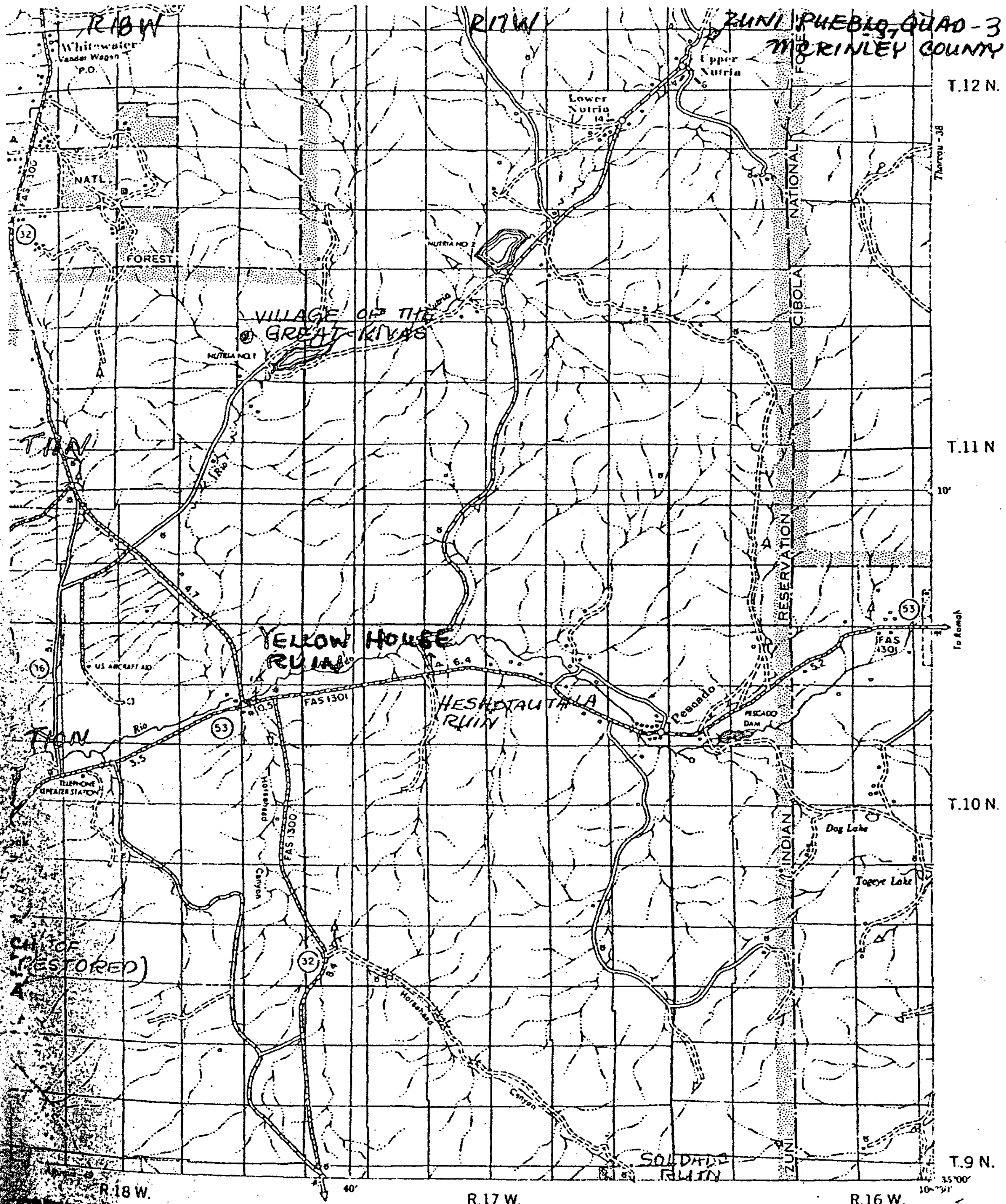
PLANNING AND PROGRAMMING DIVISION

ZUNI PUEBLO / McKINLEY COUNTY
QUAD. - 37



Gallup Quadrangle - 25
McKinley County





ZUNI PUEBLO
QUADRANGLE
37

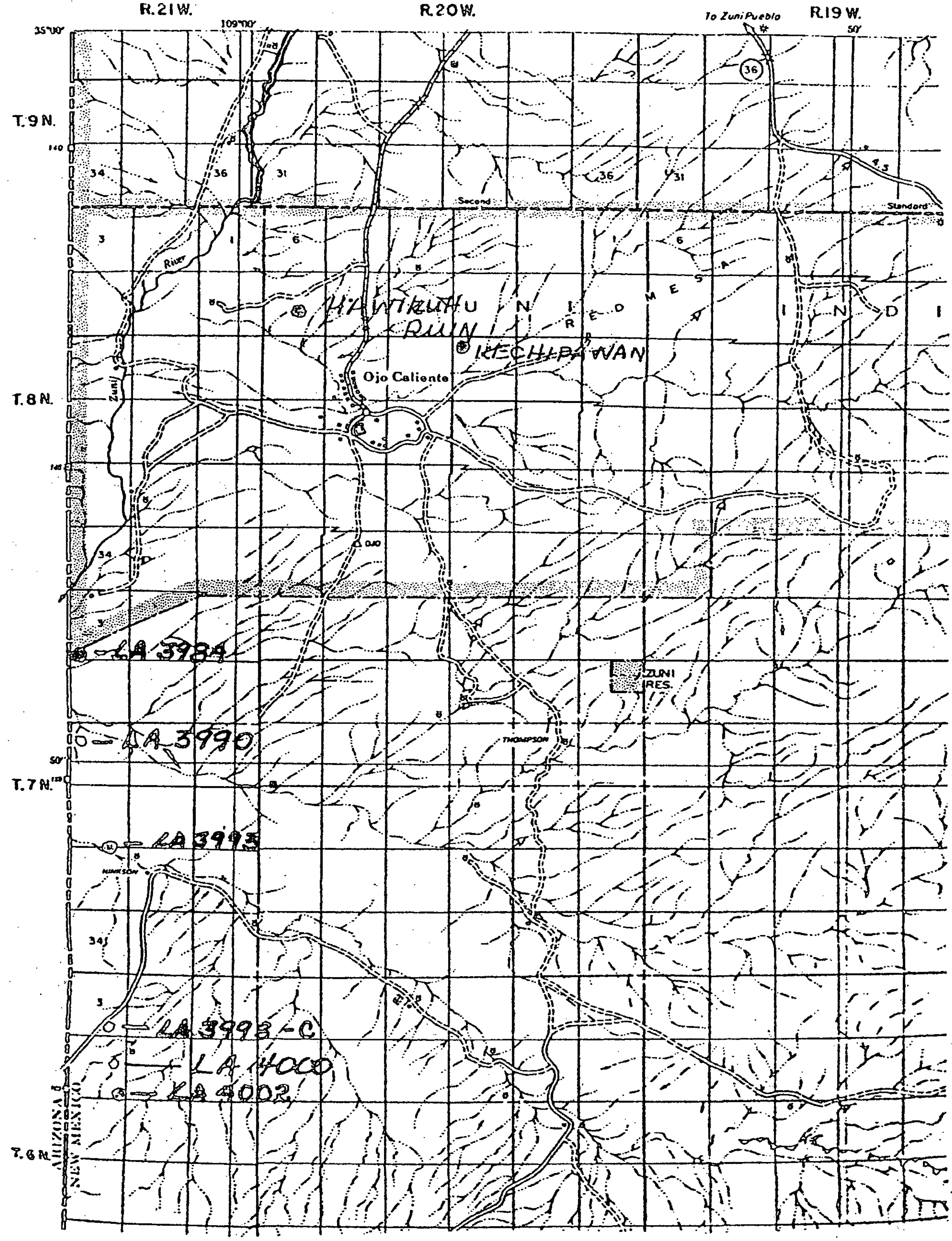
NEW MEXICO STATE HIGHWAY DEPARTMENT

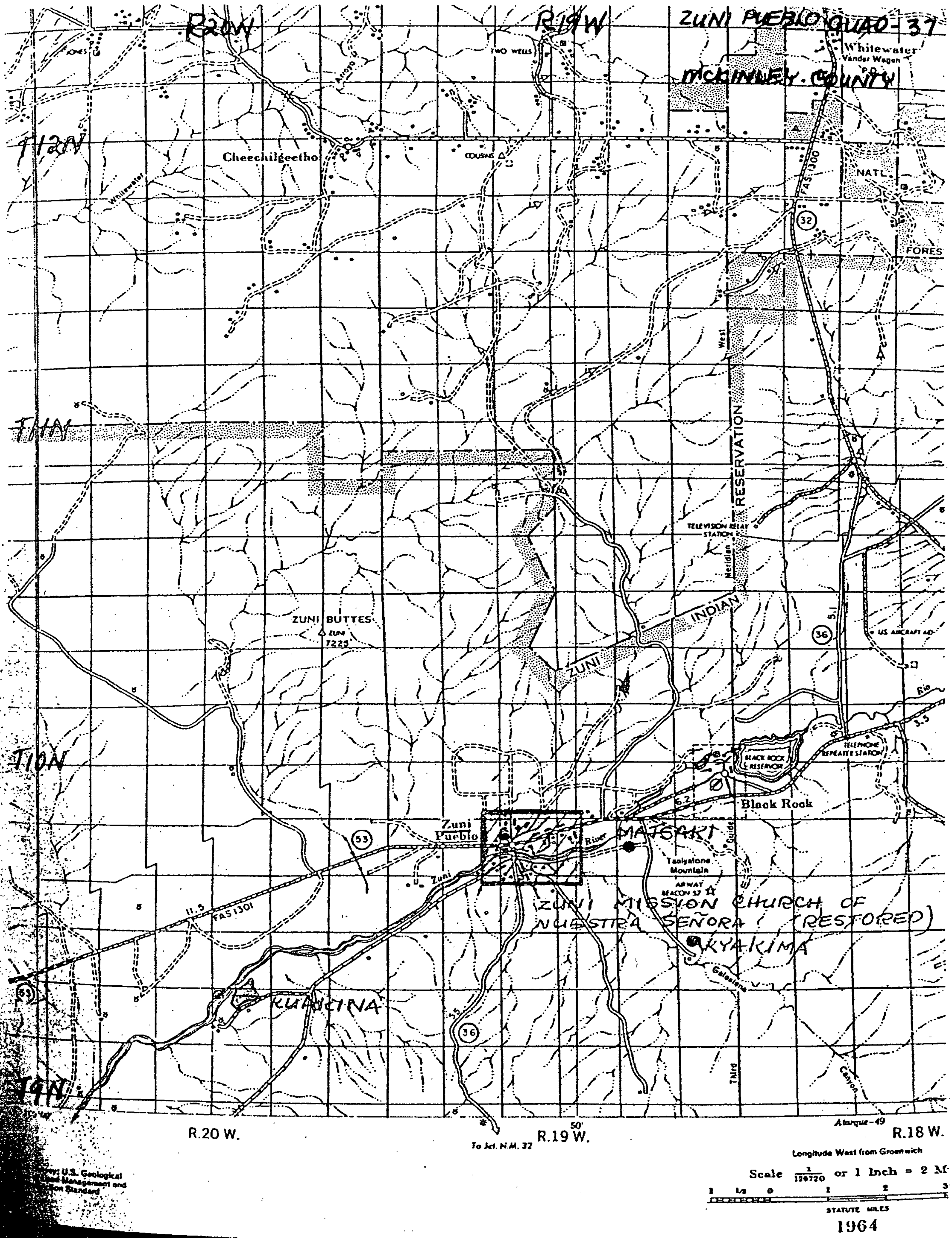
PLANNING AND PROGRAMMING DIVISION

BUREAU OF PUBLIC ROADS

ATARQUE QUAD-49

McKINLEY, VALENCIA, & CATRON COUNTIES




R20W
R19W
ZUNI PUEBLO QUAD-37
Whitewater
Vander Wagen
McKINNEY COUNTY
JONES
TWO WELLS
T12N
Cheechilgeetho
COUSINS
NATL.
FOREST
FAS 1300
32
T11N
West
RESERVATION
TELEVISION RELAY STATION
Meridian
ZUNI INDIAN
ZUNI BUTTES
ZUNI 7225
36
U.S. AIRCRAFT
Rio
T10N
BLACK ROCK RESERVOIR
TELEPHONE REPEATER STATION
Black Rock
Zuni Pueblo
53
River
Zuni
MATSAKI
Tsolyatone Mountain
AIRWAY BEACON 57
Guide
ZUNI MISSION CHURCH OF NUESTRA SEÑORA (RESTORED)
KYAKIMA
FAS 1301
11.5
3.5
6.2
5.5
Third
Canyon
T9N
R.20 W.
R.19 W.
50'
To Jct. N.M. 32
Atarque 49
R.18 W.
Longitude West from Greenwich
Scale 1/126720 or 1 Inch = 2 M
STATUTE MILES
1964

APPENDIX G

CORRESPONDENCE
CONCERNING
DEMOGRAPHY

BUREAU OF BUSINESS RESEARCH
INSTITUTE FOR SOCIAL RESEARCH AND DEVELOPMENT
THE UNIVERSITY OF NEW MEXICO ☐ ALBUQUERQUE, NEW MEXICO 87131
505/277-2216

September 6, 1974

Mr. J. J. Dorian,
Environmental Engineer
United Nuclear Industries, Inc.
P.O.Box 490
Richland, Wa. 99352

Dear Mr. Dorian:

As per our telephone conversation of September 5 I have enclosed the census material needed for your project.

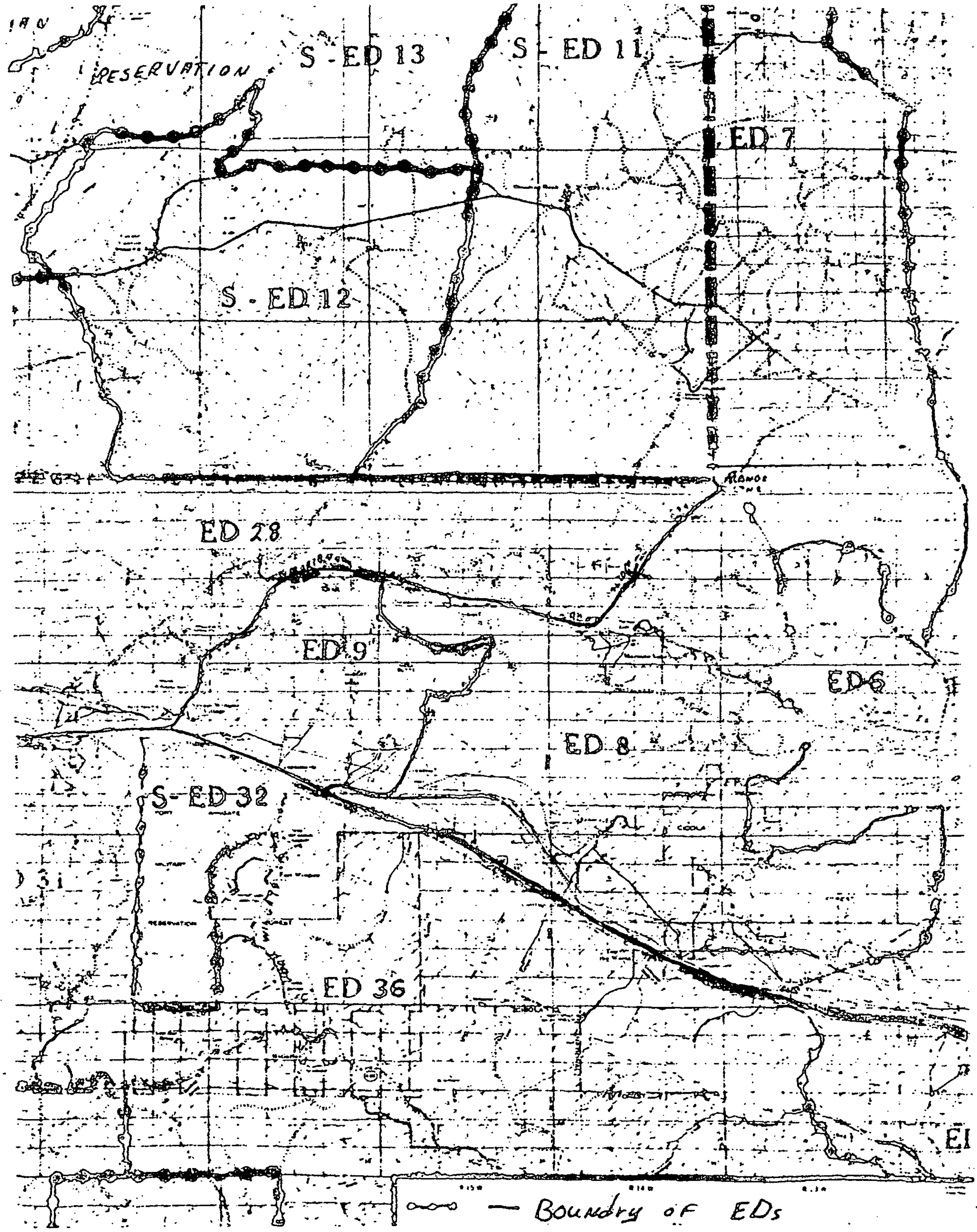
If I can be of further assistance please do not hesitate to contact me.

Sincerely,

Larry Adcock

Larry Adcock
Assistant Director

hs


RESERVATION
S - ED 13
S - ED 11
ED 7
S - ED 12
ED 28
ED 9
ED 6
ED 8
S - ED 32
ED 36
Boundry of EDs

ED#	TOTAL POPULATION	HOUSEHOLD POPULATION	TOTAL HOUSES	OCCUPIED HOUSING UNITS	VACANT YEAR-ROUND HOUS. & SEASONAL HOUS. UNITS	AVERAGE HOUSEHOLD SIZE
8	1442	1429	325	314	8	4.55
9	1489	1448	397	249	143	5.81
11	543	543	112	110	2	4.93
12	802	795	142	139	3	5.71
28	975	975	204	189	14	5.15
TOTAL	5251	5190	1180	1001	170	

5190 / 1001 = 5.18

Average Household Size = Household population / Occupied Housing Units

Household Population = Total Population - (Institutional Pop. + Group quarters Pop.)

Occupied Unit = Total Housing Units - (Vacant units + Seasonal Units)

UNITED NUCLEAR
CORPORATION

MINING AND MILLING DIVISION
AMBROSIA LAKE OPERATION

P. O. BOX 199
TELEPHONE 876-2217
GRANTS, NEW MEXICO 87020

October 16, 1974

Mr. L. V. Barker
United Nuclear Industries
P.O. Box 490
Richland, Washington 99352

Dear Lu:

This is to confirm our telephone conversation of October 15, 1974 that there are 43 people in the Church Rock mine site trailer park.

Sincerely,

UNITED NUCLEAR CORPORATION

J. O. Greenslade
Manager of Operations

JOG:gk

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS
Navajo Area Office
Window Rock, Arizona 86515

IN REPLY REFER TO:
Information
and
Statistics

SEP 3 1974

Mr. J. J. Dorian
Environmental Engineer
United Nuclear Industries, Inc.
Post Office Box 490
Richland, Washington 99352

Dear Mr. Dorian:

Your correspondence of August 27, 1974, addressed to Navajo Indian Council has been forwarded to us for reply.

Data available do not set out information you require specifically. We are enclosing a map which may be of interest to you and material on our estimate of population for the Eastern Navajo Agency. Dividing total population (30,376) by households (4,711 plus 665) yields mean household size of 5.7 persons.

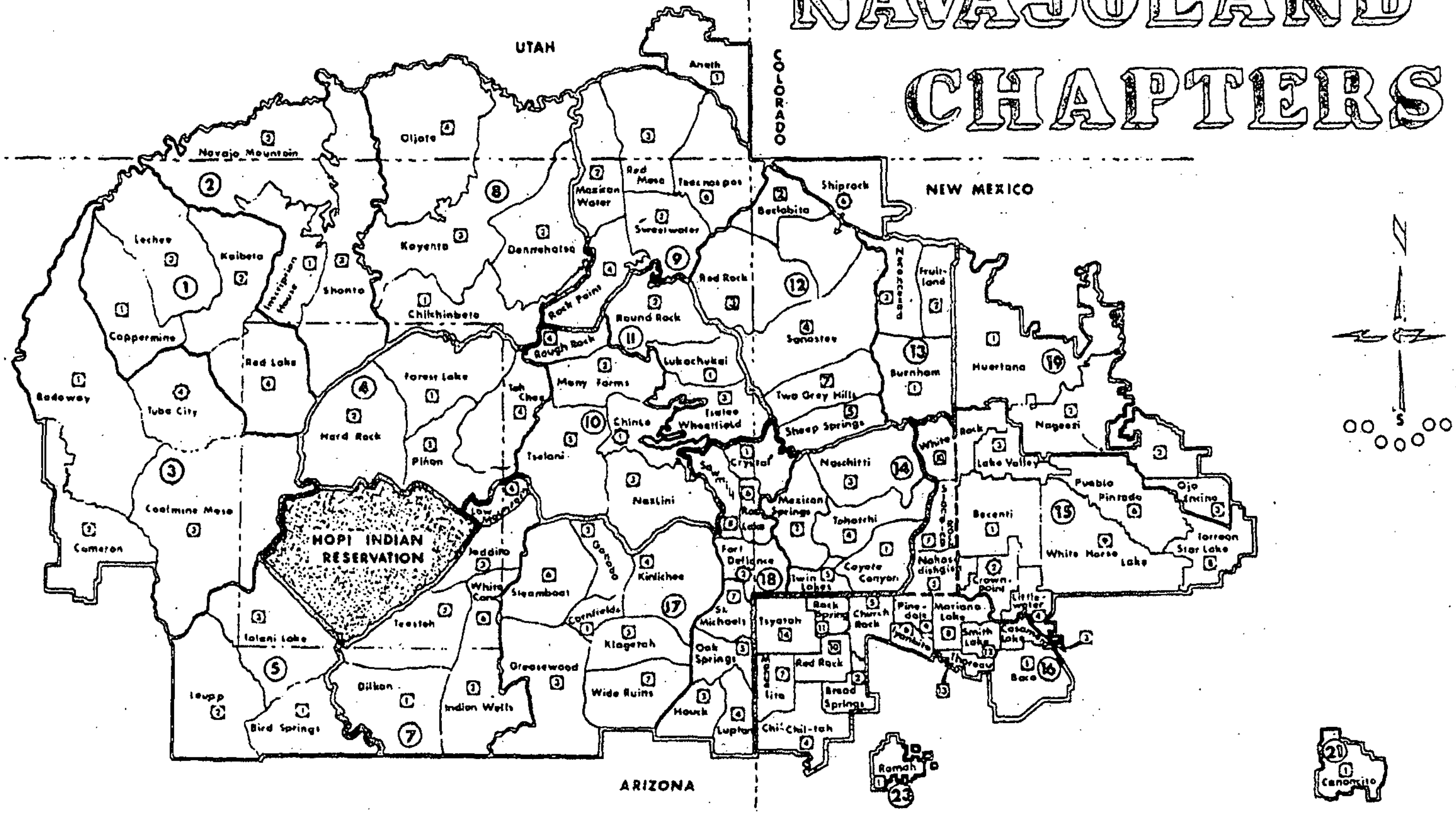
If you have other questions, feel free to call on us.

Sincerely yours,

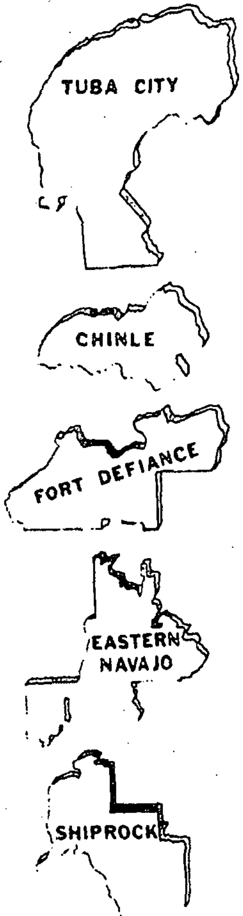
Area Vital Statistics Officer

Enclosures

NAVAJOLAND CHAPTERS



NAVAJO AREA AGENCIES



ESTIMATED POPULATION

APRIL 1, 1973

District 1 Total 4,809
1 Coppermine 1 280
2 Koibeto 1 048
3 LeChee 433
4 Red Lake 2 048

District 2 Total 3,752
1 Inscription House 1 217
2 Navajo Mountain 1 000
3 Shonto 1,535

District 3 Total 5,992
1 Bodaway 1.175
2 Cameron 1.402
3 Coalmine 1.185
4 Tuba City 2,230

District 4 Total 9.057
1 Forest Lake 1.680
2 Hard Rock 2.296
3 Pinon 3.352
4 TahChee 1,729

District 5 Total 3.500
1 Bird Springs 923
2 Loupp 1.497
3 Tolani Lake 1 080

District 7 Total 6,355
1 Dilkon 1,144
2 Indian Wells 922
3 Jeddito 891
4 Low Mountain 1,011
5 Teesto 1,360
6 White Cone 1,027

District 8 Total 6892
1 Chilchinbeto 953
2 Dinnehotso 2,178
3 Kayenta 2,223
4 Oljato 1,538

District 9 Total 6,651
1 Mexican Water 830
2 Red Mesa 1.456
3 Rock Point 1,291
4 Sweetwater 1,437
5 Teec Nos Pos 1,637

District 10 Total 10,127
1 Chinle 4,195
2 Many Farms 1,529
3 Nazlini 1,713
4 Rough Rock 893
5 *Tselani* 1,797

District 11 Total 3,711
1 Lukachukai 1,303
2 Round Rock 1,055
3 Tsailee-Wheatfield 1,353

District 12 Total 17,260
1 Aneth 1,525
2 Beclabito 907
3 Red Rock 2,253
4 Sanostee 2,201
5 Sheep Springs 1,365
6 Shiprock 6,561
7 Two Grey Hills 2,448

District 13 Total 3.563
1 Burnham 1,154
2 Fruitland 904
3 Nenahnezah 1,505

District 14 Total 6,404
1 Coyote Canyon 1,193
2 Mexican Springs 1,104
3 Naschitti 1,440
4 Tohatchi 1,267
5 *Twin Lakes* 1,400

District 15 Total 7,952
1 Becenti 574
2 Crownpoint 806
3 Lake Valley 577
4 Little Water 852
5 Nahodishgish 501
6 *Pueblo Pintado* 889
7 Standing Rock 870
8 Torreon-Star Lake 1,606
9 White Horse Lake 904
10 White Rock 373

District 16 Total 14,504
1 Baca 864
2 Bread Springs 974
3 Casamero Lake 690
4 Chi-Chil-tah 1,521
5 Church Rock 1,560
6 Iyanbito 998
7 Manuelito 782
8 Mariano Lake 809
9 Pinedale 1,380
10 Red Rock 1,691
11 Rock Springs 815
12 Smith Lake 711
13 Thoreau 885
14 Tsayatoh 821

District 17 Total 8,697
1 Cornfields 1,017
2 Ganado 984
3 Greasewood 1,329
4 Kinlichee 1,675
5 Klagetoh 1,419
6 Steamboat 1,258
7 Wide Ruins 1,015

District 18 Total 9 382
1 Crystal 333
2 Fort Defiance 3 223
3 Houck 1 188
4 Lupton 772
5 Oak Springs 805
6 Red Lake 493
7 St. Michaels 882
8 Sawmill 1,036

District 19 Total 5,866
1 Huerfano 2,349
2 Nageezi 2,296
3 *Ojo Encino* 721

District 21 Total 1,17
1 Canoncito 1217

District 22 Total 995
1 Alamo 995

District 23 Total 1,497
1 Ramah 1,497

Office Of Information & Statistics - June 14, 1973

Estimated Population
Eastern Navajo Agency
By Age, Sex, and Marital Status
January 1, 1973

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
All Ages	30,376	14,827	10,063	4,657	52	55	4,711	15,549	10,215	4,927	289	118	665
-1	176	83	83	0	0	0	0	93	93	0	0	0	0
1	148	78	78	0	0	0	0	70	70	0	0	0	0
2	257	132	132	0	0	0	0	125	125	0	0	0	0
3	543	283	283	0	0	0	0	260	260	0	0	0	0
4	545	259	259	0	0	0	0	286	286	0	0	0	0
(Under) (5)	(1,669)	(835)	(835)	(0)	(0)	(0)	(0)	(834)	(834)	(0)	(0)	(0)	(0)
5	805	400	400	0	0	0	0	405	405	0	0	0	0
6	758	364	364	0	0	0	0	394	394	0	0	0	0
7	561	281	281	0	0	0	0	280	280	0	0	0	0
8	791	398	398	0	0	0	0	393	393	0	0	0	0
9	904	444	444	0	0	0	0	460	460	0	0	0	0
(5-9)	(3,819)	(1,887)	(1,887)	(0)	(0)	(0)	(0)	(1,932)	(1,932)	(0)	(0)	(0)	(0)
10	976	499	499	0	0	0	0	477	477	0	0	0	0
11	923	454	454	0	0	0	0	469	469	0	0	0	0
12	908	443	443	0	0	0	0	465	465	0	0	0	0
13	899	433	433	0	0	0	0	466	466	0	0	0	0
14	756	385	385	0	0	0	0	371	371	0	0	0	0
(10-14)	(4,462)	(2,214)	(2,214)	(0)	(0)	(0)	(0)	(2,248)	(2,248)	(0)	(0)	(0)	(0)

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
15	803	406	404	2	0	0	2	397	390	6	0	1	0
16	903	429	428	1	0	0	1	474	470	4	0	0	0
17	780	381	374	7	0	0	7	399	386	13	0	0	3
18	759	386	372	14	0	0	14	373	356	17	0	0	2
19	743	363	346	17	0	0	17	380	353	26	1	0	6
(15-19)	(3,988)	(1,965)	(1,924)	(41)	(0)	(0)	(41)	(2,023)	(1,955)	(66)	(1)	(1)	(11)
20	739	359	325	34	0	0	34	380	339	41	0	0	3
21	690	322	292	30	0	0	30	368	311	57	0	0	2
22	655	310	267	43	0	0	43	345	277	68	0	0	3
23	690	333	272	61	0	0	61	357	273	84	0	0	4
24	603	278	226	51	0	1	53	325	248	76	1	0	3
(20-24)	(3,377)	(1,602)	(1,382)	(219)	(0)	(1)	(221)	(1,775)	(1,448)	(326)	(1)	(0)	(15)
25	593	290	222	68	0	0	68	303	201	102	0	0	2
26	573	282	207	75	0	0	76	291	200	90	1	0	2
27	544	265	184	81	0	0	81	279	183	94	1	1	2
28	514	247	156	91	0	0	94	267	152	114	1	0	5
29	519	258	163	95	0	0	95	261	142	116	1	2	7
(25-29)	(2,743)	(1,342)	(932)	(410)	(0)	(0)	(414)	(1,401)	(878)	(516)	(4)	(3)	(18)
30	475	220	130	89	0	1	89	255	110	143	1	1	8
31	452	207	107	100	0	0	100	245	98	144	0	3	9
32	488	229	122	106	0	1	106	259	110	145	3	1	9
33	423	207	90	117	0	0	117	216	69	144	1	2	9
34	433	209	65	143	0	1	143	224	68	150	4	2	9
(30-34)	(2,271)	(1,072)	(514)	(555)	(0)	(3)	(555)	(1,199)	(455)	(726)	(9)	(9)	(44)

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
35	414	197	63	133	0	1	133	217	53	156	4	4	13
36	408	212	60	151	1	0	151	196	52	137	4	3	17
37	331	162	44	117	0	1	117	169	34	128	4	3	14
38	389	171	35	136	0	0	136	218	37	173	4	4	16
39	279	113	16	96	0	1	96	166	27	128	4	7	18
(35-39)	(1,821)	(855)	(218)	(633)	(1)	(3)	(633)	(966)	(203)	(722)	(20)	(21)	(78)
40	347	184	26	155	0	3	155	163	21	137	3	2	14
41	269	105	12	92	0	1	92	164	21	136	3	4	16
42	327	145	19	124	0	2	124	182	19	154	6	3	11
43	248	120	9	110	0	1	110	128	7	115	4	2	8
44	279	134	9	123	0	2	123	145	6	133	4	2	8
(40-44)	(1,470)	(688)	(75)	(604)	(0)	(9)	(604)	(782)	(74)	(675)	(20)	(13)	(57)
45	240	120	6	111	1	2	111	120	11	104	2	3	13
46	248	127	9	116	2	0	116	121	11	102	5	3	13
47	229	105	5	98	0	2	98	124	12	107	3	2	15
48	237	123	4	118	0	1	118	114	14	93	3	4	13
49	207	99	5	92	1	1	92	108	9	92	5	2	15
(45-49)	(1,161)	(574)	(29)	(535)	(4)	(6)	(535)	(587)	(57)	(498)	(18)	(14)	(69)
50	204	95	6	88	0	1	88	109	7	93	6	3	15
51	188	93	4	88	0	1	88	95	8	83	2	2	11
52	206	99	3	93	1	2	93	107	11	91	3	2	13
53	168	83	3	78	1	1	78	85	11	67	3	4	16
54	180	91	6	83	1	1	83	89	11	69	5	4	20
(50-54)	(946)	(461)	(22)	(430)	(3)	(6)	(430)	(485)	(48)	(403)	(19)	(15)	(75)

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
55	135	66	4	61	1	0	61	69	4	58	5	2	10
56	143	73	3	67	1	2	67	70	7	58	4	1	11
57	127	69	5	62	1	1	62	58	6	47	4	1	11
58	149	71	2	68	1	0	68	78	7	60	7	4	18
59	129	61	1	56	1	3	56	68	6	51	7	4	17
(55-59)	(683)	(340)	(15)	(314)	(5)	(6)	(314)	(343)	(30)	(274)	(27)	(12)	(67)
60	126	74	1	71	1	1	71	52	3	42	5	2	8
61	119	57	2	54	0	1	55	62	3	55	3	1	6
62	151	58	0	54	3	1	56	93	5	80	7	1	12
63	114	53	0	51	0	2	53	61	4	52	4	1	9
64	123	58	3	53	1	1	55	65	2	54	8	1	11
(60-64)	(633)	(300)	(6)	(283)	(5)	(6)	(290)	(333)	(17)	(283)	(27)	(6)	(46)
65	104	49	5	40	1	3	45	55	1	46	6	2	9
66	115	57	1	53	1	2	54	58	3	43	10	2	15
67	82	41	0	37	3	1	39	41	1	32	6	2	9
68	98	54	0	54	0	0	54	44	4	34	5	1	9
69	99	47	0	47	0	0	47	52	4	43	4	1	9
(65-69)	(498)	(248)	(6)	(231)	(5)	(6)	(239)	(250)	(13)	(198)	(31)	(8)	(51)
70	77	37	1	34	2	0	36	40	3	29	6	2	10
71	53	31	2	28	0	1	30	22	0	17	5	0	5
72	52	31	0	27	3	1	31	21	0	13	6	2	8
73	50	32	0	29	2	1	31	18	1	14	3	0	4
74	63	30	0	28	1	1	29	33	1	23	8	1	10
(70-74)	(295)	(161)	(3)	(146)	(8)	(4)	(157)	(134)	(5)	(96)	(28)	(5)	(37)

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
75	47	22	0	19	2	1	21	25	3	14	5	3	9
76	50	30	0	29	1	0	30	20	1	13	4	2	7
77	42	26	0	24	2	0	26	16	1	10	4	1	6
78	36	19	0	18	1	0	18	17	2	10	4	1	7
79	40	21	0	20	0	1	21	19	2	12	4	1	7
(75-79)	(215)	(118)	(0)	(110)	(6)	(2)	(116)	(97)	(9)	(59)	(21)	(8)	(36)
80	38	15	0	14	1	0	15	23	2	11	9	1	10
81	26	13	0	12	1	0	13	13	0	9	4	0	4
82	35	20	0	19	0	1	20	15	0	9	6	0	6
83	31	16	0	15	1	0	16	15	0	13	1	1	2
84	31	17	0	14	2	1	17	14	0	10	4	0	4
(80-84)	(161)	(81)	(0)	(74)	(5)	(2)	(81)	(80)	(2)	(52)	(24)	(2)	(26)
85	13	9	0	7	2	0	8	4	0	2	1	1	2
86	14	10	0	10	0	0	10	4	0	2	2	0	2
87	13	7	0	6	1	0	7	6	1	4	1	0	2
88	14	7	1	6	0	0	7	7	0	5	2	0	2
89	16	7	0	6	1	0	6	9	0	2	7	0	5
(85-89)	(70)	(40)	(1)	(35)	(4)	(0)	(38)	(30)	(1)	(15)	(13)	(1)	(13)
90	14	8	0	6	2	0	8	6	0	4	2	0	2
91	15	9	0	7	1	1	8	6	2	1	3	0	2
92	17	8	0	7	1	0	8	9	0	5	4	0	4
93	5	3	0	3	0	0	3	2	0	1	1	0	1
94	12	6	0	5	1	0	6	6	1	1	4	0	4
(90-94)	(63)	(34)	(0)	(28)	(5)	(1)	(33)	(29)	(3)	(12)	(14)	(0)	(13)

Age in Years	Both Sexes	Males	Single	Married	Widowed	Divorced	Head of Household	Females	Single	Married	Widowed	Divorced	Head of Household
95	1	0	0	0	0	0	0	1	0	1	0	0	0
96	5	1	0	1	0	0	1	4	1	1	2	0	2
97	3	1	0	1	0	0	1	2	1	0	1	0	0
98	3	0	0	0	0	0	0	3	0	1	2	0	1
99	7	2	0	1	1	0	2	5	0	0	5	0	5
(95-99)	(19)	(4)	(0)	(3)	(1)	(0)	(4)	(15)	(2)	(3)	(10)	(0)	(8)
100	2	1	0	1	0	0	1	1	1	0	0	0	0
101	5	2	0	2	0	0	2	3	0	1	2	0	1
102	3	2	0	2	0	0	2	1	0	1	0	0	0
103	2	1	0	1	0	0	1	1	0	1	0	0	0
104	0	0	0	0	0	0	0	0	0	0	0	0	0
(100-104)	(12)	(6)	(0)	(6)	(0)	(0)	(6)	(6)	(1)	(3)	(2)	(0)	(1)

Office of Information & Statistics
Bureau of Indian Affairs
Navajo Area Office
Window Rock, Arizona 86515
January 10, 1974

APPENDIX H

EPA DISCHARGE PERMIT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VI
1600 PATTERSON
DALLAS, TEXAS 75201

NPDES DETERMINATION

The Regional Administrator, after considering the facts and the requirements and policies expressed in PL 92-500 and implementing regulations, has determined that proposed Permit No. NM0020401, United Nuclear Corporation, shall be modified and issued as indicated in a Public Notice of modification, subject to timely certification (or waiver thereof) by the state certifying agency, provided however, that any condition(s) contested in a request for an Adjudicatory Hearing submitted within 10 days from receipt of this determination shall be stayed if the Regional Administrator grants the request for Hearing.

December 28, 1974
Date

Regional Administrator
Region VI

U. S. ENVIRONMENTAL PROTECTION AGENCY

PUBLIC NOTICE

December 28, 1974

The purpose of this notice is to indicate substantial changes to the proposed permits identified on the attached list, under the authority of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500.

It is the Regional Administrator's determination to issue the modified permits unless the state certifying agency denies certification prior to the effective date of the permit.

Any person may submit a request for an adjudicatory hearing within 10 days from receipt of Regional Administrator's determination to reconsider the permit. The contested provisions of the proposed permit shall then be stayed pending final action of the Agency pursuant to 40 CFR 125.36.

Requirements which must be satisfied prior to the granting of a request for an adjudicatory hearing or for request to be party at an adjudicatory hearing may be obtained from 40 CFR 125.36(b), or from available fact sheets. Further information may be obtained by writing:

Ms. Gwendolyn Gates
U. S. Environmental Protection Agency
Region VI, Permits Branch (6AEP)
1600 Patterson St., Suite 1100
Dallas, Texas 75201

or by telephone (214) 749-1983, between 8:00 a.m. and 4:30 p.m. Monday through Friday.

3 Permit No. NM0020401 for NPDES Authorization to Discharge to waters of the United States, Public Notice of which was issued on September 14, 1974.

The applicant's mailing address is: United Nuclear Corporation
P. O. Box 199
Grants, New Mexico 87020

The discharge is made into an unnamed arroyo to the Puerco River in the Little Colorado River Basin, a water of the United States which is classified for recreation and support of desirable aquatic life, and is located on that water at the Church Rock Mining Area approximately 15 miles northeast of Gallup, New Mexico. The applicant's activities, under the standard industrial classification (SIC) code 1094 which result in the existing di charge are the mining of uranium ore.

The substantial changes from the proposed permit are:

A. The effluent limitations for outfall serial number 001, during the period beginning on the effective date and lasting through 6-30-77, have been changed from:

Effluent Characteristic	Discharge Limitations	
	Daily Avg	Daily Max
Total Suspended Solids	400 mg/l	800 mg/l
Total Uranium	N/A	2 mg/l
Dissolved Radium 226	N/A	25 pCi/l

to:

During the period beginning on the effective date and lasting through 12-31-75:

Effluent Characteristic	Discharge Limitations	
	Daily Avg	Daily Max
Total Suspended Solids	100 mg/l	200 mg/l
Total Uranium	N/A	2 mg/l
Dissolved Radium 226	N/A	30 pCi/l

and:

During the period beginning 1-1-76 and lasting through 6-30-77:

Effluent Characteristic	Dicharge Limitations	
	Daily Avg	Daily Max
Total Suspended Solids	20 mg/l	30 mg/l
Total Uranium	N/A	2 mg/l
Dissolved Radium 226	N/A	30 pCi/l

B. Schedule of Compliance. Serial Number 001

Completion of final plans	6-30-75
Commencement of construction by	3-31-76
Report of construction progress	9-30-76
Completion of construction by	3-31-77
Attainment of operational level by	6-30-77

has been changed to:

Schedule of Compliance. Serial Number 001

Completion of plans to meet 1-1-76 limitations by	4-30-75
Report of progress	9-30-75
Completion of plans to meet 7-1-77 limitations by	12-31-75
Report of progress	9-30-76
Attainment of operational level by	6-30-77

C. The following other requirement has been added to Part III:

Provisions shall be made to assure the elimination of all seepage, overflow or other sources which may result in any direct or indirect discharge to surface waters other than that authorized by this permit.

Permit No. NM0020401
Application No. NM0020401

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 1251 et. seq; the "Act"),

United Nuclear Corporation
Mining and Milling Division
3737 Princeton Drive N.E.
Albuquerque, New Mexico 87110

is authorized to discharge from a facility located at

Church Rock Operation
P. O. Box 199
Grants, New Mexico 87020

to receiving waters named

unnamed arroyo to Puerco River

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on January 28, 1975

This permit and the authorization to discharge shall expire at midnight, January 27, 1980

Signed this 28th day of December 1974

Arthur W. Busch
Regional Administrator

EPA Form 3320-4 (10-73)

A-1 EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through 12-31-75 the permittee is authorized to discharge from outfall(s) serial number(s) 001.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations kg/day (lbs/day)		Other Units (Specify)		Monitoring Requirements	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m^3/Day (MGD)	—	—	—	—	continuous	N/A
Temperature	N/A	N/A	N/A	N/A	1/week	Grab
Total Suspended Solids	N/A	N/A	100 mg/l	200 mg/l	1/week	24-hr Composite
Total Uranium	N/A	N/A	N/A	2 mg/l	1/month	24-hr Composite
Dissolved Radium 226	N/A	N/A	N/A	30 pCi/l	1/month	24-hr Composite
Total Molybdenum	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Selenium	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Vanadium	N/A	N/A	N/A	N/A	1/month	24-hr Composite

The pH shall not be less than 6.0 standard units nor greater than 9.5 standard units and shall be monitored once per week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at outfall 001, the outlet of settling pond number 2.

A-2 EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning 1-1-76 and lasting through 6-30-77, the permittee is authorized to discharge from outfall(s) serial number(s) 001.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations kg/day (lbs/day)		Other Units (Specify)		Monitoring Requirements	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m^3/Day (MGD)	—	—	—	—	Continuous	N/A
Temperature	N/A	N/A	N/A	N/A	1/week	Grab
Total Suspended Solids	N/A	N/A	20 mg/l	30 mg/l	1/week	24-hr Composite
Total Uranium	N/A	N/A	N/A	2 mg/l	1/month	24-hr Composite
Dissolved Radium 226	N/A	N/A	N/A	30 pCi/l	1/month	24-hr Composite
Total Molybdenum	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Selenium	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Vanadium	N/A	N/A	N/A	N/A	1/month	24-hr Composite

The pH shall not be less than 6.0 standard units nor greater than 9.5 standard units and shall be monitored once per week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at outfall 001, the outlet of the last settling pond.

A-3 EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning 7-1-77 and lasting through the date of expiration the permittee is authorized to discharge from outfall(s) serial number(s) 001.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m^3/Day (MGD)	—	—	—	—	continuous	N/A
Temperature	N/A	N/A	N/A	N/A	1/week	grab
Total Suspended Solids	N/A	N/A	20 mg/l	30 mg/l	1/week	24-hr Composite
Total Uranium	N/A	N/A	N/A	2 mg/l	1/month	24-hr Composite
Dissolved Radium 226	N/A	N/A	N/A	3.3 pCi/l	1/month	24-hr Composite
Total Molybdenum	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Selenium	N/A	N/A	N/A	N/A	1/month	24-hr Composite
Total Vanadium	N/A	N/A	N/A	N/A	1/month	24-hr Composite

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored once per week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at outfall 001, the outlet of the last settling pond.

B. SCHEDULE OF COMPLIANCE Serial Number 001

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

Completion of plans to meet 1-1-76 limitations by	4-30-75
Report of progress	9-30-75
Completion of plans to meet 7-1-77 limitations by	12-31-75
Report of progress	9-30-76
Attainment of operational level by	6-30-77

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. *Representative Sampling*

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. *Reporting*

Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period. The first report is due on April 28, 1975. Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Regional Administrator and the State at the following addresses:

Arthur W. Busch, R. A.
U.S. Environmental Protection Agency
Region VI, Permits Branch (6AEP)
1600 Patterson, Suite 1100
Dallas, Texas 75201

Ms. Helen Gram, Program Manager
New Mexico Environmental
Improvement Agency
P. O. Box 2348
Santa Fe, New Mexico 87501

3. *Definitions* See Part 3

a. ~~The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.~~

b. ~~The "daily maximum" discharge means the total discharge by weight during any calendar day.~~

4. *Test Procedures*

Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

5. *Recording of Results*

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. *Additional Monitoring by Permittee*

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

7. *Records Retention*

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Regional Administrator or the State water pollution control agency.

A. MANAGEMENT REQUIREMENTS

1. *Change in Discharge*

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. *Noncompliance Notification*

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the Regional Administrator and the State with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. *Facilities Operation*

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. *Adverse Impact*

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. *Bypassing*

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Regional Administrator and the State in writing of each such diversion or bypass.

6. *Removed Substances*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. *Power Failures*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *Right of Entry*

The permittee shall allow the head of the State water pollution control agency, the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *Transfer of Ownership or Control*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Regional Administrator and the State water pollution control agency.

3. *Availability of Reports*

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public

inspection at the offices of the State water pollution control agency and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. *Permit Modification*

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. *Toxic Pollutants*

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. *Civil and Criminal Liability*

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. *Oil and Hazardous Substance Liability*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. *State Laws*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by Section 510 of the Act.

9. *Property Rights*

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. *Severability*

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

1. Definitions

a. The "Daily Average" concentration means the arithmetic average (weighted by flow value) of all the daily determinations of concentration made during a calendar month. Daily determinations of concentration made using a composite sample shall be the concentration of the composite sample. When grab samples are used, the daily determination of concentration shall be the arithmetic average (weighted by flow value) of all the samples collected during that calendar day.

b. The "daily maximum" concentration means the daily determination of concentration for any calendar day.

2. Provisions shall be made to assure the elimination of all seepage, overflow or other sources which may result in any direct or indirect discharge to surface waters other than that authorized by this permit.

APPENDIX I

DESIGN OF TAILINGS DISPOSAL SYSTEM

UNITED NUCLEAR CORPORATION
CHURCH ROCK URANIUM MILL
McKINLEY COUNTY, NEW MEXICO

DESIGN OF TAILINGS DISPOSAL SYSTEM

September 1974

Prepared By
KAISER ENGINEERS
Division of Henry J. Kaiser Co.

DESIGN
OF
TAILINGS DISPOSAL SYSTEM

TABLE OF CONTENTS

2. SUMMARY AND CONCLUSIONS

2.1 Tailings Dam

The tailings dam forming the westerly and northerly sides of the disposal pond will consist of an earth starter dam averaging 12 ft. in height which will be raised continuously by placement and compaction of tailings during the 15 year period of facility operation until a final average dam height of 70 ft. is reached. The length of the final dam will be 7600 ft.

2.2 Design Capacity

The final dam will have a storage capacity of 375 million cu. ft. and will cover an area of approximately 200 acres.

2.3 Dam Construction

The dam will be constructed of coarse tailings material separated from the slurry using cyclones operating on the crest of the dam. The cyclone overflow consisting of fine sands, slimes and liquid, will be discharged into the pond. The underflow will be stockpiled near the crest of the dam. The stockpiled material will later be hauled, placed and compacted using the centerline method of tailings dam construction.

2.4 Design Criteria

Criteria used in determination of the pond capacity are given in Section 3. "Discussion".

2.5 Ancillaries

Dam integrity and safety considerations will require construction of a flood channel to control natural runoff crossing the property, intercept ditches to prevent runoff from entering the pond, and a system to collect runoff from the downstream face of the dam.

2.6 Pipelines

The tailings disposal system will require initially, 7000 ft. of 8 inch slurry piping, 3600 ft. of 4 inch pipe for recycling a portion of the free liquid in the pond, and 600 ft. of 4 inch dam runoff stormwater discharge piping. An additional 1000 ft. of 6 inch stormwater discharge piping will be required to convey the mill area stormwater to the tailings pond.

CHURCH ROCK URANIUM MILL
McKINLEY COUNTY, NEW MEXICO

DESIGN OF TAILINGS DISPOSAL SYSTEM

1. INTRODUCTION

1.1 Project Description

The Church Rock Uranium Mill and Tailings Disposal System will be located entirely on property owned by United Nuclear Corporation, consisting of all of Section 2, Township 16 N, Range 16 W, N.M.P.M., in McKinley County, New Mexico, about 16 miles northeast of Gallup.

1.2 Uranium Mill

The Mill will have a capacity of 4,000 tpd and will use the acid leach, solvent extraction process. It will be located near the northwest corner of the property, as shown in SK-TD-4.

1.3 Tailings Disposal System

The major solid waste from the mill will be tailings consisting of finely ground sandstone particles from which the uranium has been chemically extracted. The tailings will be pumped to an on-site disposal pond as a slurry at a rate of 787 gpm. The liquid portion of the slurry will consist of water, sulfuric acid, and small quantities of other process chemicals such as kerosene. The tailings pond will be located in the southeasterly half of the property and will be formed on the west and north sides by a retention dam built from compacted coarse tailings solids, (see drawing SK-TD-4). The liquid and slimes portion of the tailings will be discharged entirely within the boundaries of the pond. Stormwater runoff from the mill site and the exterior (downstream) face of the retention dam will also be collected and pumped into the pond. A portion of the free liquid collected in the pond will be returned to the mill for reuse. The remaining liquid in the pond will evaporate, except for a very small quantity which will percolate into the ground. A portion of the coarse tailings will be hauled or for use as mine backfill while the remaining solids will be permanently retained within the pond area.

3. DISCUSSION

3.1 Design Criteria

The following criteria were used in design of the tailings disposal system.

3.1.1 Life

The life of the mine supplying ore to the mill will be 15 years.

3.1.2 Ore Input Rates

The mill will process 2,000 tpd of ore for the first two years and 4,000 tpd for the remaining 13 years.

3.1.3 Particle Size of Tailings

Tailings will consist of material with the following gradation:

Sieve Size	Percent Retained
No. 28	3%
No. 200	80%

3.1.4 Mine Backfill

After the third year of mill operation, 50% of tailings material retained on the No. 200 sieve will be recovered from the tailings and used in the mine for backfilling.

3.1.5 Tailings Slurry Characteristics (55% solids)

	Sp. Grav.	TPH	GPM
Dry Solids	2.7	166.67	246.91
Solution	1.01	136.36	540.05
Pulp	--	303.03	786.96

3.1.6 Recycled Liquid

A minimum 125 gpm of tailings liquid will be pumped from the tailings pond to the No. 6 counter current decant thickener at the mill.

3.1.7 Dry Density of Tailings

The average dry density of tailings deposited in place in the pond is estimated to be 80 lbs. per cu. ft.

3.1.8 Embankment Stability

The ultimate embankment has been designed for a static safety factor against slope failure of 1.5 and a safety factor of greater than 1.0 under earthquake conditions. Evaluation of the seismicity of the area indicates that the maximum bedrock acceleration to be expected at the site is 0.1 g.

3.1.9 Freeboard

The dam will have a five foot minimum freeboard at all times.

3.2 Hydrology

3.2.1 Precipitation

Design monthly and annual rainfall is based on monthly rainfall records for Gallup, New Mexico from 1938 to 1960 obtained from the U.S. Weather Bureau Climatological Summary, and records from 1961 to 1972 obtained from John W. Shomaker, Consulting Hydrologist.

3.2.1.1 Design Annual Rainfall

The design annual rainfall was calculated to be 13.83 inches/year. This value was obtained by determining the consecutive 15-year averages of annual rainfall for the recorded period and projecting them to a 100-year return frequency by the Gumbel method of extreme values.

3.2.1.2 Design Monthly Rainfall

Design monthly rainfall was obtained by proportioning the design annual rainfall in Paragraph 3.2.1.1 with the average monthly rainfall for the period of record.

3.2.1.3 Possible Maximum Precipitation (PMP)

The final PMP storm volume for the project area will be estimated by John W. Shomaker. A preliminary PMP storm volume of 20 inches was used for design of the tailings pond. This preliminary value was based on designs of similar uranium tailings dams which have been approved by the State of New Mexico.

3.2.2 Evaporation Rates

Average monthly evaporation rates were obtained from an evaporation map for shallow reservoirs in New Mexico prepared for New Mexico State Engineer Technical Report No. 31 by Hale, Reiland and Beverage, 1965. This map showed an evaporation rate of

50 inches per year at the project location. Monthly evaporation rates are listed along with design monthly rainfall below.

Month	Evaporation (in.)	Precipitation (in.)
January	0.5	0.84
February	0.5	0.90
March	2.5	1.02
April	4.5	0.85
May	7.0	0.71
June	8.5	0.60
July	8.0	2.25
August	7.0	2.34
September	6.0	1.36
October	3.0	1.30
November	1.5	0.67
December	1.0	0.99
Total	50.0	13.83

3.2.3 Infiltration

It is assumed, for purposes of determining liquid accumulation in the tailings pond, that the infiltration rate of liquid from the pond to the existing soil is zero. Percolation tests were performed at the site in conformance with Bureau of Reclamation Method E-19 at three locations by the project soils consultant, Sergent, Hauskins and Beckwith. The results obtained indicate a percolation rate between 4 and 27 feet per year. Infiltration from the tailings pond is expected to be even less than this amount due to the accumulation of fines settling out of the tailings slurry.

3.2.4 Entrapped Water

A substantial amount of water will be entrapped in the voids between solids particles in the deposited tailings. Based on a dry density of 80 lbs per cu. ft. and a specific gravity of 2.7 for the solid portion of tailings deposits, a cubic foot of saturated tailings deposits has been assumed to have the following composition:

	Volume	Weight (lbs/cu.ft.)
Solids	47.5%	80
Liquid	52.5%	33.1
	100.0%	113.1

3.3 Drainage Systems

The tailings pond will be bounded by drainage and diversion structures. These structures will have a design flow capacity equal to the probable maximum flood estimated by John W. Shomaker, Consulting Hydrologist. The probable maximum flood is assumed to be the peak runoff resulting from a storm of 500-year return frequency.

3.3.1 Flood Channel

A flood channel with a 60-ft. bottom width and 2:1 side slopes will confine runoff from the 18.7 sq. mi. watershed to the north of the property. The flood channel will parallel the main paved road across the property and will be set back 15 feet from the easterly boundary of an easement within which two pipelines owned by El Paso Natural Gas Company are situated. The flood channel will have a capacity of 8,650 cu. ft. per sec. and will be lined with riprap for erosion protection.

3.3.2 Diversion Channel

The northeast side of the tailings dam intercepts natural drainage collected from a 580 acre watershed to the east of the property. This drainage will be diverted to the north by a diversion channel which will join the main flood channel at the north side of the property. Design capacity of the diversion channel will be 2500 cu.ft./sec. The westerly bank of the diversion channel will also contain an earth dam which will further protect the tailings dam from erosion by runoff from the east watershed. The diversion channel and the easterly face of the diversion dam will be covered with riprap for erosion protection.

3.3.3 Intercept Ditches

In order to minimize the quantity of storm water entering the tailings pond, intercept ditches will be constructed along the southeast pond limit. The first ditch will be constructed at an elevation of approximately 6975 ft. As the elevation of the pond increases throughout its life, two more intercept ditches will have to be constructed outside the pond limit. The design flow for these ditches will be 630 cu. ft. per sec. based on a 96 acre watershed.

3.3.4 Runoff Collection System

A system for collecting runoff from the downstream face of the retention dam will be constructed. The system will also collect any seepage through the filter blanket under the downstream face of the dam and return these waters to the pond.

The system will consist of a collection ditch parallel to the dam, a stormwater retention basin at the southeast corner of the pond, a pumping station, and pipeline for discharging the collected water into the tailings pond. Initially, the collection ditch will be located midway between the downstream toe of the starter dam and the downstream toe of the ultimate (15-year) dam. Later, a ditch will have to be constructed at the downstream toe of the ultimate dam. The runoff collection system will be capable of retaining the maximum surface runoff from a storm of 50-year return frequency, which is estimated to be less than two inches.

3.4 Tailings Pond

Tailings slurry will be discharged through wet-cyclones at the crest of the dam. The overflow containing slimes and liquid will be discharged into the pond. The underflow containing coarse sands will be used for mine backfill and for raising the dam.

3.4.1 Starter Dam

Before mill operations begin, a starter dam will be built of compacted on-site clayey soils. It will have a crest elevation of 6,956 feet, will range from 0 to 46 feet high and will be about 5,000 feet long. The starter dam will have sufficient storage capacity for six months of mill operation and enough freeboard to contain a 20-inch PMP flood. The freeboard is also sufficient to contain the flood volume of a 50-year storm, assuming total failure of the intercept ditches along the southeast pond limit. The starter dam will contain a five foot high bench of compacted soil extending out an average distance of 50 feet from the upstream toe. The purpose of this bench is to provide a stable foundation over which the coarse material forming the upstream side of the retention dam will be compacted in place.

3.4.2 Tailings Dam Build-Up

The starter dam will be raised by successive lifts utilizing the centerline method of dam construction. The following table shows the minimum required growth for storage of tailings. The minimum growth rate will be seven feet per year for the first three years and three feet per year for the remaining 12 years. The actual growth rate should exceed this in order to complete work on the dam prior to shut-down of the mill. This will allow planting of the downstream face of the dam, to be accomplished while the mill is active.

Years from Start-Up	Accumulated Tailings* (Million cu.ft.)	Min. Crest Elev.	Recommended Crest Elev. for Early Planting	Maximum ** Surface Area (Million sq.ft.)
0	0	6956	6956	
.5	15.6	6959.5	6959.5	1.9
1	24.7	6963	6963	2.2
1.5	33.8	6966.5	6966.5	2.9
2	42.9	6970	6970	3.3
3	90.8	6977	6977	4.3
4	116.5	6980	6982	4.6
5	138.4	6983	6987	4.9
6	162.1	6986	6992	5.2
7	184.0	6989	6997	5.4
8	205.9	6992	7002	5.6
9	227.8	6995	7007	5.8
10	249.7	6998	7012	6.0
11	273.3	7001	7014	6.2
12	295.2	7004		6.4
13	317.1	7007		6.6
14	339.0	7010		6.8
15	365.3	7014		7.0

* Includes tailings liquid and solids and stormwater runoff.
** Based on minimum crest elevation.

3.4.3 System Operation

3.4.3.1 Construction

The downstream face of the dam will be maintained at a 3:1 slope. Construction will consist of hauling, placing, spreading and compacting coarse sands from

cyclone underflow in successive lifts beginning at the downstream toe of the dam, above a three-foot layer of machine-placed filter material and ending at the upstream shoulder of the crest. Construction of the upstream "face" of the dam will consist of compacting in-place sands after removal of stockpiled underflow so that not more than a 5 ft. depth of consolidated sand deposits requiring vibration remain on top of previously compacted material. The volume to be compacted in this manner will be that contained inside an imaginary plane at a 1:1 slope from the upstream shoulder of the ultimate dam crest, sloping down toward the pond. Construction will not take place during winter months when snow and ice will prevent adequate compaction of fill.

3.4.3.2 Instrumentation and Monitoring

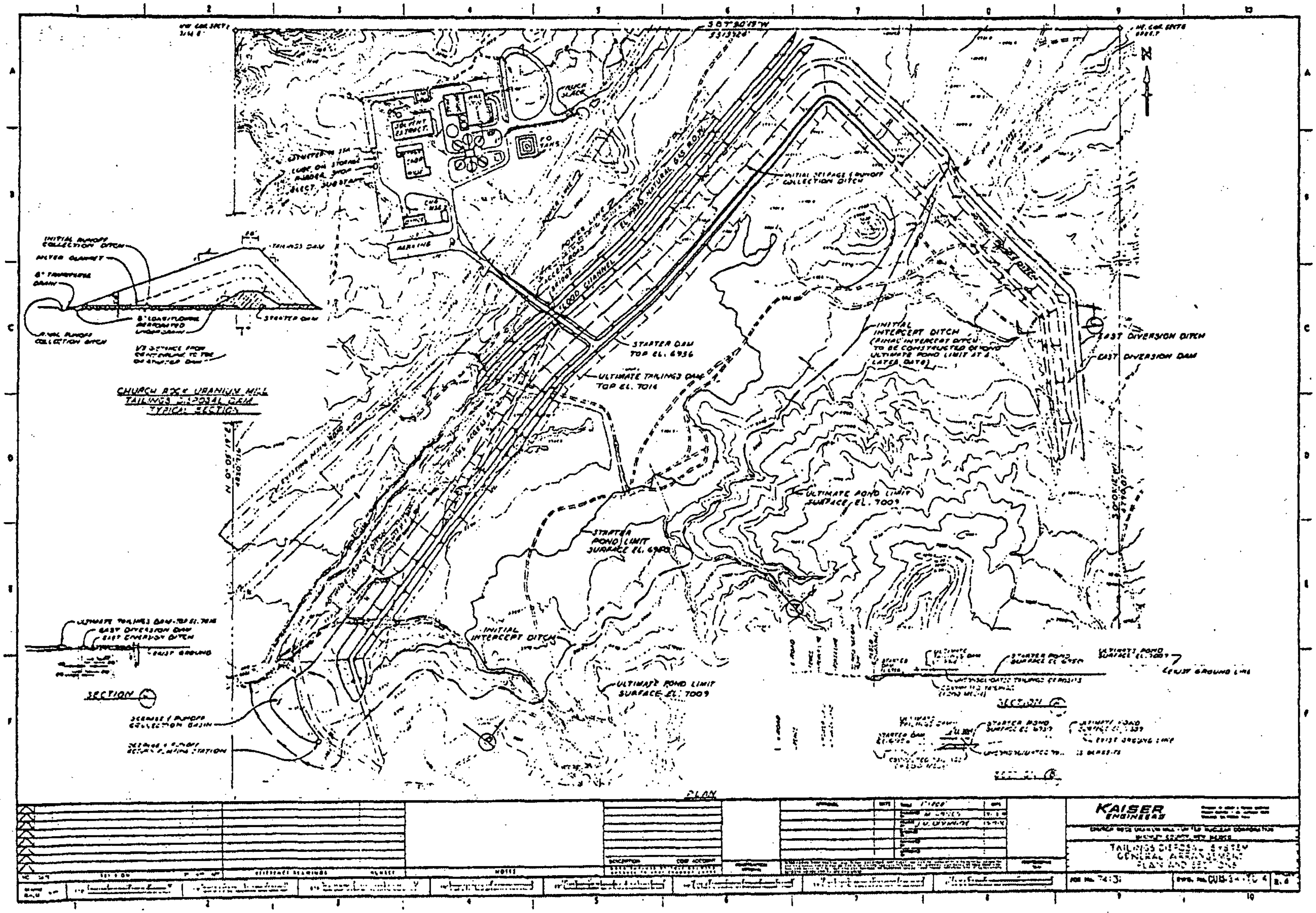
To monitor the stability of the dam, piezometers will be installed in the downstream face of the starter dam and in the tailings dam as the dam is raised. Settlement gages will not be necessary since the crest elevation of the dam will be continually raised. Monitoring wells will be installed downstream from the tailings dam and on the north and south sides of the pond. These will provide a means for regularly sampling groundwater to detect possible contamination by seepage and to measure the amount of seepage.

3.5 Pipelines

The tailings will be pumped from the mill through an 8" surface pipeline and will be aligned along the access road to the dam. It will branch into two 8" lines along the dam crest from which slurry will be fed into a bank of four 10-inch cyclones. Recycled liquid will be collected from the pond and pumped through 4" surface pipelines back to the No. 6 counter current decant thickener.

3.6 Planting

During the period in which the tailings dam is being raised, the downstream face will be continually covered with compacted tailings. As soon as the final dam height is reached, the downstream face will be planted to prevent erosion. As discussed in Paragraph 3.4.2, the planting of the downstream face should be begun prior to shut-down of the mill. The surface of the tailings pond will be planted after the mill is shut-down. During the life of the mill, test beds of tailings will be prepared. Experimentation with different depths of soil cover and specimens of local flora will take place to determine the minimum depth of soil cover necessary to insure continued healthy growth without benefit of artificial irrigation.



KAISER ENGINEERS
TAILINGS DISPOSAL SYSTEM
GENERAL ARRANGEMENT
PLAN AND SECTIONS
CHURCH ROCK URANIUM MILL
TAILINGS DISPOSAL DAM
TYPICAL SECTION
INITIAL RUNOFF COLLECTION DITCH
TAILINGS DAM
STARTER DAM
STARTER DAM TOP EL. 6956
ULTIMATE TAILINGS DAM TOP EL. 7014
INITIAL SEEPAGE & RUNOFF COLLECTION DITCH
INITIAL INTERCEPT DITCH
EAST DIVERSION DITCH
EAST DIVERSION DAM
ULTIMATE POND LIMIT SURFACE EL. 7009
STARTER POND LIMIT
INITIAL INTERCEPT DITCH
SEEPAGE & RUNOFF COLLECTION BASIN
SEEPAGE & RUNOFF RETURN PUMPING STATION
FLOOD CHANNEL
SOLVENT EXTRACT.
TRUCK SCALE
EXIST GROUND
EXIST GROUND LINE
SECTION
PLAN

APPENDIX J

PREOPERATIONAL ENVIRONMENTAL DATA

Controls for Environmental Pollution, Inc.
1925 Rosina • P.O. Box 5351 • Santa Fe, New Mexico 87501 • Telephone

May 16, 1975

United Nuclear Industries, Inc.
1201 Jadwin Avenue
Richland, Washington 99352

Attention: Mr. Noel F. Savignac

Dear Noel:

As per our telephone conversation on May 15, 1975, attached is a corrected report.

Very truly yours,

CONTROLS FOR ENVIRONMENTAL POLLUTION, INC.

James J. Mueller
President

JJM:bo

Enclosure

CUSTOMER United Nuclear Industries, Inc.
ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Avenue
CITY Richland, Washington 99352
INVOICE NO. 411084

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Gross Alpha, Gross Beta, Thorium-230, Radium-226, and Total Uranium in Surface Water Analysis - 6 samples

Sample Identification	Date Collected	Analysis	ugU/l	dpm/l
#1	10/10/74	Alpha		3,431±141
		Beta		1,041±36
		Th-230		166±0.38
		Ra-226		25.2±3.2
		Total Uranium	1,126	
#2	10/10/74	Alpha		4,443±192
		Beta		1,279±40
		Th-230		179±0.39
		Ra-226		44.2±12.5
		Total Uranium	1,466	
#3	10/10/74	Alpha		3,667±233
		Beta		768±31
		Th-230		10.2±0.09
		Ra-226		41±9
		Total Uranium	1,494	
#4	10/10/74	Alpha		6,825±591
		Beta		1,354±41
		Th-230		134±0.34
		Ra-226		15±6
		Total Uranium	1,636	

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James J. Mueller, President

11/21/74

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Controls for Environmental Pollution, Inc.
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CUSTOMER United Nuclear Industries, Inc.
ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Avenue
CITY Richland, Washington 99352
INVOICE NO. 411084

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Gross Alpha, Gross Beta, Thorium-230. Radium-226, and Total Uranium in Surface Water Analysis - 6 samples

Sample Identification	Date Collected	Analysis	ugU/l	dpm/l
#5	10/10/74	Alpha		5,396±686
		Beta		678±30
		Th-230		3.93±0.07
		Ra-226		8±4
		Total Uranium	1,664	
#6	10/10/74	Alpha		6,573±604
		Beta		659±29
		Th-230		13.5±0.13
		Ra-226		38±9
		Total Uranium	1,532	

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CUSTOMER	United Nuclear
ATTENTION	T. E. Dabrowski
ADDRESS	1201 Jadwin Ave.
CITY	Richland, Washington 99352
INVOICE NO.	411138

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water - Standard Chemical Series for Water (Churchrock Site)

Sample Identification	Date Collected	Analysis	mg/l Sample #1	Sample #2	Sample #3
#1	10/10/74	Bicarbonate	195	203	197
#2	10/10/74	Calcium	2.38	3.87	6.47
#3	10/10/74	Carbonate	15.1	8.5	12.3
		Hardness	7.1	9.8	13.4
		Magnesium	0.7	1.2	3.1
		Nitrate	< 0.1	< 0.1	0.1
		Phosphate	0.36	1.00	1.84
		Potassium	0.66	0.86	0.94
		Sodium	136	136	105
		Sulfate	81	85	98
		Suspended Solids	68	318	566
		Arsenic	< 0.01	< 0.01	< 0.01
		Beryllium	*	*	*
		Cadmium	< 0.001	< 0.001	< 0.001
		Copper	0.01	< 0.01	< 0.01
		Lead	< 0.001	< 0.001	< 0.001
		Mercury	< 0.4 ug/l	< 0.4 ug/l	< 0.4 ug/l
		Selenium	< 0.001	< 0.001	< 0.001
		Zinc	0.01	< 0.01	0.02
		pH	8.64	8.68	8.70

*Will be reported 11/22/74.

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James J. Mueller, President

11/21/74 PAGE 1 OF 1 PAGE

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ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Ave.
CITY Richland, Washington 99352
INVOICE NO 411138

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water - Standard Chemical Series for Water (Churchrock Site)

Sample Identification	Date Collected	Analysis	Sample #4	Sample #5	Sample #6
#4	10/10/74	Bicarbonate	203	209	203
#5	10/10/74	Calcium	7.77	17.06	13.55
#6	10/10/74	Carbonate	5.0	< 1.0	3.5
		Hardness	38.1	68.4	46.2
		Magnesium	2.6	3.5	2.8
		Nitrate	0.1	0.4	0.7
		Phosphate	0.20	0.28	0.40
		Potassium	1.78	3.54	2.66
		Sodium	105	104	122
		Sulfate	98	112	105
		Suspended Solids	2312	5660	3672
		Arsenic	< 0.01	< 0.01	< 0.01
		Beryllium	*	*	*
		Cadmium	< 0.001	< 0.001	< 0.001
		Copper	< 0.01	0.01	0.12
		Lead	< 0.001	< 0.001	< 0.001
		Mercury	< 0.4 ug/l	< 0.4 ug/l	< 0.4 ug/l
		Selenium	< 0.001	< 0.001	< 0.001
		Zinc	0.01	0.04	0.03
		pH	8.54	8.32	8.45

*Will be reported 11/22/74.

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11/21/74

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CUSTOMER United Nuclear
ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Ave.
CITY Richland, Washington 99352
INVOICE NO. 411138

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water - Standard Chemical Series for Water (Churchrock Site)

Date Collected	Analysis	Sample #1	Sample #2	Sample #3	Sample #4	Sample #5	Sample #6
10/10/74	Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

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11/22/74

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United Nuclear Industries, Inc.
T. E. Dabrowski
1201 Jadwin Avenue
Richland, Washington 99352
411084

REPORT OF ANALYSIS

RECEIVED 11/04/74 | CUSTOMER ORDER NUMBER

ANALYSIS Air Particulate for Gross Alpha and Beta

Sample Identification	Date Collected	pCi/m³ Gross Alpha	Gross Beta
UNC #1 At bend in road (Route 566) opposite arrow on tree inside fence, in line with Three Pole Power line.	10/02/74	0.0000 ± 0.0001	0.000 ± 0.001
UNC #2 Far East side of South Fence (Property Line). At "Private Property, No Trespassing" sign on fence.	10/02/74	0.0000 ± 0.0001	0.000 ± 0.001
UNC #3 On South Property Line Fence (East of Route 566) at arroyo.	10/02/74	0.0000 ± 0.0001	0.000 ± 0.001
UNC #4 In front of TLD tree location and south of stack of metal pipe at mill site. (West of Route 566)	10/02/74	0.0003 ± 0.0001	0.000 ± 0.001

All air samples were taken at each of the TLD locations.

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James J. Mueller, President
11/11/74 PAGE 1 OF 1 PAGE

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CUSTOMER United Nuclear Industries, Inc.
ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Avenue
CITY Richland, Washington 99352
INVOICE NO 411138

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Gross Alpha, Gross Beta, Thorium-230, Radium-226, and Total Uranium in Surface Soil Analysis - 4 Samples

Sample Identification	Analysis	pCi/gm	ugU/gm	dpm/gm
#1	Alpha			4.5±1.7
	Beta			3.9±1.2
	Th-230	0.00±0.01		
	Ra-226	0.00±0.01		
	Total Uranium		<1	
#2	Alpha			5.6±1.9
	Beta			5.3±1.2
	Th-230	0.47±0.02		
	Ra-226	0.25±0.01		
	Total Uranium		2	
#3	Alpha			10.4±3.9
	Beta			4.7±1.2
	Th-230	0.47±0.01		
	Ra-226	0.62±0.01		
	Total Uranium		<1	
#4	Alpha			26.7±7.6
	Beta			3.9±1.2
	Th-230	0.43±0.03		
	Ra-226	0.91±0.01		
	Total Uranium		<1	

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ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Avenue
CITY Richland, Washington 99352
INVOICE NO. 411138

REPORT OF ANALYSIS

SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Gross Alpha, Gross Beta, Thorium-230, Radium-226, and Total Uranium in Subsurface Soil Analysis - 4 Samples

Sample Identification	Analysis	pCi/gm	ugU/gm	dpm/gm
#1	Alpha			5.5±1.9
	Beta			3.9±1.2
	Th-230	0.25±0.01		
	Ra-226	0.43±0.01		
	Total Uranium		<1	
#2	Alpha			12.7±3.7
	Beta			5.6±1.2
	Th-230	0.41±0.01		
	Ra-226	0.39±0.01		
	Total Uranium		7	
#3	Alpha			7.9±3.0
	Beta			3.9±1.1
	Th-230	0.39±0.02		
	Ra-226	0.49±0.01		
	Total Uranium		7	
#4	Alpha			27.9±9.0
	Beta			4.3±1.2
	Th-230	0.43±0.01		
	Ra-226	0.72±0.01		
	Total Uranium		<1	

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11/21/74 PAGE 1 OF 1 PAGE

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ATTENTION T. E. Dabrowski
ADDRESS 1201 Jadwin Ave.
CITY Richland, Washington 99352
INVOICE NO 411138

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SAMPLES RECEIVED 10/16/74

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Vegetation Analysis - (Churchrock Site)

Sample Identification	Analysis	ugU/g	dpm/g
#1	Alpha		3.3±1.7
	Beta		7.9±0.5
	Thorium-230		0.00±0.05
	Radium-226		0.38±0.29
	Total Uranium	< 1	
#2	Alpha		0±5
	Beta		8.9±0.5
	Thorium-230		0.00±0.05
	Radium-226		0.00±0.01
	Total Uranium	< 1	
#3	Alpha		0±5
	Beta		13.6±0.6
	Thorium-230		0.00±0.05
	Radium-226		0.00±0.01
	Total Uranium	< 1	
#4	Alpha		3.0±1.9
	Beta		9.8±0.5
	Thorium-230		0.00±0.05
	Radium-226		0.00±0.01
	Total Uranium	< 1	

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James J. Mueller, President
11/21/74 PAGE 1 OF 1 PAGE

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Controls for Environmental Pollution, Inc.
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May 27, 1975

Mr. Noel F. Savignac
Senior Health Physicist
United Nuclear Industries, Inc.
1201 Jadwin Avenue
Richland, Washington 99352

Dear Noel:

The following is the TLD data from United Nuclear Industries, Inc.'s Churchrock site. The TLD devices were placed in the field on October 17, 1974 and removed on April 17, 1975. The following are the locations and data:

Locations	10/17/74 thru 4/17/75 mRem
#1 At bend in road (Route 566) opposite arrow on tree inside barbed wire fence in line with three pole power line. (Large tree just north of three power poles.)	93
#2 Far east side of south fence (property line). At "Private Property - No Trespassing" sign on fence.	100
#3 On south property line fence (East of Route 566) at Arroyo.	88
#4 On small tree set up on a slight ridge just east and south of stack of metal pipe at Mill Site (West of Route 566).	96
#5 TLDs on fence were destroyed and removed; therefore, no TLDs could be found in the area.	

Mr. Noel F. Savignac
Page 2
May 27, 1975

If further information is required, please feel free to contact me.

Very truly yours,

CONTROLS FOR ENVIRONMENTAL POLLUTION, INC.

James J. Mueller
President

JJM: bo

CUSTOMER United Nuclear Industries, Inc.
ATTENTION Noel F. Savignac
ADDRESS 1201 Jadwin Ave.
CITY Richland, WA 99352
INVOICE NO. 506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 6/05/75 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS · Surface Water Analysis -

Sample Identification	Date Collected	Analysis	pCi/l	ugU/l
#1	6/04/75	Alpha	1680±68	
		Beta	463±17	
		Thorium-230	35.6±3.6	
		Radium-226	40.5±4.1	
		Total Uranium		2310
#2	6/03/75	Alpha	635±53	
		Beta	85±9	
		Thorium-230	77.5±27.8	
		Radium-226	0.55±0.11	
		Total Uranium		1600
#3 (Prior to discharge)	6/03/75	Alpha	251±37	
		Beta	29±8	
		Thorium-230	14.3±1.4	
		Radium-226	3.86±0.31	
		Total Uranium		920
#3	6/03/75	Alpha	225±25	
		Beta	21±8	
		Thorium-230	8.60±0.90	
		Radium-226	2.89±0.27	
		Total Uranium		535
#4	6/04/75	Alpha	604±43	
		Beta	72±9	
		Thorium-230	55.5±5.6	
		Radium-226	12.8±0.6	
		Total Uranium		1540

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James J. Mueller, President
7/03/75

Controls for Environmental Pollution, Inc.
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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Ave.
Richland, WA 99352
506123

REPORT OF ANALYSIS

6/05/75 CUSTOMER ORDER NUMBER

Surface Water Analysis -

Sample Identification	Date Collected	Analysis	pCi/l	ugU/l
#5	6/04/75	Alpha	481±39	
		Beta	68±9	
		Thorium-230	10.4±1.0	
		Radium-226	64±6	
		Total Uranium		1450

NOTE: All samples were high in solids which could contribute the higher activity from the first collection.

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James J. Mueller, President
7/03/75

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CUSTOMER United Nuclear Industries, Inc.
ATTENTION Noel F. Savignac
ADDRESS 1201 Jadwin Ave.
CITY Richland, WA 99352
INVOICE No. 506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 6/05/75 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Air Particulate (ambient air) analysis -

Sample Identification	Date Collected	Analysis	pCi/m^3	ugU/m^3
#1 Tot. Vol. = $199.5m^3$	6/03/75	Alpha	0.000±0.005	
		Beta	0.020±0.016	
		Thorium-230	0.0000±0.0001	
		Radium-226	0.00000±0.00005	
		Total Uranium		0.013
#2 Tot. Vol. = $394.8m^3$	6/03/75	Alpha	0.000±0.005	
		Beta	0.010±0.008	
		Thorium-230	0.00000±0.00005	
		Radium-226	0.00000±0.00003	
		Total Uranium		0.068
#3 Tot. Vol. = $305.6m^3$	6/04/75	Alpha	0.000±0.005	
		Beta	0.015±0.010	
		Thorium-230	0.00000±0.00006	
		Radium-226	0.0021±0.0003	
		Total Uranium		0.018
#4 Tot. Vol. = $290.1m^3$	6/04/75	Alpha	0.000±0.005	
		Beta	0.021±0.011	
		Thorium-230	0.00000±0.00007	
		Radium-226	0.0107±0.0008	
		Total Uranium		0.009

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James J. Mueller, President
7/03/75

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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Ave.
Richland, WA 99352
506123

REPORT
ANALY

SAMPLE RECEIVED 6/05/75

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil Analysis -

Sample Identification	Date Collected	Analysis	pCi/g (wet)	ugU/g (we
#1 0-2"	6/03/75	Alpha	2.68±0.90	
		Beta	1.66±0.67	
		Thorium-230	0.44±0.04	
		Radium-226	0.54±0.05	
		Total Uranium		1.4
#1 2-4"	6/03/75	Alpha	2.67±0.99	
		Beta	1.40±0.66	
		Thorium-230	0.39±0.04	
		Radium-226	0.47±0.05	
		Total Uranium		1.9
#2 0-2"	6/03/75	Alpha	4.59±1.55	
		Beta	4.02±0.75	
		Thorium-230	0.63±0.06	
		Radium-226	1.13±0.11	
		Total Uranium		2.1
#2 2-4"	6/03/75	Alpha	9.34±2.29	
		Beta	4.52±0.77	
		Thorium-230	0.57±0.06	
		Radium-226	0.61±0.06	
		Total Uranium		1.6
#3 0-2"	6/04/75	Alpha	3.07±1.57	
		Beta	3.27±0.73	
		Thorium-230	0.65±0.07	
		Radium-226	0.60±0.06	
		Total Uranium		1.7

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James J. Mueller, President
7/03/75

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CUSTOMER United Nuclear Industries, Inc.
ATTENTION Noel F. Savignac
ADDRESS 1201 Jadwin Ave.
CITY Richland, WA 99352
INVOICE NO. 506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 6/05/75

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil Analysis -

Sample Identification	Date Collected	Analysis	pCi/g (wet)	ugU/g (wet)
#3 2-4"	6/04/75	Alpha	6.82±2.04	
		Beta	3.32±0.73	
		Thorium-230	0.60±0.06	
		Radium-226	0.71±0.07	
		Total Uranium		1.7
#4 0-2"	6/04/75	Alpha	5.71±1.93	
		Beta	1.48±0.66	
		Thorium-230	0.43±0.04	
		Radium-226	0.41±0.04	
		Total Uranium		2.5
#4 2-4"	6/04/75	Alpha	5.78±2.22	
		Beta	1.59±0.66	
		Thorium-230	0.39±0.04	
		Radium-226	0.97±0.10	
		Total Uranium		1.6

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James J. Mueller, President

7/03/75

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CUSTOMER United Nuclear Industries, Inc.
ATTENTION Noel F. Savignac
ADDRESS 1201 Jadwin Ave.
CITY Richland, WA 99352
INVOICE NO. 506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 6/05/75

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Vegetation Analysis -

Sample Identification	Date Collected	Analysis	pCi/g (dry)	ugU/g (dry)
#1	6/03/75	Alpha	0.0±0.1	
		Beta	13.6±0.4	
		Thorium-230	0.0±0.1	
		Radium-226	0.0±0.1	
		Total Uranium		0.9
#2	6/03/75	Alpha	0.0±0.1	
		Beta	11.4±0.4	
		Thorium-230	0.0±0.1	
		Radium-226	0.0±0.1	
		Total Uranium		1.1
#3	6/04/75	Alpha	0.0±0.1	
		Beta	11.9±0.4	
		Thorium-230	0.0±0.1	
		Radium-226	0.0±0.1	
		Total Uranium		0.4
#4 (mixed vegetation conifer needles and grasses)	6/04/75	Alpha	0.0±0.1	
		Beta	8.77±0.33	
		Thorium-230	0.0±0.1	
		Radium-226	0.0±0.1	
		Total Uranium		0.3
#4 (leaves - oak)	6/04/75	Alpha	0.0±0.1	
		Beta	5.56±0.27	
		Thorium-230	0.0±0.1	
		Radium-226	0.0±0.1	
		Total Uranium		0.2

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James J. Mueller, President
7/03/75

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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Avenue
Richland, Washington 99352
506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 06/05/75 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#1	06/04/75	Bicarbonate	205
		Carbonate	12.5
		Hardness	9.7
		Total Phosphorus as Phosphate	<0.1
		Sulfate	59
		Suspended Solids	356
		pH Units	8.90
#2	06/03/75	Bicarbonate	203
		Carbonate	1.2
		Hardness	421
		Total Phosphorus as Phosphate	<0.1
		Sulfate	474
		Suspended Solids	8,900
		pH Units	8.37
#3 (PRIOR TO DISCHARGE)	06/03/75	Bicarbonate	196
		Carbonate	<0.1
		Hardness	555
		Total Phosphorus as Phosphate	<0.1
		Sulfate	656*
		Suspended Solids	7,200
		pH Units	8.41

*Duplicate analysis verified.

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James J. Mueller, President
07/03/75

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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Avenue
Richland, Washington 99352
506123

06/05/75

Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#4	06/04/75	Bicarbonate	201
		Carbonate	9.6
		Hardness	90.3
		Total Phosphorus as Phosphate	< 0.1
		Sulfate	140
		Suspended Solids	1,600
		pH Units	8.81
#5	06/04/75	Bicarbonate	202
		Carbonate	10.7
		Hardness	87.4
		Total Phosphorus as Phosphate	< 0.1
		Sulfate	56
		Suspended Solids	3,400
		pH Units	8.68

James J. Mueller, President
07/03/75 2 2

CUSTOMER United Nuclear Industries, Inc.
ATTENTION Noel F. Savignac
ADDRESS 1201 Jadwin Avenue
CITY Richland, Washington 99352
INVOICE NO. 506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 06/05/75 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#1	06/04/75	Mercury	< 0.0004
#2	06/03/75	Mercury	0.0004
#3 (PRIOR TO DISCHARGE)	06/03/75	Mercury	< 0.0004
#4	06/04/75	Mercury	< 0.0004
#5	06/04/75	Mercury	0.0004
#1	06/04/75	Nitrate	0.6
#2	06/03/75	Nitrate	2.1
#3 (PRIOR TO DISCHARGE)	06/03/75	Nitrate	5.0
#4	06/04/75	Nitrate	0.6
#5	06/04/75	Nitrate	0.8

APPROVED BY [signature]
James J. Mueller, President
07/03/75

Controls for Environmental Pollution, Inc.
1925 Rosina ∘ P. O. Box 5351 ∘ Santa Fe, New Mexico 87501 ∘ Telephone 505/982-9841

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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Avenue
Richland, Washington 99352
506123

SAMPLE RECEIVED 06/05/75 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#1	06/04/75	Calcium	16.9*
		Magnesium	2.3*
		Potassium	0.35
		Sodium	137
		Arsenic	0.01
		Beryllium	< 0.001
		Copper	0.020
		Cadmium	< 0.001
		Lead	0.002
		Selenium	0.02
		Zinc	0.18
#2	06/03/75	Calcium	89.6*
		Magnesium	88.1*
		Potassium	1.4
		Sodium	149
		Arsenic	0.01
		Beryllium	< 0.001
		Copper	0.008
		Cadmium	< 0.001
		Lead	< 0.001
		Selenium	0.03
		Zinc	0.11

*Duplicate analyses verified.

APPROVED BY
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07/03/75

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CONTRACT	United Nuclear Industries, Inc.
ATTENTION	Noel F. Savignac
ADDRESS	1201 Jadwin Avenue
CITY	Richland, Washington 99352
INVOICE NO	506123

REPORT OF ANALYSIS

SAMPLES RECEIVED 06/05/75

CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#3 (PRIOR TO DISCHARGE)	06/03/75	Calcium	227*
		Magnesium	144*
		Potassium	2.0
		Sodium	144
		Arsenic	<0.01
		Beryllium	<0.001
		Copper	0.033
		Cadmium	<0.001
		Lead	0.009
		Selenium	<0.01
		Zinc	0.376
#4	06/04/75	Calcium	28.7*
		Magnesium	24.1*
		Potassium	0.58
		Sodium	107
		Arsenic	0.02
		Beryllium	<0.001
		Copper	0.018
		Cadmium	<0.001
		Lead	<0.001
		Selenium	0.02
		Zinc	0.272

*Duplicate analyses verified.

APPROVED BY [signature]

James J. Mueller, President

07/03/75

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United Nuclear Industries, Inc.
Noel F. Savignac
1201 Jadwin Avenue
Richland, Washington 99352
506123

REPORT OF ANALYSIS

RECEIVED 06/05/75 | CUSTOMER ORDER NUMBER

OF ANALYSIS: Surface Water Analysis -

Sample Identification	Date Collected	Analysis	mg/l
#5	06/04/75	Calcium	24.0*
		Magnesium	11.5*
		Potassium	1.0
		Sodium	130
		Arsenic	<0.01
		Beryllium	<0.001
		Copper	0.009
		Cadmium	<0.001
		Lead	<0.001
		Selenium	0.01
		Zinc	0.14

*Duplicate analyses verified.

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07/03/75

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