CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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# THE SITE

This section includes baseline descriptions of the physical, cultural, biological, and socioeconomic environments that might be affected by the construction and operation of MINERALS' proposed Anderson uranium project.

## 2.1 SITE LOCATION AND LAYOUT

The proposed uranium mining and milling project is located in Yavapai County, Arizona, approximately 100 miles northwest of Phoenix (Figure 2.1-1). Access to the site will be by a newly constructed paved country road running westward from U.S. Highway 93.

MINERALS has obtained the mining rights on approximately 4260 acres of land located in T11N, R10W and T12N, R10W (Figure 2.1-2). The U.S. Bureau of Land Management (BLM) owns the surface rights to approximately 2820 acres of this land and the state of Arizona owns the surface rights to the remaining 1440 acres (Figure 2.1-2). A state grazing lease is held by a private individual on 800 acres of the claim area (Figure 2.1-3).

MINERALS intends to mine the uranium deposits located in portions of Sections 9, 10, 11, 14, and 15 of T11N, R10W (Figure 2.1-4). It is

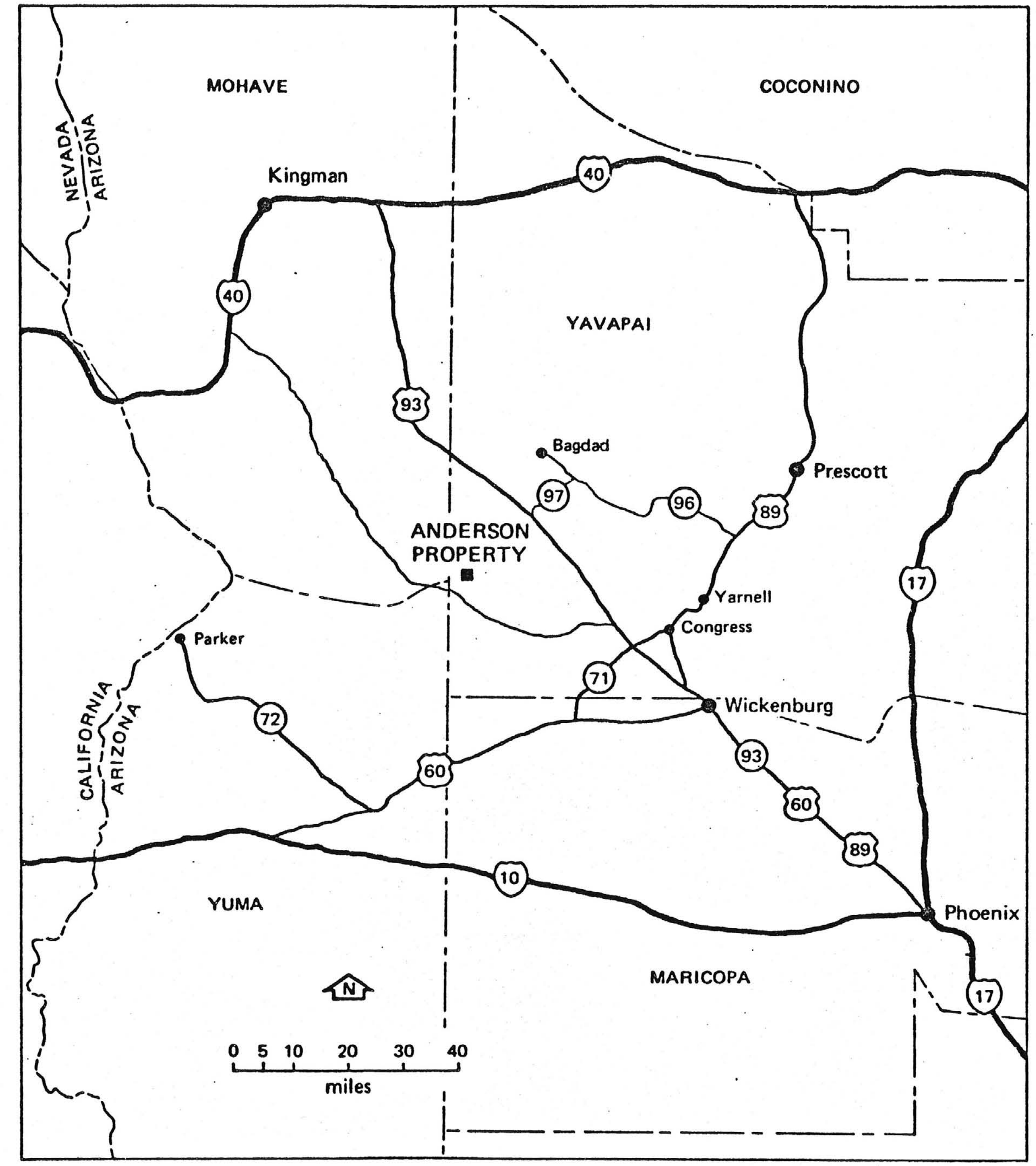



Figure 2.1-1. LOCATION OF ANDERSON PROPERTY

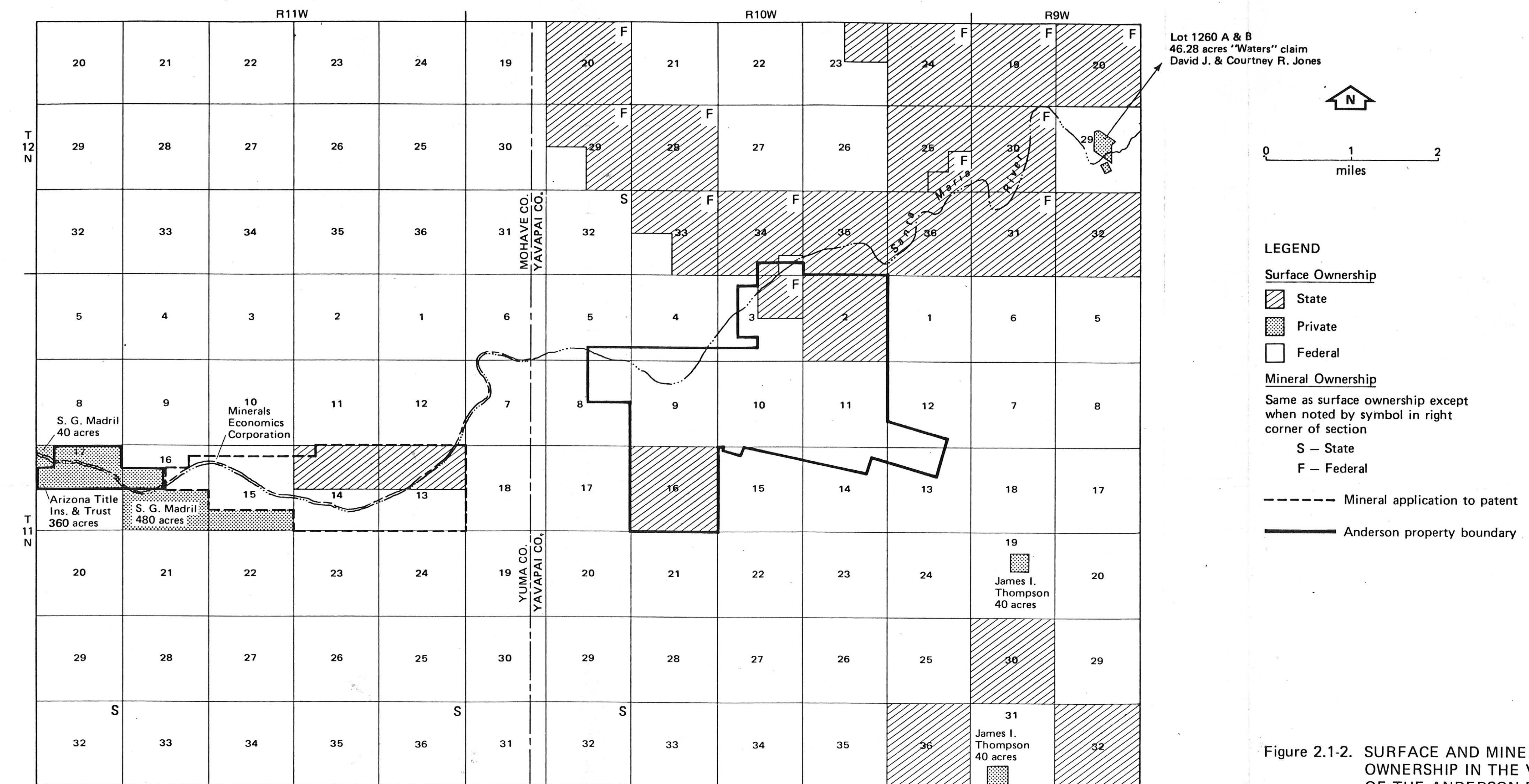
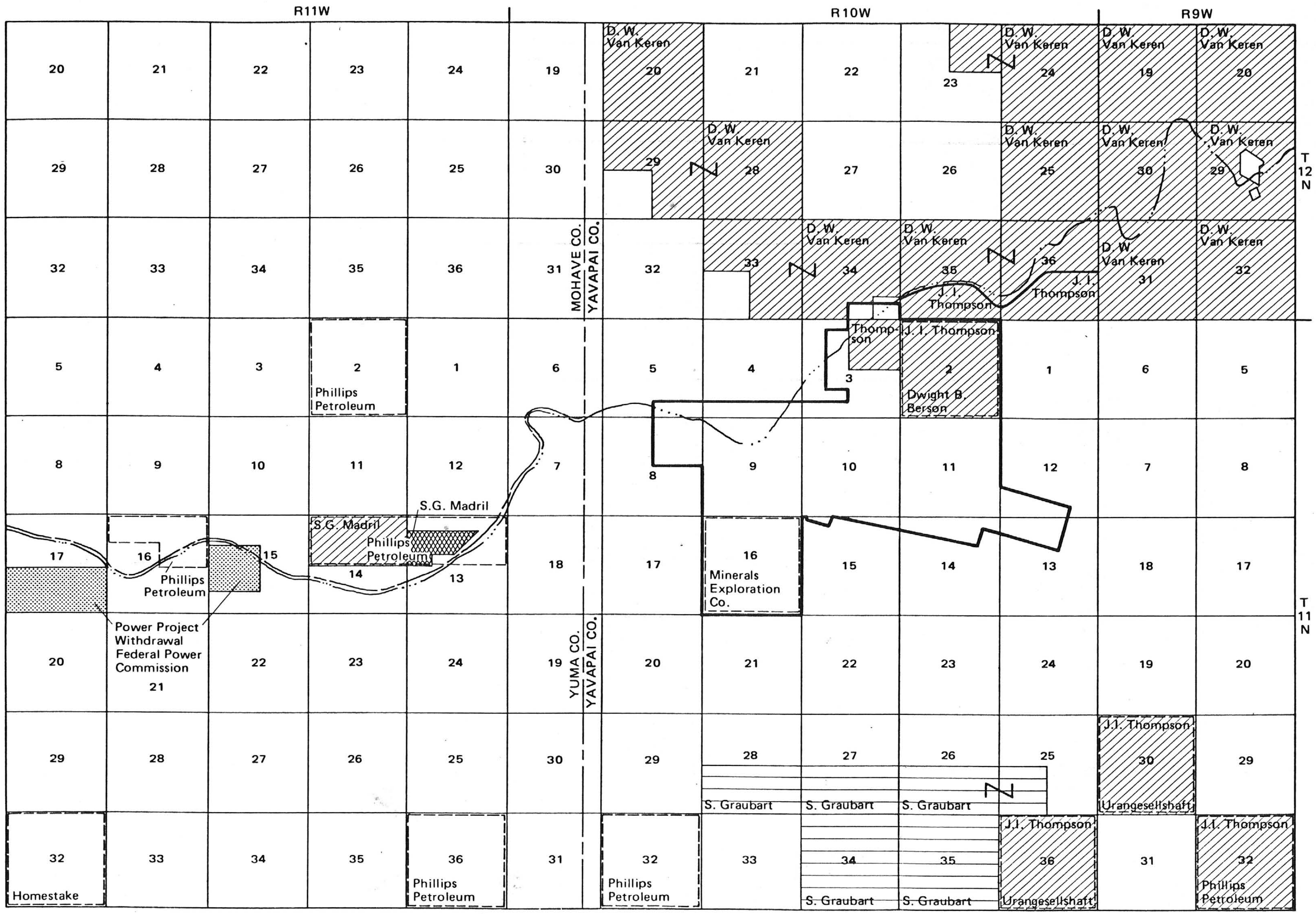



Figure 2.1-2. SURFACE AND MINERAL OWNERSHIP IN THE VICINITY OF THE ANDERSON PROPERTY

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LEGEND

- Federal withdrawal
- Federal oil & gas lease
- State grazing lease
- State agricultural lease
- State prospecting permit
- Anderson property boundary

Note: Surface leasee identified at top of section; subsurface leasee identified at bottom of section

Figure 2.1-3. LEASES, WITHDRAWALS, AND SPECIAL USE AREAS IN THE VICINITY OF THE ANDERSON PROPERTY

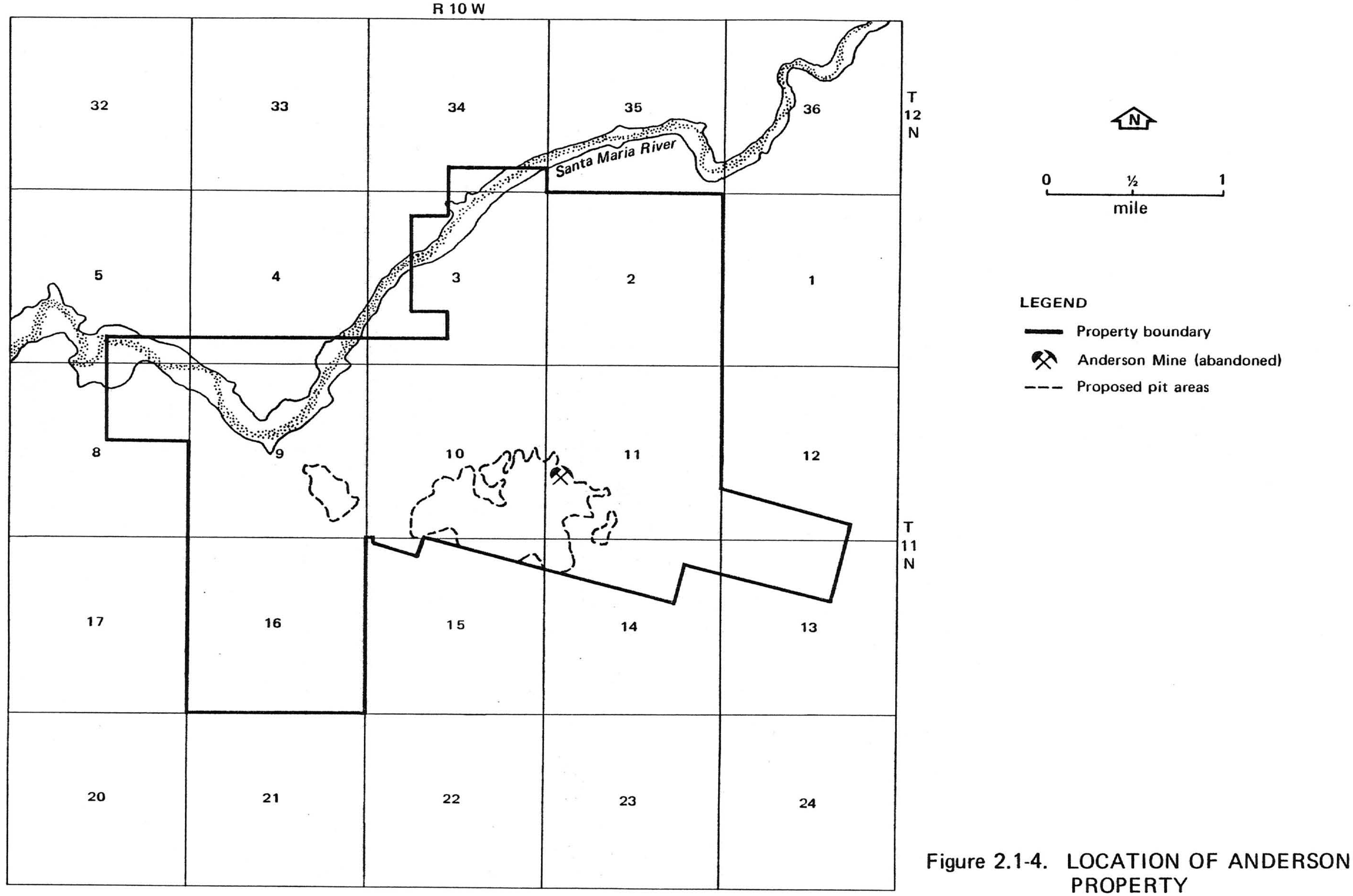



Figure 2.1-4. LOCATION OF ANDERSON PROPERTY

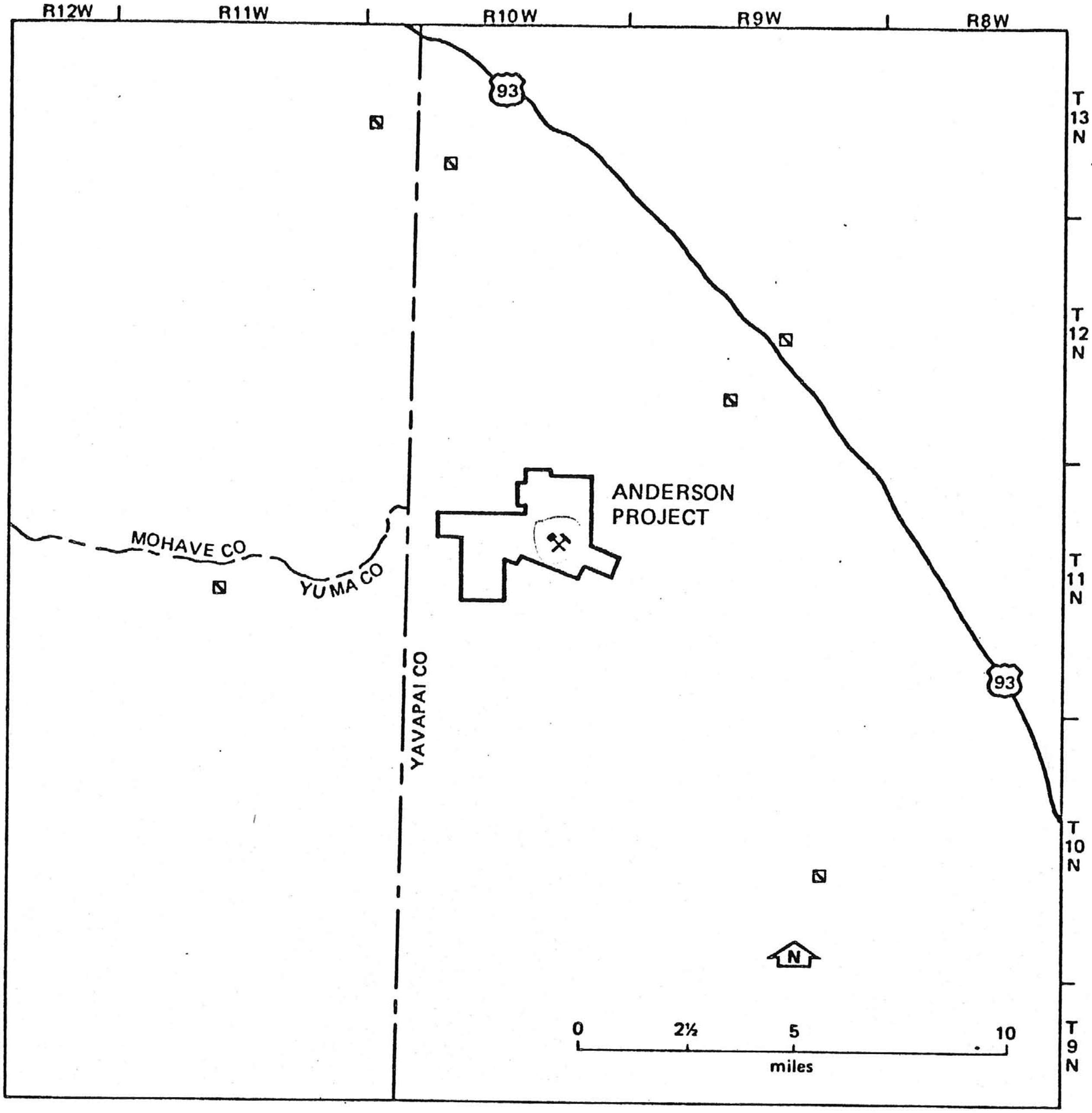
estimated that the proposed mine, waste dump, and haul roads will cover about 760 acres. The mill and related facilities will cover an additional 40 acres. Mining may be extended to other areas within the mining claims described above in the event that economically valuable uranium deposits are discovered on them.

## 2.2 REGIONAL DEMOGRAPHY AND LAND USES

The following section discusses demography/demographic characteristics, land use and ownership, economic environment, housing and public facilities, and services in the project region. The geographic area to be discussed consists of southwestern Yavapai and northwestern Maricopa counties in west-central Arizona (Figure 2.1-1). Much of the discussion is focused on the town of Wickenburg, located approximately 43 miles southeast of the Anderson property in Maricopa County. Wickenburg is the largest community and principal trade center in the study region and is expected to experience the greatest socioeconomic impact as a result of project implementation. Attention is also given to the small communities of Congress and Yarnell, located about 28 and 37 miles east-southeast of the property, respectively.

### REGIONAL DEMOGRAPHY

The project region is sparsely populated, rural, and largely undeveloped. Approximately 20 people currently live on ranches or farms within 10 miles of the Anderson property (Figure 2.2-1). The closest community to the property is Bagdad, located approximately 22 miles to the north-northeast (Figure 2.1-1). Population estimates by annular sector (cardinal points) and distance are given in Table 2.2-1 for a 50-mile radius from the proposed mill site.




LEGEND

Farm or Ranch

Note: Each household represents roughly 6.3 persons
(Source: Urban Decision Systems, Inc., 1978)

Figure 2.2-1 LOCATION OF FARMS OR RANCHES WITHIN TEN MILES OF THE ANDERSON PROPERTY

Table 2.2-1. POPULATION DISTRIBUTION WITHIN 50 MILES OF THE ANDERSON PROPERTY

| | | | Direction (miles) | | | |
|---|---|---|---|---|---|---|
| Direction | 0-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 |
| NNE | 0 | 0 | 89 | 2966 | 0 | 0 |
| NE | 0 | 0 | 0 | 0 | 558 | 0 |
| ENE | 13 | 0 | 0 | 0 | 0 | 21125 |
| East | 0 | 0 | 0 | 985 | 0 | 0 |
| ESE | 0 | 0 | 0 | 0 | 0 | 907 |
| SE | 0 | 6 | 0 | 0 | 3394 | 1332 |
| SSE | 0 | 0 | 0 | 0 | 619 | 0 |
| South | 0 | 0 | 0 | 0 | 0 | 0 |
| SSW | 0 | 0 | 0 | 0 | 0 | 875 |
| SW | 0 | 0 | 0 | 289 | 0 | 0 |
| WSW | 0 | 6 | 0 | 0 | 0 | 958 |
| West | 0 | 0 | 0 | 0 | 0 | 0 |
| WNW | 0 | 0 | 0 | 0 | 0 | 7956 |
| NW | 0 | 0 | 0 | 0 | 312 | 0 |
| NNW | 0 | 13 | 0 | 0 | 0 | 317 |
| North | 0 | 0 | 0 | 0 | 0 | 0 |

Source: Urban Decision Systems, Inc., 1977

LAND USE AND OWNERSHIP

Because implementation of the proposed project will alter existing land use patterns within Yavapai County, this section focuses primarily on that county.

Livestock grazing and wildlife habitat are the predominant land uses in Yavapai County and constitute 60 percent of the total county land area (5,178,000 acres) (Table 2.2-2). National forest lands, primarily in the central and eastern portions of the county, represent 38.5 percent of the land area, while urbanized areas (Prescott, Yarnell, Congress) occupy less than one percent. Lands classified as agricultural cropland constitute 0.5 percent (24,000 acres) of the total.

Mineral extraction activities are concentrated at Bagdad, where Cyprus Bagdad Copper Company operates an open pit copper mine, concentrator, and refinery. There is also an underground mine and concentrator operated by Cyprus Bruce Copper & Zinc Company at Bagdad. A limited amount of placer gold mining is done in the Stanton area and around the Vulture Mountains. Generalized existing land uses in Yavapai County are shown in Figure 2.2-2.

Most of the land in the county is under government control (Table 2.2-3). National Forest lands cover about 38.5 percent of the county; while the BLM administers 9.1 percent of the land and other federal agencies control 2.3 percent. The State of Arizona owns almost 1.4

Table 2.2-2. EXISTING LAND USES, 1975 YAVAPAI COUNTY

| Land Use | Acreage* | Percent |
|---|---|---|
| Urbanized Areas | 40,000 | 0.8 |
| National Forest Lands | 1,993,000 | 38.5 |
| Indian Reservations | 4,000 | 0.1 |
| Agricultural Cropland | 24,000 | 0.5 |
| Lake Pleasant Regional Park | 6,000 | 0.1 |
| Desert or Mountainous Areas | 3,111,000 | 60.0 |
| TOTAL | 5,178,000 | 100.0 |

Source: Ferguson, Morris and Associates, Inc., 1975.

*Numbers rounded to nearest thousand.

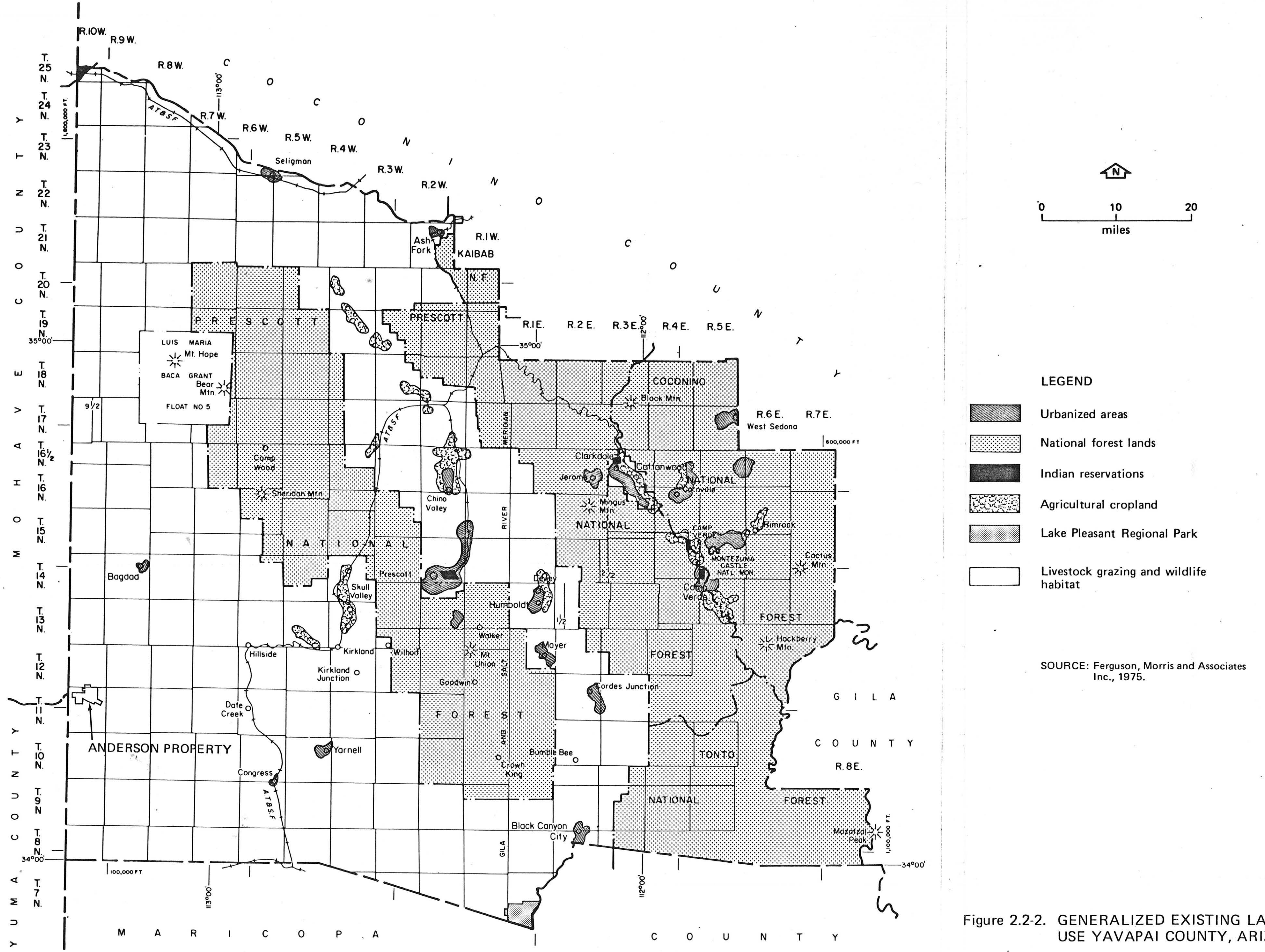



Figure 2.2-2. GENERALIZED EXISTING LAND USE YAVAPAI COUNTY, ARIZONA

Table 2.2-3 LAND OWNERSHIP IN YAVAPAI COUTY

| Ownership | Acreage* | Percent |
|---|---|---|
| Federal | 2,582,000 | 50.0 |
| Indian reservations | 4,000 | 0.1 |
| National forests | 1,993,000 | 38.5 |
| Prescott | 1,205,000 | 23.3 |
| Coconino | 428,000 | 8.2 |
| Tonto | 335,000 | 6.5 |
| Kaibab | 25,000 | 0.5 |
| U.S. Bureau of Land Management | 472,000 | 9.1 |
| Other | 120,000 | 2.3 |
| State | 1,399,000 | 27.0 |
| Private | 1,190,000 | 23.0 |
| TOTAL | 5,171,000 | 100.0 |

Source: Ferguson, Morris and Associates, Inc., 1975.

*Numbers rounded to nearest thousand.

million acres (27.0 percent) in Yavapai County, while private ownership accounts for almost 1.2 million acres (23.0 percent). Existing land ownership patterns in the county are presented in Figure 2.2-3.

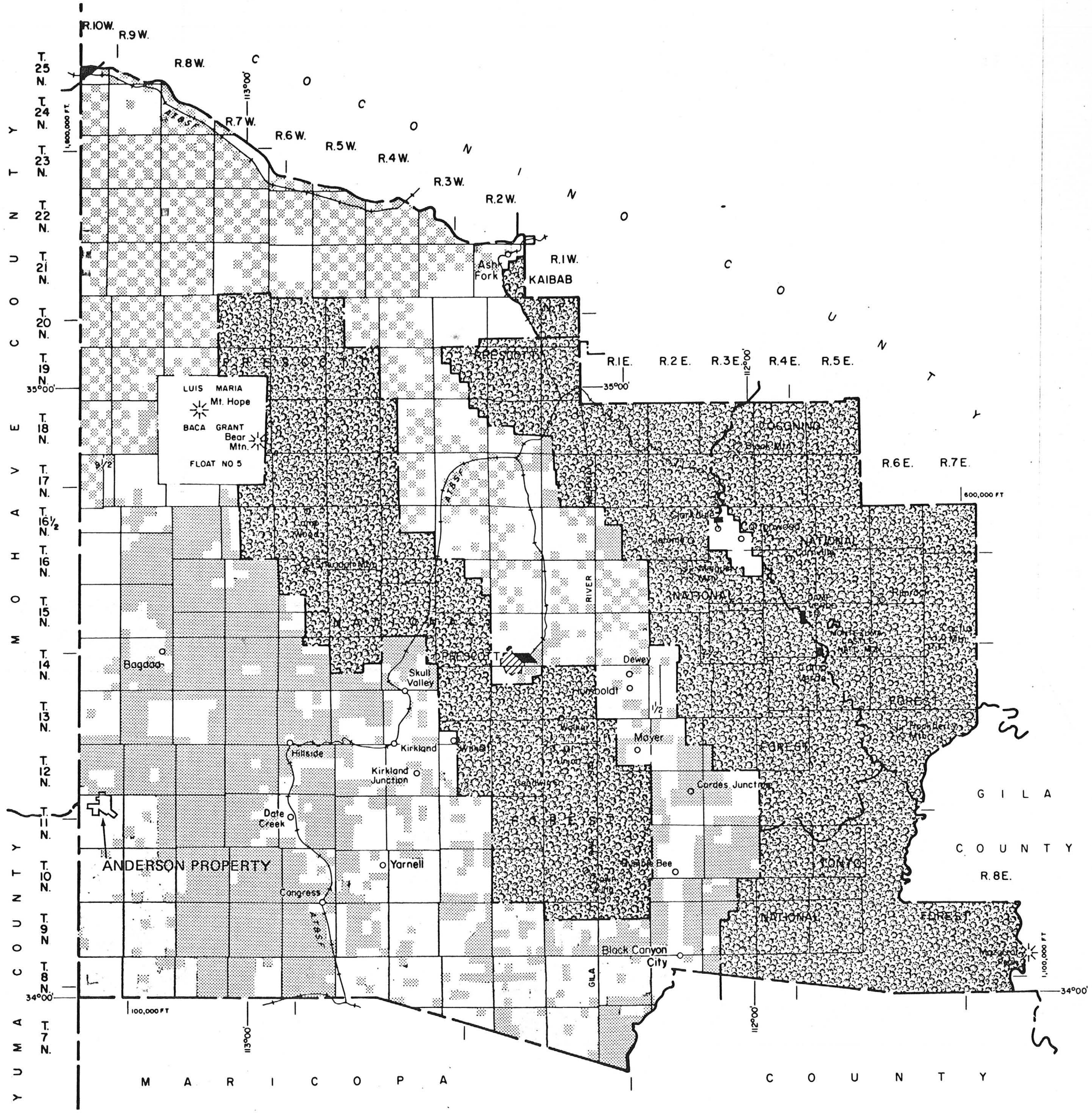
Other than mineral exploration activities associated with this project, the Anderson property and adjacent areas are currently used exclusively for livestock grazing and wildlife habitat. Uranium was surface-mined on the property in the 1950s, and the abandoned pit is still present in the SW 1/4 of Section 11, T11N, R10W. Surface and mineral ownership of the property and adjacent areas is shown in Figures 2.1-2 and 2.1-3.

SOCIOECONOMICS

Wickenburg

Wickenburg is located approximately 54 miles northwest of Phoenix. Sit was founded in the 1860s by prospectors attracted to the area by rich gold strikes in the nearby hills. Situated on the main route to California, served by the Santa Fe Railroad, and having a dry, mild climate and productive grazing land, the early boom town became an important freighting and stage junction as well as an attractive place for early settlers.

Today, as in the past, Wickenburg's physiographic location plays an important role in its continued growth. Tourism, cattle ranching, and agriculture still remain the communities' principal economic

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miles

LEGEND

- Bureau of land management
- State lands
- National forest
- Indian reservations
- Private

SOURCE: Ferguson, Morris and Associates Inc., 1975.

Figure 2.2-3. GENERALIZED LAND OWNERSHIP YAVAPAI COUNTY, ARIZONA activities. However, light industry and retirement-oriented facilities have recently assumed preeminence in the economy and further diversification can be expected.

Population. Since 1950, the population of Wickenburg has increased at a slower rate than Maricopa County as a whole (Table 2.2-4). This is due almost entirely to metropolitan growth in the Phoenix area. Between 1950 and 1960, population increased by approximately 41 percent in Wickenburg and roughly doubled in the county. From 1960 to 1970, the community registered a population increase of about 10 percent while Maricopa County again experienced a substantially higher rate of growth (about 46 percent). In recent years, considerable growth has occurred in Wickenburg, although the county has continued to expand at a faster rate.

Wickenburg's population consists of more elderly and fewer minority group members on a percentage basis than Maricopa County or the state. The community has recently become a popular retirement center for Phoenix residents, as evidenced by the high percentage of Wickenburg residents 65 years of age and older (Table 2.2-5). Table 2.2-6 suggests a high degree of racial homogeneity in the community. Minorities comprise only about 10 percent of the residents, compared to 19.7 percent for Maricopa County, and 27.9 percent for the state.

Population projections have been prepared for Wickenburg by the Maricopa Association of Governments and for Maricopa County and the state by the Arizona Department of Economic Security (Table 2.2-7).

Table 2.2-4. POPULATION CHANGE, 1950 - 1977

| | Wickenburg | Maricopa County | Arizona |
|---|---|---|---|
| Total Population | | | |
| 1950 | 1736 | 331,770 | 749,587 |
| 1960 | 2445 | 663,510 | 1,302,161 |
| 1970 | 2698 | 969,425 | 1,775,400 |
| 1977 | 3015 | 1,289,059 | 2,350,950 |
| Percent Change | | | |
| 1950 - 1960 | +40.8 | +100.0 | +73.7 |
| 1960 - 1970 | +10.3 | +46.1 | +36.3 |
| 1970 - 1977 | +11.7 | +33.0 | +32.4 |

Sources: U.S. Bureau of the Census, 1973
Office of Planning, Arizona Department of Economic Security, 1977

Table 2.2-5. POPULATION BY AGE, 1976 (PERCENT OF TOTAL POPULATION)

| Age Group | Wickenburg | Maricopa County | Arizona |
|---|---|---|---|
| Percent under 19 years | 21.2 | 35.9 | 37.0 |
| Percent 20-64 years | 44.5 | 53.0 | 52.7 |
| Percent 65 years and over | 34.3 | 11.1 | 10.3 |

Source: Arizona Department of Economic Security, 1976

Table 2.2-6. WICKENBURG'S RACIAL COMPOSITION - 1975 (PERCENT OF TOTAL POPULATION)

| Ethnic Composition | Wickenburg[a] | Maricopa County | State |
|---|---|---|---|
| White | 89.9 | 80.3 | 72.1 |
| Black | 0.4 | 3.3 | 2.9 |
| Indian | - | 1.1 | 5.5 |
| Other | - | 0.6 | 0.7 |
| Spanish Surname | 9.7 | 14.6 | 18.8 |

Source: [a]CETA Grant Demographic Study, 1976
Arizona Department of Economic Security, 1975

Table 2.2-7. POPULATION PROJECTION, 1977 - 1995

| Projected Population | Wickenburg[a] | Maricopa County | Arizona |
|---|---|---|---|
| 1977 | 3,015 | 1,289,059 | 2,350,950 |
| 1980 | 3,500 | 1,405,001 | 2,569,442 |
| 1985 | 4,500 | 1,611,597 | 2,934,908 |
| 1990 | 5,600 | 1,827,021 | 3,303,716 |
| Percent Change | | | |
| 1977-1995 | +122.0 | +58.8 | +55.4 |

Source: [a]Maricopa Association of Governments, 1977
Arizona Department of Economic Security, 1977

It is projected that the population of Wickenburg and Maricopa County will increase over the next two decades with the community growing at a substantially faster rate than the county. Population in the community is expected to more than double between 1977 and 1995, compared to 59 percent projected growth rate for the county during the same period.

Employment and Income. Approximately 291 businesses are located in the Wickenburg area (Arizona Office of Economic Planning and Development, 1977). Service and retail trade are the principal employers and income producers in the area, accounting for about 40 percent and 35 percent, respectively, of the total number of businesses identified (Table 2.2-8)

Table 2.2-8. NUMBER OF FIRMS IN THE WICKENBURG AREA BY MAJOR INDUSTRIAL CATEGORY, 1977

| Industry | Number | Percent |
|---|---|---|
| Agriculture and Mining | 5 | 1.7 |
| Construction | 17 | 5.8 |
| Manufacturing | 7 | 2.4 |
| Transportation and Public Utilities | 13 | 4.5 |
| Wholesale Trade | 8 | 2.7 |
| Retail Trade | 100 | 34.4 |
| Finance, Insurance and Real Estate | 20 | 6.9 |
| Services | 117 | 40.2 |
| Public Administration | 4 | 1.4 |
| TOTAL | 291 | 100 |

Source: Arizona Office of Economic Planning and Development, 1977

The increase in service and retail trade establishments in recent years may be attributed to increased travel and retirement oriented activities in the community.

Agriculture continues to be a mainstay of Wickenburg's economy. Five agricultural companies operate in the area with a total of 20,660 acres under cultivation. Thirty-three ranches with an estimated value of approximately nine million dollars are also located near the community. Agriculturally rich Centennial Valley is located to the west of Wickenburg.

Nonagricultural employment in Wickenburg is concentrated in the retail trade and service sectors (Table 2.2-9). Approximately 76 percent of the 1421 workers in the Wickenburg area are employed in these sectors. Approximately 1/5 of service employment is seasonal. As Wickenburg continues to increase in popularity as a retirement and tourist center, additional employment opportunities in the nonagricultural sectors can be expected. Table 2.2-10 further breaks down employment into basic and nonbasic sectors. Services and retail trade dominate basic employment, accounting for 79 percent of all basic employment and 75 percent of total employment.

Table 2.2-11 summarizes general labor force and income characteristics of the Wickenburg area in relation to the county and state for 1975. The unemployment rate in Wickenburg (6.7 percent) was lower than the rate recorded for the county (11 percent) and state (10.1

Table 2.2-9. EMPLOYMENT IN THE WICKENBURG AREA, BY MAJOR INDUSTRIAL CATEGORY, 1977[a]

| Industry | Full-Time | Part-Time | Seasonal |
|---|---|---|---|
| Agriculture and Mining | 15 | 2 | 0 |
| Construction | 36 | 9 | 20 |
| Manufacturing | 20 | 4 | 4 |
| Transporation and Public Utilities | 40 | 8 | 7 |
| Wholesale Trade | 15 | 5 | 1 |
| Retail Trade | 369 | 83 | 17 |
| Finance, Insurance and Real Estate | 54 | 17 | 1 |
| Services | 377 | 113 | 118 |
| Public Administration | 66 | 3 | 15 |
| Total | 992 | 244 | 85 |

Source: Arizona Office of Economic Planning and Development, 1977

[a]The figures on this table represent all workers employed in the Wickenburg area regardless of their place of residence. This would include region residents and in-commuters but exclude out-commuters.

Table 2.2-10. BASIC, NONBASIC, FULL-TIME EMPLOYMENT IN WICKENBURG AREA, BY MAJOR INDUSTRIAL CATEGORY, 1977

| Industry | Basic | Nonbasic | Total | Base/Service Ratio |
|---|---|---|---|---|
| Agriculture and Mining | 3.7 | 11.6 | 15.3 | .32 |
| Construction | 11.0 | 37.3 | 48.3 | .29 |
| Manufacturing | 16.4 | 2.0 | 18.4 | 8.2 |
| Transportation and Public Utilities | 17.6 | 26.1 | 43.7 | .67 |
| Wholesale Trade | 5.8 | 5.3 | 11.1 | 1.09 |
| Retail Trade | 177.4 | 195.3 | 372.7 | .91 |
| Finance, Insurance and Real Estate | 22.1 | 31.5 | 53.6 | .70 |
| Services | 176.6 | 212.1 | 388.7 | .83 |
| Public Administration | 20.0 | 46.6 | 66.6 | .43 |
| Total | 450.6 | 567.8 | 1018.4 | - |

Source: Arizona Office of Economic Planning and Development, 1977

Table 2.2-11. GENERAL LABOR FORCE AND INCOME CHARACTERISTICS, 1975

| | Wickenburg | Maricopa County | Arizona |
|---|---|---|---|
| Total Employed (Percent) | 93.3[a] | 89.0 | 89.9 |
| Total Unemployed (Percent) | 6.7[a] | 11.0 | 10.1 |
| Median Family Income | 10,442 | 14,336 | 13,362 |
| Per Capita Income | - | 5,800 | 5,383 |

Source: [a]Arizona Office of Economic Planning and Development
Arizona Department of Economic Security

percent). Families in the community earned considerably less on a percentage basis than the families in the county and state (37 percent less than the county and 28 percent less than the state). This is characteristic of many relatively isolated communities in the Southwest.

Housing. A lack of necessary infrastructure and an unresponsive financial market has limited housing construction in Wickenburg. Due to overall inflation and spiraling construction, finance and land costs, average home prices have risen from $20,400 in 1970 to over $35,000 in 1976. Moreover, costs have risen at a faster rate than average household income, reducing the purchasing power of the prospective buyer (Maricopa Association of Governments, 1978). The vacancy rate in Wickenburg for conventional single family units is less than two percent. Vacancies in other types of housing fluctuate widely during the year as a result of the winter and early spring influx of temporary residents. Rents have increased in the community due to demand, inflation and increased costs of maintenance and utilities.

Table 2.2-12 shows the housing composition in Wickenburg. The single family unit, still favored in the community, dominates the housing market. However, in recent years, the community has witnessed a marked increase in mobile homes and more development is expected. Currently, over half of Wickenburg's residents live in single family units, many of which are located in the Sunnygrove and Palo Verde West subdivisions, approximately 35 percent live in mobile homes concentrated

Table 2.2-12. HOUSING UNITS IN WICKENBURG (AUGUST, 1977)

| Type of Unit | Number | Percent of Total |
|---|---|---|
| Single Family | 678 | 54.2 |
| Multiple Family | 129 | 10.3 |
| Mobile Homes | 444 | 35.5 |
| Total | 1251 | 100.0 |

Source: Donald W. Hutton, November 1977, personal communication in Westpark and Country Club mobile home parks, and about 10 percent reside in apartments. Several sizeable additions to the housing stock are in various stages of planning, including a proposed major subdivision which will provide between 700 and 800 housing units.

Community attitudes. In Wickenburg, community attitudes are very tangible and apparent and may be used as a barometer of the direction in which the community is moving. Comunity image, size, and environmental quality are important issues to Wickenburg residents. These issues are directly related to economic changes in the area.

Wickenburg's population is still relatively homogeneous; social and institutional relationships have remained fairly stable through the years. Its residents are fairly cautious towards major growth, especially if it contributes to a decline in environmental quality and hence, in the community's attractiveness as a popular retirement and tourist center. However, as Wickenburg increases its reliance on tourism and seeks further diversification of its economic base through light industry, a gradual change will occur in the community's social and cultural composition. New job opportunities will cause considerable in-migration and provide employment for a large segment of the population in the region. The new population, some of which would be typically young and blue-collar, is expected to have different values and lifestyles than the present population and may influence the existing social, cultural, and institutional structure.

Public Facilities and Social Services. Wickenburg's water supply comes from three wells. Water storage is provided by two elevated tanks with a combined capacity of 900,000 gallons. The water system has a capacity to serve up to 7000 people. Several projects to increase the water system are in various stages of planning, including development of three additional wells, construction of a two million gallon storage reservoir and additional high capacity mains, and development of a new water source and storage/distribution system capable of serving 14,000 people in southeastern Wickenburg and the surrounding area. Estimated costs for these projects are $337,500 for the reservoir, $84,240 for well development, $794,160 for main line construction, and $265,475 for the additional water system.

Wickenburg operates a 600,000 gallon per day (gpd) activated sludge treatment plant that can provide adequate service for 6000 people. However, the sewage plant is subject to flooding from the Hassayampa River. The community has proceeded with the construction of a new treatment facility at a higher site and expansion of the wastewater collection system. The new plant will be capable of initially serving 8000 people, with a final design capacity for 25,000 people. It is currently planned to have the facilities in service by early January 1980.

Solid waste collection services are provided by the community. Solid waste is hauled to a disposal site near the Wickenburg airport. The site is expected to reach full capacity in about 1981 under projected usage rates.

Wickenburg receives electricity from the Arizona Public Service Company (APS). Natural gas is also supplied by APS.

The Community Hospital in Wickenburg has 35 beds and a staff that includes four medical doctors and consulting specialists from Phoenix. Other health services are provided by the Wickenburg Medical Center, the Health Analysis Center, two chiropractic offices, and the Meadows, an alcoholism treatment center.

The Wickenburg Police Department, Maricopa County Sheriff's Department, and the Arizona Department of Public Service provide police protection to the community. The Wickenburg Police Department has a staff of nine that includes a chief, a sergeant, desk clerk, and six patrolmen. The department has four patrol cars. The Maricopa County Sheriff's Department substation located in Wickenburg is staffed by a sergeant, 11 deputies, and a detective. A 37-member sheriff's posse has also been organized in the Wickenburg area for search and rescue operations. The Department of Public Safety has assigned eight officers to patrol the Wickenburg area.

Fire protection is provided by the Wickenburg Volunteer Fire Department. The community's 23 volunteers operate three pumpers with a combined capacity of 2850 gallons and 1000-gallon tanker with a 750-gallon pump. The community has a National Board Class 6A insurance rating.

Wickenburg School District 9 encompasses approximately 700 square miles of northwestern Maricopa County and serves many neighboring districts. Table 2.2-13 lists districts in the region that send all or part of their students to Wickenburg's school system. Educational facilities within the school sys tem are presently adequate (Table 2.2-14). Enrollment projections for the district are provided in Table 2.2-15. The estimates are based on projected population and age distribution in the Wickenburg area, and assume that the population in the unincor porated areas of the region will remain relatively stable. Expansion of all three schools in the district has been proposed as enrollment is expected to increase slightly over the next five years.

Prescott National Forest provides a variety of recreational opportunities within a short distance of Wickenburg. Developed recreational facilities within the community include four parks, a playground, a picnic area, an athletic field, two tennis courts, a shooting range, a swimming pool, and rodeo grounds. School facilities include two gymnasiums, two playgrounds, and an athletic field. In addition, private recreational facilities (e.g., Wickenburg Country Club) help meet the recreational demands of the residents. Finally, Phoenix provides a wide range of of recreational facilities within a reasonable distance from the community.

Access to the Wickenburg area is provided by U.S. Highway 60 and 89-93 (Figure 2.1-1). U.S. Highway 60 connects the community with Phoenix to the southeast. Six miles north of Wickenburg, U.S. Highway

2.2-13. OUTSIDE DISTRICTS SERVED BY WICKENBURG SCHOOL DISTRICT 9

| District | All High School | All or Part Elementary School |
|---|---|---|
| Aguila District 65 | X | |
| Champie District 14 | X | X |
| Congress District 17 | X | X |
| Morristown District 75 | X | |
| Nadaburg District 81 | X | |
| Peeples Valley District 55 | X | X |
| Rincon District 47 | X | X |
| Walnut Grove District | X | |
| Yarnell District 52 | X | X |

Source: Wickenburg Unified School District 9, 1977

Table 2.2-14. WICKENBURG SCHOOL SYSTEM ENROLLMENT, 1977

| School | Grades | Enrollment | Student Capacity | Enrollment as Percent of Capacity | Number of Teachers | Student Teacher Ratio |
|---|---|---|---|---|---|---|
| MacLennan Elementary School | K-5 | 350 | 400 | 88 | 21 | 16.7:1 |
| Garcia Elementary School | 6-8 | 220 | 270 | 82 | 16 | 13.8:1 |
| Wickenburg High School | 9-12 | 440 | 540 | 82 | 29 | 15.2:1 |

Source: Wickenburg Unified School District 9, 1977.

Table 2.2-15. WICKENBURG SCHOOL DISTRICT 9 ENROLLMENT PROJECTIONS, 1979-1995

| School | Grades | Projected Enrollment 1979 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| MacLennan Elementary | K-5 | 368 | 377 | 433 | 495 | 556 |
| Garcia Elementary | 6-8 | 237 | 247 | 303 | 365 | 426 |
| Wickenburg High | 9-12 | 455 | 463 | 513 | 566 | 620 |
| TOTAL | | 1060 | 1087 | 1249 | 1426 | 1602 |

89-93 divides and provides direct access to Las Vegas, Nevada (U.S. 93) or Prescott and the Grand Canyon (U.S. 89). Construction of the Black Canyon Highway (Interstate 17 south to Phoenix) and completion of the Brenda Cutoff (Interstate 10 east to Phoenix) have considerably decreased traffic in the Wickenburg area (Table 2.2-16). Rail transportation (freight service only) is provided by the Santa Fe Railroad. Regional bus service is provided by Greyhound Lines and Continental Trailways as well as two local bus lines. Motor freight service is provided by two interstate and two intrastate lines.

The Wickenburg Municipal Airport, located five miles west of town, provides private aircraft service and hangar space. The community plans to improve the airport for commercial use. At present, commercial air service is provided by the Phoenix Sky Harbor International Airport.

Financial Resources. The greatest source of revenues for Arizona taxing jurisdictions are from local property taxes and through transfers from taxes collected by the state. Large capital expenditures are generally financed through bonded indebtedness based on assessed valuation and capitalized through the property tax or through intergovernmental transfer payments. Assessed valuation of real and personal property (except mines, railroads, and some utilities) is fixed by county assessment. Real property is assessed at 15 percent of cost.

Arizona levies a four percent sales tax. In addition, incorporated communities levy an additional one percent tax on retail sales. Public finance data for the potentially impacted taxing jurisdictions in the project region are provided in Table 2.2-17.

Table 2.2-16. TRAFFIC VOLUMES ON WICKENBURG HIGHWAYS

| Highway | Length in Miles | Average Annual Daily Traffic 1974 | 1975 | 1976 |
|---|---|---|---|---|
| U.S. Highway 89 (at Jct. 60) | 15.54 | 1300 | 1600 | 1700 |
| U.S. Highway 60 (at Jct. 89) | 1.84 | 5200 | 5400 | 6000 |
| U.S. Highway 93 (at Jct. 89 | 10.85 | 1600 | 1900 | 1500 |

Source: Arizona Department of Transportation, 1976

Table 2.2-17. ASSESSED VALUATION, BONDED INDEBTEDNESS, TAX RATES, AND REVENUE FOR WICKENBURG AND PROJECT REGION, 1977 (DOLLARS)

| Government Entity | Assessed Valuation | Total Bonded Indebtedness | Tax Rate (Per $100 Assessed Valuation) | Total Revenues |
|---|---|---|---|---|
| Town of Wickenburg | 5,453,146 | -0- | 1.61 | 1,442,214[a] |
| School District 9, Wickenburg Unified | 10,265,000 | 490,000 | 5.09 | 1,761,081 |
| School District 17, Congress | 2,382,050 | -0- | 2.70 | 103,458 |
| Yavapai County | 223,223,582 | 23,829,352 | 3.28[b] | 10,505,509 |

Source: Town of Wickenburg, 1977
Superintendent of Schools, School District 9, 1977
Yavapai County Clerk's Report, 1977

[a]does not include interfund transfers

[b]includes Junior College rate (1.3499)

## Yarnell

Yarnell is located in Yavapai County on U.S. 89, approximately 80 miles northwest of Phoenix and 37 miles southwest of Prescott. The town is 37 miles from the Anderson property. Situated high in the Weaver Mountains, Yarnell's 4782-foot elevation provides an excellent year-round climate. The Yarnell area includes the small community of Peeples Valley located immediately northeast of Yarnell.

Yarnell was founded in 1893 after gold was discovered in the area. Today, it is an incorporated retirement community of approximately 1000 people. The town's growth rate between 1970 and 1977 was appreciably slower than that of Yavapai County. The town's most attractive assets for growth have been its pleasant climate, its natural surroundings, and its low cost of living. In addition to the town's new role as a retirement community, Yarnell serves the many cattle ranches in the surrounding area.

There are 3 motels with a total of 30 units and three small trailer parks in Yarnell. Housing values range from approximately $15,000 to $35,000 due to the large number of mobile homes favored by retired people. Housing availability is estimated to average 25 units at any one time.

Yarnell's municipal service system is presently adequate to serve a larger population. Rugged terrain in the area has generally prohibited large scale housing development. However, several sizable developments are in the planning stages, including county approval for construction of 100 single family homes, the purchase of two parcels of land totaling about 86 acres for single family housing, and zoning for a 13-acre trailer park development.

Yarnell has a small commercial and service sector that serves the community and the immediate surrounding area. Commercial businesses include three motels, two gas stations, two grocery stores, and a small assortment of clothing stores, cafes, and curio shops. There is no large or small industry in the Yarnell area.

The water system in this community is operated by the Yarnell Water Improvement Association. Expansion of the system was recently completed to allow for community growth. The main water source is wells located in Peeples Valley. The present production and distribution capacity is 936,000 gpd, which is currently limited to 360,000 gpd by the transfer pumps. Summer peak demand is estimated at 120,000 gpd. Water storage is provided by a 500,000-gallon elevated storage tank.

Sewage disposal in Yarnell is provided by septic tanks. APS provides electricity to the town. There is no natural gas supplied to the area.

There is a shortage of medical services in Yarnell. The area normally has only one physician. Major health care is available in Wickenburg and Prescott, both about half an hour's drive from Yarnell.

Three county deputies reside in Yarnell, providing adequate local law protection for the community. Yarnell staffs a 10-member volunteer fire department. The town's National Board insurance rating is 8.

Yarnell School District 52 operates an elementary school for grades K-6. Present enrollment is 64, but new classroom facilites provide capacity for 150 students. Junior and senior high school students are bused to Wickenburg.

Developed recreational opportunities within the community are limited. Recreational activities within close range of Yarnell are offered in Prescott National Forest.

U.S. 89 provides intrastate and interstate truck transportation to Yarnell. Greyhound buses serve the community. The nearest airport is located in Wickenburg.

## Congress

Congress is located at the junction of U.S. 89 and 71, approximately 28 miles south-southeast of the Anderson property in Yavapai County. The unincorporated community began as a bustling mining camp of nearly 2500 people in the late 1880s. Today there is very little activity in the old mines surrounding Congress. The community presently has a population of about 500. More than 36 percent of these people are retired. The people living in Congress are dependent on Wickenburg for employment and community services. Local commerce consists of three gas stations, three cafes, one motel, and a post office.

Housing in Congress ranges from older, somewhat deteriorated single family units and scattered mobile homes to modern, well designed and constructed homes throughout the main residential area. A lack of demand and available financing has inhibited housing development in the community. However, recent construction has occurred one mile west of Congress in a development know as Paso Del Sol. The major subdivision has on-site provisions (including water) for at least 100 large lots. Home prices start at $35,000. The development is about one quarter complete.

The Congress Water Company recently expanded the town's water system. The company estimates that it has 200 hookups and is capable of supplying an additional 200 hookups. The water system consists of two wells that produce less than 100,000 gpd. Peak usage in 1976 was estimated at 30,000 gpd. Water storage capacity is more than adequate at 450,000 gallons.

Congress relies on Wickenburg for educational facilities. Law enforcement and fire protection are supplied by Yavapai County and Wickenburg.

The community has no sewage treatment system, relying solely on septic tanks. Electric and gas service in Congress is provided by APS.

## 2.3 CULTURAL RESOURCES

### HISTORY AND ARCHAEOLOGY

There are no historical or archaeological sites in the vicinity of the Anderson property that are included in or currently being considered for inclusion in the National Register of Historic Places. This statement is based on a review of the register and correspondence with the Arizona State Historic Preservation Officer (Appendix A).

Few historical or archaeological field studies have been conducted in the vicinity of the property. The earliest known archaeological survey done in the region was conducted by Malcom Rogers in the 1930s (Powers et al. 1977). Rogers is said to have recorded sites along the Bill Williams River to the west of the property. The Arizona State Museum is currently excavating six archaeological sites located during a survey of the Bagdad to Wikieup pipeline corridor that runs to the east of the property. Personnel from Arizona State University are conducting surveys of the cultural resources in the vicinity of Alamo Reservoir, located on the Santa Maria River about eight miles downstream from the Anderson property.

In order to determine the extent of the cultural resources on the property, MINERALS contracted the Museum of Northern Arizona to conduct a historical and archaeological survey of the area. This survey covered approximately 9500 acres in portions of T11N, R10W and T11N, R9W and included all of the land to be disturbed by the proposed mining and milling activities (Figure 2.3-1).

Approximately 15.5 percent of the 9500 acres was surveyed. This survey included 12 randomly located transects generally one mile long by 100-meters (approximately 328 feet) wide and examination of specific areas that could potentially contain cultural sites. Cultural sites were defined according to the following criteria:

- any structural remains
- any artifact scatter of 10 or more items per 10 square meters (108 square feet)
- any historic material pre-dating 1950; the site had to include either structural remains or more than 10 historic artifacts per 10 square meters (Powers et al. 1977).

One historic (NA15, 166) and 13 prehistoric sites were identified during the survey. The historic site and eight of the prehistoric sites are located on the property. The remaining five sites are located within two miles of the right-of-way for the proposed access road. Table 2.3-1 is a list of the types of artifacts found at each site. The likely activities that took place at the prehistoric sites are listed in Table 2.3-2.

The single historic site is located on the banks of an intermittent stream in the south half of Section 9, T11N, R10W. This site consists of a 50-gallon drum, a 1000-gallon water tank, a wash tub, some cut logs and bleached stock bones. It is believed to have been a cattle watering station, possibly dating from the 1920s (Powers et al., 1978).

Table 2.3-1. TYPES OF ARTIFACTS FOUND ON AND IN THE VICINITY OF THE ANDERSON PROPERTY

| Site No. | CERAMICS: Tizon Brown Ware | CERAMICS: Prescott Gray Ware | CERAMICS: Lower Colorado Buff Ware | CERAMICS: Gila Plain | CERAMICS: Pai plainwares | GROUND STONE: Manos | GROUND STONE: Metates | CHIPPED STONE: Projectile Points | CHIPPED STONE: Bifaces | CHIPPED STONE: Scrapers | CHIPPED STONE: Choppers | CHIPPED STONE: Cores | CHIPPED STONE: Utilized Flakes | CHIPPED STONE: Debitage | MISCELLANEOUS: Other | MISCELLANEOUS: Structures | MISCELLANEOUS: Historic Artifacts | MISCELLANEOUS: Bone | MISCELLANEOUS: Charcoal/Ash | MISCELLANEOUS: Vegetal Remains |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NA15,166 | | | | | | | | | | | | | | | | | X | | | |
| NA15,167 | | | | | | | | | | | | X | | X | | X | | | | |
| NA15,168 | | | | | | | | | | | | | | X | X | | | | | |
| NA15,169 | X | X | | X | | X | X | | | | | | | X | | | | | X | |
| NA15,170 | | | | | | X | | | X | | | X | | X | X | X | | | | |
| NA15,171 | | | | | | X | X | | | | | | X | X | | | | | | |
| NA15,172 | | | | | | | | | | X | | | X | X | | | | | | |
| NA15,173 | | | | | | X | | | X | | | X | X | X | | | | | | |
| NA15,174 | X | | | | | X | X | X | X | X | | X | X | X | | | | | | |
| NA15,175 | X | X | | | X | X | | | X | X | X | | X | X | | | | | | |
| NA15,176 | X | X | X | | X | X | X | X | X | X | X | | X | X | | X | X | X | X | X |
| NA15,177 | | | | | | | | | | | | | X | X | | | | | | |
| NA15,178 | | | | | | | | | | X | | X | X | X | | | | | | |
| NA15,179 | | | | | | | | | | | | | X | X | | | | X | X | X |

Source: Powers et al., 1978

Table 2.3-2. PROBABLE ACTIVITIES THAT TOOK PLACE AT ARCHAEOLOGICAL SITES

| | | | | STONE WORKING | | | | |
|---|---|---|---|---|---|---|---|---|
| | Animal Procurement/ Processing | Plant Processing | Plant Procurement | Final Reduction | Secondary Reduction | Immediate Use | Further Reduction | Initial Reduction |
| Cluster 1 | | | | | | | | |
| NA15,167 | | | | | | | X | |
| NA15,170 | | X | X | | | X | X | |
| NA15,177 | | | X | | | X | | X |
| NA15,178 | | | X | | | X | | X |
| Cluster 2 | | | | | | | | |
| NA15,168 | | | | | X | | X | X |
| NA15,171 | | X | X | | X | X | X | |
| NA15,172 | | X | | | X | | X | X |
| NA15,173 | | | X | | | X | X | |
| Cluster 3 | | | | | | | | |
| NA15,169 | | X | | | X | | | |
| NA15,174 | X | X | | X | X | | X | |
| NA15,175 | | X | | X | X | | X | |
| NA15,176 | X | X | | X | X | | | |
| NA15,179* | X | | | | | | | |

*No collections were made at this site and only a few artifacts were present at the surface. There is a potential that other activities may have taken place there.

Source: Powers et al., 1978

Except for site NA15,179, the 13 prehistoric sites are geographically clustered into 3 groups. Each group is located on or near a major drainage in the area. Site NA15,179, is set apart from the others approximately six miles southeast of the property. The specific locations of the archaeological sites have been provided to BLM and Arizona state archaeologists. However, for their protection, these locations have not been provided in this report at the request of the Museum of Northern Arizona. Interested parties may obtain this information by contacting Mr. Alexander J. Lindsay, Jr., Coordinator of Archaeological Research, Museum of Northern Arizona.

One group of prehistoric sites appears to represent a plant procurement area. This hypothesis is based on the presence of many utilized flakes and the absence of other more finished implements. This type of artifact denotes that lithic materials were reduced at the site for immediate use. A lack of charcoal or ash and animal bones excludes the possibility that activities such as animal procurement or food processing regularly took place at these sites.

While some plant procurement and processing was carried out at the second group of sites, this area appears to have been used primarily for the collection and reduction of lithic material into cores, secondary cores and blanks. These partially-worked stones were then transported to another location for further reduction into finished tools. One of the sites in this group is a prehistoric quarry and many cores were found in the area.

The third group of sites is located to the southeast of the Anderson property. The activities that appear to have taken place at these sites were involved primarily with the secondary processing of materials (both food and lithic material) brought in from other areas. The presence of pottery at some of the sites and a rockshelter (site NA15,176) indicates that this group was used on a more permanent basis than the other two. Site NA15,176 has been extensively vandalized.

Site NA15,179 is a rockshelter. Artifacts found at this site indicate that it was used for animal processing. This rockshelter has been affected by only a few small vandal pits and is in relatively pristine condition.

The archaeological sites on the Anderson property and in adjacent areas are significant because they appear to represent a wide variety of different subsistence and manufacturing activities. These sites constitute evidence of the ways in which prehistoric people adapted to the Mohave-Sonoran Desert ecotone. The two rockshelter sites are particularly important in this respect. They not only offer the opportunity to recover specimens of plant and animal species used by prehistoric inhabitants but also provide a source of radiocarbon samples that can be used to date the period of occupation of the area. Site NA15,176 offers the potential for dating several of the ceramic types found in the area that are poorly understood at the present time.

PALEONTOLOGY

MINERALS contracted the Musuem of Northern Arizona to conduct a paleontological survey of 11,840 acres that included the Anderson property. A total of 11 fossil locations were identified during this survey (Figure 2.3-2 and Table 2.3-3).

The lacustrine and fluvial sediments that outcrop on the property generally contain few fossils; however, some horizons contain numerous palm and water reed fragments (Breed and Billingsley, 1977). Palm root impressions are also common throughout the area. Silicified palm fragments should have been more abundant than what was observed during the survey. The lack of these fossils is due primarily to a thorough examination of the surface area by amateur rock hounds over the past several years.

Very few vertebrate fossils were found during the survey. Isolated specimens may have been removed by rock hounds, but these fossils were probably never abundant on the property. Fossil fish remains were found at sites 3 and 10 (Figure 2.3-2). These specimens are very poorly preserved and fragile. The fish species has been tentatively identified in the Family Cyprinidae (western minnow) by Dr. E. Wiley of the University of Kansas; the genus and species are not known. The age of these fossils ranges from Eocene to Recent, closer dating cannot be made due to their poor condition. One tooth fragment of a rhinoceros (Diceratherium sp.) was found in a talus slope near outcrops of white calcareous sandstone (site 9). The distal end of a left humerus from a

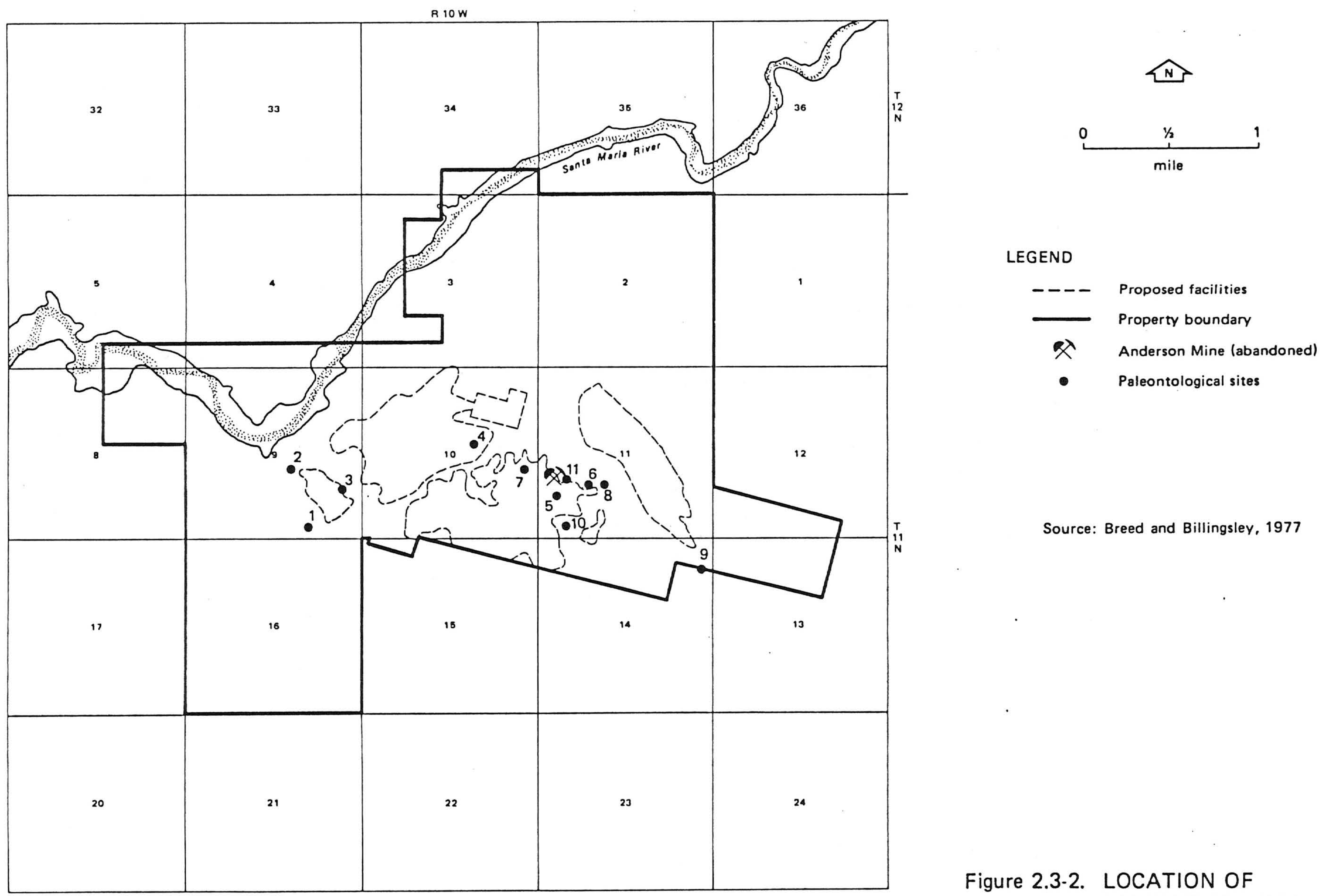


Figure 2.3-2. LOCATION OF PALEONTOLOGICAL SITES

Table 2.3-3. PALEONTOLOGICAL SITES ON THE ANDERSON PROPERTY

| Site No. | Site Description | Fossil Description |
|---|---|---|
| 1 | Draw on east side of road in white siliceous and calcareous fine-grained siltstone | Water reeds |
| 2 | In silica in abandoned mine | Petrified palm and occasional roots |
| 3 | Paper thin beds of calcareous shale, 70-80 yards NE of overhang | Fish and worm burrows |
| 4 | Grey marl in wash | Pollen |
| 5 | White bed of siliceous and calcareous shale and siltstone between green mudstone layers | Rhinocerous jaw bone found by A. P. Deutsch, camel humerus and gastropods |
| 6 | Thin bed of siliceous limestone in steep gully | Silicified gastropods and pelecypods |
| 7 | Anderson Mine excavations | Palm bark containing carnotite |
| 8 | In silica in eastern section of Anderson mine pit | Weathered palm roots |
| 9 | Near top of steep talus slope | Rhinocerous tooth fragments |
| 10 | Paper thin beds of calcareous shale | Fish |
| 11 | Pink layers of calcareous siltstone | Water reeds |

Source: Breed and Billingsley, 1977

camel (Oxydactylus sp.) was found in a cemented fine-grained layer of green calcerous mudstone (site 5). These mammalian fossils are approximately 15 to 20 million years old (Breed and Billingsley, 1977). Other known finds of vertebrate remains in the area are a rhinocerous fossil discovered by A. P. Deutsch in the late 1950s and a few bone fragments found by Mr. Charles Smith in 1972.

Numerous small internal molds of aminocolid gastropod and pelecypod shells, completely replaced with silica, were present in siliceous limestone. These fossils have been tentatively identified as Physa sp., Planorbis sp., and Campeloma sp. by Dr. Dale Nations of Northern Arizona University.

A sample of calcareous siltstone was collected for pollen analysis (site 11). Dr. Hevly of Northern Arizona University found 22 pollen grains and several algal relics (fragments, cysts, and spores) in this sample.

AESTHETICS

Like most of the desert in southwestern Arizona, landforms constitute by far the most dominant visual element in the landscapes on the Anderson property. Since vegetation is quite sparse, the patterns created by erosion are not masked. The details of even minor drainages or rock outcrops can be seen at a distance.

As can be seen in Figure 2.4-2, the Anderson property is located in rugged terrain. Erosion has created a wide variety of strongly angular forms that tend to hold viewer attention. While the maximum relief on the property is only about 700 feet, slopes are generally quite steep, approaching near-vertical walls along many reaches of the Santa Maria River. These slopes are cut by numerous, often relatively straight, erosion channels that visually accentuate their steepness. The channel of the Santa Maria River contrasts strongly with the surrounding mountains. Visually, this channel creates a flat, smooth "ribbon" cutting through areas of highly irregular topography. This visual effect is increased by the contrast between the light-colored alluvial sediments and bordering green vegetation of the channel and the darker grays, browns, and reds of the surrounding land.

Except in foreground views (0 to 0.5 mile), the vegetation in the area adds little color or form to the landscapes. However, much of the vegetation, particularly the saguaro cactus and Joshua trees, are large enough to provide a grainy texture to most middleground (0.5 to three miles) and some background (beyond three miles) views.

## 2.4 GEOLOGY

### REGIONAL CHARACTERISTICS

#### Physiography and Topography

The Anderson property is located in the Sonoran Desert section of the Basin and Range Province (Fenneman, 1931). Although its boundaries cannot be specifically defined, the Basin and Range Province is generally considered to cover the entire state of Nevada, north- and southeastern California, southeastern Oregon, southern Idaho, western Utah, and northwestern Arizona, as well as parts of northern Mexico. The province is characterized by sets of roughly parallel mountain ranges separated by desert basins that are frequently internally drained. This characteristic structure was formed by horst and graben block faulting.

Mountain ranges in the Sonora Desert region are lower (seldom rising more than 4000 feet above mean sea level [msl]) and perhaps older than the mountains in the central portion of the Basin and Range Province. In addition, many of the basins in this desert are not internally drained. Mountain ranges in the Sonoran Desert trend roughly in a north-northwest to south-southeast direction and are generally quite symmetrical. Individual summits are normally of about equal height and they are laterally equidistant from their valley margins (Dunbier, 1968). The mountains cover approximately one-fifth of the land, while mountain pediments -- broad rock platforms that surround and form the base of these mountains -- cover two-fifths of the area (Fenneman, 1931).

The Anderson property lies along the northeast margin of the Date Creek Basin, a small structural basin bordered to the north and east by the Black Mountains, to the south by the Harcuvar Mountains, and to the west by the Buckskin Mountains (Figure 2.4-1). These mountains rise 3000 to 4000 feet above sea level and are bordered by broad, alluvium-filled valleys. Three drainages cross the basin: the Santa Maria River, Date Creek, and Bullard Wash. The general gradient of these drainages is to the west and northwest.

All of the drainages on the Anderson property grade to the north and northwest into the Santa Maria River (Figure 2.4-2). The erosion of these tributaries southward into the Date Creek Basin surface has resulted in a series of subparallel gullies and ridges trending north and northwest, frequently controlled by northwest-to-southeast oriented faulting. Maximum topographic relief on the property is about 700 feet.

## General Geology

Precambrian igneous and metamorphic rocks and thick sections of Tertiary volcanic rocks and interbedded sediments are characteristic of the stratigraphy of the Sonoran Desert. This appears to be due to continued uplift in this portion of the Basin and Range Province, which has resulted in erosion of Paleozoic and Mesozoic rocks (although a few isolated outcrops do occur). Igneous intrusions are more common in the Sonoran Desert than in other portions of the province because

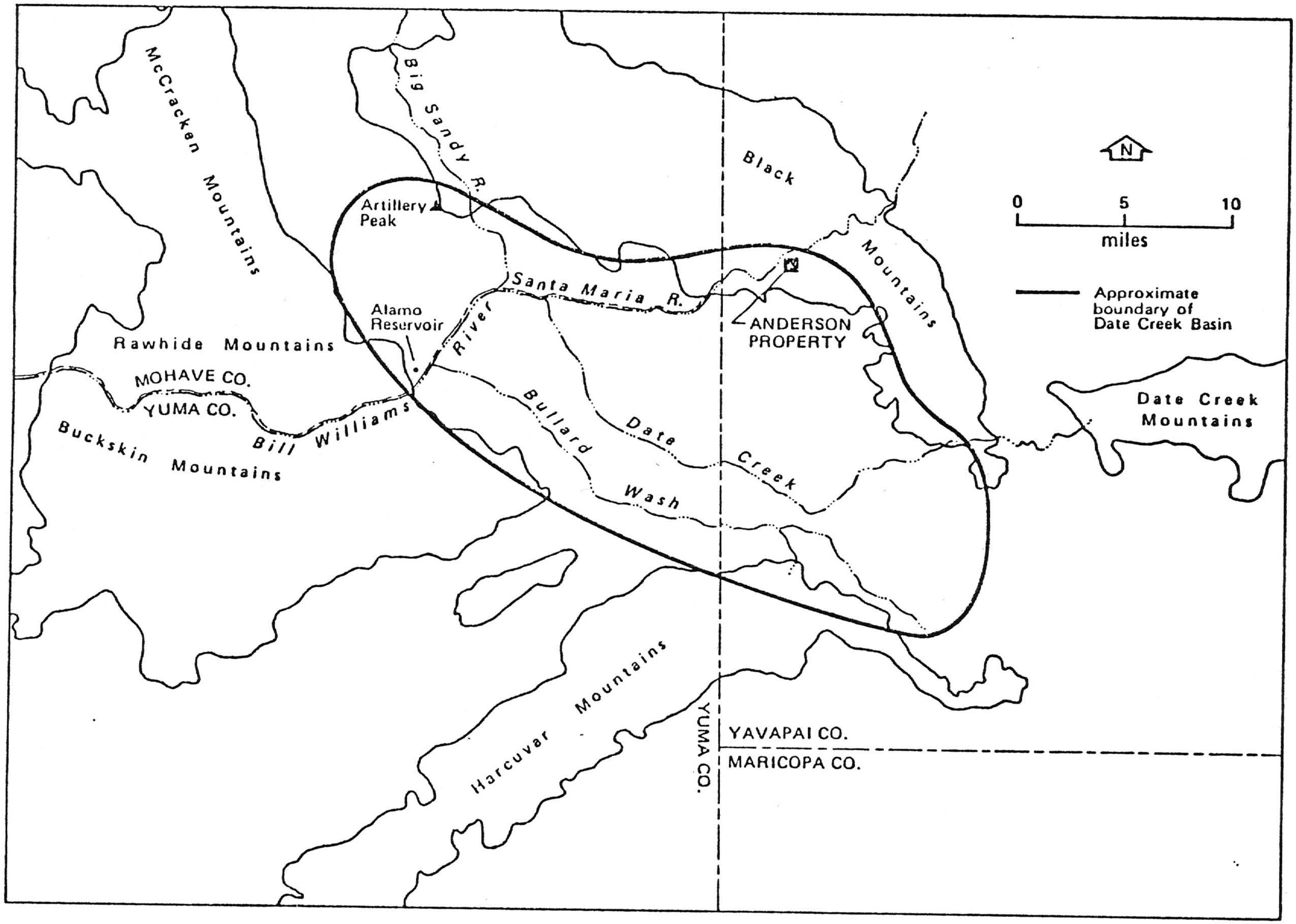


Figure 2.4-1. PHYSIOGRAPHY IN THE VICINITY OF THE ANDERSON PROPERTY

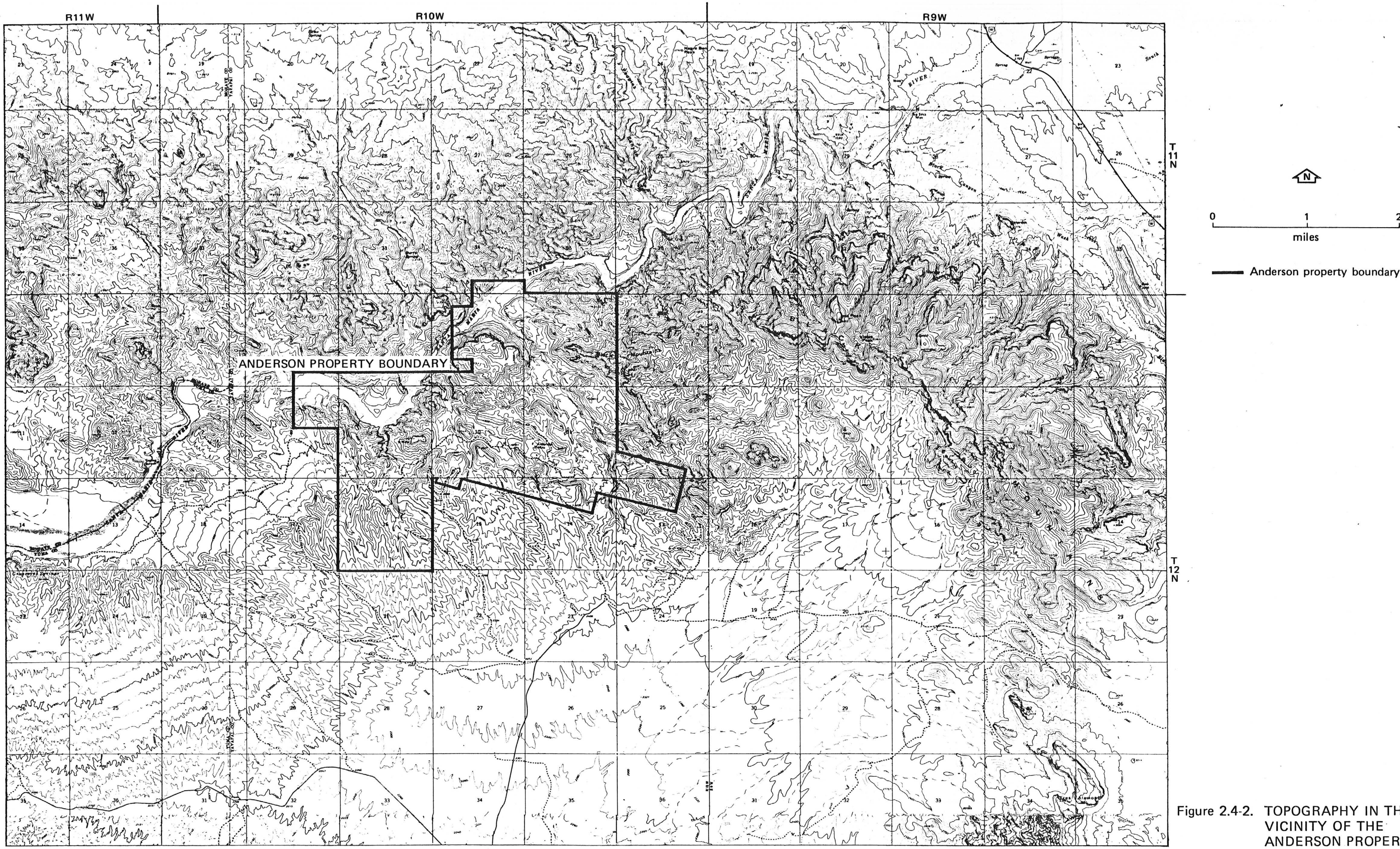


Figure 2.4-2. TOPOGRAPHY IN THE VICINITY OF THE ANDERSON PROPERTY

erosion has extended more deeply into the stratigraphic succession and the region is in a more advanced stage of arid-land pedimentation.

Masses of igneous rock were again intruded into the existing rocks during repeated activity in the late Cretaceous. Some volcanic activity also occurred at that time. From the late Cretaceous, and particularly in the Tertiary, deposition was renewed with terrestrial and then lacustrine sediments, as well as the intrusion of volcanic rocks. Since the cessation of volcanic activity in the Quaternary, the region has been undergoing a new cycle of erosin on the mesas and mountains, with deposition of sands and gravels in the valleys.

Tectonic History

In the early Precambrian era, a broad northeast-trending geosyncline extended across much of central Arizona. At the end of this time, compression and uplift during the Mazatzal Orogeny created roughly northeast-trending mountain ranges in this region. Accompanying this orogeny was extensive volcanism and the implacement of many granitic plutonic bodies.

Erosion greatly reduced these mountains during middle Precambrian time. However, central Arizona remained an area of uplift throughout the remainder of the Precambrian and during most of the Paleozoic and Mesozoic eras. At the end of the Precambrian the Grand Canyon Disturbance resulted in deformation and intrusion of diabase to the northwest and southwest of central Arizona.

During the Paleozoic era the area of uplift, called Mazatzal Land, remained relatively stable. At the same time, the Cordilleran Geosyncline to the northwest and the Sonoran Geosyncline to the southeast of Mazatzal Land downwarped and were the sites of the deposition of thousands of feet of Paleozoic sediments. Deposition in these geosynclines continued into the Mesozoic.

From the Mesozoic into the Cenozoic era the relative movement of the North American Plate westward or northwestward increased the compressional forces on the western portion of the continent. A trench or subduction zone formed along the North American Plate margin, and the small plate or plates between it and the Pacific Plate were subducted. This activity initiated a series of orogenies that generally progressed eastward, deforming the Cordilleran Geosyncline and also affecting the Sonoran Geosyncline. Although parts of this general activity have been given separate names, many researchers now apply the name Laramide Orogeny to the entire series of deformations.

In the middle of the Cenozoic (Late Oligocene), the northern portion of the East Pacific Rise was either subducted into the California trench system or passed eastward under the North American Plate. As a result, the trench system ceased and transform movement between the North American and Pacific plates was initiated, releasing compression forces and creating tensional forces. With the transform movement and related tensional forces, western North America is literally being pulled apart. The Basin and Range block faulting is the result of this tension stretching of the earth's crust. Commonly associated with the transform movement is basaltic volcanic occurrences, possibly derived from ocean basin sources subducted beneath the continental plate.

Although it is not proven, it generally appears that the southwest Arizona portion of the Basin and Range Province is a marginal wrench zone between the rest of the Basin and Range Province to the north, the Colorado Plateau to the east and northeast, the Salton Sea Rift to the west, and the Sierra Madre in Mexico to the south. The Sonoran Desert is acting as a pivotal point between the movement of plates to the north, south, and west.

## LOCAL GEOLOGY

### General

The geology of the area in the vicinity of the Anderson property is relatively complex and further complicated by numerous northwest-to-southeast-trending structural features generally downfaulted to the southwest. No detailed regional geologic map is available for the area; however, the geological units exposed on the property are all Cenozoic in age, resting on Jurassic granites. Precambrian rocks outcrop north of the property.

Sediments dip an average of about 7° to the south on the Anderson property. Since the land surface rises to the south, the depth to a given stratigraphic unit becomes progressively greater in a southerly direction (Figure 2.4-3). Erosion of the overlying conglomerate and basalt has exposed the mineralized units to be mined at the land surface on a portion of the property. Uranium mineralization occurs at depths greater than 1000 feet below the land surface to the south of the Anderson property.

Local Stratigraphy

Nine informal stratigraphic units have been identified by Minerals Exploration Company on the Anderson property. From youngest to oldest, they are: alluvium, upper conglomerate, basaltic volcanic flows and dikes, lower conglomerate, lacustrine sediments, andesitic volcanic flows, felsic to intermediate volcanic clastic sediments, felsic to intermediate (extremely varied composition) intrusions and flows, and crystal-
line intrusive rocks.

Alluvium (Quaternary) (Qal).* Unconsolidated sands and gravels are present in most of the stream courses on the Anderson property. At least one older alluvial terrace is present in the northeast portion of the area and remnants of several older alluvial deposits are present along some of the deeper drainages. Most of these older deposits have well-developed caliche zones within them. Recent alluvial deposits along the Santa Maria River contain groundwater and are discussed in detail in Section 2.6.

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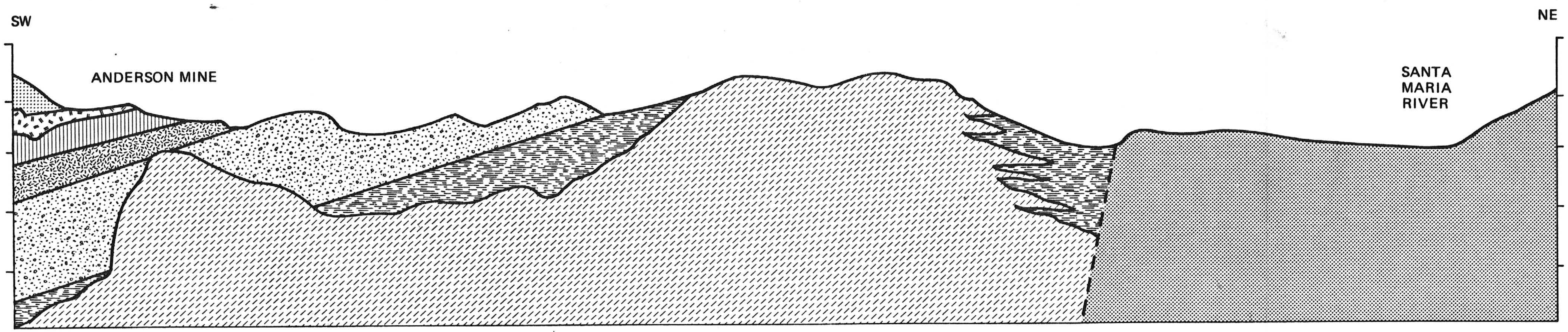
*The symbols given after each heading refer to the mapping symbols on Figure 2.4-3.




LEGEND

- Quaternery-Tertiary conglomerate, 0-400', tan to white, sandy to very coarse, locally calcite cemented, granitic metamorphic felsic and basalitic clasts
- Tertiary Miocene basalt, black, fine-grained to aphanitic, calcite-filled amygdules, commonly parallel to flow surface, 0-120'
- Tertiary miocene conglomerate, tan to brown siltstone grades upward into arkosic sandstone and then into conglomerate with granitic and felsic clasts, 200-450'
- Tertiary Miocene lacustrine sediments, basal arkosic sandstone, carbonaceous siltstone and lignite, silty limestone, limy siltstone, green siltstones and mudstones, tuffaceous material throughout, 0-400'
- Tertiary volcanic andesite, gray, gray-brown, red-brown, fine-grained, vesicular augite andesite, locally containing calcite-filled amygdules
- Tertiary volcaniclastic sediments, gray to white, felsic to intermediate tuffs, ash flows, lahar breccias, upper section yellow-tan to tan, sandy
- Tertiary felsic to intermediate volcanics, white to gray, pink-gray, necks, flows and tuffs
- Jurassic granite, brown, purple-gray, biotite granite

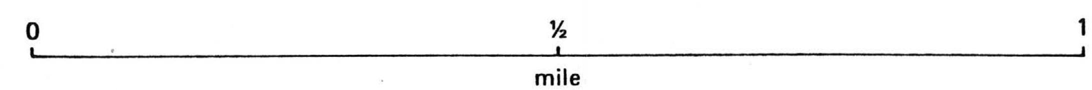



Figure 2.4-3. GENERALIZED CROSS SECTION OF THE ANDERSON PROPERTY (refer to Figure 2.4-4 for location of cross section)

Upper Conglomerate (Quaternary Tertiary) (Qcgl). The upper conglomerate unconformably overlies either the basaltic volcanics or the lower conglomerate. This unit is composed of cobbles and boulders of felsic and mafic volcanics, basalt, granite, and metamorphics in a matrix of medium- to coarse-grained arkosic sandstone. The presence of basaltic boulders differentiates it from the lower conglomerate. The unit is weakly to moderately indurated and is locally well-cemented by calcite. Like the lower conglomerate, this formation contains groundwater (see Section 2.6).

Basaltic Volcanics (Miocene) (Tmb). Basaltic volcanic flows unconformably overlie the lower conglomerate, forming erosionally resistant caps on many of the mesas and eroding cliffs in the area. Ljung et al. (1976) describe the basalt as "black fine-grained to aphanitic, containing calcite-filled amygdules, and commonly jointed parallel to the flow surface." The basalt attains a maximum thickness of 120 feet southeast of Flat Top Mesa and thins to the east. At least two flows are present in the western portion of the property. To the northeast of Flat Top Mesa (NE 1/4 Sec. 10, T11N, R10W) several dikes, possibly basaltic, have been noted. These dikes cut the felsic to intermediate and andesitic volcanics; however, no direct pipe has been observed to the basaltic flows from these dikes. Pierce* reports that a sample of basalt taken at the Anderson Mine in the southeast 1/4 of Section 10, T11N, R10W, was dated (Potassium Argon Method) at 13 to 14 million years old, or Miocene in age. Basalt to the west of the property at Palmerita Ranch

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*W. Pierce, Arizona Bureau of Mines, personal communication, 1977.

has recently been dated at 11 million years old, and samples from Malpais Mesa, northeast of the property, are 8 to 9 million years old.*

Lower Conglomerate (Miocene) (Tmc). A tan to brown siltstone is usually present immediately above the lacustrine sediments. This siltstone grades upward into arkosic sandstones and then into the conglomerate. The unit is composed primarily of arkosic sands and granitic and metamorphic clasts. Minor amounts of rhyolitic and andesitic volcanic materials are present throughout the unit. The sandstone and conglomerate may be either locally well cemented by calcite or relatively unindurated. To the southwest, where the lake beds interfinger with sandstones, the lower conglomerate is indistinguishable from these sandstones. This conglomerate unit contains groundwater which may be present in sufficient quantities to provide a source of water.

Lacustrine Sediments (Miocene) (Tml). The lacustrine sediments unconformably overlie the andesitic volcanics over most of the Anderson property. However, east of the center of the property they overlie the volcani-clastic sediments and farther to the east they onlap the felsic to intermediate volcanics. The felsic to intermediate volcanics or the tuffaceous part of the volcani-clastic sediments were encountered immediately below the lacustrine sediments in one drill hole in the southeast 1/4 of Section 10, T11N, R10W.

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*W. Pierce, Arizona Bureau of Mines, personal communication, 1977.

Evidence now suggests that deposition of the lacustrine sediments occurred in a restricted basin. These sediments probably represent time-transgressive facies deposited within a narrow, probably shallow, basinal feature. This type of depositional environment exhibits complex rationships between individual facies, such as lensing out, vertical and horizontal gradation, and interfingering. Ljung et al. (1976) simplified these complexities by dividing the lake-bed sequence into four subunits: (1) a basal coarse clastic unit; (2) a mudstone-siltstone unit containing interrelated carbonaceous zones; (3) a succession of interbedded limestones, silicified limestones, cherts, mudstones, and siltstones; and (4) a thin, fissile, fossiliferous marker bed that has been designated the top of the lacustrine unit.

The lake sediments include green siltstones and mudstones, white calcareous siltstones, and silty limestone or calcareous tuffaceous material. Much of this material is silicified to varying extents and was partly derived from volcanic ashes and tuffs common throughout the lake beds. Also present in the lacustrine sequence are zones of carbonaceous siltstone and lignitic material. A basal arkosic sandstone was encountered in drill holes along the southern boundary of the property. To the south and southwest, the "typical" lake beds interfinger with, and eventually are replaced by, a thick, medium- to coarse-grained, arkosic sandstone unit. It is not known whether this unit relates to the basal arkosic sandstone mentioned above.

All of the lake bed facies may exhibit some uranium mineralization. However, the highest grade and most consistent mineralization is located in the carbonaceous siltstones and lignitic materials.

In addition to the organic material in the carbonaceous zones, abundant plant remains (including twigs, reeds, and small roots) are present in the lacustrine sediments. Reyner et al. (1956) identified abundant silicified palm-type wood in these sediments. In addition, many faunal fossil remains are present in the deposits. Freshwater molluscs, up to 1.5 inches long, are locally common. Thin, laminated, calcareous siltstone near the top of the lake beds contains small freshwater fish fossils. The leg bone of a duck found in the unit has been dated as Miocene by the Los Angeles County Museum. A jaw of a rhinoceros reportedly found at the Anderson property is on display at the Wickenburg Museum. Breed and Billingsley et al. (1977), of the Museum of Northern Arizona, collected fossils at the Anderson property in April 1977. Included in their finds were a camel bone, a rhinoceros tooth (Miocene), and freshwater fish fossils (for further discussion of paleontological resources refer to Section 2.3).

Halpenny (1977) refers to a coarse-grained unit (barren sand) which which appears to be the equivalent to the basal red arkosic sandstone of the lucustrine sediments. The barren sandstone lies immediately above the volcanic andesite basement. It is absent near outcrop and increases in thickness to the south (see Section 2.6).

Andesitic Volcanics (Tertiary) (Tva). A series of andesitic volcanic flows unconformably overlies the felsic to intermediate volcanics or the volcani-clastic sediments. Reyner (1956) described the unit as a fine-grained, vesicular, augite andesite locally containing calcite-filled amygdules. The flows are generally purple, red-brown, gray-brown, or gray. In several areas of outcrop they are interbedded by volcani-clastic sediments composed of felsic volcanic pebbles and arkosic sands. The andesitic flows have been considered "basement"* on the Anderson property, as no uranium mineralization has been observed in or below them. Before depositon of the lacustrine sediments, erosion and faulting developed a complex paleotopography and locally thick red-brown paleosols on the top of the andesitic volcanics. Agglomerate is also reported as occurring at the top of this formation underlying the lake bed sediments (Halpenny, 1977). This agglomerate contains groundwater and is discussed further in Section 2.6.

Volcani-Clastic Sediments (Tertiary) (Tvg). Interbedded with and unconformably overlying the felsic to intermediate volcanics are tuffs, ashes, and volcani-clastic sediments. All of these appear to be of felsic to intermediate composition and are therefore believed to be contemporaneous with the felsic to intermediate volcanics. However, deposition of this unit continued after the felsic to intermediate volcanic activity ceased, as this unit is also interbedded with the overlying andesitic volcanics.

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*"Basement" is used here in reference to the uranium mineralization basement; that is, mineralization lies above it.

The most complete section of this unit is located in the northeast portion of the property. Here the basal part of the section is composed of white felsic to intermediate tuffs, thin ash flows or volcani-clastic sediments, lahar breccias, and volcanic bombs. Volcani-clastic sediments increase upward in the section, and the color changes from white to yellow-tan to tan. These sediments include felsic volcanic material and arkosic sandstone.

Many aspects of these sediments (crossbedding, thin continuous beds, etc.) lead to the conclusion that they were deposited in a lake bed ancestral to that of the overlying lacustrine sediments.

Where exposed on the surface or encountered in drill holes, these volcani-clastic sediments exhibit no anomalous gamma activity.

Felsic to Intermediate Volcanics (Tertiary) (Tuf). Unconformably overlying the crystalline basement, or in fault contact with it, is a series of felsic to intermediate volcanics. This series includes intrusive necks, flows, lahar breccias, and tuffs. These volcanic rocks appear to be rhyolitic to andesitic in composition and are generally white to light gray in color.

Crystalline Intrusive Rock (Jurassic) (J). In the extreme northeast portion of the property, the Santa Maria River and its tributaries have cut into a crystalline basement complex. These rocks are low in quartz content but have been termed granitic (they were termed biotite granite by the analytical lab, despite the apparent low quartz content).

This granitic rock is purplish-gray in color, medium-to-coarse crystalline to pegmatitic, and is intruded by veins of quartz and plagioclase feldspar with large crystals of hornblende and black biotite. A sample of the crystalline basement complex was dated as Jurassic (157.5 million years ago, ±3 million years) by the Geochron Laboratories Division of Kruger Enterprises.

## Local Structure

As discussed above, the Anderson property is located in the Sonoran Desert section of the Basin and Range Physiographic Province and the local geology exhibits the general structural pattern common to this region. Parallel to subparallel fault blocks with usually normal bounding faults predominate. These faults are often rotational or hinged and may have experienced some longitudinal movement. While much of the Basin and Range faulting is on the magnitude of thousands of feet of displacement, displacement along faults at the Anderson property are measured in tens and hundreds of feet.

Faulting on the property was active before, during and after the deposition of the Miocene section (lake beds, lower conglomerate, and basalt). The general dip of the sediments is 5° to 15° to the south, steepening to the north along the granite front. The general dip to the south appears to be the result of the recurrent nature of the faulting, and in these areas dips on the drag folds may surpass 20°. Many of the onlap, pinchout, and lens relationships in the lake beds are probably due to or related to recurrent contemporaneous faulting.

The recurrent and hinging nature of the faulting makes it extremely difficult to predict how a specific fault will affect the individual stratigraphic units along it. At one point along a fault there may be only a few feet of vertical displacement, while 200 feet beyond that point portions of the section may be displaced several tens of feet. Many of the faults that displace the lake beds show diminished or no movement in the basalt, and most of the faults die out before or in the upper conglomerate. The faulting and basalt flows are relatively contemporaneous. Therefore, the basalt is not heavily fractured.

Three major faults - the East Boundary Fault System, Fault 1878 (so named because it intersects a hill of 1878 feet elevation adjacent to the Anderson property), and the West Boundary Fault System - are present in the area. In addition there are many parallel faults that have less displacement (Figure 2.4-4). All of these faults trend between N30°W and N55°W. Another set of faults trending more westerly (N65°W) is present, at least in the south-central portion of the property. A set trending northeast has been conjectured by Urangesellschaft and others, but it has not been observed in the field.

The West Boundary Fault System includes at least two distinct normal faults. Movement on these faults is down to the southwest. Vertical offset of the volcanic basement across the two faults is approximately 100 feet. Another fault is indicated to the southwest that vertically offsets the volcanic basement about 250 feet. Including

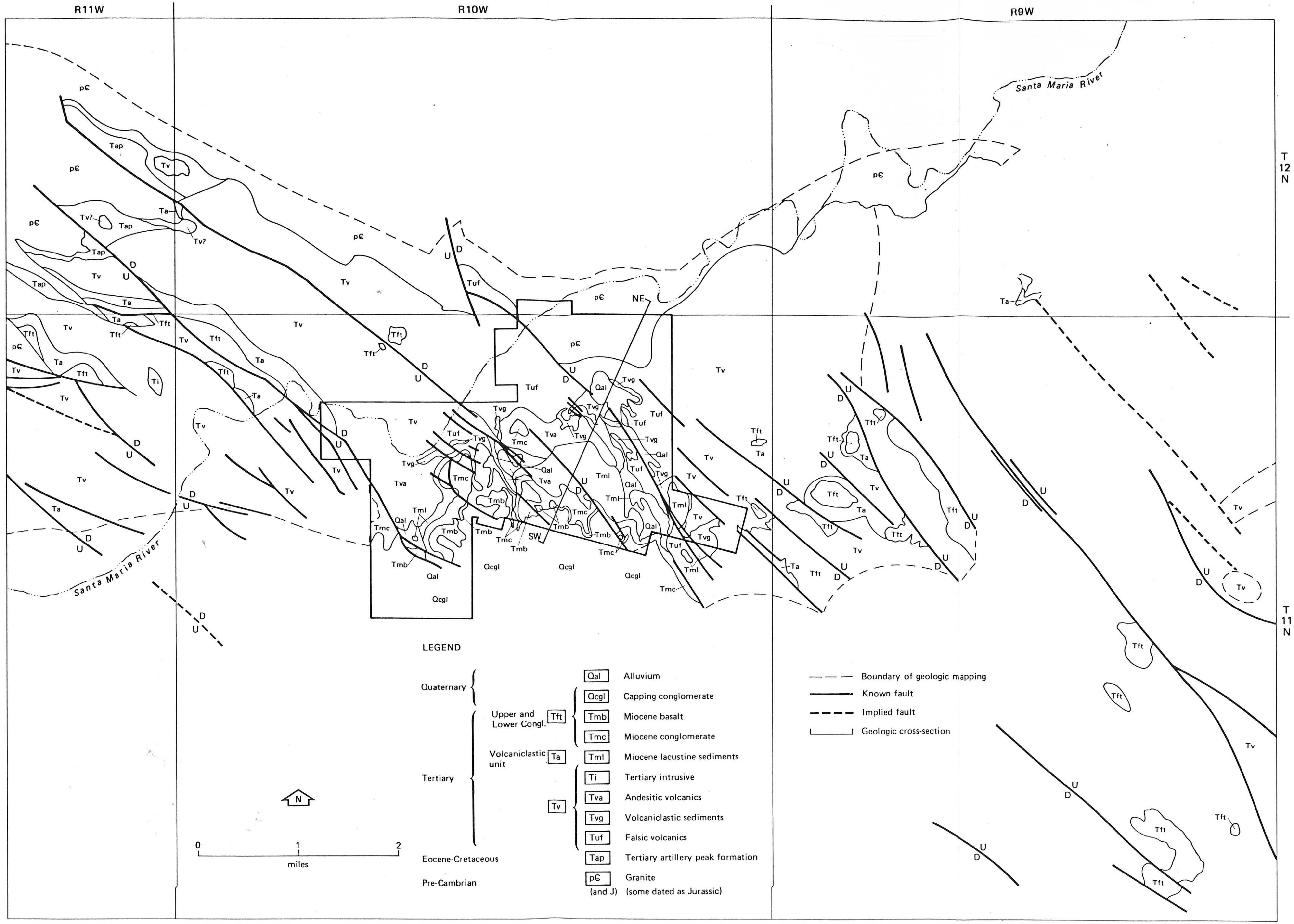



Figure 2.4-4. GEOLOGY OF THE ANDERSON PROPERTY

all three faults of the West Boundary Fault System, total vertical offset of the basement volcanics across the system is more than 700 feet, and vertical offset of the basalt is less than 200 feet.

A large hinge fault, fault 1878 exhibits 200 feet of vertical displacement near the southern boundary of the property. To the northwest along the fault strike, displacement appears to decrease and movements appear to be distributed across a zone of faults. The movement along this normal fault has been down to the southwest. Along the zone of faults, movement, while generally down to the southwest, has produced horst/graben features.

The East Boundary Fault System consists of several large faults along the eastern and northern portions of the property. These faults are beyond the limits of mineralization and have not been thoroughly explored. In general, they are downthrown to the southwest and several of them probably have displacements approaching 1000 feet. The westernmost fault of this system marks the foot of the Black Mountains, and the more eastern faults in the system lie within the Black Mountains.

## Geologic History of the Anderson Property

Many of the regional geologic trends are reflected on the Anderson property. The mine is located in an area that has been marginal or is marginal to every regional deformation.

The lack of Paleozoic rocks on the property is the result of the area's position on the margin of Mazatzal Land, a positive, stable area. Rocks of this era were either not deposited or have eroded away.

After a long period of relative quiescence, the Laramide Orogeny began in the Mesozoic. During the later Jurassic, the granite on the northeastern margin of the property was emplaced. This was the result of the Nevadian Orogeny, a local name for part of the Laramide Orogeny.

The felsic volcanics on the Anderson property are possibly associated with the subduction of the Pacific plates into the California trench system. It is expected that dating of these volcanics would provide ages falling in the late Cretaceous to middle Tertiary.

With the termination of the trench system at the end of the Oligocene, Basin and Range block, transform, and normal faulting began. The lacustrine sediments have been dated paleontologically as Miocene, and a geochemical date of Miocene (13 to 14 million years ago) has been obtained for the basalt. These lake beds were probably formed in the early or middle Miocene. During this time, while volcanism was waning, ash and tuff deposits were still common.

Drill hole data lead to the conclusion that deposition of the lacustrine sediments occurred in a very restricted area. To the north of the Anderson property in Section 4, T11N, R10W, the basalt caps Hill 2826 (Figure 2.4-2) and is underlain by the lower conglomerate.

This in turn rests unconformably on the "basement volcanics." Two possibilities arise: (1) the lake beds were never deposited there, or (2) they were deposited and subsequently eroded. The fact that the lake beds thin rapidly northward suggests that the beds were never deposited there. The intertonguing and interfingering of the "typical" lake beds with clastic siltstones and medium- to coarse-grained sandstones to the southwest and south limits the lake boundary in this direction. The relationship of coarse-grained lithologies in this direction and the lack of them to the north in the "typical" lake-bed sequence implies that the sediment source was from the west or the south. Drilling has traced the lake beds and mineralization to the southeast. Drilling to the southeast of Urangesellschaft's claims (adjacent to the southern boundary of the Anderson property) has encountered interbedded green siltstones and sandstones and little mineralization. Thus, it appears that the lacustrine sediments were deposited in an area less than three miles wide and only about five or six miles long. The lake trended roughly northwest-southeast and generally paralleled the dominant post-Oligocene faulting trend of the area. One further lithologic implication is of interest. The northern and northeastern margin of the lake was probably the Black Mountains. It is known that the lake sediments thin markedly in this direction and some agglomerates are present within the lake bed sequence north of the proposed mill site.

The lower conglomerate overlying the lake beds attests to the continuation of Basin and Range faulting and development. Erosion from nearby sources, possibly from the north or northeast, is indicated. Near the end of the Miocene the basaltic volcanics flowed across part of the area, possibly marking the passage of the East Pacific Rise beneath the area. Normal faulting continued and the upper conglomerate was deposited. Its very coarse texture implies nearby sediment sources and a high-energy environment of deposition, as it would require a strong current of water to carry such boulders. The inclusion of fresh basaltic boulders suggests the source was to the north and that the transporting agent may have been the Santa Maria River.

## Mineralization

Uranium mineralization on the Anderson property is primarily associated with carbon. In fact, it is suspected that mineralization not associated with carbonaceous material may represent the pinchout of this material or very thin carbonaceous laminae. The primary mineralized zones on the property are carbonaceous siltstone and lignitic facies in lake beds. In addition, occasional mineralization has been noted in the basal sandstone of the lacustrine sediments and in the lower conglomerate where uranium was deposited as fracture fillings around and below the main mineralized zones after remobilization. Carbonaceous material is known to occur in these two units.

Carbon tends to immediately fix uranium when soluble forms of the mineral come in contact with it. Much of the mineralization is at the top or bottom of the carbonaceous facies; however, mineralization does occur in the middle of some carbonaceous zones. This latter relationship implies that mineralization occurred contemporaneously with the deposition of the carbonaceous material.

Silicification of various parts of the lake sediments on the property probably occurred soon after deposition. Devitrification of the tuffaceous and ashy lake-bed sediments and/or the felsic volcanics were probably the primary sources of silica.

Reyner et al. (1956) suggest three possible origins for the uranium on the Anderson property: hypogene, ash leach, and bog deposition. A fourth possible origin is mobilization across the Date Creek Basin.

Reyner et al. (1956) cite field evidence in favor of a hypogene source and state that "(1) uranium ore has not been observed beyond the boundary faults; (2) intense silicification has altered mudstone and limestone; (3) limonite and hematite staining occurs on bedding and fracture planes; (4) calcite, chalcedony, sepiolite, and manganese are found associated with the west bounding fault." This field evidence can have different interpretations. Drilling data indicate that the carbonaceous sediments also have not been observed beyond the boundary faults. This may explain why the mineral is localized within this area. Further, if uranium-bearing solutions migrated up faults, one would expect mineral and grade to be concentrated along the faults. Subsurface interpretations indicate no such association. Data indicate that faulting offsets mineralization. Intense silification is probably a result of devitrification of silicic volcani-clastic sediments. Bentonite, can also be an alteration product of tuffaceous material. Hematite and limonite stain on bedding and fracture planes was possibly derived from pyrite associated with carbonaceous material. Calcite, sepiolite, chalcedony, and manganese deposited along this zone, but without associated uranium. Such deposits cannot significantly be cited as evidence that uranium-bearing solutions migrated up the fault zone.

Support for this source, over devitrification, is implied by mineralization throughout the carbonaceous materials. If the source had been from overlying sediments containing volcanic fragments, mineralization would be expected only at the top of the carbonaceous zones. Further, if mineralization had been tied with devitrification, uranium should be present in all of the partings and fractures where silica was deposited. This is not the case on the Anderson property.

A fourth possibility for the deposition mechanism is that the uranium was mobilized from the western Date Creek Basin, carried by groundwater across the basin, and deposited in the reducing environment of the lacustrine sediments. It is interesting to note that uranium mineralization in the western Date Creek Basin is limited to the Artillery Peak Formation of Oligocene age. Overlying the Artillery Peak Formation is the Chapin Wash Formation, which is composed of altered (red) arkosic sandstones. Pierce (1976) suggests correlation of the Chapin Wash and the Anderson Lake sediments. Sedimentation at the Anderson property suggests a western or southern source. Groundwater movement during the Miocene therefore may have been easterly across the basin from the west. Uranium, remobilized from the Artillery Peak Formation, or derived from the same source but later, could have been carried in soluble form across the basin to the lacustrine sediments where the reducing environment of the carbonaceous facies precipitated its deposition. Other sources (ashes, tuffs, granites, and hot springs) may have contributed to some extent to the mineralization of the lacustrine sediments.

## 2.5 SEISMOLOGY

### HISTORICAL EARTHQUAKE ACTIVITY

Seismic activity in Arizona or adjacent portions of California that may affect the Anderson property can be assessed in part by examining the earthquake history of the region. The locations and magnitudes of earthquakes that occurred within 100 miles (160 km) of the property between 1930 and July 1976 are shown in Figure 2.5-1. This epicenter map includes events located by their reported effects and events located by modern seismographic instruments. Earthquakes occurring prior to the early 1900s in the Arizona area were not well-recorded instrumentally, and locations were generally assigned on the basis of earthquake effects on people and structures. The Modified Mercalli (MM) intensity scale is used to rate earthquakes by reported effects and observations (Table 2.5-1). Distribution of the reports of effects provides an estimate of both the size and location of an earthquake. Since this analysis depends on recorded reports, its accuracy depends on population density and distribution at the time of the earthquake. After approximately 1902 there was an improvement in seismographic instrument coverage in the region that includes Arizona. Upgrading of instrumental coverage also made possible the more accurate indication of earthquake size as a Richter magnitude determined from seismographic recordings.

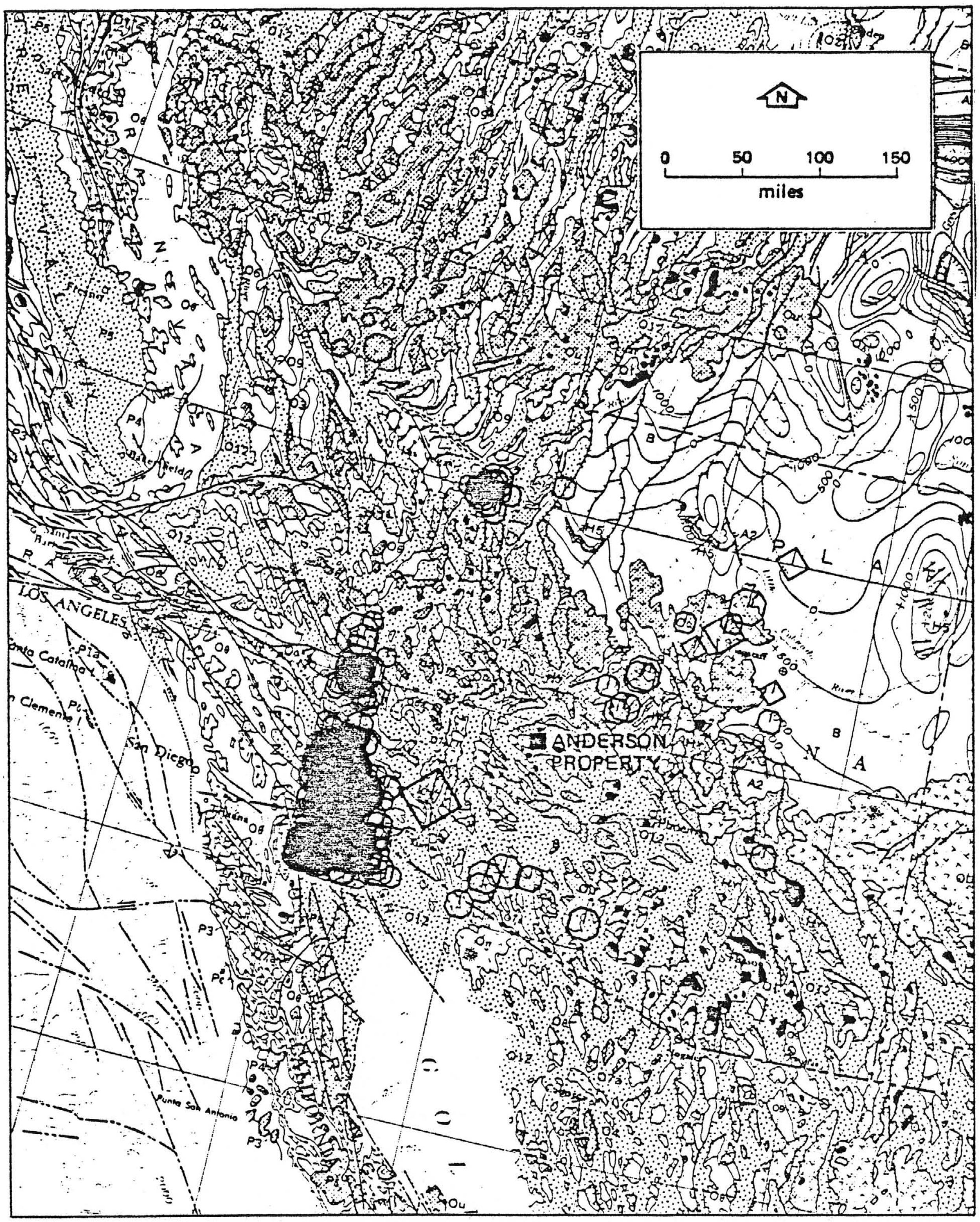
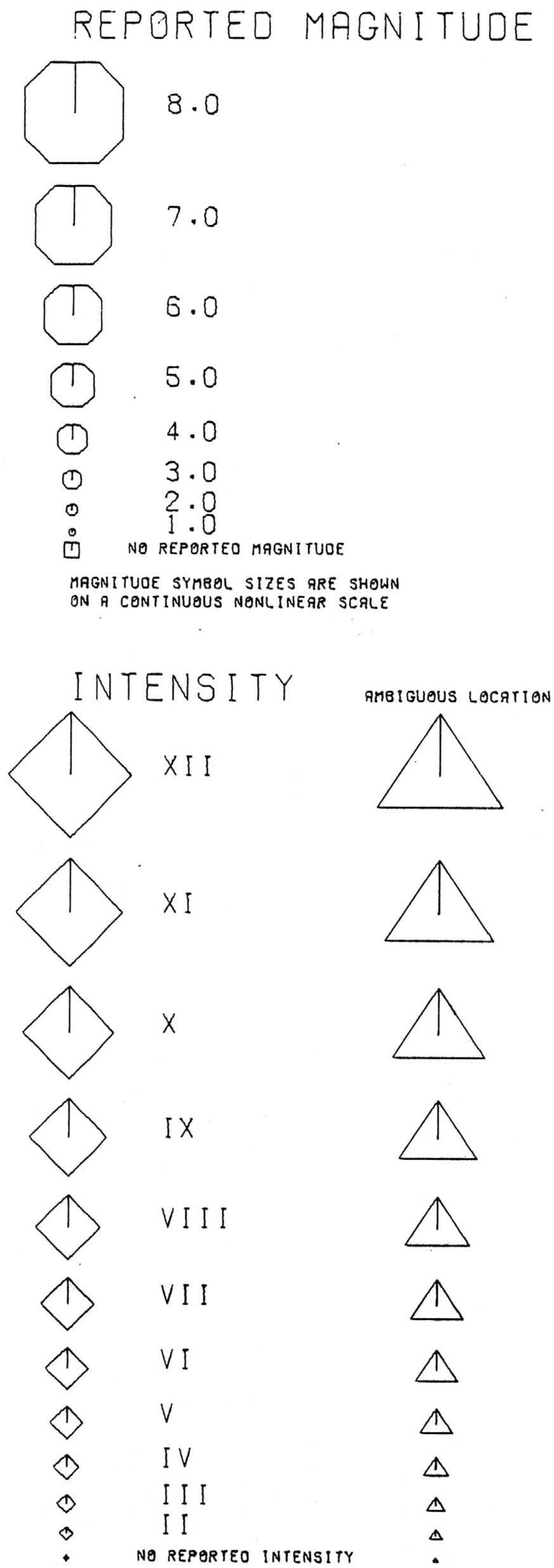



Figure 2.5-1. HISTORICAL SEISMICITY WITHIN
A 200-MILE RADIUS OF THE
PROPOSED FACILITY

LEGEND for Figure 2.5-1




4

# MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITY

**1931**

(BASED ON OBSERVER'S REFERENCE TO SCALE OF "EFFECTS")

Approximate Ground Acceleration

$a/g = \frac{\text{Acceleration}}{\text{Gravity}}$

0.002g.
0.003g.
0.004g.
0.005g.
0.006g.
0.007g.
0.008g.
0.009g.
0.01g.
0.02g.
0.03g.
0.04g.
0.05g.
0.06g.
0.07g.
0.08g.
0.09g.
0.1g.

I Not felt by people, except under especially favorable circumstances. Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly.

II Felt indoors by a few people, especially on upper floors of multi-story buildings, and by sensitive or nervous persons. As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended.

III Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that due to passing of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases. Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly.

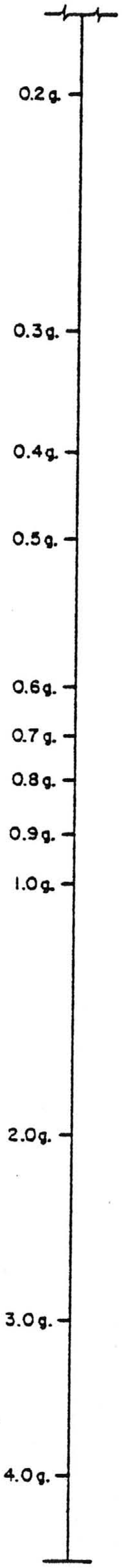
IV Felt indoors by many, outdoors by few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like a heavy body striking building or the falling of heavy objects inside. Dishes, windows and doors rattle; glassware and crockery clink and crash. Walls and house frame creak, especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary cars rock noticeably.

V Felt indoors by practically everyone, outdoors by most people, with slight excitement. Awakens many or most sleepers. Frightens a few people with slight excitement; some persons may run outdoors. Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerably. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop or run fast or slow. Small objects move and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly.

VI Felt by everyone, indoors and outdoors. Awakens all sleepers, frightens many people; general excitement, and some persons run outdoors. Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes and glasses, and a few windows, break. Knick-knacks, books and pictures fall. Furniture overturns in many instances. heavy furnishings move.

VII Frightens everyone. General alarm, everyone runs outdoors. People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged.

Table 2.5-1




VIII General fright and alarm approaches panic. Persons driving cars are disturbed. Trees shake strongly and branches and trunks break off (especially palm trees). Sand and mud erupts in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperature of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings with some partial collapse; heavy in some wooden houses with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet ground and steep slopes crack to some extent. Chimneys, columns, monuments, and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns.

IX Panic is general. Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other masonry buildings, some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged, and underground pipes sometimes break.

X Panic is general. Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally as beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures and their foundations are destroyed. Railroad rails bend slightly. Pipe lines buried in earth, tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces.

XI Panic is general. Disturbances in ground are many and widespread, varying with the ground material. Broad fissures, earth slumps, and land-slips develop in soft wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures especially near shock centers; great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly and some thrust endwise. Pipe lines buried in earth are put completely out of service.

XII Panic is general. Damage is total and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied and numerous shearing racks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air.

The seismic activity data presented in Figure 2.5-1 began in 1930 for the Arizona area. In order to provide an earlier historical record, additional historical seismicity catalogs were examined. Townley and Allen (1939) report earthquakes in Arizona for the period 1850 to 1928. For this period the majority of the reported earthquakes occurred either in northern Arizona, north of Flagstaff or in southwestern Arizona near the Gulf of California and the San Andreas fault zones. None of the larger magnitude events reported by Townley and Allen appear to have occurred closer than about 80 miles (130 km) from the site. In the publication Earthquake History of the United States (Coffman and von Hake, 1973), 14 earthquakes are listed for Arizona. All of these events are included in either the National Oceanic and Atmospheric Administration data presented in Figure 2.5-1 or in Townley and Allen (1939).

Figure 2.5-1 indicates 8 earthquakes within 100 miles (160 km) of the Anderson property. The closest events lie at a distance of 26 to 37 miles (42 to 60 km) northeast of the property. Two of these events (in 1973 and 1974) are suspected explosions. The largest of these 8 earthquakes occurred on February 4, 1976, 50 miles (80 km) northeast of the property and had a magnitude of 4.9.

Published curves relating the decrease of intensity level with increasing distance from the earthquake epicenter (Brazee, 1977) suggest that the maximum intensity that has occurred on the property in the hisotrical period is III to IV MM. This level of intensity is not normally associated with structural damage (Richter, 1958).

## EARTHQUAKES AND REGIONAL TECTONICS

The majority of the earthquakes located either by observed effects or by instrumental analysis in Arizona are associated with two zones of seismic activity. The major zone lies along the San Andreas, San Jacinto, and other fault zones in eastern California and encroaching slightly into southwestern Arizona. This zone is clearly identified by the dense concentrations of seismic events in Figure 2.5-1 and is located approximately 150 miles (240 km) or more from the property. The second zone is a region of very diffuse and low-level seismic activity in northern Arizona. This zone is located approximately 100 miles (160 km) or more from the property.

## EARTHQUAKE RECURRENCE

Because of the low level of seismic activity within 100 miles (160 km) of the Anderson property, it is difficult to estimate the recurrence of earthquakes and associated ground motions. Algermissen et al. (1976) have published a report and map for the contiguous United State s that presents contours representing the probability of exceeding a given level of acceleration (expressed as a percent of gravity) in 50 years at various locations (Figure 2.5-2). Since the Anderson property lies outside of the 0.04g contour, it can be concluded that there is a 10 present or less chance of exceeding an acceleration of 0.04g on the property over the next 50 years.

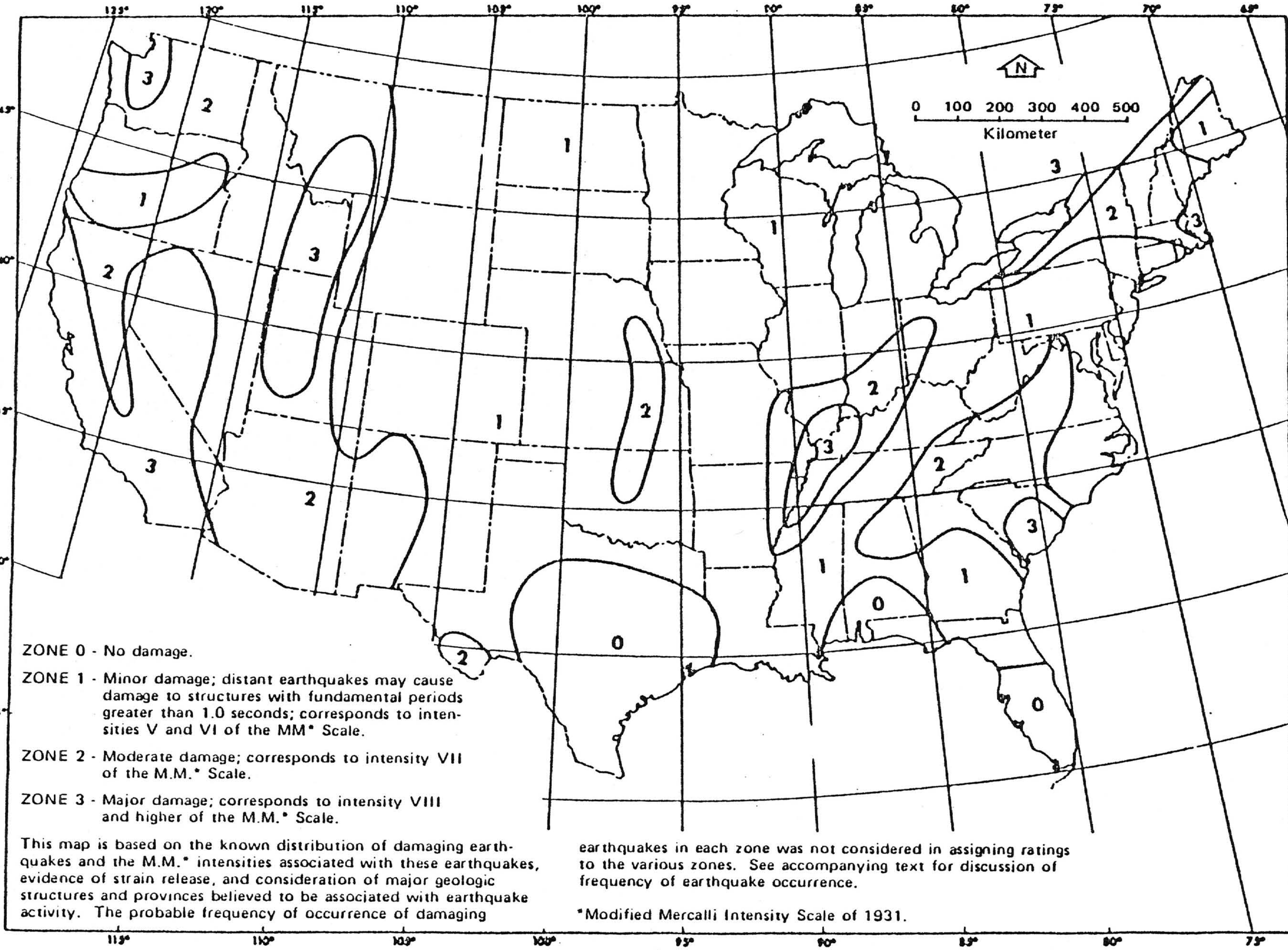



Figure 2.5-2. SEISMIC RISK MAP OF THE UNITED STATES

property over the next 50 years. Effects from such an acceleration level would depend heavily on the period and duration of the ground shaking and on the site response characteristics. However, this level of acceleration in itself would not be expected to cause other than minor damage, if any, to properly designed and well-built structures.

## 2.6 HYDROLOGY AND WATER QUALITY

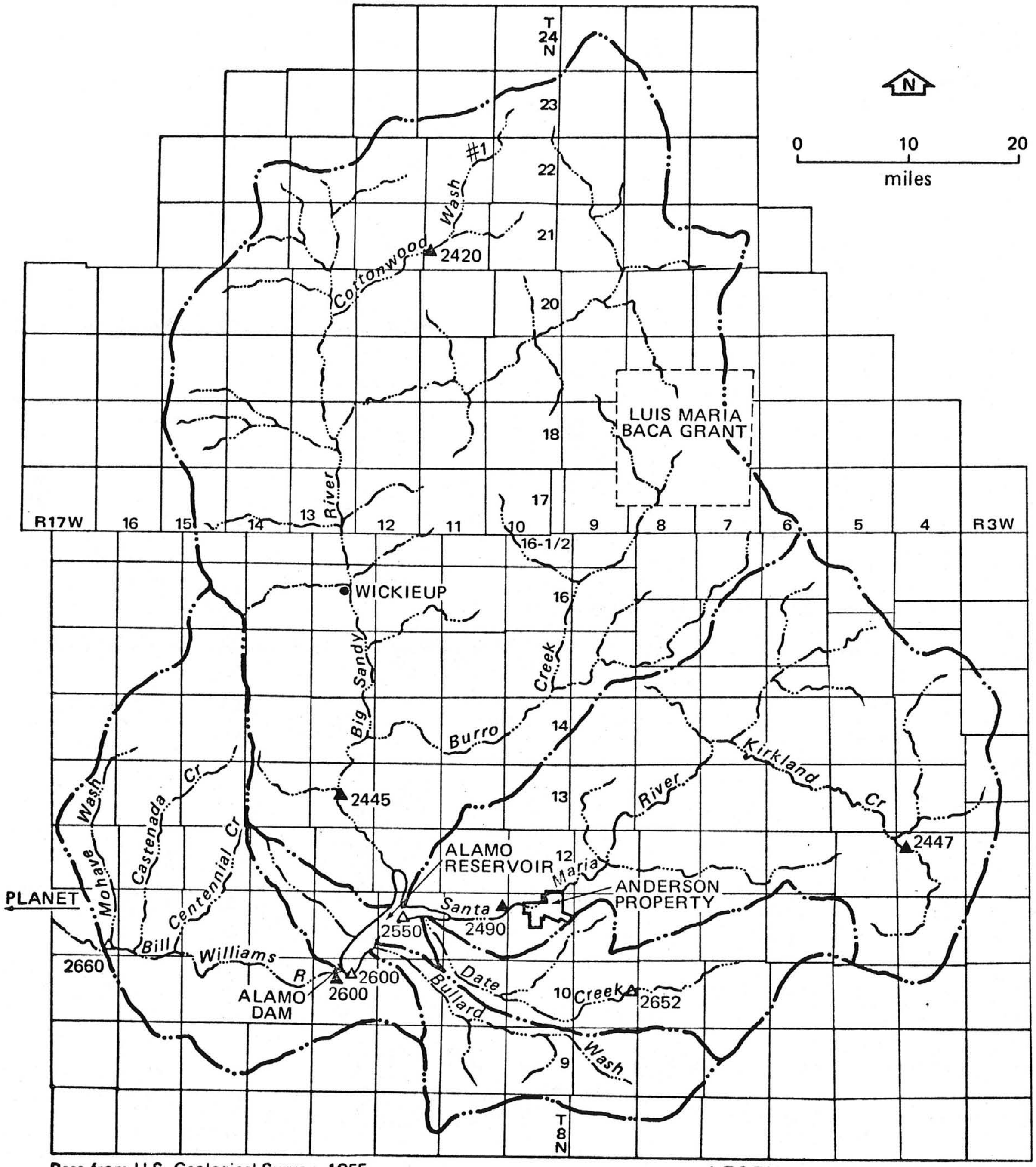
### SURFACE WATER HYDROLOGY

Most streams in southwestern Arizona have surface flows for only short periods during the year. This is due largely to the low annual precipitation and high evapotranspiration rate of the region. High infiltration rates also reduce surface flows.

The Anderson property is drained by the Santa Maria River and several of its tributaries. The Santa Maria watershed covers approximately 1520 square miles and constitutes about 30 percent of the Bill Williams River Basin.

#### Regional Surface Water Hydrology

The Bill Williams River Basin covers approximately 5140 square miles (Figure 2.6-1). The principal subbasins within the basin are listed in Table 2.6-1. The northwest portion of the river basin lies in the Central Highlands water province. Unit runoff for streams in this province ranges from 1 to about 10 inches (Figure 2.6-2). Most of Arizona's perennial streams originate in this mountainous region, and these streams provide approximately 50 percent of the state's total surface runoff (Arizona State Water Plan, 1975). The rest of the Bill Williams River Basin is located within the Basin and Range Province. Surface runoff in the low mountains and alluvial valleys of this province ranges from less than 0.1 inch to 0.5 inch.




Base from U.S. Geological Survey, 1955, state base map, 1: 500,000.

**Source:** Water Development Corporation, 1977a.

LEGEND

▲ Gaging station active in 1977

△ Former gaging station

**Figure 2.6-1.** BILL WILLIAMS RIVER DRAINAGE BASIN, ARIZONA

Table 2.6-1. AREAS OF SUBBASINS IN THE BILL WILLIAMS RIVER BASIN

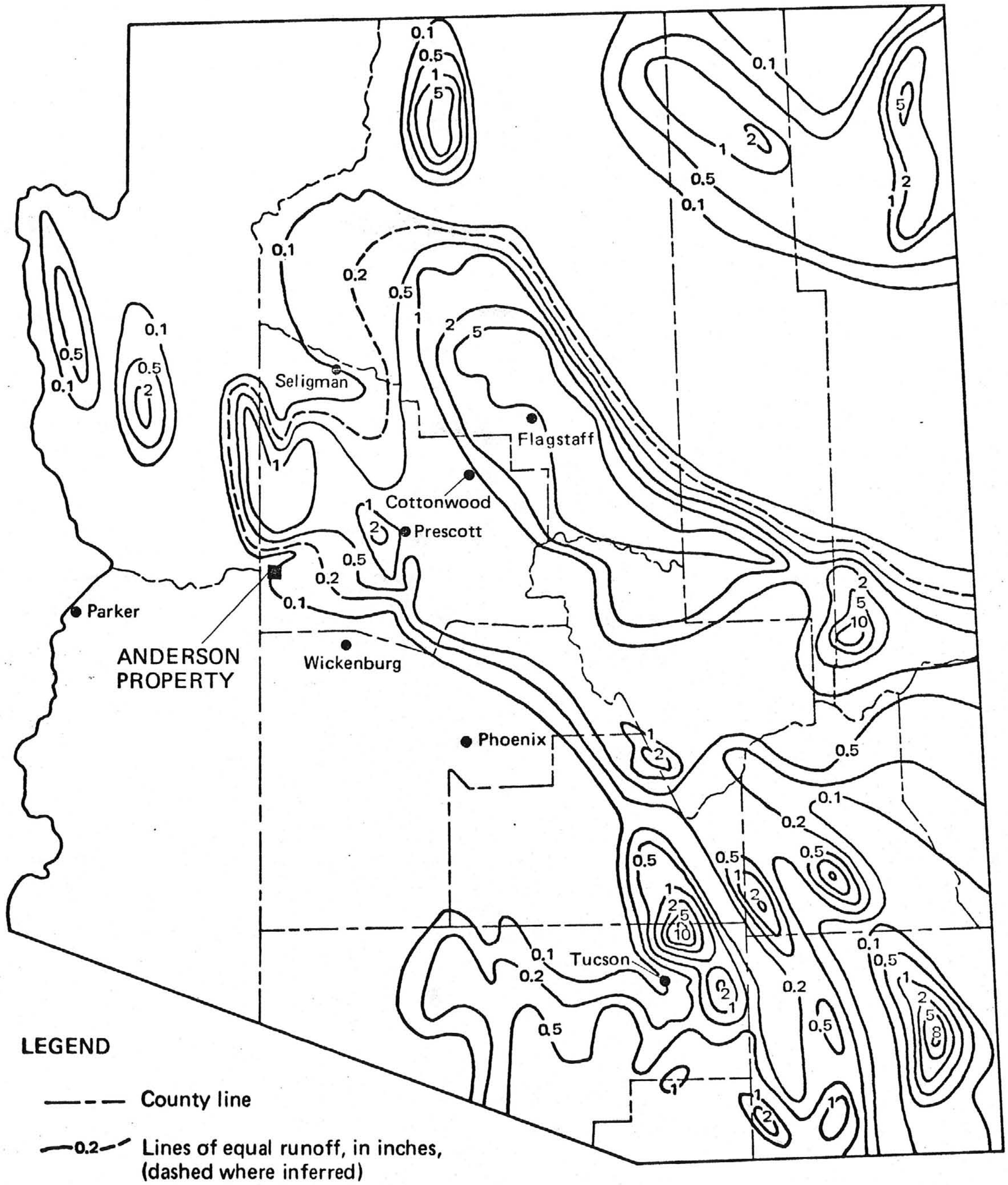
| Subbasin | Area (sq mi) | Approximate Percent of Total Area |
|---|---|---|
| Big Sandy River | | |
| Above gaging station 2420* on Cottonwood Wash | 143 | |
| Above gaging station 2445 on Big Sandy River | 2800 | |
| Above mouth of Big Sandy at Alamo Reservoir | 2810 | |
| Total | 2810 | 55 |
| Santa Maria River | | |
| Above gaging station 2447 on Kirkland Creek | 109 | |
| Above gaging station 2490 on Santa Maria River | 1210 | |
| Date Creek and local washes | 310 | |
| Total | 1520 | 29 |
| Bullard Wash (runoff into Alamo Reservoir) | 400 | 8 |
| Centennial Wash and Castenada Wash (runoff into Bill Williams River) | 410 | 8 |
| Total drainage area of Bill Williams River Basin at Planet | 5140 | |

*See Table 2.6-2 and Figure 2.6-1 for locations of gaging stations within the drainage basin.

Table 2.6-2. STREAMFLOW GAGING STATIONS IN BILL WILLIAMS RIVER BASIN

| Gaging Gaging Station | Location | Drainage Area (sq mi) | Period of Record |
|---|---|---|---|
| 2660 | Bill Williams River at Planet Ranch (about 6 miles upstream of discharge point into Lake Havasu) SE 1/4 SW 1/4 Sec. 36, T11N, R17W | 5140 | 1913-1915, 1928-1946 |
| 2600 | Bill Williams River below Alamo Dam, SE 1/4 SE 1/4 Sec. 4, T10N, R13W | 4730 | 1939-1975 |
| 2445 | Big Sandy downstream of Wikieup, SE 1/4 Sec. 16, T13N, R13W | 2800 | 1966-1975 |
| 2420 | Cottonwood Wash No. 1, NW 1/4 Sec. 29, T21N, R11W | 143 | 1964-1975 |
| 2550 | Santa Maria River near Alamo Dam, NE 1/4 SW 1/4 Sec. 9, T11N, R12W | 1520 | 1939-1966 |
| 2490 | Santa Maria River downstream from Anderson Mine, SE 1/4 Sec. 12, T11N, R11W | 1210 | 1966-1975 |
| 2447 | Kirkland Creek, SE 1/4 Sec. 7, T12N, R4W | 109 | 1973-1975 |
| 2652 | Date Creek, NW 1/4 SE 1/4 Sec. 13, T10N, R9W | 310 | 1939-1944 |

Source: Water Development Corp., 1977a.




**Source:** Mineral and Water Resources of Arizona, undated.

**Figure 2.6-2.** AVERAGE ANNUAL UNIT RUNOFF

Precipitation within the Bill Williams River Basin is strongly influenced by elevation and ranges from up to about 20 inches per year in the higher mountains to the north and east to less than 10 inches per year in the desert regions to the south. Mean annual precipitation data for selected weather stations in the vicinity of the basin are provided in Table 2.6-3. The data from Prescott, Cottonwood, and Seligman are indicative of the precipitation in the higher portions of the basin, while the records for Parker are typical of the precipitation in the low desert regions of the basin. Throughout the basin, precipitation normally occurs in the late summer and early fall in conjunction with thunderstorm activity and during the winter in the form of snow at higher elevations.

Evaporation rates in the basin are also influenced by elevation. The average annual lake evaporation rate is approximately 50 inches at higher elevations, while it reaches 80 inches in the lower desert regions (Arizona State Water Plan, 1975).

As could be expected from these climatic conditions, perennial or near-perennial streams within the Bill Williams River Basin are only found in the mountains to the north and the east. Examples of such streams are Cottonwood Wash No. 1 and the upper reaches of Kirkland Creek (Figure 2.6-1).

Table 2.6-3. CLIMATE OF SELECTED ARIZONA WEATHER STATIONS

| Station | County | Elevation (feet) | Mean Annual Temperature Max (°F) | Mean Annual Temperature Min (°F) | Mean Annual Precipitation (inches) |
|---|---|---|---|---|---|
| Cottonwood | Yavapai | 3320 | 77.6 | 48.4 | 11.12 |
| Prescott | Yavapai | 5389 | 69.4 | 35.4 | 18.47 |
| Seligman | Yavapai | 5219 | 71.0 | 35.2 | 11.07 |
| Parker | Yuma | 425 | 88.1 | 51.8 | 5.04 |

Source: Arizona State Water Plan, 1975.

The large rivers in the basin -- the Santa Maria, Big Sandy, and Bill Williams rivers -- are located in the hot, dry southern portion of the basin. All of them are intermittent.

Smaller washes in the southern portion of the basin, such as lower Date Creek, Bullard Wash, Centennial Wash, and Castenada Wash are dry during most of the year except after rain storms. Flash floods occur in these washes, during which the runoff is highly erosive. Deposition from flash floods has assisted in creating the broad alluvial channels common to the Santa Maria, Big Sandy, and Bill Williams rivers.

An example of the seasonal distribution of average monthly flow for two of the rivers in the basin, the Bill Williams and the Big Sandy, are given in Figure 2.6-3. As can be seen in this figure and in Table 2.6-4, the maximum monthly discharge for the streams in the basin

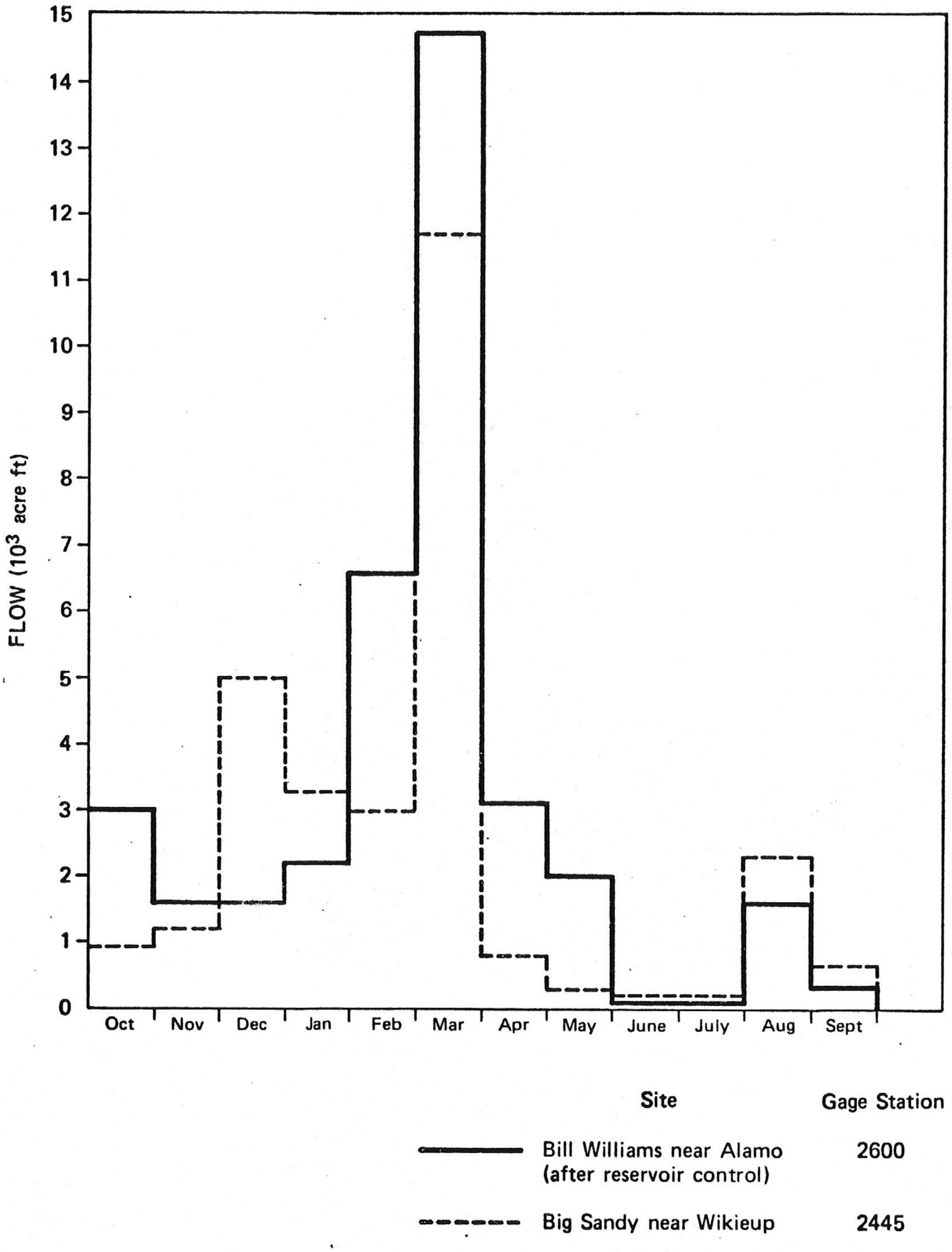



Figure 2.6-3. SEASONAL DISTRIBUTION OF AVERAGE MONTHLY FLOW

Table 2.6-4. FLOW AND DISCHARGE DATA FOR GAGING STATIONS IN BILL WILLIAMS RIVER BASIN

| | | | | Annual Flow | | | Monthly Flow | | Daily Flow | | | | Zero Flow | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location[a] | Gaging Station | Period of Record | Drainage Area (sq mi) | Average Annual Flow (acre-ft) | Maximum Annual Flow (acre-ft) | Water Year of Maximum Annual Flow | Maximum Monthly Discharge (cfs) | Date of Maximum Monthly Discharge | Average Daily Discharge (cfs) | Peak Instantaneous Discharge (cfs) | Water Year or Date of Peak Instantaneous Discharge | Recurrence Interval for Peak Instantaneous Discharge (years) | Average Number of Days of Zero Flow in One Water Year | Maximum Number of Days of Zero Flow[b] | Beginning of Maximum Zero Flow Period[c] |
| Bill Williams River near Planet | 2660 | 1913-15, 1928-46 | 5,140 | 106,800 | 436,800 | 1940-41 | 269,000 | Feb. 1932 | 142 | 92,500 | 1936-37 | | 0 | 0 | — |
| Bill Williams River near Alamo (before Alamo Res.) | 2600 | 1939-68 | 4,730 | 66,760 | 527,600 | 1940-41 | 201,500 | Mar. 1941 | 90 | 65,100[d] | 8/29/51 | 20 | 0 | 0 | — |
| Bill Williams River near Alamo (after Alamo Res.) | 2600 | 1968-75 | 4,730 | 30,909 | 162,500 | 1972-73 | 75,620 | Mar. 1973 | 49.4 | 4,950 | 1968-69 | | 76 | 163 | 1974-75 |
| Big Sandy River | 2445 | 1966-75 | 2,800 | 30,127 | 115,600 | 1972-73 | 73,380 | Mar. 1973 | 37.7 | 28,000 | 12/7/66 | | 19 | 163 | 1974-75 |
| Cottonwood Wash No. 1 (tributary to Big Sandy River) | 2420 | 1964-75 | 143 | 2,746 | 4,860 | 1965-66 | 2,340 | Dec. 1965 | 3.83 | 7,000 | 1963-64 | | <1 | 10 | 1963-64 |
| Santa Maria River near Alamo Res. | 2550 | 1939-66 | 1,520 | 22,282 | 197,800 | 1940-41 | 76,400 | Mar. 1941 | 36.1 | 33,600 | 8/29/51 | 30 | 0 | 0 | — |
| Santa Maria River | 2490 | 1966-75 | 1,210 | 29,816 | 150,400 | 1972-73 | 63,620 | Mar. 1973 | 37.3 | 13,500 | 12/7/66 | 10 | 282 | 409 | 6/20/73 |
| Kirkland Creek (tributary to Santa Maria River) | 2447 | 1973-75 | 109 | 1,190 | 1,990 | 1973-74 | 253 | Aug. 1973 | 2.76 | 785 | 1972-73 | | 4 | 11 | 1972-73 |
| Date Creek (tributary to Santa Maria River) | - | 1939-44 | 127 | 1,690 | 7,700 | 1940-41 | 3,860 | Mar. 1941 | 2.69 | 1,400 | 1940-41 | | 357 | 365 | 1939-40 |

Source: Water Development Corp., 1977a.

[a]Locations of gaging stations are described in Table 2.6-2 and are shown in Figure 2.6-1.

[b]Or maximum number of days of zero flow in a water year.

[c]Or water year containing maximum zero flow period.

[d]Peak instantaneous discharge (computed by USGS from high water marks) of 86,000 cfs occurred September 6, 1939.

normally occurs in February or March. This discharge is in response to increased runoff resulting from snowmelt. The other major period of flow in these streams occurs in the late summer and early fall in response to precipitation and runoff from thunderstorms.

The average annual flows in the Santa Maria and Big Sandy rivers are comparable even though the Big Sandy has a much larger watershed. This is probably due to higher overall precipitation in the Santa Maria River watershed, since a larger percentage of this watershed is located in mountainous terrain. Table 2.6-5 provides peak discharges for the Santa Maria, Big Sandy, and Bill Williams rivers for selected recurrence intervals.

Infiltration also plays an important role in the surface hydrology of the basin. Long reaches of the Santa Maria, Big Sandy, and Bill Williams rivers, and of the principal washes in the basin, are composed of coarse alluvium. The high permeability of this material, coupled with groundwater levels well below the depth of the stream channel, can drastically reduce surface flows. Substantial groundwater flow, in the form of underflow, also occurs in these channels where the alluvium is underlain by impervious material such as bedrock. Consequently, surface flow in the major streams of the basin may be highly influenced by surface-subsurface water exchange that is regulated by the nature of the underlying sediments and the degree of saturation of these sediments.

Underflow has been identified as the possible cause of what appears to be contradictory flow data for the Santa Maria and Bill Williams

Table 2.6-5. PEAK DISCHARGES FOR SELECTED RIVERS IN THE BILL WILLIAMS RIVER BASIN

| Recurrence Interval (years) | Santa Maria near Bagdad, Gage 2490 (cfs) | Santa Maria near Alamo, Gage 2550 (cfs) | Bill Williams* near Alamo, Gage 2600 (cfs) |
|---|---|---|---|
| 5 | 8,000 | 9,800 | 24,200 |
| 10 | 13,800 | 16,900 | 41,800 |
| 20 | 22,400 | 27,400 | 68,000 |
| 50 | 33,500 | 41,100 | 102,000 |
| 100 | 41,500 (extrapolated) | 50,900 | 126,000 |

Source: Patterson and Somers, 1966.

*Before construction of Alamo Reservoir and Dam, which now controls flow at Alamo gaging station.

rivers (Water Development Corp., 1977a). The Santa Maria River flows perennially at gaging station 2550 and is quite often dry several miles upstream at station 2490. Apparently, the underlying impermeable layer rises near the downstream station and brings streambed underflow to the surface. The surface flow of the Bill Williams River at Planet is approximately 50 to 90 percent of the upstream flow near Alamo Dam during floods; however, during low-flow periods surface flow at Planet is two to four times greater than that at Alamo Dam. Groundwater recharge during high-flow periods and seepage into the streams during low-flow periods are assumed to be the causes for this phenomenon.

A prominent hydrologic feature within the Bill Williams River Basin is the Alamo Dam and Reservoir, constructed by the U.S. Army Corps of Engineers in the mid-1960s (Figure 2.6-1). The dam was constructed to control flooding in the basin. Both the Big Sandy and Santa Maria rivers flow into the reservoir. The Bill Williams River is fed by the release or overflow from this reservoir.

The Alamo Reservoir contains a recreational pool of 10,000 acre-feet of water with a surface area of 556 acres. A maximum of 1,040,000 acre-feet of water can be stored in the reservoir below the spillway. Annual evaporation loss from the recreational pool is approximately 3290 acre-feet, or about 10 percent of the average annual flow of the Bill Williams River downstream of the dam. Prior to construction of Alamo Dam, the Bill Williams River was a perennial stream. Since the dam was built, the river has had an average of 76 zero flow days a year (Table 2.6-4). The average annual flow in the Bill Williams River at Alamo was 66,760 acre-feet for the period of record prior to construction of the dam and 30,909 acre-feet for the period of record following completion of the dam. This difference in flow is much larger than the evaporation loss and rate of change in storage and must also be attributed to seepage losses and/or differences in precipitation amounts between the two periods.

## Water Rights

The Santa Maria River surface water rights are fully appropriated (Table 2.6-6). Approximately 650 acre-feet per year is appropriated in the vicinity of Palmerita Ranch. Most of this water is used for crop irrigation. An additional 272 acre-feet per year is appropriated from Grapevine Springs for irrigation purposes. Below the Alamo Reservoir, Sevier Mineral annually appropriates 729 acre-feet of water from the Santa Maria River. A total of 724 acre-feet is used for mining. The remaining 5 acre-feet is used for domestic purposes.

## Local Surface Water Hydrology

Surface water hydrology studies were conducted on the Anderson property in 1977. One stage gage was established on the Santa Maria River, and gages were established on seven tributaries of the Santa Maria that drain the property (Figure 2.6-5). The cross sections of the channels were measured and notes were taken on channel geometry. Rainfall was monitored at each gaging station, with a single precipitation

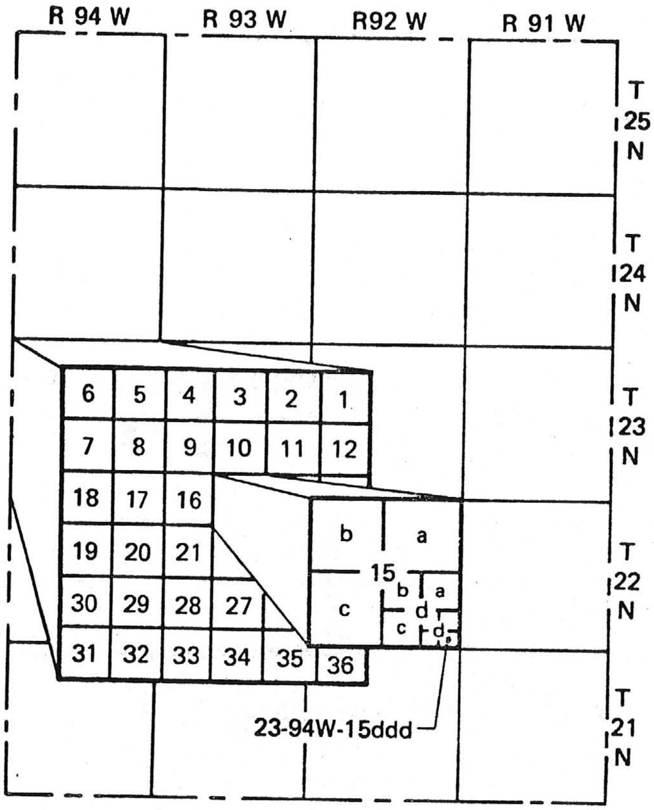
Table 2.6-6. SURFACE WATER RIGHTS NEAR THE ANDERSON PROPERTY

| Source | Application No. | Permit No. | Certificate No. | Priority Date | Owner | Diversion Point* | Quantity of Water** (acre-feet/year) | |
|---|---|---|---|---|---|---|---|---|
| Santa Maria River | 3124 | 2183 | 2086 | 04/17/51 | Fuller | 11-11W-16 ac | Irr.<br>Stock<br>Dom. | 85<br>1.1<br>0.9 |
| Santa Maria River | 3123 | 2182 | 2067 | 04/17/51 | Fuller | 11-11W-16 cb | Irr.<br>Stock<br>Dom. | 380<br>1.7<br>0.9 |
| Santa Maria River | 1042 | 712 | 410 | 11/22/29 | Whitaker | 11-12W-15 aa | Irr. | 181 |
| Total Santa Maria River | | | | | | | | 650.6 |
| Grapevine Springs | 255 | 214 | 166 | 12/16/21 | Madril | 11-11W-22 ab | Irr. | 127 |
| Grapevine Springs | 256 | 215 | 166 | 12/16/21 | Madril | 11-11W-22 ab | Irr. | 54 |
| Grapevine Springs | 257 | 216 | 166 | 12/16/21 | Madril | 11-11W-22 ab | Irr. | 91 |
| Total Grapevine Springs | | | | | | | | 272.0 |
| Spring | 4806 | -- | -- | 02/28/65 | Van Keuren | 11-9W-4 ab | Stock | 0.5 |
| Pass | 508 | -- | -- | 10/07/24 | Howard Sheep Co. | 11-9W-22 d | Stock | 5 |
| Wash | 258 | -- | -- | 02/02/27 | Howard Sheep Co. | 11-9W-31 cc | Stock | 45 |
| Spring | 4683 | -- | -- | 09/23/63 | Carson | 12-9W-6 cc | Stock | 0.5 |
| Spring | 4681 | -- | -- | 09/23/63 | Van Keuren | 12-10W-3 ab | Stock | 0.5 |
| Wash | 2409 | -- | -- | 12/28/65 | Van Keuren | 12-10W-8 dd | Stock | 127.75 |
| Spring | 4682 | -- | -- | 09/26/63 | Van Keuren | 12-10W-20 cb | Stock | 146 |
| Ravine | 1373 | -- | -- | 01/15/57 | Knight | 10-8W-32 bb | Stock | 1.1 |
| Wash | 1372 | -- | -- | 01/15/57 | Knight | 10-8W-32 dd | Stock | 1.1 |

Source: Water Development Corp., 1977b and Minerals Exploration Company, 1977.

*Refer to Figure 2.6-4 for explanation of location numbering system.

**Irr. = irrigation; Dom. = domestic.




EXPLANATION: Well and test hole numbers in this report describe the location of wells and test holes according to the Bureau of Land Management's system of land subdivision as follows: first number, township; second number, range; third number, section; first letter, 160-acre tract (quarter section) within that section; second letter, 40-acre tract (quarter-quarter section) within that quarter section; third letter, 10-acre tract (quarter-quarter-quarter section) within that quarter-quarter section. The 160-acre, 40-acre, and 10-acre tracts are designated a, b, c, and d in a counterclockwise direction beginning in the northeast corner. For example, well 23-94W-15ddd is in the SE¼SE¼SE¼ Sec. 15, T23N, R94N. When two or more wells are located in the same 10-acre tract, the wells are numbered serially in the order they were inventoried.

Figure 2.6-4. LOCATION NUMBERING SYSTEM

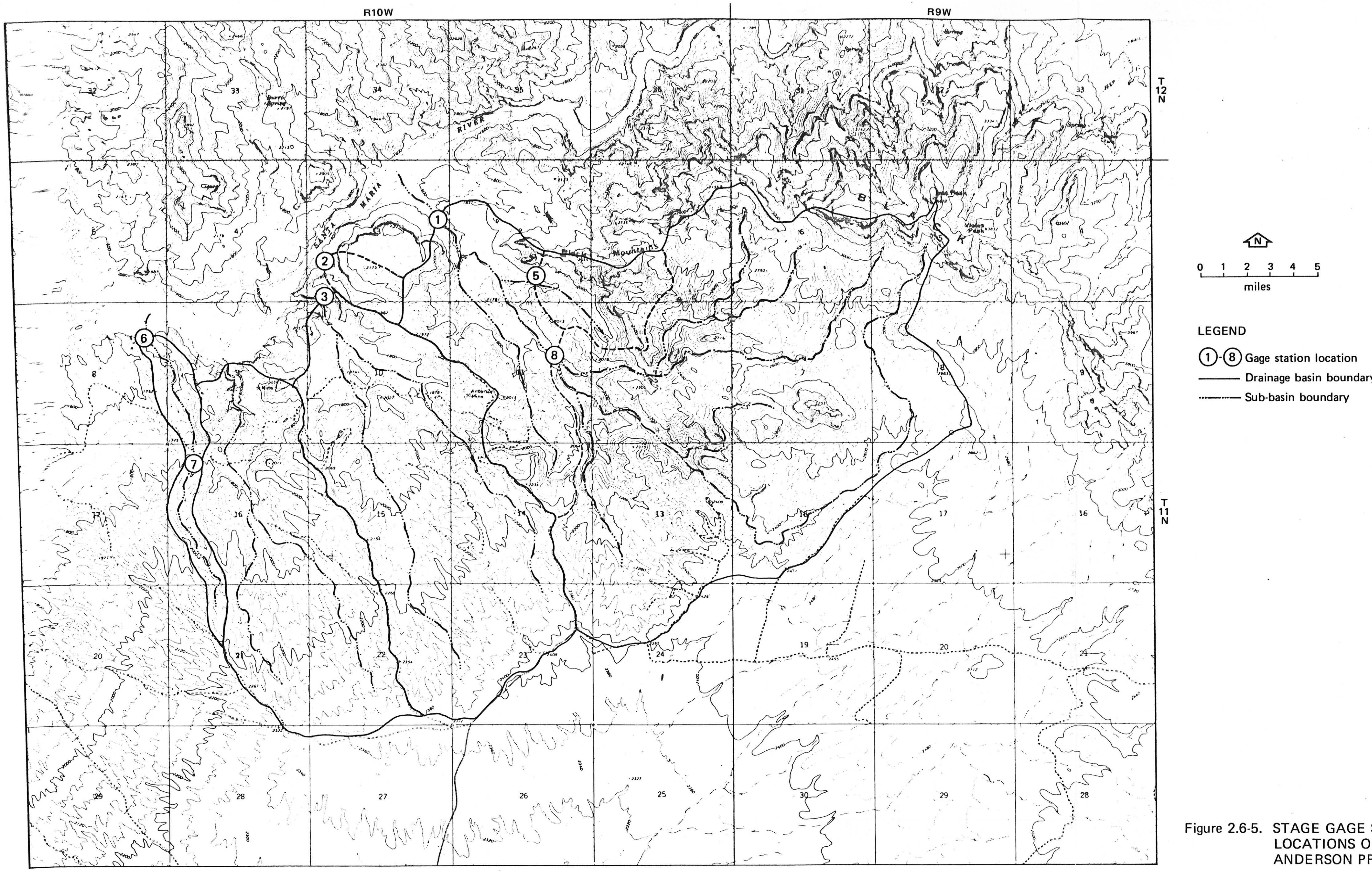



Figure 2.6-5. STAGE GAGE STATION LOCATIONS ON THE ANDERSON PROPERTY

event (0.51 inches in two hours) that resulted in runoff occurring on August 15. Pertinent hydrologic data for each of the eight tributaries is presented in Table 2.6-7.

The drainages studied during this hydrology program can be divided into the following categories: flat, wide alluvial washes; narrow alluvial washes; and rocky, steep canyons. Alluvial washes (stream stations 1, 3, 4, 6, and 8) are the most common type of drainage channel on the property. The washes normally consist of sand and gravel and are bounded by rocky canyon walls. Sparse vegetation frequently grows in the washes at lower elevations. The channel bottom slopes of these washes generally range from very gradual to moderate. Stream stations 5 and 7 were located in narrow, rocky canyons with moderate channel slopes. While both of these canyons consisted largely of gravel and small boulders, station 7 was established in an area of fine sand. Stream station 2 was located in a steep, narrow canyon. The streambed consists of solid rock and contains numerous large boulders. The channel of this canyon meanders to a considerable extent.

Surface flow seldom occurs in the drainages on the Anderson property except for flash floods immediately following thunderstorms. The dry soil of the washes and canyons tends to seal when wet, inhibiting infiltration and resulting in relatively high runoff. This runoff is normally quite erosive, particularly in the steeper, narrower canyons. Using the U.S. Soil Conservation Service method for estimating

Table 2.6-7. HYDROLOGIC DATA FOR SUBBASINS IN THE VICINITY OF THE ANDERSON PROPERTY

| Stream Station | Drainage Area (sq mi) | Drainage Length (mi) | Lag Time (hr) |
|---|---|---|---|
| 1 | 8.0 | 7.9 | 2.1 |
| 2 | 0.17 | 0.66 | 0.28 |
| 3 | 3.4 | 3.7 | 1.1 |
| 5 | 0.50 | 0.70 | 0.30 |
| 6 | 0.41 | 1.3 | 0.48 |
| 7 | 0.20 | 2.4 | 0.79 |
| 8 | 6.0 | 6.4 | 1.7 |

Source: Water Development Corp., 1977a.

Note: The average watershed slope for all subbasins has been assumed to equal 10 percent, as given in Water Development Corp. (1977) for the subbasin contributing to flow at stream station 1. The vegetation cover type for the subbasins is desert shrub and cover density is approximately 40 percent. Soils in all the subbasins are classified in group C. The cover number used for the watersheds is 79.

runoff (Water Development Corp. 1977a), the drainages on the property have a potential maximum water retention (infiltration, interception, and surface storage) of only about 2.7 inches. The lag time between the centroid of rainfall and peak runoff for these drainages ranges from 0.28 to 2.1 hours.

During the single runoff event recorded during the hydrology program, the high-water mark at gaging stations 1, 2, 3, 5, 6, and 8 ranged from 3 to 6 inches (Table 2.6-8). Station 7 in the steep canyon was washed out. No runoff was recorded in the Santa Maria River (station 4), as the water created its own channel at a distance from the stage gage within the broader wash.

Peak discharge was estimated for each tributary over selected recurrence intervals and for the probable maximum precipitation (PMP) event (Table 2.6-9) using the runoff and triangular hydrograph method of the U.S. Soil Conservation Service (1972). Peak discharge was not estimated for the Santa Maria River because of unknown but apparently significant effects of infiltration and underflow. The largest discharges are expected to occur at stations 1, 3, and 8. Peak discharge for these stages ranges from approximately 250 cfs for the 5-year recurrence interval (Station 3) to over 12,000 cfs during the PMP event (Station 1). Peak discharges at stations 2, 6, and 7 are expected to be minimal because of their small drainage areas.

Peak stages for each of the Santa Maria tributaries were estimated (Table 2.6-9) using Manning's Equation and the channel cross sections

Table 2.6-8. CHANNEL GEOMETRY OF STREAM STATIONS

| Stream Station | Stream Location | Approx. Elevation (ft, msl) | Channel Geometry | Channel Bottom Slope (%) | Streambed Material(s) | Manning's Roughness Factor $(ft^{1/6})$ | Field Observations of Runoff Event |
|---|---|---|---|---|---|---|---|
| 1 | 11-10W-3add | 1598 | Flat, wide, alluvial wash | 2.2 | Sand, gravel | 0.025 | 3-inch water mark |
| 2 | 11-10W-3cbd | 1580 | Steep, rocky, narrow canyon terminating into free overfall | 34.0 | Rock, large boulders | 0.040 | 5-inch water mark |
| 3 | 11-10W-10bbb | 1544 | Flat, wide, alluvial wash | 3.5 | Sand, fine gravel | 0.025 | 6-inch water mark |
| 4 | 11-10W-9aab | 1710 | Flat, very wide, alluvial wash | 0.5 | Sand, fine gravel | 0.025 | Flow created channel 8 inches deep and 50 feet wide |
| 5 | 11-10W-2dab | 1735 | Moderate slope, narrow rocky canyon | 8.1 | Gravel, small boulders | 0.035 | 6-inch water mark |
| 6 | 11-10W-8ada | 1576 | Flat, narrow wash with wide flood plain containing low vegetation | 2.5 | Sand, gravel | 0.025 | 6-inch water mark |
| 7 | 11-10W16-bba | 1868 | Narrow, highly erodible gully | 2.3 | Sand | 0.020 | Flow created channel 8-12 inches deep and 28 feet wide |
| 8 | 11-10W-11aca | 1826 | Flat, wide alluvial wash containing low vegetation | 2.3 | Sand, gravel | 0.025 | 4-inch water mark |

See Figure 2.6-4 for description of location numbering system.

shown in Figures 2.6-6 through 2.6-8. It was assumed that the energy line slope during the peak stage was approximately 20 percent greater than the channel bottom slope. Although this assumption is arbitrary, it is felt that the peak stage estimates are correct to the order of magnitude. Because of the effects of cross-sectional area and wetted perimeter on flow, peak stage for each channel is not merely proportional to discharge. For example, the peak stage in narrow canyons may be as high as the peak stage in wide alluvial washes for a correspondingly low discharge. The low stage values estimated for station 2 are probably related to the high channel slope, which would create supercritical flow.

## GROUNDWATER HYDROLOGY

As discussed earlier, the Bill Williams River Basin is contained within both the Central Highlands and the Basin and Range provinces, two major physiographic regions in Arizona. In the Basin and Range Province, groundwater generally occurs in unconfined or "water table" aquifers formed in alluvial valleys between mountain blocks. The alluvium, which may be several thousand feet thick, consists of inter-bedded clays, silts, sands, and gravels. Recharge is small and occurs mainly along mountain fronts and the normally dry stream courses. In the Central Highlands province, small valleys between volcanic mountain blocks filled with unconsolidated sediments are the main source of

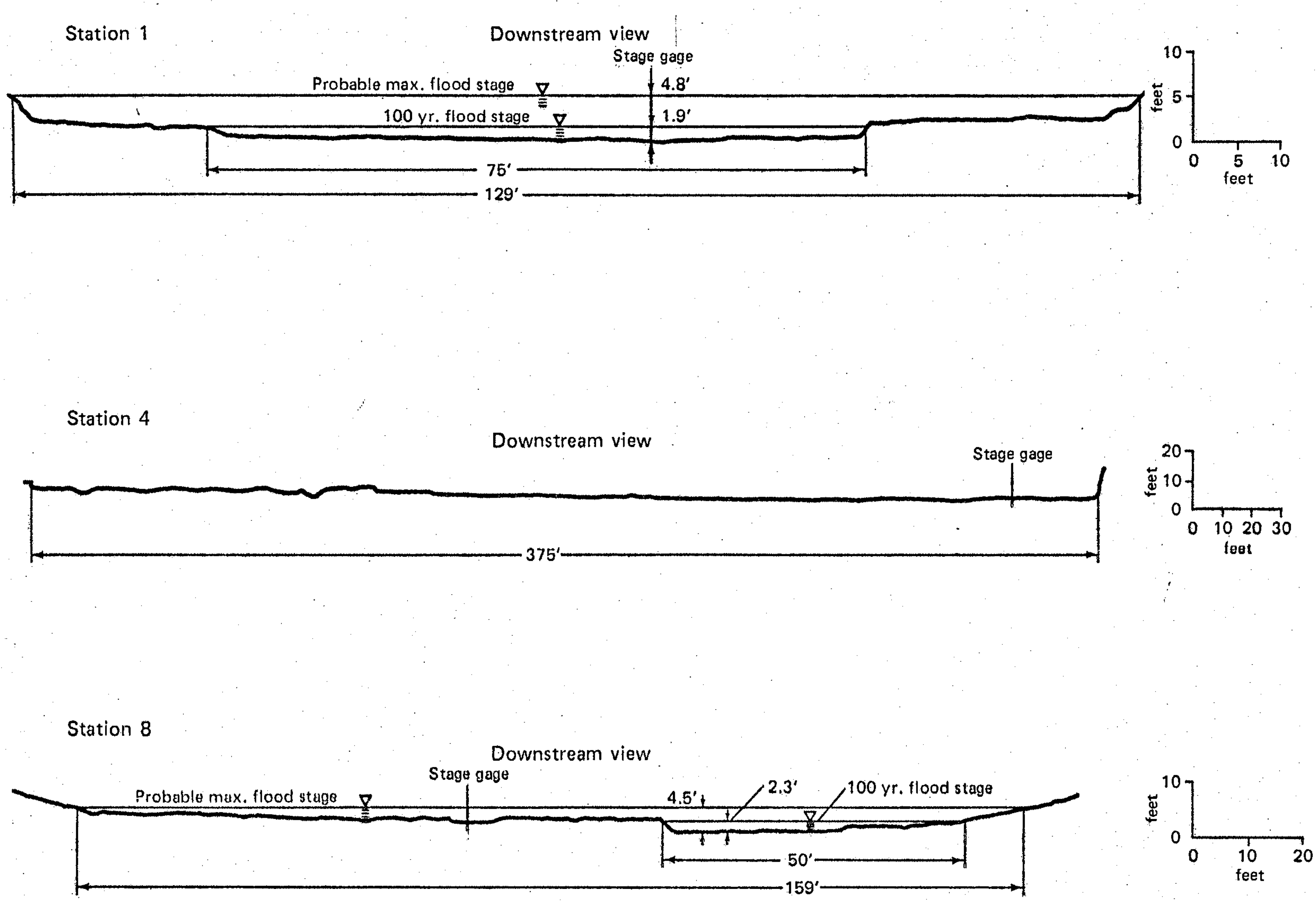



Figure 2.6-6. CHANNEL CROSS SECTIONS AT STATIONS 1, 4, AND 8

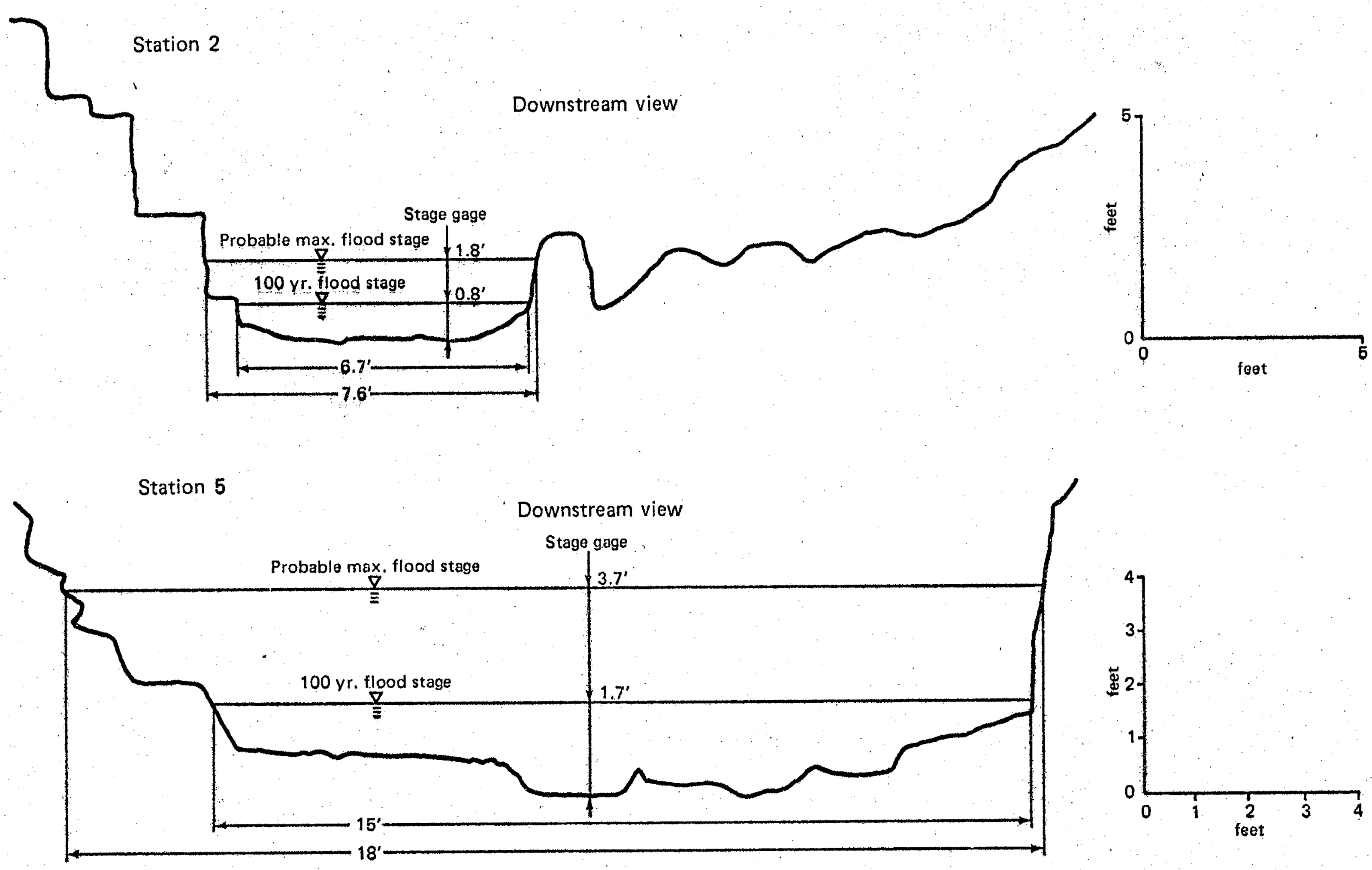



Figure 2.6-7. CHANNEL CROSS SECTIONS AT STATIONS 2 AND 5

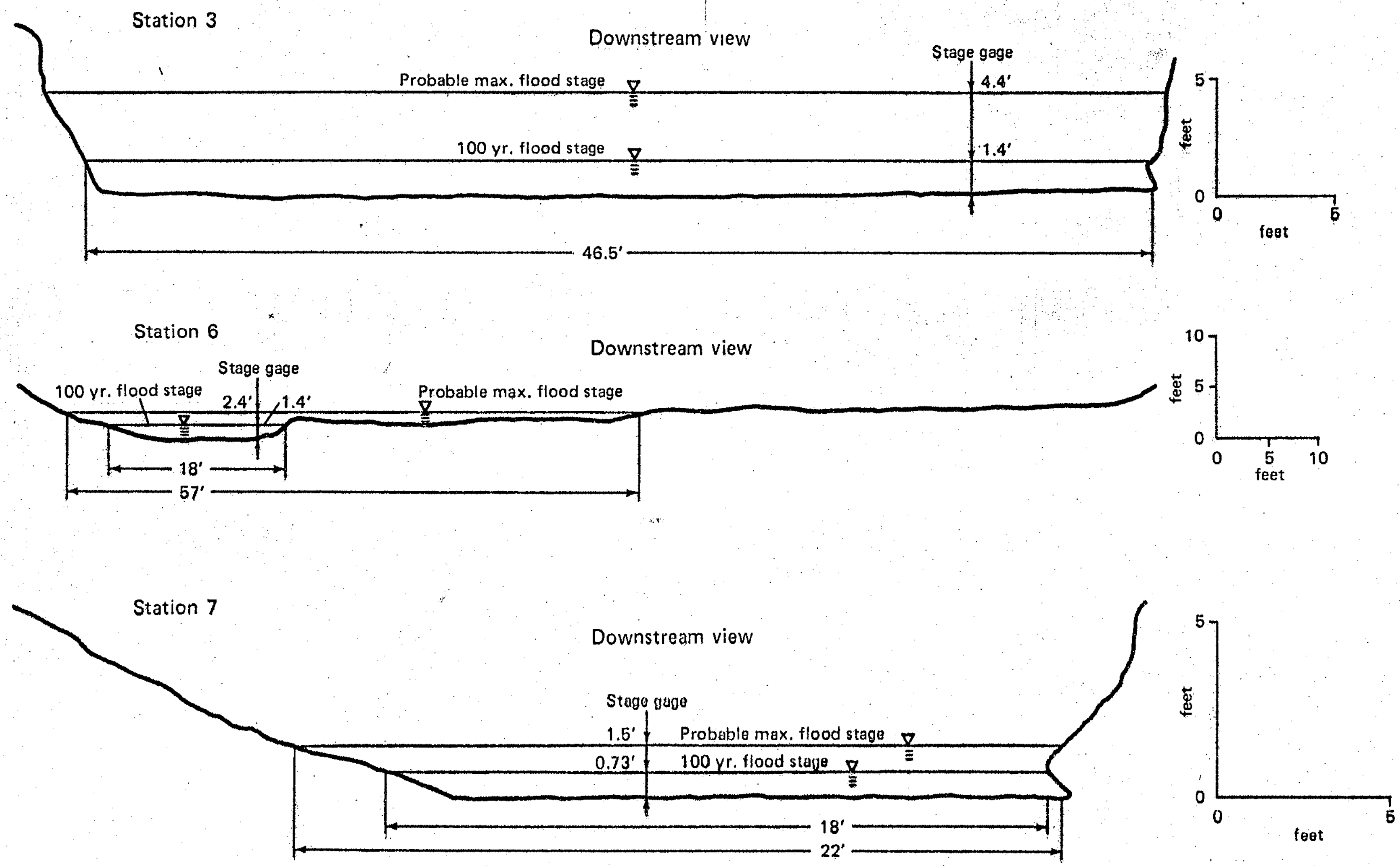



Figure 2.6-8. CHANNEL CROSS SECTIONS AT STATIONS 3, 6, AND 7

groundwater. The mountain blocks offer little potential for the development of groundwater except in places where the rocks are fractured or large solution cavities have formed.

## Regional Groundwater Uses and Rights

Groundwater provides approximately 60 percent of the annual water requirements of Arizona. Most of this water is used for irrigation. Heavy pumpage for irrigation in many of the basins of the state has caused large changes in the flow pattern of groundwater and substantial drops in the water table. The groundwater reservoir in much of the state has been established over geologic time, and replenishment from recharge areas is much less than pumpage. In this context, groundwater may be considered a nonrenewable resource. Currently, withdrawal from developed aquifers annually exceeds recharge by about 2.2 million acre-feet and the average annual decline in water tables is as high as 14 feet per year for selected basins in central Arizona (Water Development Corp., 1977b).

Approximately 23 million acre-feet of groundwater is stored in the Bill Williams River Basin (Ariz Wtr Comm. ~~Water Development Corp.,~~ 1977b). It is estimated that 17 million acre-feet is stored between the water table and 700 feet below the land surface. The remaining 6 million acre-feet lies from 700 to 1200 feet below the land surface. (The depths currently considered practical for irrigation and municipal water withdrawals are 700 and 1200 feet, respectively.) Approximately 5600 acre-feet of this water is used annually for irrigation and 3600 acre-feet per year is used for municipal and industrial purposes. The annual depletion (withdrawal minus recharge) is about 7300 acre-feet.

In Arizona, groundwater rights are associated with land surface ownership. Table 2.6-10 lists the groundwater rights in the vicinity of the Anderson property.

Local Groundwater Hydrology

The following discussion is based primarily on studies conducted by Water Development Corp. (1977b) and Dames & Moore (1977). The purpose of the studies conducted by Water Development Corp. was to determine feasible sources of surface water and/or groundwater in the vicinity of the Anderson property for use in milling operations. The studies included a review of the surface water and groundwater characteristics of the property, compilation of existing well productivity, and test drilling in selected areas. The purpose of the Dames & Moore study was to determine the stability of the ultimate open pit slopes. A large number of drill holes were measured for static water level.

Alluvium. The alluvial valley of the Santa Maria River varies substantially in width and depth to bedrock. For example, the Santa Maria flows in a narrow canyon from 500 to 1000 feet wide north of the Anderson Mine. Between gaging station 2490 and the Alamo Reservoir (Figure 2.6-1), the valley is one-half to one mile wide. In this reach, the depth to bedrock is approximately 60 feet. As mentioned above, the

Table 2.6-10. GROUNDWATER RIGHTS IN THE VICINITY OF THE ANDERSON PROPERTY

| Location* | Well Depth (feet) | Casing Depth (feet) | Case Diameter (inches) | Depth to Water (feet) | Yield (gpm) | Drawdown (feet) | Owner |
|---|---|---|---|---|---|---|---|
| 10-8W-3 dc | 180 | 180 | 8 | 110 | 6 | 30 | Bar D Four Ranch |
| 10-8W-5 dab | 265 | — | 12 | 120 | — | — | USGS |
| 10-8W-5 bbb | 216 | — | 12 | 120 | — | — | USGS |
| 10-8W-5 bbb | 130 | — | 6 | 120 | — | — | USGS |
| 10-8W-5 abd | — | — | 12 | 136 | — | — | USGS |
| 10-8W-12 ddb | 10 | 10 | 22 | 1 | 600 | 1 | Evans |
| 10-8W-12 aad | 75 | Incomplete, File Date 11/76 | | | | | Matthews |
| 10-8W-13 dca | 24 | — | — | 12 | — | 1 | Anderson |
| 10-8W-14 aaa | 40 | 40 | 10 | 28 | 400 | — | Evans |
| 10-8W-14 abd | 180 | Incomplete, File Date 12/76 | | | | | Torzec |
| 10-8W-14 adb | 200 | Incomplete, File Date 12/76 | | | | | Torzec |
| 10-8W-24 aad | 360 | 30 | 5 | 82 | 3 | 0 | Knight |
| 11-8W-21 bcb | 175 | 175 | 7 | 100 | — | — | James |
| 12-8W-3 ccc | 120 | 120 | 7 | 82 | — | — | James |
| 12-8W-27 bbb | 100 | 100 | 6 | 28 | — | — | James |
| 12-9W-24 dab | 50 | 50 | 8 | — | 5 | — | Curtis |
| 11-10W-11 ccc | 200 | 200 | 5 | 50 | 125 | — | Minerals Exploration Company |
| 11-10W-24 aca | 100 | 22 | 7 | 10 | — | — | Weaver |
| 12-10W-1 bbb | 100 | — | — | — | 6 | 5 | Curtis |
| 12-10W-12 ddc | 50 | 50 | 8 | 25 | 5 | — | Curtis |
| 11-11W-16 abc | 61 | — | — | — | — | — | — |
| 11-11W-16 dd | 64 | 64 | 20 | 19 | 800 | 12 | Three Rivers Ranch |
| 11-11W-17 dda | 60 | 60 | 20 | 10 | 1800 | 30 | Fuller |
| 11-11W-31 abb | 1769 | 520 | 16 | — | — | — | — |
| 11-11W-31 bbb | 888 | 268 | 16 | 60 | 470 | — | Fuller |
| 11-11W-31 bbb | 400 | 400 | 8 | 64 | 10 | 0 | Fuller |

Source: Minerals Exploration Company, 1977

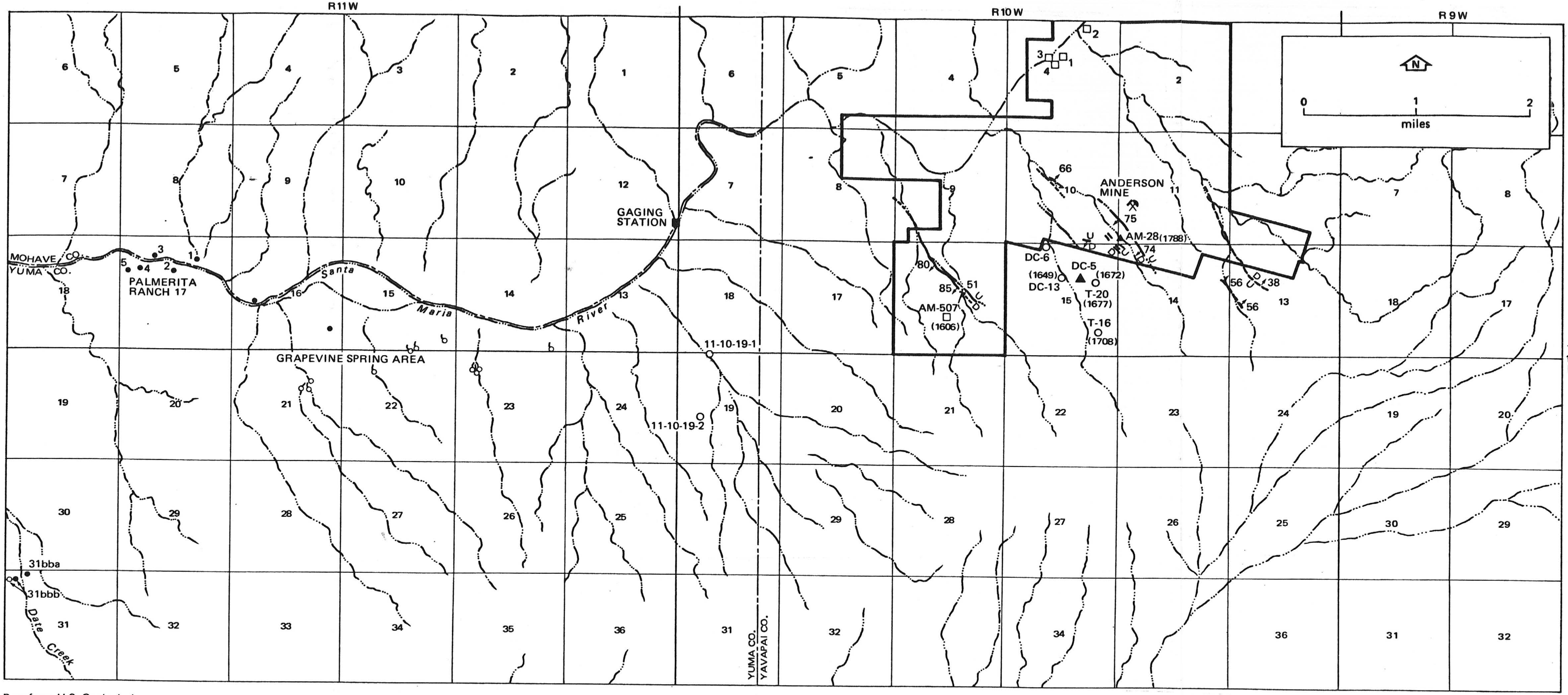
*Refer to Figure 2.6-4 for explanation of location numbering system.

volume of alluvium, and particularly the depth of the material, influences the proportion of surface flow to underflow in the river valley.

Seven irrigation wells are located in the recent alluvium of the Santa Maria River near the Palmerita Ranch (Figure 2.6-9). These wells range in depth from 60 to 196 feet, with a maximum discharge of 2700 gallons per minute (gpm) (Table 2.6-11). The depth to the static water level in these wells generally decreases downstream. This is consistent with the concept that the groundwater in the alluvium consists of underflow that is forced toward the surface as the depth of the alluvium decreases.

As part of a water supply investigation, four hydrologic exploration holes were drilled by Water Development Corp. in the alluvium of the Santa Maria River in Section 3, T11N, R10W (Figure 2.6-9). Well depths ranged from 27 to 61 feet (Table 2.6-12). Well 1 was airlifted for three hours, creating a discharge of about 100 gpm and a drawdown of approximately 7 feet. It would appear that the alluvium in this area, though porous and permeable, is not sufficiently deep (and perhaps not wide enough) to provide substantial groundwater storage.

A 24-hour pump test on well 2 in the alluvium near the Palmerita Ranch was conducted by Water Development Corp. in 1977. During this test the average flow rate was 21.8 gpm. Formation constants (transmissivity and storage coefficients) were estimated on the basis of the rate of drawdown at the pumped well and the surrounding observation




Base from U.S. Geological survey maps.
Source: Water Development Corp., 1977.

LEGEND

- ● Irrigation well
- ○ Stock well
- ▲ Drilling water supply well
- Spring
- Intermittent stream
- □ Hydrologic exploration hole
- Fault showing dip (dashed where approximate)
- Anderson property boundary

Figure 2.6-9. PRINCIPAL WELLS IN THE VICINITY OF THE THE ANDERSON PROPERTY ble 2.6-11. WELL RECORD DATA FOR ALLUVIAL WELLS NEAR PALMERITA RANCH

| 11 Ident. No. | Well Location* | Date Drilled | Owner | Use | Depth (feet) | Casing Diameter (inches) | Depth to Static Water Level | | Discharge (gpm) | Drawdown (feet) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Feet | Date | | |
| | 11-11W- | | | | | | | | | |
| | 16cba** | Jul. 1951 | Fuller | Irrigation | 61 | - | - | - | - | - |
| | 16dd** | Jun. 1951 | Fuller | Irrigation | 64 | 20 | 19 | - | 800 | 12 |
| 1 | 17acaa | Sep. 1963 | Fuller | Irrigation | 60 | 20 | 17.08 | 11/6/77 | 1800 | 30 |
| 2 | 17bdaa | - | Fuller | Irrigation | 150 | 20 | 14.70 | 11/6/77 | 2198 | 17.49 |
| 3 | 17bcaa | - | Fuller | Irrigation | - | 20 | 14.82 | 11/6/77 | - | - |
| 4 | 17bcba | - | Fuller | Irrigation | 196 | 18 | 10.51 | 11/6/77 | - | - |
| 5 | 17bcbc | Sep. 1973 | Fuller | Irrigation | 188 | 18 | 12.33 | 11/6/77 | - | - |
| | 11-12W- | | | | | | | | | |
| | 10dda | Aug. 1961 | Fuller | Irrigation | 143 | 16 | 10 | Aug. 1961 | 2700 | 20 |
| | 14dac | Aug. 1961 | Fuller | Irrigation | 239 | 16 | 33 | 1961 | 2200 | 51 |
| | 14ddd | Aug. 1961 | Fuller | Irrigation | 239 | 16 | - | - | 2200 | 50 |

ource: Water Development Corp., 1977b. Data from Arizona State Land Department and U.S. Geological Survey.

*Refer to Figure 2.6-4 for location numbering system.

*No longer operable.

ble 2.6-12. HYDROLOGIC EXPLORATION HOLES IN THE ALLUVIUM OF THE SANTA MARIA RIVER NORTH OF THE ANDERSON MINE

| Well Number | Well Location* | Depth (feet) | Casing Diameter (inches) | Casing Type | Depth to Static Water Level (feet) | Approx. Elevation of Ground Surface Above msl (feet) | Approx. Elevation of Static Water Level Above msl (feet) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | 11-10W-3bca | 57 | 6 | Pre-perforated | 23.6 | 1600 | 1576 | Airlifted for 3 hr @ 100 gpm, created drawdown of 7 ft |
| 2 | 11-10W-3aba | 27 | 5 | Pre-perforated | 19 | 1520 | 1501 | Encountered bedrock @ 27 ft |
| 3 | 11-10W-3bcb | 30 | - | - | - | 1500 | - | Drilling discontinued @ 30 ft |
| 4 | 11-10W-3bcc | 61 | 5 | Pre-perforated | - | 1600 | - | Considered to hit bedrock |

ource: Water Development Corp., 1977b.

Refer to Figure 2.6-4 for location numbering system.

wells (wells 1, 3, 4, and 5). For the pumped well, the transmissivity was determined to be approximately $2.5 \times 10^6$ gallons per day per foot (gpd/ft). Transmissivity was estimated to be from $1 \times 10^6$ to $1.5 \times 10^6$ gpd/ft in wells 1 and 3. These higher values may be related to the partial penetration of well 1 and the effects of an irrigation channel near well 3. Infiltration from nearby irrigation channels caused a rise in the groundwater level in well 5 and also biased the data for well 4. The short-term storage coefficient ranged from 0.06 to 0.08 for well 1 and was approximately 0.02 for well 3. The long-term storage coefficient for the alluvial aquifer is thought to be in the range of 0.2 (Water Development Corp., 1977b).

Lower Sandstone Conglomerate. Table 2.6-13 provides information on wells in the vicinity of the Anderson property that are located in the lower sandstone conglomerate unit. (The upper capping conglomerate is essentially above the water table.) The only existing wells tapping this unit that are located on the property are AM-28 and AM-507. AM-28 was originally drilled to 535 feet for mineral exploration and was later converted to a water supply well. This well has been cased to 200 feet (blank casing down to 60 feet). Well AM-28, located between two major northwesterly trending features (Figure 2.6-9), has a static water level elevation of 1788 feet, the highest elevation of any well in the vicinity of the property. Well AM-507 was drilled for hydrologic information and is located about 1500 feet southwest of one of the able 2.6-13. WELLS IN THE LOWER SANDSTONE CONGLOMERATE UNIT IN THE ANDERSON PROPERTY AREA

| Well dent. No. | Well Location* | Owner | Use | Well Depth (feet) | Blank Casing Diameter** (inches) | Depth to Static Water Level (feet) | Approx. Elevation of Ground Surface Above msl (feet) | Elevation of Static Water Level Above msl (feet) | Depth Interval of Blank Casing (feet) | Approximate Depth Interval of Lower Sandstone Conglomerate (feet) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M-28 | 11-10W-8ccc | Minerals Exploration | Water supply | 200*** | 5 9/16 | 52.4 | 1840 | 1788 | 0-60 | 0-205 | Pump test April 14, 15, 1977 @ 57 gpm, drawdown of 22.4 ft |
| M-507 | 11-10W-16cad | Minerals Exploration | Hydrologic test | 1495 | 5 | 394 | 2000 | 1606 | 0-450 | 365-1495 | Airlift from 800 ft created flow of 123 gpm |
| C-6 | 11-10W-15bab | Urangesell-schaft | Mineral explor. | 685 | a | | | | | | Encountered no water in overlying conglomerate |
| 1-10-19-1 | 11-10W-19bba | | Mineral explor. | 505 | a | | | | | | Reported to produce abundant water between 400 to 505 ft |
| 1-10-19-2 | 11-10W-19cba | | Mineral explor. | 1640 | a | | | | | 255->1385 | |
| | 10-12W-2bbb | Fuller | Irrig. | 580 | 10-6 | 200 | | | | 200->580 | Discharge 280 gpm, drawdown 50 ft |
| | 10-12W-12aaa | Fuller | Irrig. | 1563 | 18-12 3/4 | 246.7 | | | | 200->1563 | Reported unsatisfactory for irrigation |
| | 11-11W-31bba | Fuller | Irrig. | 1769 | 16-8 | | | | | 200-1500 | |
| | 11-11W-31bbb | Fuller | Irrig. | 888 | 16 | 60 | | | | 200->800 | Discharge 470 gpm, drawdown 270 ft |
| | 11-11W-31bbb | Fuller | Stock | 400 | 8 | 64 | | | | 200->400 | Discharge 10 gpm, drawdown 0 ft |

ource: Water Development Corp., 1977b.

*Refer to Figure 2.6-4 for location numbering system.
*Two values indicate a change in diameter with depth.
*Original depth 535 feet.
[a]No casings for exploration boreholes.

two major structural features on the property (Figure 2.6-9). The hole was air-drilled, and water was encountered at a depth of 485 feet. A static water level of 394 feet was measured after airlifting ceased.

A brief pump test was performed on well AM-28. The average flow rate during this test was 57 gpm. The initial and final water depths in the well were 56.2 and 78.6 feet, respectively, yielding a total drawdown of 22.4 feet and a specific capacity of 2.5 gpm/ft of drawdown. The quantity of this rate of drawdown data did not warrant calculation of formation constants.

<u>Barren Sand.</u> All of the wells in the barren sand unit are located to the south of the Anderson property (Figure 2.6-9). The water supply well (DC-5) for Urangesellschaft U.S.A. is the only well known to be producing from this unit. Perforated casing extends from 750 to 950 feet in this well and a submersible pump is located at 815 feet. The top of the barren sand unit is at approximately 800 feet (Table 2.6-14). A static water level of 328 feet was measured in well DC-5 on December 1, 1976; consequently, it appears that the barren sand unit is confined, with an artesian head in the range of 500 feet.

A 10-hour pump test was conducted on well DC-5 by Water Development Corp. in 1977. The average flow rate during this test was 30.7 gpm.

Table 2.6-14. WELLS IN THE BARREN SAND IN THE ANDERSON MINE AREA

| Well Ident. No. | Well Location* | Owner | Use | Well Depth (feet) | Blank Casing Diameter (inches) | Depth to Static Water Level (feet) | Date of Static Water Level Measurement | Approx. Elevation of Ground Surface above msl (feet) | Approx. Elevation of Static Water Level above msl (feet) | Depth Interval of Blank Casing (feet) | Approximate Depth Interval of Barren Sand (feet) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DC-5 | 11-10W-15aca | Urangesell-schaft | Water supply | 950** | 5 9/16 | 328 | 12/1/76 | 2000 | 1672 | 0-750 | <800->860 | Discharge 25 gpm with pump depth of 815 ft |
| DC-8 | | Urangesell-schaft | Mineral explora. | 1465 | 60 | - | - | - | - | 60-1150 | | No water reported after drilling |
| DC-13 | 11-10W-15acb | Urangesell-schaft | Mineral explora. | 1153 | 3 | 311 | a | 1960 | 1649 | 0-650 | | No water reported after drilling |
| T-16 | 11-10W-15ddb | Urangesell-schaft | Mineral explora. | 1450 | 3 | 452 | a | 2160 | 1708 | 0-1150 | | Little water from 1200 to 1350 ft |
| T-18 | | Urangesell-schaft | Mineral explora. | 1405 | 3 | - | - | - | - | 0-1150 | | Little water from 1200 to 1300 ft |
| T-20 | 11-10W-15adb | Urangesell-schaft | Mineral explora. | 1060 | 3 | 323 | a | 2000 | 1677 | 336-720 | | No water reported after drilling |

Source: Water Development Corp., 1977b.

*Refer to Figure 2.6-4 for location numbering system.
**Original depth 1040 feet.
[a]Measured during Water Development Corp. field program initiated in November 1976.

The initial and final water depths in the well were 337.1 and 359 feet, respectively, yielding a total drawdown of 21.9 feet and a specific capacity of 1.4 gpm/ft of drawdown. The transmissivity determined from the test was approximately 1000 gpd/ft.

Local Groundwater Movement

The elevation of static water levels in the wells penetrating the barren sand and lower conglomerate units are shown in parentheses in Figure 2.6-9. Figure 2.6-10 provides a generalized piezometric surface map of the area based on the water level measurements presented in Table 2.6-15. In spite of the uncertain sources of the water in these bore holes, the data are useful for discussing general trends in groundwater movement. In addition, considerable faulting and fracturing in the vicinity of the Anderson property appears to have resulted in sufficient movement of water between units that it is not appropriate to treat the units as independent.

The water elevations for wells in the Barren Sand unit (Section 15, T11N, R10W) generally decrease to the west and north toward the Santa Maria River. This movement is in opposition to the general dip of the sediments to the south and the east.

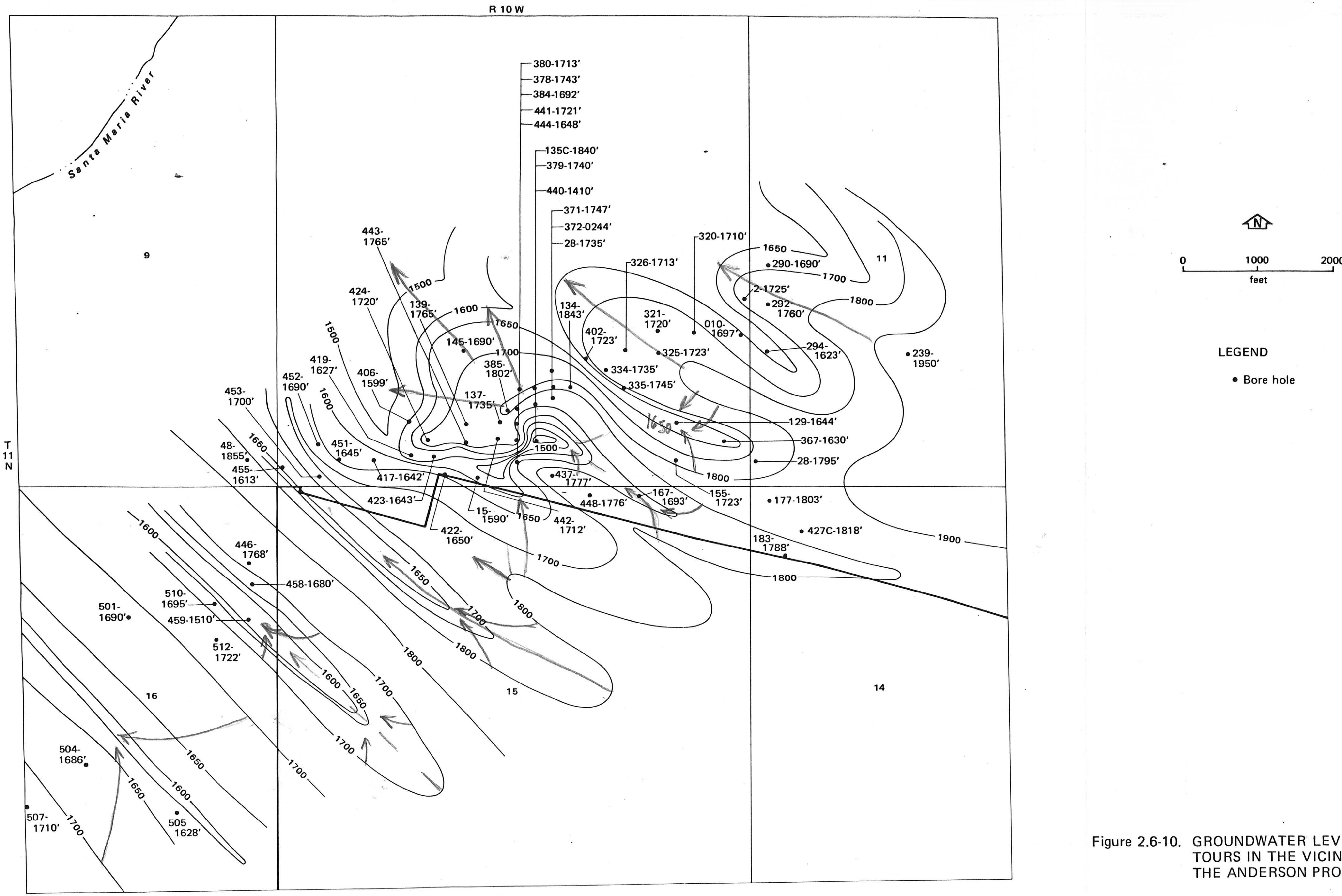



Figure 2.6-10. GROUNDWATER LEVEL CONTOURS IN THE VICINITY OF THE ANDERSON PROPERTY

Table 2.6-15. BORE HOLES IN WHICH STANDING WATER LEVELS WERE MEASURED

| Hole Number | Depth to Water (feet) | Collar Elevation (feet) | Coordinates | Approximate Water Elevation (feet) |
|---|---|---|---|---|
| AM-15 | 245 | 1826 | 1,202,199.0N<br>639,760.0E | 1581 |
| AM-23 | 262<br>250 | 1988 | 1,203,080.0N<br>640,601.0E | 1726<br>1738 |
| AM-134 | 277<br>266 | 2008 | 1,203,201.0N<br>640,800.0E | 1731<br>1742 |
| AM-135 | (+300) dry | 1992 | 1,203,203.0N<br>640,395.0E | -1692 |
| AM-137 | 178 | 1924 | 1,202,815.0N<br>640,005.0E | 1732 |
| AM-140 | (+300) dry | 1921 | 1,202,787,0N<br>640,806.0E | -1621 |
| AM-371 | 266 | 2008 | 1,203,394.5N<br>640,590.0E | 1742 |
| AM-372 | 243<br>245<br>244 | 1996 | 1,203,196.1N<br>640,608.9E | 1753<br>1751<br>1752 |
| AM-374 | (+300) dry | 2019 | 1,203,596.9N<br>640,226.9E | -1719 |
| AM-378 | 212 | 1948 | 1,202,960.4N<br>640,191.0E | 1736 |
| AM-379 | 235 | 1972 | 1,203,019.4N<br>640,400.2E | 1739 |
| AM-380 | 267 | 1983 | 1,203,180.9N<br>640,220.9E | 1716 |
| AM-384 | 238 | 1937 | 1,202,798.4N<br>640,181.3E | 1699 |
| AM-403 | 144 | 1893 | 1,202,977.5N<br>639,480.1E | 1749 |

Table 2.6-15. (continued)

| Hole Number | Depth to Water (feet) | Collar Elevation (feet) | Coordinates | Approximate Water Elevation (feet) |
|---|---|---|---|---|
| AM-405 | 148 | 1906 | 1,202,863.3N<br>639,377.5E | 1758 |
| AM-406 | 321 | 1918 | 1,202,814.6N<br>638,996.1E | 1597 |
| AM-417 | 361 | 1984 | 1,202,388.9N<br>638,606.2E | 1623 |
| AM-419 | 318 | 1940 | 1,202,435.1N<br>639,026.2E | 1622 |
| AM-423 | 256 | 1902 | 1,202,429.4N<br>639,278.5E | 1646 |
| AM-424 | 304 | 1899 | 1,202,609.0N<br>639,206.6E | 1595 |
| AM-422-C | 262 | 1915 | 1,202,200.8N<br>639,410.1E | 1653 |
| AM 427-C | 260 | 2078 | 1,201,595.9N<br>643,387.1E | 1818 |
| AM 155 | 337 | 2068 | 1,202,385.0N<br>641,995.0E | 1713 |
| AM 167 | 312<br>308 | 2004 | 1,201,989.0N<br>641,580.0E | 1698<br>1702 |
| AM 177 | 209 | 2014 | 1,201,940.0N<br>643,033.0E | 1801 |
| AM 213 | (+360) dry | 1953 | 1,201,996.2N<br>645,397.5E | 1593- |
| AM 234 | (+500) dry | 2208 | 1,201,395.6N<br>645,858.5E | 1708- |

Table 2.6-15. (concluded)

| Hole Number | Depth to Water (feet) | Collar Elevation (feet) | Coordinates | Approximate Water Elevation (feet) |
|---|---|---|---|---|
| AM 437 | 123<br>126 | 1894 | 1,202,209.8N<br>640,592.7E | 1771<br>1768 |
| AM 448 | 159 | 1930 | 1,201,992.1N<br>641,025.6E | 1771 |
| AM 354 | (+300) dry | 1997 | 1,202,216.9N<br>641,577.5E | 1677 |
| AM 444-C | 217 | 1902 | 1,202,355.0N<br>639,974.7E | 1685 |
| AM 442 | 151 | 1891 | 1,202,627.5N<br>639,974.7E | 1740 |
| AM 134 | 277 | 2008 | 1,203,201.0N<br>640,800.0E | 1731 |
| AM 132 | (+300) dry | 2020 | 1,203,567.0N<br>604,391.0E | 1720 |
| AM 183 | 267 | 2051 | 1,201,301.0N<br>634,198.0E | 1784 |
| AM 504 | 218 | 1852 | 1,198,995.9N<br>635,388.9E | 1634 |
| AM 498 | 153 | 1788 | 1,201,443.8N<br>633,529.6E | 1635 |
| AM 459 | (520) dry | 2026 | 1,200,597.6E<br>637,206.9E | 1506 |

Source: Dames & Moore, 1977 and Minerals Exploration Company, 1977.

Groundwater elevations in wells penetrating the lower conglomerate (AM-28 and AM-507) decrease to the west-southwest. A west-southwest decline in water table elevations in this unit is further substantiated by Grapevine Springs, which begin at approximately 1400 feet in elevation.

The static water levels in the boreholes drilled in the vicinity of the proposed mine range from dry to 1818 feet (Table 2.6-15). Water levels generally tend to decrease in a west-southwest direction, although there are some anomalies. In the vicinity of the fault that crosses the lower half of this section, water levels range from 1700 to 1750 feet. To the south and parallel to the fault, water levels are reduced to about 1600 feet. Continuing in a southwest direction, water levels increase to about 1620 feet. To the north and parallel to the fault, water levels range from 1730 to 1750 feet, with the exception of three bore holes that are dry at depths between 1620 and 1720 feet. These dry holes are also parallel to the fault.

There appears to be a general west-southwesterly movement of groundwater in the lower conglomerate unit that is strongly influenced locally by the northwesterly-trending faults in the area. The effects of these faults are indicated by local northwesterly-trending anomalies in water table elevations. Presumably such anomalies are associated with groundwater movement along the faults.

## WATER QUALITY

### Surface Water Quality

Surface flow in the vicinity of the Anderson property normally occurs for only short periods during and immediately after precipitation. A single brief period of runoff was recorded on the property during the study period; however, personnel were not present to obtain water samples. Consequently, surface water quality data are not available for the property.

The water quality monitoring station nearest to the property is located on the Bill Williams River (USGS 09426600) near Planet, Arizona. This station is approximately 43 miles downstream from the Anderson property below the Alamo Reservoir. Data from this station were not included in this report since the hydrologic regime below the reservoir is different from the regime in the vicinity of the property. In addition, the impoundment of the water upstream from the monitoring station can be expected to substantially modify its chemical characteristics.

The results of water quality analyses conducted on a sample taken in the Bill Williams River at the confluence of the Big Sandy and Santa Maria rivers are provided in Table 2.6-16. For comparison, this table also presents pertinent water quality criteria. The drinking water standards presented in the table were compiled from the 1962 U.S. Public Health Service standards, the 1965 U.S. EPA Interim Primary Drinking Water Regulations, and Quality Criteria for Water (EPA, 1976). The water quality

Table 2.6-16. SURFACE WATER QUALITY OF THE BILL WILLIAMS RIVER AT THE CONFLUENCE OF THE BIG SANDY AND THE SANTA MARIA RIVERS

| Constituent | Concentration (mg/l) | Drinking Water Standard* | Water Quality Standards for Wildlife/Livestock |
|---|---|---|---|
| Redox Potential (units) | +245 | -- | -- |
| Specific Conductance (μmho/cm) | 780 | -- | -- |
| TDS | 550 | 280 | 500 |
| pH (units) | 8.5 | 5-9 | 6-9 |
| Calcium | 0.001 | -- | -- |
| Magnesium | 21 | -- | -- |
| Potassium | 7 | -- | -- |
| Sodium | 100 | -- | -- |
| Bicarbonate | 280 | -- | -- |
| Cloride | 72 | 250 | -- |
| Sulfate | 84 | 250 | -- |
| Total Iron | 8.2 | 0.3 | |
| Soluble Iron | <0.1 | -- | -- |
| Manganese | 0.26 | 0.5 | -- |
| Total Phosphorus | 0.31 | -- | -- |
| Nitrogen as Nitrate | 0.4 | 10 | 22.6 |
| Carbonate | 1.8 | -- | -- |
| Fluoride | 1.5 | 1.4 | 2.0 |
| Boron | 0.21 | 0.1-2.4 | 5.0 |
| Aluminum | 11 | -- | 5.0 |
| Arsenic | 0.03 | 0.5 | 0.2 |

Table 2.6-16 (concluded)

| Constituent | Concentration (mg/l) | Drinking Water Standard* | Water Quality Standards for Wildlife/Livestock |
|---|---|---|---|
| Chromium | 0.011 | 0.05 | 1.0 |
| Copper | 0.04 | 1.0 | 0.5 |
| Molybdenum | <0.05 | — | — |
| Nickel | 0.034 | — | — |
| Selenium | <0.003 | 0.01 | 0.05 |
| Vanadium | <0.05 | — | 0.1 |
| Zinc | 0.007 | 5.0 | 25 |
| Total Uranium (pCi/l) | 0±3 | — | — |
| Radium-226 (pCi/l) | 0.12±0.04 | 5 | 5 |
| Radium-228 (pCi/l) | 0±1 | — | — |
| Thorium-228 (pCi/l) | 0±0.1 | — | — |
| Thorium-230 (pCi/l) | 0±0.1 | — | — |
| Thorium-232 (pCi/l) | 0±0.2 | 15 | 15 |
| Gross Alpha | 0±3 | — | — |
| Gross Beta | 16±2 | — | — |

Source: Analyses conducted by LFE Environment Laboratories of Richmond, California. Sample collected on 09/16/77.

*Unless otherwise noted

criteria for wildlife and livestock use that are given in the table have been extracted from the 1973 proposed water quality standards developed for the EPA by the National Academy of Sciences. These criteria preceded the 1976 standards published by the EPA, which are concerned only with the health of humans and of aquatic and marine organisms.

As can be seen in Table 2.6-16, the water from the Bill Williams River is of fairly good quality. It does, however, exceed drinking water standards for total iron and both the drinking water standard and the livestock and wildlife-use standard for TDS.

Flash flooding following storms is typical on the Anderson property. During these flood events the quality of surface water is extremely variable, depending largely on the geologic composition of the streambed. In most cases, however, this water is laden with sediments. The sediment yield from runoff in the vicinity of the Anderson property varies from 0.2 to 1 acre-foot of material per square mile per year (Arizona Water Commission 1975).

Groundwater Quality

Groundwater samples were collected from a total of 10 sources (Figure 2.6-11) representing all of the major geohydrologic units in the vicinity of the Anderson property (i.e., alluvium, barren sand, lower conglomerate, and volcanics). These samples were analyzed for major water quality constituents, minor constituents, trace elements, and radioactive constituents. The results of these analyses are presented

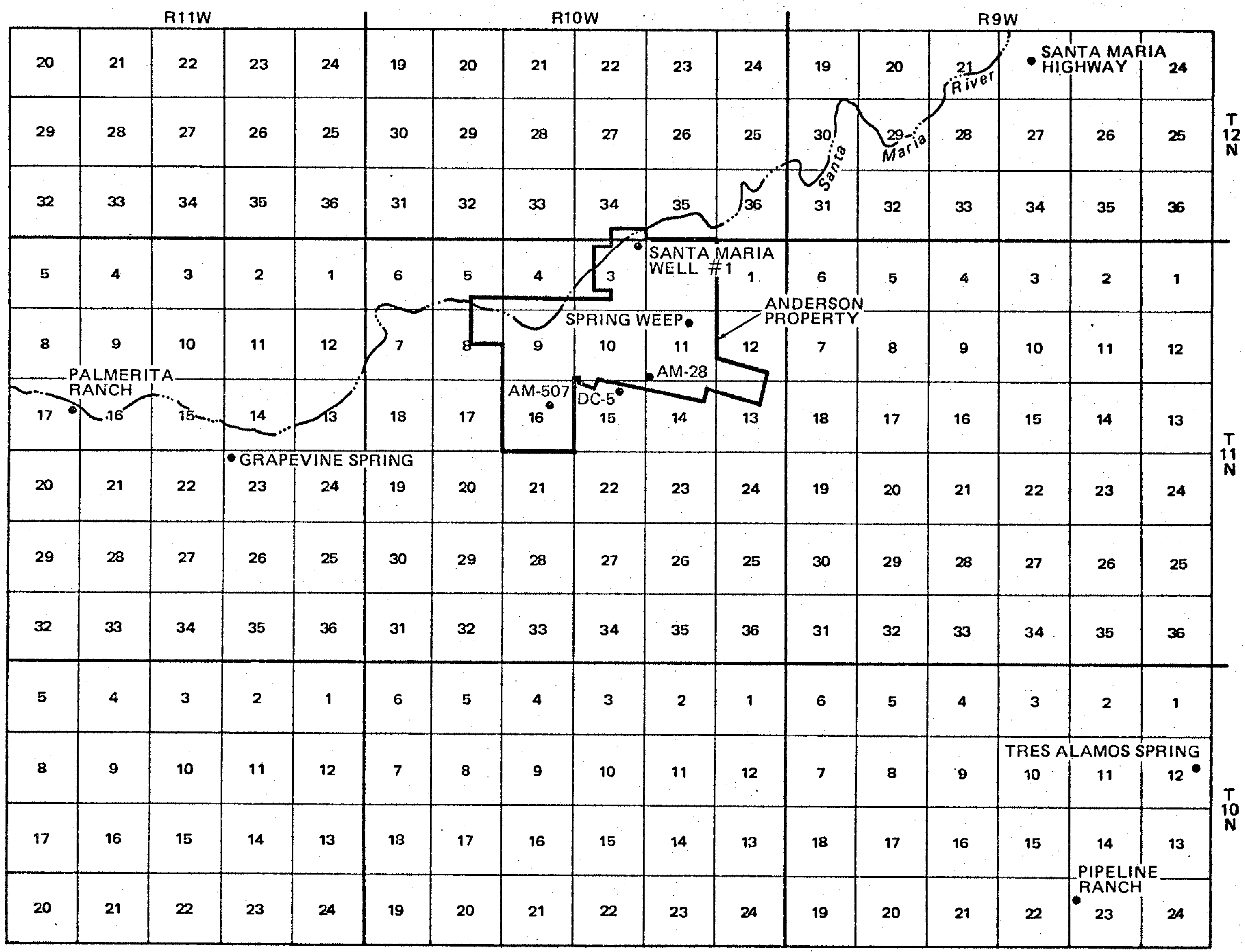



Figure 2.6-11. LOCATION OF GROUNDWATER SAMPLE SITES

on Tables 2.6-17 through 2.6-20. For comparison, these tables also present pertinent water quality criteria in a manner similar to that described for Table 2.6-16.

The data indicate that different types of water are present in the various formations underlying the Anderson property. In the alluvium, water is dominated by calcium bicarbonate (Table 2.6-17). In the barren sand unit, the water has a high pH and is dominated by sodium bicarbonate and sodium carbonate. In the lower conglomerate unit, the water is again dominated by calcium bicarbonate. Water from both of the wells drilled into the volcanics was dominated by sodium bicarbonate.

The major potential uses of groundwater in the vicinity of the Anderson property are wildlife and livestock watering and domestic consumption. Based on the recommended criteria provided in Tables 2.6-17 through 2.6-20, groundwater in the area is of fairly good quality for these uses. However, there are several cases where water quality criteria are exceeded. Except for water from the lower conglomerate unit, water samples from each of the geologic units underlying the property exceeded the drinking water standard for total dissolved solids (TDS) (Table 2.6-17). Fluoride in the water from the barren sand unit exceeded the maximum allowable concentration of 2.4 mg/l for drinking water (Table 2.6-18). Studies have shown that water containing more than 4.0 mg/l of fluoride causes mottled teeth. Untreated water from this unit has the potential of causing this problem. Water from the barren sand unit, alluvium, and volcanics also exceeded the

Table 2.6-17. MAJOR WATER QUALITY CONSTITUENTS (in mg/l unless otherwise noted)

| Identification | Well Location* | Date Sampled | Redox Potential (mV) | Specific Conductance (μmho/cm) | TDS | pH | Ca | Mg | K | Na | $HCO_3$ | Cl | $SO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alluvium Wells (Qal) | | | | | | | | | | | | | |
| Palmerita Ranch | 11-11W-17ac | 4/12/77 | +16.0 | 460 | 220 | 7.6 | 41 | 10 | 4 | 48 | 197 | 23 | 32 |
| | | 9/16/77 | - | 400 | 260 | 7.6 | 42 | 12 | 3.2 | 40 | 200 | 28 | 30 |
| Pipeline Ranch | 10-9W-23bc | 5/1/77 | -70.7 | 390 | 239 | 8.1 | 30 | 13 | 2 | 22 | 190 | 13 | 24 |
| | | 9/16/77 | +249 | 400 | 270 | 7.4 | 62 | 12 | 2.1 | 22 | 220 | 11 | 15 |
| Santa Maria Well #1 | 11-10W-3ab | 3/17/77 | +14.0 | 561 | 470 | 7.7 | 105 | 9 | 6 | 57 | 212 | 41 | 57 |
| | | 9/16/77 | +245 | 550 | 370 | 7.4 | 58 | 19 | 5.2 | 55 | 240 | 47 | 53 |
| Santa Maria Highway | 12-9W-22bd | 5/1/77 | -45.9 | 1185 | 785 | 7.8 | 64 | 32 | 3 | 92 | 286 | 117 | 110 |
| | | 9/16/77 | +249 | 960 | 730 | 7.6 | 90 | 20 | 5.9 | 120 | 360 | 7.4 | 110 |
| AM-507 | 11-10W-16ca | 4/20/77 | - | 390 | 340 | 8.0 | 9 | 4 | 5 | 78 | 178 | 18 | 29 |
| Barren Sand Well (Tmb) | | | | | | | | | | | | | |
| DC-5 | 11-10W-15ab | 12/19/76 | - | 850 | 663 | 8.9 | 1 | 0.2 | 2 | 200 | 366 | 33 | 25 |
| | | 4/15/77 | +34.2 | 714 | 666 | 8.8 | 1 | 0.3 | 3 | 197 | 322 | 36 | 13 |
| Lower Conglomerate (Tmc) | | | | | | | | | | | | | |
| AM-28 | 11-10W-11cc | 12/1/76 | - | 290 | 200 | 7.3 | 23 | 16 | 3 | 14 | 146 | 10 | 12 |
| | | 4/15/77 | +125.0 | 390 | 221 | 8.0 | 22 | 10 | 3 | 15 | 112 | 11 | 14 |
| | | 9/16/77 | +237 | 260 | 150 | 7.6 | 23 | 13 | 3.1 | 17 | 120 | 11 | 7.6 |
| Grapevine Springs | 11-11W-23bb | 11/13/76 | - | 290 | 227 | 8.4 | 24 | 5 | 2 | 40 | 132 | 14 | 20 |
| | | 5/1/77 | -53.7 | 355 | 262 | 7.7 | 1** | 4 | 2 | 32 | 137 | 15 | 20 |
| | | 9/16/77 | +238 | 350 | 180 | 8.2 | 25 | 4.3 | 2 | 45 | 150 | 17 | 13 |
| Volcanics (Tvf) | | | | | | | | | | | | | |
| Tres Alamos Spring | 10-9W-12ad | 5/3/77 | -60.0 | 710 | 591 | 8.1 | 30 | 38 | 0.5 | 60 | 264 | 53 | 42 |
| | | 9/16/77 | +238 | 380 | 260 | 7.8 | 26 | 22 | 1.7 | 35 | 200 | 30 | <1 |
| Spring Weep | 11-10W-11ba | 7/18/77 | - | 675 | 280 | 8.7 | 10 | 2 | 9 | 185 | 179 | 60 | 26 |
| Drinking Water Standards | | | - | - | 500 | 5-9 | - | - | - | - | - | 250 | 250 |
| Water Quality Standard for Wildlife/Livestock | | | - | - | - | 6-9 | - | - | - | - | - | - | - |

*Refer to Figure 2.6-4 for location numbering system.

**Probable analytical error.

<u>Note:</u> CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

82

Table 2.6-18. MINOR WATER QUALITY CONSTITUENTS (all analyses in mg/l)

| Identification | Date Sampled | Total Fe | Soluble Fe | Mn | $PO_4$ (as P) | $NO_3$ (as N) | $CO_3$ | F | B | Laboratory |
|---|---|---|---|---|---|---|---|---|---|---|
| Alluvium Wells (Qal) | | | | | | | | | | |
| Palmerita Ranch | 4/12/77 | 0.006 | <0.001 | 0.001 | <0.1 | 0.9 | 0 | 0.89 | 0.2 | CEP |
| | 9/16/77 | 0.31 | <0.1 | 0.019 | 0.074 | 0.86 | 0 | 1.0 | <0.1 | LFE |
| Pipeline Ranch | 5/1/77 | 0.018 | 0.014 | <0.001 | 0.2 | 0.6 | 0 | 0.05 | 0.3 | CEP |
| | 9/16/77 | 0.005 | <0.1 | <0.005 | 0.026 | 2.2 | 0 | 0.53 | <0.1 | LFE |
| Santa Maria Well #1 | 3/17/77 | 5.9 | 0.39 | 0.076 | 0.7 | <0.1 | 0 | 0.89 | 0.1 | CEP |
| | 9/16/77 | 23 | <0.1 | 0.19 | 0.29 | 0.92 | 0 | 0.86 | 0.15 | LFE |
| Santa Maria Highway | 5/1/77 | 0.3 | 0.05 | 0.114 | 1.8 | 0.4 | 0 | 2.03 | 0.4 | CEP |
| | 9/16/77 | 0.23 | <0.1 | 0.13 | 0.15 | 0.4 | 0 | 2.5 | 0.35 | LFE |
| AM-507 | 4/29/77 | - | - | - | - | 2.8 | 0 | 1.4 | - | BC |
| Barren Sand Well (Tmb) | | | | | | | | | | |
| DC-5 | 12/19/76 | - | - | - | - | 0.4 | 40 | 4.2 | - | BC |
| | 4/15/77 | 0.002 | <0.001 | 0.001 | <0.1 | 0.3 | 27.3 | 4.2 | 1.0 | CEP |
| Lower Conglomerate (Tmc) | | | | | | | | | | |
| AM-28 | 12/1/76 | - | - | - | - | 3.8 | 0 | 0.7 | - | BC |
| | 4/15/77 | 0.001 | <0.001 | <0.001 | <0.1 | 5.0 | 0 | 0.7 | 0.1 | CEP |
| | 9/16/77 | 0.012 | <0.01 | <0.005 | <0.02 | 3.9 | 0 | 0.87 | <0.1 | LFE |
| Grapevine Springs | 11/13/7 | - | - | - | - | 1.2 | 11.9 | 0.6 | - | BC |
| | 5/1/77 | 0.261 | 0.100 | 0.043 | 3.1 | 1.3 | 0 | 0.1 | 0.3 | CEP |
| | 9/16/77 | 0.24 | <0.1 | <0.037 | 0.063 | 1.2 | 0 | 0.58 | <0.1 | LFE |
| Volcanics (Tvf) | | | | | | | | | | |
| Tres Alamos Spring | 5/3/77 | 0.18 | 0.014 | 0.014 | 1.0 | 2.0 | 0 | 0.07 | 1.2 | CEP |
| | 9/16/77 | 0.06 | 0.22 | 0.015 | 0.013 | 0.1 | 0 | 0.44 | <0.1 | LFE |
| Spring Weep | 7/18/77 | 0.046 | 0.004 | 0.004 | 0.1 | 1.6 | 15.6 | 2.4 | 0.2 | CEP |
| Drinking Water Standards | | 0.3 | - | 0.50 | - | 10 | - | 1.4 | 1.0<br>2.4 | |
| Water Quality Standards for Wildlife/Livestock | | - | - | - | - | 22.6 | - | 2.0 | 5.0 | |

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

83

Table 2.6-19. TRACE WATER QUALITY CONSTITUENTS (all analyses in mg/l)

| Identification | Date Sampled | Al | As | Cr | Cu | Mo | Ni | Se | V | Zn | $SiO_2$ | Laboratory |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alluvium Wells (Qal) | | | | | | | | | | | | |
| Palmerita Ranch | 4/12/77 | <0.1 | <0.01 | <0.001 | 0.003 | 0.01 | 0.001 | <0.01 | 0.01 | 0.13 | 2.0 | CEP |
| | 9/16/77 | 0.17 | <0.01 | <0.005 | <0.01 | <0.05 | 0.009 | <0.005 | <0.05 | 0.003 | 25.0 | LFE |
| Pipeline Ranch | 5/1/77 | <0.1 | <0.01 | 0.002 | <0.001 | 0.004 | 0.01 | <0.01 | 0.02 | <0.01 | 3.4 | CEP |
| | 9/16/77 | <0.1 | 0.005 | 0.011 | 0.03 | <0.05 | 0.008 | <0.005 | <0.05 | 0.087 | 14.0 | LFE |
| Santa Maria Well #1 | 3/17/77 | 0.01 | 0.02 | <0.001 | 0.001 | 0.001 | 0.001 | 0.01 | <0.01 | 0.03 | 30.4 | CEP |
| | 9/16/77 | 1.3 | 0.0006 | 0.007 | 0.03 | <0.05 | 0.045 | <0.004 | <0.05 | 0.31 | 9.4 | LFE |
| Santa Maria Highway | 5/1/77 | 0.9 | 0.01 | 0.003 | <0.001 | 0.001 | 0.01 | <0.01 | 0.01 | <0.01 | 6.28 | CEP |
| | 9/16/77 | 0.15 | 0.008 | 0.007 | <0.01 | <0.05 | 0.016 | <0.003 | <0.05 | 0.003 | 24.0 | LFE |
| Barren Sand Well (Tmb) | | | | | | | | | | | | |
| DC-5 | 4/15/77 | 0.01 | 0.12 | 0.001 | 0.029 | <0.001 | 0.001 | 0.01 | 0.03 | 0.01 | 40.0 | CEP |
| Lower Conglomerate (Tmc) | | | | | | | | | | | | |
| AM-28 | 4/15/77 | <0.1 | 0.011 | 0.001 | 0.001 | <0.001 | 0.001 | <0.01 | 0.02 | 0.02 | 5.0 | CEP |
| | 9/16/77 | <0.1 | 0.008 | 0.007 | <0.01 | <0.005 | 0.005 | <0.005 | <0.05 | 0.21 | 17.0 | LFE |
| Grapevine Springs | 5/1/77 | 0.9 | 0.01 | 0.015 | <0.001 | <0.001 | 0.01 | 0.1 | 0.01 | <0.01 | 3.14 | CEP |
| | 9/16/77 | 1.2 | 0.012 | 0.007 | <0.001 | <0.05 | 0.007 | <0.005 | <0.05 | 0.007 | 14.0 | LFE |
| Volcanics (Tvf) | | | | | | | | | | | | |
| Tres Alamos Spring | 5/3/77 | 0.9 | 0.01 | 0.003 | <0.001 | 0.004 | <0.01 | 0.20 | 0.03 | <0.01 | 7.2 | CEP |
| | 9/16/77 | <0.01 | <0.005 | <0.005 | <0.01 | <0.05 | 0.005 | <0.005 | <0.05 | 0.019 | 31.0 | LFE |
| Spring Weep | 7/18/77 | 0.5 | <0.01 | 0.001 | 0.001 | 0.001 | <0.01 | <0.01 | 0.03 | <0.01 | -- | CEP |
| Drinking Water Standards | | - | 0.5 | 0.05 | 1.0 | - | - | 0.01 | - | 5.0 | -- | |
| Water Quality Standards for Wildlife/Livestock | | 5.0 | 0.2 | 1.0 | 0.5 | - | - | 0.05 | 0.1 | 25 | -- | |

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

Table 2.6-20. RADIOACTIVE TRACE CONSTITUENTS (all analyses in pCi/1 unless noted)

| Identification | Date Sampled | Total U (mg/1) | Rn-222 | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | Gross Alpha | Gross Beta | Laboratory |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alluvium Wells (Qal) | | | | | | | | | | | |
| Palmerita Ranch | 4/12/77 | 0.0050 | - | <0.6 | 7±3 | 1.9±1.0 | 2.3±1.1 | <0.6 | 2±2 | 5±2 | CEP |
| | 9/16/77 | | | 0.06±0.04 | 0±1 | 0±0.2 | 0±0.1 | 0±0.1 | 0±2 | 6±2 | LFE |
| Pipeline Ranch | 5/1/77 | 0.0072 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | 3±2 | 3±2 | CEP |
| | 9/16/77 | | | 0±0.04 | 0±1 | 0±0.2 | 0±0.1 | 0±0.2 | 0±3 | 6±2 | LFE |
| Santa Maria Well #1 | 3/17/77 | 0.0115 | - | <0.6 | <1.0 | 2.1±1.0 | 2.9±1.2 | 1.4±0.9 | 4±3 | 4±2 | CEP |
| | 9/16/77 | | | 0.09±0.04 | 0±1 | 0±0.1 | 0±0.03 | 0±0.3 | 0±2 | 7±2 | LFE |
| Santa Maria Highway | 5/1/77 | 0.0188 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | 8±5 | 3 | CEP |
| | | | | 0.06±0.04 | 0±1 | 0±0.2 | 0±0.2 | 0±0.2 | 0±3 | 13±2 | LFE |
| Barren Sand Well (Tmb) | | | | | | | | | | | |
| DC-5 | 4/15/77 | 0.0460 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | 21±5 | 7±2 | CEP |
| Lower Conglomerate (Tmc) | | | | | | | | | | | |
| AM-28 | 4/15/77 | 0.0076 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | 2±1 | 3 | CEP |
| | 9/16/77 | | | 0.09±0.04 | 0±1 | 0±0.1 | 0±0.1 | 0±0.1 | 0±2 | 4±2 | LFE |
| Grapevine Springs | 5/1/77 | 0.0111 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | <2 | 3 | CEP |
| | | | | 0±0.04 | 0±1 | 0±0.1 | 0±0.2 | 0±0.2 | 0±2 | 3±2 | LFE |
| Volcanics (Tvf) | | | | | | | | | | | |
| Tres Alamos Spring | 5/3/77 | 0.0169 | - | <0.6 | <1.0 | <0.6 | <0.6 | <0.6 | 7±4 | 4±2 | CEP |
| | 9/16/77 | | | 0±0.04 | 0±1 | 0±0.2 | 0±0.1 | 0±0.2 | 0±3 | 5±2 | LFE |
| Spring Weep | 7/18/77 | 0.0152 | 0±2 | 0±0.08 | 0±2 | - | 0.4±0 | 0±0.1 | 0±4 | 12±1 | LFE |
| Drinking Water Standards | | | - | 5 | - | - | - | 15 | - | - | |
| Water Quality Standards for Wildlife/Livestock | | | - | 5 | - | - | - | 15 | - | - | |

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

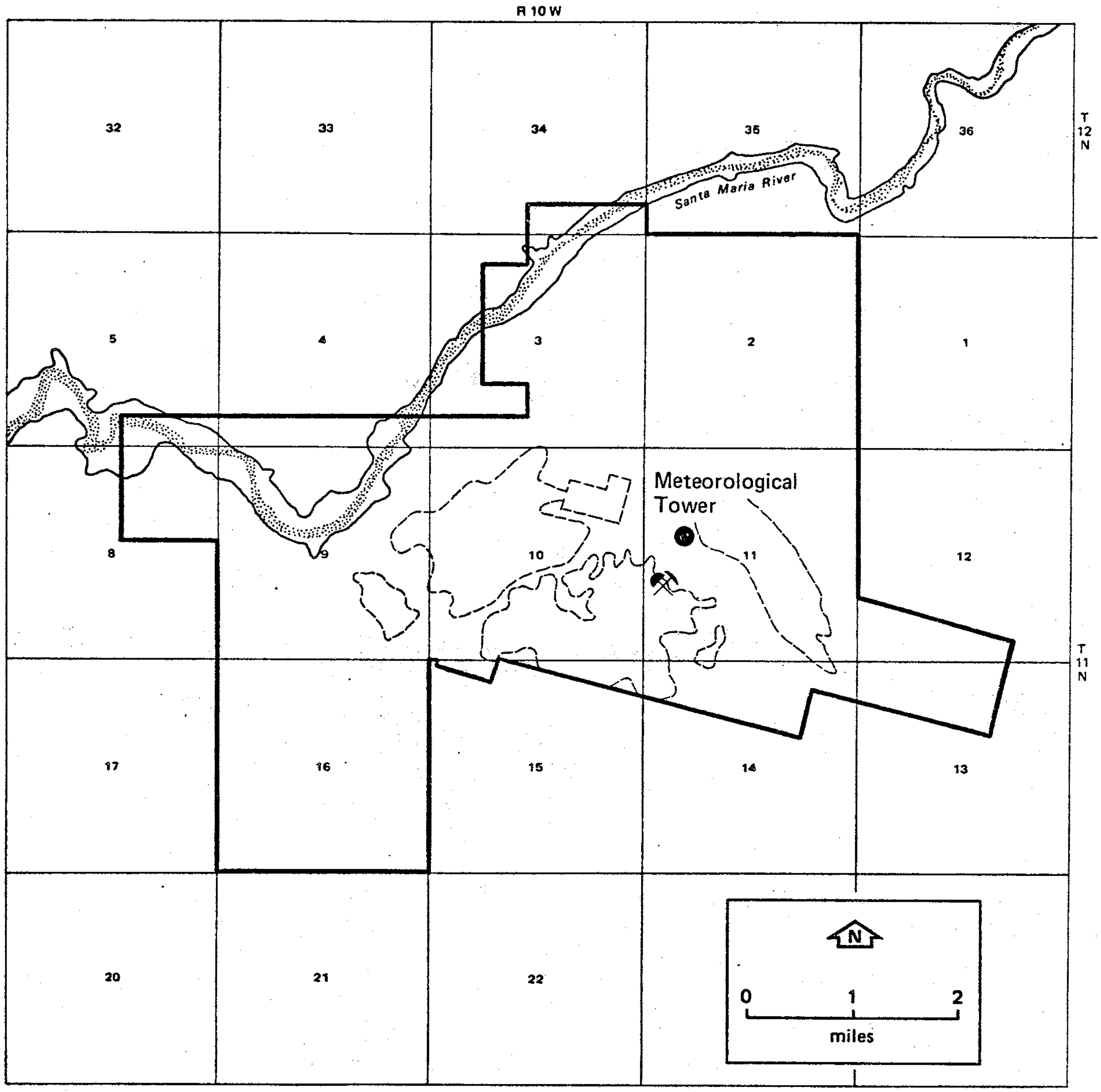
fluoride criterion for wildlife and livestock use (Table 2.6-18). Water from Santa Maria Well no. 1 exceeded the drinking water standard for iron (Table 2.6-18). Since most of the other samples taken from wells drilled into alluvium contained low concentrations of iron, this fairly high reading may be more indicative of sampling problems, such as an oxidized well casing, than the actual quality of the water. Water from Tres Alamos Spring is of poorer quality than most of the other samples taken in the vicinity of the Anderson property. This water exceeded the drinking water standards for both boron and selenium (Tables 2.6-18 and 2.6-19). It also exceeded the wildlife and livestock watering criterion for selenium (Table 2.6-19).

## 2.7 METEOROLOGY AND AIR QUALITY

A meteorological monitoring program was initiated on the Anderson property in December 1976. A mechanical weather station measuring wind direction, wind speed, and temperature was installed atop a 30-foot meteorological tower (Figure 2.7-1). Early in June 1977, instrumentation was added to measure relative humidity (at 30 feet) and rainfall (at about 10 feet). Estimates of wind direction deviation were used to estimate atmospheric stability for each hour according to methods developed by Slade (1966).

The tower was initially installed on a leveled area approximately 15 to 20 feet below and 200 feet south of the crest of a low hill. Examination of initial meteorological station strip charts indicated that wind turbulence induced by the hill caused exadurated oscillation of the wind vane (known as a "wake effect") during northerly winds above about 5 mph. The actual wind direction was discernable with reasonable accuracy, but chart interpretation was difficult. To remedy this situation, the tower was relocated to the top of the hill in June 1977 when precipitation and relative humidity sensors were installed. Comparison of wind data before and after relocation of the station indicates that hourly direction measurements were not significantly affected by turbulence.

Air quality was measured during two 5-day continuous monitoring programs near the meteorological tower site. Monitoring was first conducted from 8:00 p.m. on July 13, 1977, to 3:00 p.m. on July 18,




LEGEND

- Proposed facilities
- Property boundary
- Anderson Mine (abandoned)

**Figure 2.7-1.** METEOROLOGICAL AND AIR QUALITY MONITORING LOCATION

1977. The second monitoring period began at 10:00 a.m. on November 10, 1977, and ended at 8:00 a.m. on November 14, 1977. Additional monitoring is planned for mid-spring 1978. Total suspended particulates, sulfur dioxide, carbon monoxide, photochemical oxidants, nitrogen dioxide, and hydrocarbons will be measured for a 5-day period.

During the two monitoring periods conducted to date, 24-hour suspended particulate concentrations were determined with a standard high-volume air sampler (EPA reference method) fitted with a constant flow controller (± 1 cubic foot per minute), 24-hour sulfur dioxide concentrations were determined by the West-Gaeke bubbler method* (EPA reference method) and ozone concentrations were measured continuously with a Bendix 8002 Chemiluminescence Ozone Monitor (EPA equivalent method). In addition, MINERALS began a suspended particulate monitoring program at the site in September 1977. The latter program includes collection of 24-hour particulate samples once each week (usually on the weekend) according to a schedule approved by the Arizona Bureau of Air Quality Control for the project site. Monitoring is scheduled to continue to at least September, 1978. At a minimum of once each quarter, one of the samples collected by MINERALS will be analyzed for sulfate, nitrate, and lead.

Site data are presented in this section, along with long-term regional data, to describe the existing meteorological and air quality conditions.

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* Bubbler solutions were provided and analyzed by the Arizona Department of Health Services, Bureau of Air Quality Control, under the coordination of Mr. James Guyton, Monitoring Section Manager.

METEOROLOGY

The Anderson property is located in a semiarid desert region with the following general characteristics: abundant sunshine, light rainfall, moderate wind speeds, low relative humidity, and large diurnal temperature fluctuations. Summers are hot and winters are relatively mild.

Temperature

July is usually the hottest month, and January and December are usually the coldest months in the region. Based on an analysis of long-term temperature data for various regional weather stations* the normal mean annual temperature on the property is estimated to be about 66° to 67°F. Normal mean temperatures are estimated to be about 48° to 49°F during January and December, and 87°F during July. Normal monthly means and extremes in Phoenix (Figure 2.7-2) are presented in Table 2.7-1 to indicate annual variations. Comparisons of concurrent temperature data at Phoenix and the property during a 9-month period (December 1976 to August 1977) indicate that mean daily minimum and mean daily maximum temperatures are generally about 3°F cooler at the site, while daily minimum and maximum temperatures are generally about 2°F and 5°F cooler, respectively. The minimum temperature reported at the Phoenix Sky Harbor Airport was 19°F in January 1971, and the maximum

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* Normal mean annual and monthly (January, July, and December) temperatures for the 30-year period from 1941 to 1970 (U.S. Department of Commerce, 1973) were analyzed for 8 regional weather stations at elevations ranging from 323 feet msl to 3773 feet msl and were found to indicate a good correlation between temperature and elevation. Correlation coefficients ranged from −0.94 to −0.99.

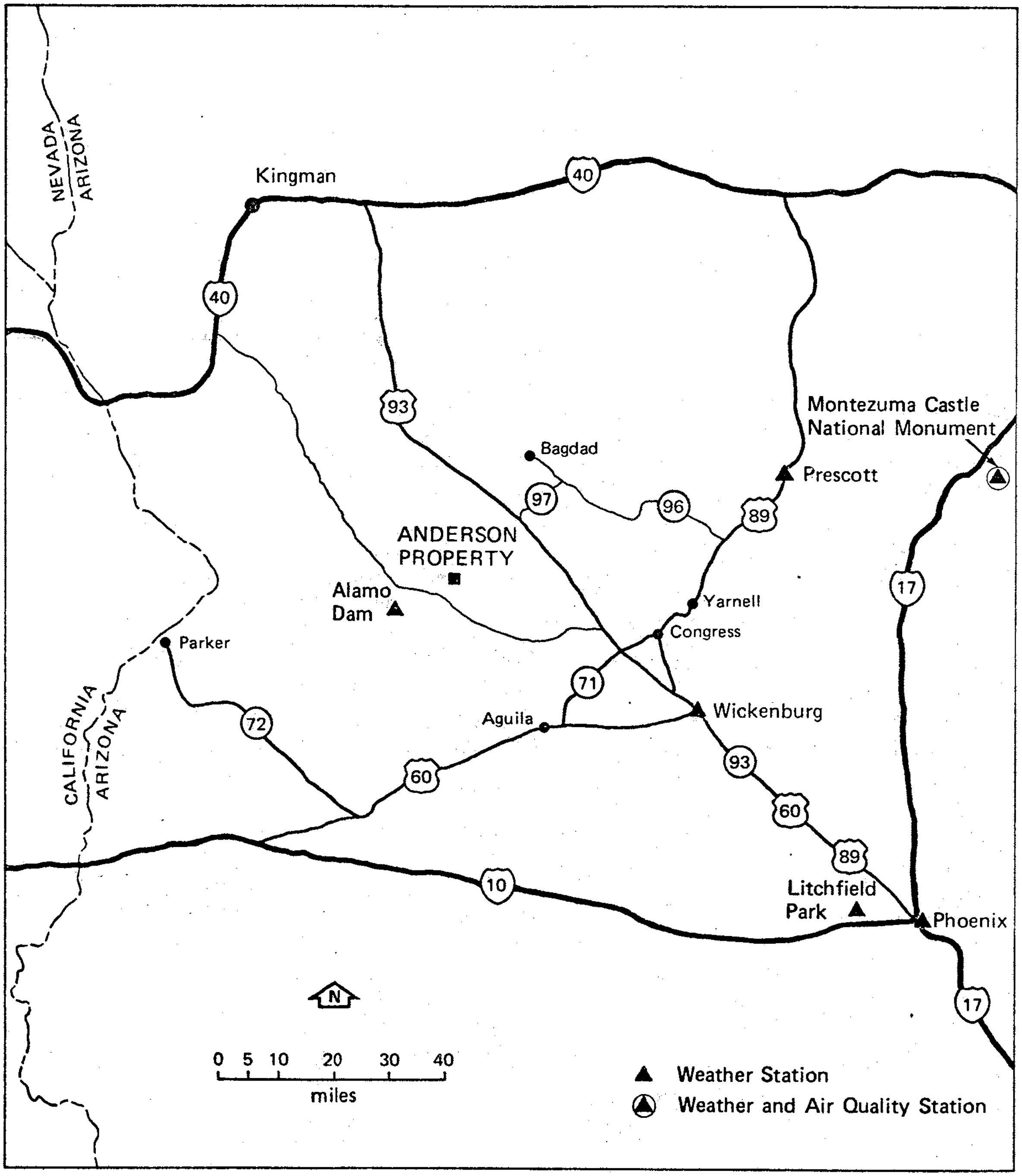


Figure 2.7-2. REGIONAL METOROLOGICAL AND AIR QUALITY MONITORING STATIONS

Table 2.7-1. NORMAL MEAN AND EXTREME TEMPERATURES REPORTED FOR PHOENIX, ARIZONA

| | Means[a] | | | Extremes[b] | |
|---|---|---|---|---|---|
| Month | Daily Maximum | Daily Minimum | Monthly | Record Highest | Record Lowest |
| January | 64.8 | 37.6 | 51.2 | 88 | 19 |
| February | 69.3 | 40.8 | 55.1 | 89 | 26 |
| March | 74.5 | 44.8 | 59.7 | 95 | 25 |
| April | 83.6 | 51.8 | 67.7 | 101 | 37 |
| May | 92.9 | 59.6 | 76.3 | 110 | 40 |
| June | 101.5 | 67.7 | 84.6 | 116 | 51 |
| July | 104.8 | 77.5 | 91.2 | 115 | 67 |
| August | 102.2 | 76.0 | 89.1 | 116 | 61 |
| September | 98.4 | 69.1 | 83.8 | 110 | 47 |
| October | 87.6 | 56.8 | 72.2 | 103 | 34 |
| November | 74.7 | 44.8 | 59.8 | 93 | 31 |
| December | 66.4 | 38.5 | 52.5 | 82 | 24 |
| Annual | 85.1 | 55.4 | 70.3 | 116 | 19 |

Source: U.S. Department of Commerce, 1976.

[a]Period of record: 30 years, 1941-1970.

[b]Period of record: 15 years, 1962-1976.

was 116°F in August 1975. Other stations in the Phoenix vicinity have reported temperatures as high as 118°F and as low as 16°F. On the average, temperatures exceed 90°F about 165 days each year and fall below 32°F only about 13 days a year in Phoenix. Monthly and daily mean, maximum, and minimum temperatures observed at the site during the study period are presented in Appendix B-1.

Relative Humidity

Table 2.7-2 presents mean relative humidity observed on the Anderson property for specific hours of the day for June through August 1977. Table 2.7-3 presents similar data for Phoenix for each month of the year. Comparisons of concurrent Phoenix and Anderson property data indicate that relative humidity on the property is generally higher and does not exhibit as great a diurnal variation as in Phoenix (and other reporting stations in Arizona at similar elevations). This relatively small diurnal range suggests the possibility of a malfunctioning relative humidity sensor. Relative humidity patterns at the property are probably more similar to those observed in Phoenix than the site data would indicate.*

Phoenix data (Table 2.7-3) demonstrate an annual cycle, with maximum relative humidity occurring in winter as a result of cooler temperatures and the occasional passage of moisture-laden Pacific air masses, and a secondary maximum (apparent in the 11 a.m. and 5 p.m. data) occurring in August (the month of peak thunderstorm activity and peak precipitation)

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* Because of the suspected instrument malfunction, interpretation of site data was discontinued beyond August 1977.

Table 2.7-2. MEAN DIURNAL RELATIVE HUMIDITY ON THE ANDERSON PROPERTY: JUNE-AUGUST 1977

| | Relative Humidity (%) | | | |
|---|---|---|---|---|
| Month | 5 a.m. | 11 a.m. | 5 p.m. | 11 p.m. |
| June | 26 | 25 | 24 | 24 |
| July | 39 | 37 | 33 | 29 |
| August | 47 | 44 | 40 | 43 |

Table 2.7-3. NORMAL MEAN DIURNAL RELATIVE HUMIDITY IN PHOENIX, ARIZONA

| | Relative Humidity (%) | | | |
|---|---|---|---|---|
| Month | 5 a.m. | 11 a.m. | 5 p.m. | 11 p.m. |
| January | 66 | 44 | 30 | 55 |
| February | 59 | 37 | 25 | 47 |
| March | 58 | 33 | 23 | 44 |
| April | 44 | 23 | 15 | 29 |
| May | 36 | 17 | 12 | 22 |
| June | 35 | 18 | 12 | 22 |
| July | 46 | 28 | 20 | 33 |
| August | 53 | 34 | 24 | 39 |
| September | 53 | 31 | 23 | 40 |
| October | 53 | 30 | 22 | 42 |
| November | 61 | 38 | 28 | 52 |
| December | 69 | 48 | 35 | 60 |
| Annual | 53 | 32 | 22 | 41 |

Source: U.S. Department of Commerce, 1976.

Period of record: 15 years, 1962-1976.

as a result of moist air masses originating in the Gulf of Mexico and along the western coast of Mexico.

Precipitation

Tropical air masses from the Gulf of Mexico and the western coast of Mexico are the source of peak monthly rainfall in Arizona, occurring as widespread thunderstorm activity in July and August. The other rainfall season occurs during the winter months, from November through March, when the area is subjected to occasional storms from the Pacific Ocean. While this is classed as a rainfall season, there can be periods lasting a month or more in this season (or in any other season) when practically no precipitation occurs. Spring and fall are generally dry, although substantial precipitation has fallen on occasion during every month of the year.

Analysis of regional precipitation data for selected stations at various elevations (Table 2.7-4) indicates that normal annual precipitation on the Anderson property may range from about 7.5 inches at lower elevations (near the Santa Maria River, about 1600 feet msl) to about 11 inches at higher elevations (in southern portions of the property where ground level rises to elevations of 2300 to 2400 feet msl). Normal annual precipitation at the proposed mill site (approximate elevation 1800 feet msl) is probably between 8 and 9 inches. Normal monthly and annual precipitation reported in Phoenix provides an indication of general seasonal fluctuations in precipitation (Table 2.7-5).

Table 2.7-4. NORMAL ANNUAL PRECIPITATION AT SELECTED REGIONAL WEATHER STATIONS

| Station[a] | Elevation (feet msl) | Annual Precipitation (inches) |
|---|---|---|
| Litchfield Park[b] | 1030 | 7.56 |
| Phoenix Skyharbor Airport[b] | 1117 | 7.05 |
| Alamo Dam[c] | 1100, 1480[d] | 7.41 |
| Wickenburg[b] | 2095 | 10.76 |
| Montezuma Castle National Monument[b] | 3180 | 11.07 |

[a] Station locations are shown in Figure 2.7-2.

[b] Period of record: 30 years, 1941-1970.
Source: U.S. Department of Commerce, 1973.

[c] Period of record: 10 years, 1963-1968 and 1970-1973.
Source: U.S. Department of Commerce, 1963-1973.

[d] Alamo Dam station elevation changed in 1970 from 1100 feet to 1480 feet msl.

Table 2.7-5. NORMAL MONTHLY AND ANNUAL PRECIPITATION AT PHOENIX SKY HARBOR AIRPORT

| Month | Precipitation (inches) |
|---|---|
| January | 0.71 |
| February | 0.60 |
| March | 0.76 |
| April | 0.32 |
| May | 0.14 |
| June | 0.12 |
| July | 0.75 |
| August | 1.22 |
| September | 0.69 |
| October | 0.46 |
| November | 0.46 |
| December | 0.82 |
| Annual | 7.05 |

Source: U.S. Department of Commerce, 1973.

Period of record: 30 years, 1941-1960.

Table 2.7-6. MONTHLY PRECIPITATION OBSERVED ON THE ANDERSON PROPERTY, JUNE - DECEMBER 1977

| Month | Total Monthly Precipitation (inches) |
|---|---|
| June | 0.19 |
| July | 0.58 |
| August | 0.98 |
| September | 1.41 |
| October | 0.29 |
| November | 0.14 |
| December (1-16) | 0.02 |

Data from the Anderson property are presently available for seven months, June through December 1977 (Table 2.7-6). Drought conditions existed in the region during 1977. During July and August, normally the wettest months of the year, a total of only 1.75 inches of rain was observed at the property. Other stations in the region reported abnormally low precipitation amounts that ranged between 1.5 and 2 inches below normal during the same period (U.S. Department of Commerce, 1977).

Most of the precipitation within the region occurs as rainfall. Usually snow, sleet, and hail account for traces or small percentages of total annual precipitation. However, stations in the region have reported from 1 to 16.5 inches of snowfall on occasion. During a 68-year period of record (1895-1962) at the Phoenix Post Office (elevation 1083 feet msl), a maximum of one inch of snow has fallen (most recently in January 1937). In Wickenburg (elevation 2095 feet msl), a maximum of two inches has fallen (most recently in December 1960) during a 51 year period of record from 1912 to 1962 (Green and Sellers, 1964). At Montezuma Castle National Monument (elevation 3180 feet), more than 1000 feet above the elevation of the proposed mill site, about 2.1 inches of snow normally falls. However, during a 24-year period of record from 1939 to 1962, a maximum of 16.5 inches was recorded in January 1949 (Green and Sellers, 1964). Wickenburg and Montezuma Castle National Monument are both shown in Figure 2.7-2.

Wind Speed, Wind Direction

Winds are generally light to moderate on the Anderson property (Figure 2.7-3). From the latter part of December 1976 through November 1977, hourly average wind speeds were observed to be 4 mph or less about 32 percent of the time, and 7 mph or less about 63 percent of the time. High hourly average wind speeds (25 mph or greater) were observed a total of 15 times (about 2 percent of the total observations). Almost half of these occurrences were observed in August with corresponding average wind directions ranging from northeast to southeast. Two occurrences were observed in June from the southeast, and four occurrences were observed in March and April from the west-northwest and the northwest. The remaining three occurrences were observed in the fall (September through November) from the south-southeast and east-southeast.

During the study period, predominant wind directions were west-southwesterly and westerly. Together those directions occurred almost 20 percent of the time. The next most frequent wind directions were northerly (11.7 percent) and southerly (9.6 percent). As indicated in Figure 2.7-4, general southerly directions dominated northerly winds; winds out of the east-southeast through west-southwest occurred about 1.5 times more often than west-northwest through east-northeast winds. Figure 2.7-5 summarizes the relationship between wind direction and wind speed observed on the property. Comparisons of site data with concurrent data from regional weather stations (including Phoenix,

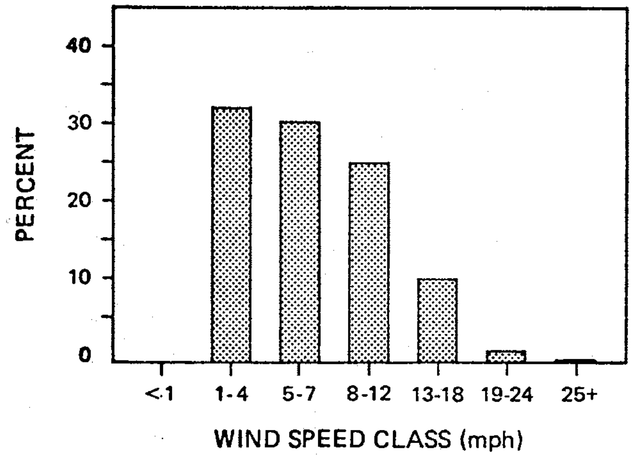


Figure 2.7-3. RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED CLASSES AT PROJECT SITE: December 22, 1976 - November 30, 1978

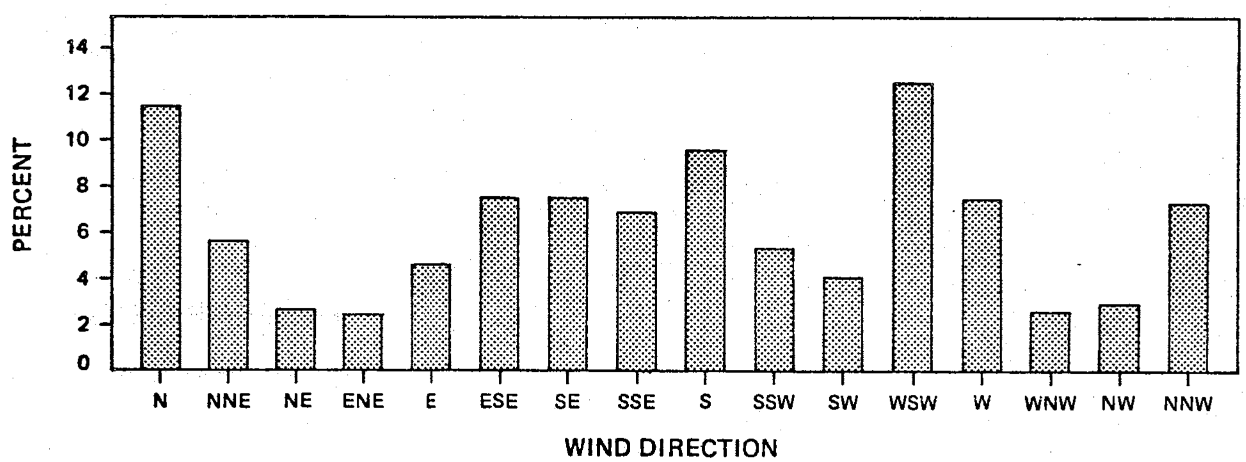


Figure 2.7-4. RELATIVE FREQUENCY DISTRIBUTION OF WIND DIRECTION AT PROJECT SITE: December 22, 1976 - November 30, 1978

Prescott, and Yuma) indicate that wind direction patterns on the property are significantly different from other areas in the region.

Winds on the Anderson property exhibited a relatively complex diurnal pattern that varied with the seasons. The differences in seasonal patterns (mostly between winter and summer) are probably the combined result of terrain effects and regional circulation that both change with the seasons. During the winter, wind direction was observed to usually follow a full 360-degree, counter-clockwise diurnal shift, with general northerly directions predominating during early morning (after midnight) and continuing almost until noon. Beginning around noon and continuing through about 6:00 p.m., west-southwesterly winds predominated. Subsequently, the wind direction shifted through south and east during evening hours, returning to northerly flow at about midnight. Data taken during the first half of December 1977 also indicate this same general pattern.

During summer, winds exhibited a cyclic southeast-southwest pattern, shifting through south. Directions north of east and west occurred only about 22 percent of the time, and only during morning hours. Topography and its effects on local meteorology are complex in the site area, but it is suspected that daytime southwesterly directions are the result of general up-gradient flow along the Santa Maria River. Nighttime southeasterly directions are probably the result of down-gradient flow from higher terrain southeast of the meteorological tower site. Spring and

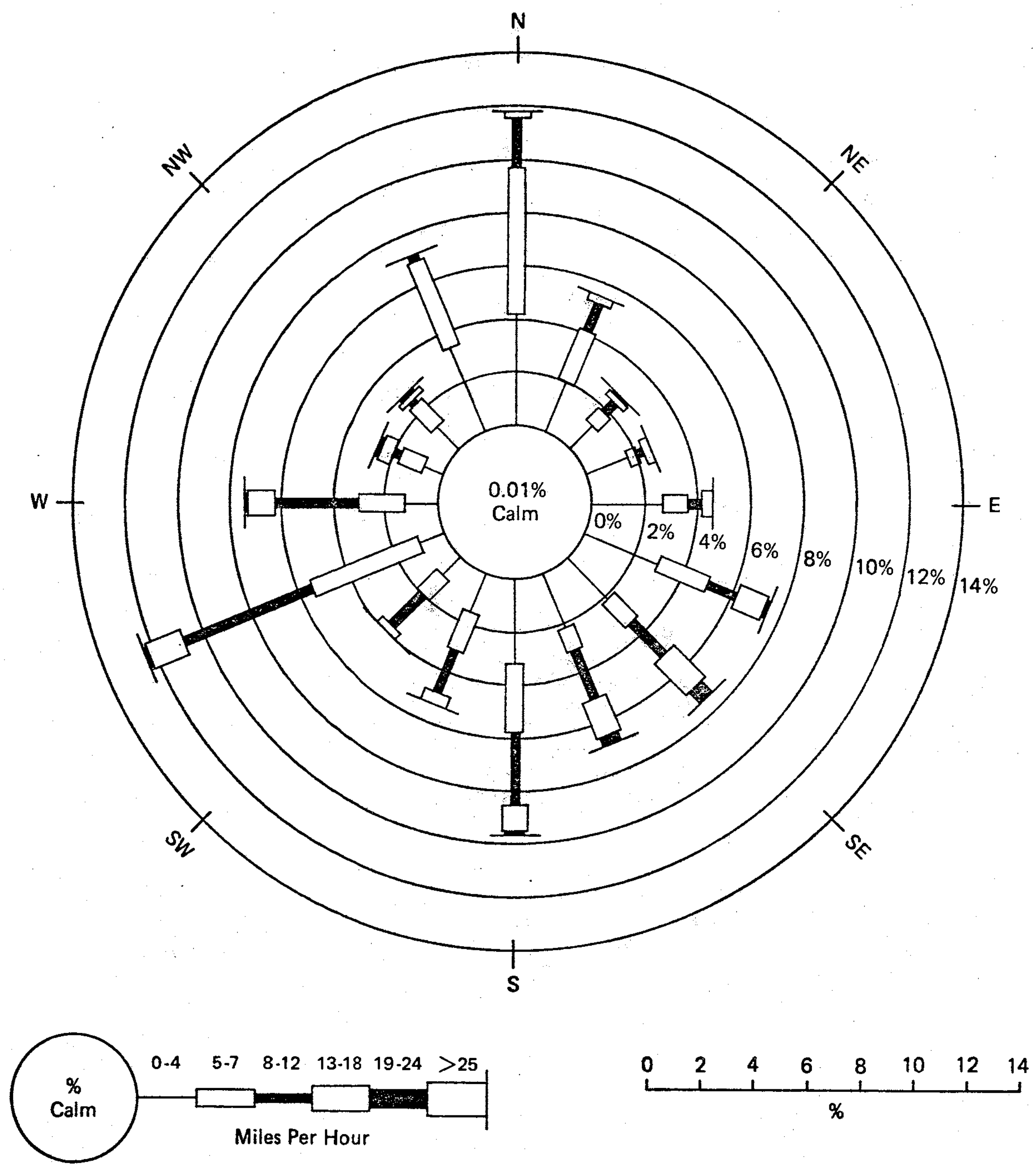


**Figure 2.7-5** WIND ROSE FOR THE PROJECT SITE, FOR THE PERIOD DECEMBER 1976 THROUGH NOVEMBER 1977, ANNUAL AVERAGE CONDITIONS

fall both appear to be periods of transition. The diurnal wind direction distributions for these two seasons are similar and appear to represent combinations of the summer and winter patterns. Diurnal frequency distributions for each season and for the entire study period are provided in Appendix B-2.

Dispersion Climatology

In addition to wind speed and wind direction, the ability of the of the atmosphere to disperse air pollutants depends on several atmospheric variables including stability, mixing depth, and topographic boundaries. Topography is relatively rugged on the property and in some directions, primarily to the south, may tend to inhibit dispersion potential.

Pasquill (1961) and Turner (1964) have developed methods for estimating atmospheric stability based on surface meteorological observations. The input parameters for these calculations are solar altitude, cloud cover, ceiling height, and wind speed. Methods are also available for the estimation of atmospheric stability from the standard deviation of wind direction (sigma-theta, $\sigma_\theta$). According to the Pasquill system, atmospheric stability is classified as follows:

| Pasquill Stability Classification | Degree of Atmospheric Stability | $\sigma_\theta$ * |
|---|---|---|
| A | Extremely unstable | 25° |
| B | Unstable | 20° |
| C | Slightly unstable | 15° |
| D | Neutral | 10° |
| E | Slightly stable | 5° |
| F | Stable | 2.5° |
| G | Extremely stable | 1.7° |

No long-term estimates of atmospheric stability are available for the vicinity of the Anderson property. However, data collected near the property indicate that relatively good atmospheric dispersion conditions exist much of the time. Estimates of atmospheric stability class based on determinations of wind direction deviation, sigma-theta ($\sigma_\theta$ using methods developed by Slade, 1966), indicate a relatively high occurrence of good dispersion conditions. Stability classes A through D occurred about 71 percent of the time during the study period (Table 2.7-7). A relative frequency distribution of wind direction and wind speed by stability class is presented in Appendix B-3 for the study period. This distribution was used for the radiological impact assessment and annual average dispersion modelling for non-radiological air quality impact assessments.

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* Based on Table 2 of NRC Safety Guide 23 (NRC, 1972).

Table 2.7-7. SEASONAL AND ANNUAL RELATIVE FREQUENCY DISTRIBUTIONS OF ATMOSPHERIC STABILITY CLASSES ON THE ANDERSON PROPERTY

| Season | Percent Occurrence of Stability Classes | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F&G |
| Winter | 2.9 | 11.0 | 18.4 | 35.3 | 29.8 | 2.5 |
| Spring | 4.7 | 17.2 | 14.6 | 40.7 | 19.5 | 3.2 |
| Summer | 1.8 | 22.0 | 12.9 | 43.9 | 16.4 | 3.0 |
| Fall | 2.2 | 7.9 | 12.3 | 36.2 | 28.2 | 13.3 |
| Annual | 2.9 | 14.7 | 14.3 | 39.3 | 23.1 | 5.7 |

Period of Record: December 22, 1976 - November 30, 1977.

Mixing depth, a measure of the thickness of the atmospheric layer into which air pollutants can be mixed, is an additional useful indicator of dispersion potential. Better dispersion results from greater mixing depth, with a greater volume of air available for dilution of pollutants. Furthermore, the mixing depth typically increases as wind speeds increase.

Low-level nocturnal temperature inversions, which result in low mixing depths, commonly form in the region, particularly in winter. Mixing depth usually increases in the morning and afternoon as daytime solar radiation increases surface temperatures, resulting in convective mixing. During the winter, upper-level inversions can also extend through daylight hours. If these inversions persist, they can create stagnant conditions near ground level for extended periods.

Holzworth (1972) studied mixing depths and wind speeds within the mixing layer for a number of weather stations and generated isopleths for the United States. Table 2.7-8 presents estimated mixing depths and wind speeds for the Anderson property from Holzworth's work. Diurnal variations and seasonal variations in afternoon mixing depths are pronounced, but only small variations in seasonal morning depths were noted. Holzworth's data indicate that low morning mixing depths exist, especially in the winter. However, afternoon mixing depths are among the highest in the country. The average morning wind speeds within the mixing layer are less than afternoon wind speeds, and average wind speeds in winter and autumn are generally less than those in summer and spring, as would be expected.

Based on the above information, atmospheric dispersion conditions on the Anderson property are expected to be reasonably good. As in most areas of the country, the lowest potential for dispersion of atmospheric pollutants usually occurs during the morning, with light wind speeds, high stabilities, and a shallow mixing layer. The highest dispersion potential should occur during spring and summer afternoons. Topography will play a role in dispersion of emissions from proposed project activities. Some topographic effects have been approximated for assessment of project-related impacts through the use of the EPA Valley Model as discussed in Section 4.0.

Severe Weather

Thunderstorms are frequent during the summer and early fall, when moist air moves into the region from the Gulf of Mexico and the western

Table 2.7-8. ESTIMATED AVERAGE MIXING DEPTHS AND WIND SPEEDS IN MIXING LAYERS FOR THE ANDERSON PROPERTY

| | Mixing Depths (meters) | Wind Speeds (meters/sec) |
|---|---|---|
| <u>Annual</u> | | |
| Morning | 300 | 4 |
| Afternoon | 2400 | 6 |
| <u>Winter</u> | | |
| Morning | 280 | 3.5 |
| Afternoon | 1300 | 4.5 |
| <u>Spring</u> | | |
| Morning | 300 | 4.5 |
| Afternoon | 2600 | 7 |
| <u>Summer</u> | | |
| Morning | 250 | 4 |
| Afternoon | 3200 | 6 |
| <u>Autumn</u> | | |
| Morning | 250 | 3.5 |
| Afternoon | 2100 | 5 |

Source: Holzworth, 1972.

coast of Mexico. Related precipitation is usually light, but a heavy local storm can produce over an inch of rain in a single day. The maximum precipitation reported to have fallen within 24 hours over a 38-year period of record at Phoenix was 3.07 inches (U.S. Department of Commerce, 1975). Hailstorms are observed infrequently in this area.

Table 2.7-9 shows the maximum precipitation estimated for any given location on the property (point precipitation) for specific durations and recurrence intervals. The table was compiled using technical procedures outlined by Hershfield (1961) and Miller (1964). Maximum short-term precipitation is usually associated with summer thunderstorms, although winter storms may on occasion deposit comparable amounts of moisture.

Table 2.7-9. ESTIMATED MAXIMUM POINT PRECIPITATION (inches) FOR SELECTED DURATIONS AND RECURRENCE INTERVALS AT THE PROPERTY

| | Recurrence Interval | | | | |
|---|---|---|---|---|---|
| Duration | 2 years | 10 years | 25 years | 50 years | 100 years |
| 1 hour | 0.7 | 1.3 | 1.6 | 1.8 | 2.0 |
| 12 hours | 1.5 | 2.5 | 3.0 | 3.5 | 4.0 |
| 24 hours | 1.8 | 3.0 | 3.6 | 4.0 | 4.6 |
| 2 days | 2.2 | 3.3 | 4.7 | 5.0 | 5.3 |
| 7 days | 2.6 | 4.5 | 5.5 | 6.5 | 7.0 |
| 10 days | 3.0 | 5.0 | 6.0 | 7.5 | 8.0 |

Sources: Hershfield, 1961; Miller, 1964.

Strong winds can occur in the project area along with thunderstorm activity in the spring and summer. Based on computations by Thom (1968), "extreme-mile" wind speeds 30 feet above the ground are estimated for selected recurrence intervals on the property as follows:

| | | | | |
|---|---|---|---|---|
| Maximum speed (mph) | 62 | 65 | 74 | 80 |
| Recurrence interval (years) | 10 | 25 | 50 | 100 |

The project area is susceptible to duststorms, which vary greatly in intensity, duration, and time of occurrence. The basic conditions for blowing dust are found in the general region: wide areas of exposed, dry topsoil and strong, turbulent winds. Duststorms usually occur during the warmer months following frontal passages and are occasionally associated with thunderstorm activities.

Tornadoes have been observed in the general region, but they occur infrequently. Based on the work of Markee et al. (undated), the probability (P) of a tornado striking a given point on the Anderson property is estimated to be $1.2 \times 10^{-4}$. The recurrence interval (1/P) of such an incident is estimated to be about 8300 years.

AIR QUALITY

The Anderson property is located in an isolated rural area of west-central Arizona. Air quality is generally very good and is influenced by natural processes, and occasionally by long-range transport of air pollutants from major urban centers. The nearest town is Bagdad, about 22 miles north-northeast of the property (Figure 2.1-1); the nearest major roadway is U.S. Highway 93 about 13 miles to the northeast; and the nearest major urban center is Phoenix, about 100 miles southeast of the property.

Existing air quality data are sparse for this area of Arizona and are not adequate to describe air quality on the property with statistical significance. Air quality monitoring on the Anderson property, described earlier in this section, has included two five-day monitoring programs, one in the summer and the other in the autumn of 1977, during which suspended particulate matter, sulfur dioxide, and ozone were measured continuously. A one-year monitoring program to measure suspended particulate concentrations once a week was also begun by MINERALS in September 1977.

The property is located within an area that has recently been designated by the EPA (1978) as an "attainment area" for suspended particulate matter and sulfur dioxide, indicating that National Ambient Air Quality Standards (NAAQS) (Table 2.7-10)* for these major pollutants are not exceeded. However, the EPA has determined that attainment status for photochemical oxidants, nitrogen dioxide, and carbon monoxide to be unclassifiable, on the basis that adequate monitoring data are not presently available for the area to determine attainment.

According to provisions of the federal Clean Air Act for Prevention of Significant Deterioration of Air Quality, the Anderson property and surrounding region have been designated Class II. The closest Class I areas are the Sycamore Canyon Wilderness Area to the northeast and the

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*Arizona has adopted the NAAQS. In the case of suspended particulate matter, the primary annual standard and the secondary 24-hour standard have been adopted.

Table 2.7-10. NATIONAL AMBIENT AIR QUALITY STANDARDS

| Pollutant | Description | Pollutant Standard: Primary | Pollutant Standard: Secondary |
|---|---|---|---|
| Total suspended particulates | Solid and liquid particles in the atmosphere, including dust, smoke, mists, fumes, and spray | 75 $\mu g/m^3$, annual geometric mean; 260 $\mu g/m$, maximum 24-hour average | 60 $\mu g/m^3$, annual geometric mean; 150 $\mu g/m^3$, maximum 24-hour average |
| Sulfur dioxide | Heavy, pungent, colorless gas formed from combustion of coal, oil, and other sources | 80 $\mu g/m^3$ (0.03 ppm), annual arithmetic mean; 365 $\mu g/m^3$ (0.14 ppm), maximum 24-hour average | 1300 $\mu g/m^3$ (0.5 ppm), maximum 3-hour average |
| Carbon monoxide | Invisible, odorless gas formed from combustion of gasoline, coal, and other fuels; largest man-made fraction comes from automobiles | 10 $mg/m^3$ (9 ppm), maximum 8-hour average; 40 $mg/m^3$ (35 ppm), maximum 1-hour average | Same as primary |
| Photochemical oxidants (such as ozone) | Pungent, colorless toxic gases; ozone is one component of photochemical smog | 160 $\mu g/m^3$ (0.08 ppm), maximum 1-hour average | Same as primary |
| Nitrogen dioxide | Brown, toxic gas formed from fuel combustion. Under certain conditions, it may be associated with ozone production. | 100 $\mu g/m^3$ (0.05 ppm), annual arithmetic mean | Same as primary |
| Hydrocarbons corrected for methane | Known to react with nitrogen oxides to form photochemical oxidants | 160 $\mu g/m^3$ (0.24 ppm) 3-hour average from 6 a.m. to 9 p.m. | Same as primary |

Source: Hoffman et al., 1975.

Pine Mountain Wilderness Area to the east. Both of these Class I areas are about 80 miles from the property.

Particulate Matter

Sampling performed on the property to date* indicates generally low concentrations of particulate matter. The state/federal 24-hour standard of 150 $\mu g/m^3$ (micrograms per cubic meter) was not exceeded (Table 2.7-11). The highest value measured on the property was 104 $\mu g/m^3$, when the wind speed averaged 13 mph and ranged as high as 23 mph. Natural blowing dust is expected to have been the cause of this concentration. The geometric mean of the 38 particulate samples taken on the property is 14 $\mu g/m^3$. Data collected by the state from 1971 through 1976 at a background surveillance station located at Montezuma Castle National Monument (Figure 2.7-2) indicate similar air quality conditions (Table 2.7-12).

Significant surface activities (i.e., vehicular and equipment travel and drilling with air drills) began with the resumption of mineral exploration prior to the February 25, 1978 sampling period. Exploration will be continued on a 10-day on, 4-day off schedule. Activities were initially concentrated in the vicinity of the proposed TP-2 and TP-3 pit areas (Figure 3.1-3) which are less than 1/2 mile southwest of the sample site. It is meaningful to note in Table 2.7-11 that no significant corresponding increase in measured suspended particulate concentrations was observed during these activities.

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*A standard high-volume air sampler fitted with a constant flow controller ($\pm$1 cfm) to increase sampling accuracy and calibrated with a calibrated orifice flow meter has been used to collect samples.

Table 2.7-11. TWENTY-FOUR-HOUR SUSPENDED PARTICULATE CONCENTRATIONS MEASURED ON THE ANDERSON PROPERTY[a]

| Date | Concentration ($\mu g/m^3$) | Date | Concentration ($\mu g/m^3$) |
|---|---|---|---|
| 7/13/77 | 38 | 12/9/77 | 19 |
| 7/14/77 | 58 | 12/16/77 | 23 |
| 7/15/77 | 73 | 12/23/77 | 23 |
| 7/16/77 | 39 | 12/31/77 | 10 |
| 7/17/77 | 77 | | |
| | | 1/7/78 | 6 |
| 9/16/77 | 20 | 1/12/78[c] | 3 |
| 9/26/77 | 21 | 1/12/78 | 2 |
| | | 1/4/78 | 5 |
| 10/1/77 | 13 | 1/21/78 | 7 |
| 10/8/77 | 6 | 1/28/78 | 5 |
| 10/15/77 | 11 | | |
| 10/16/77 | 7 | 2/4/78 | 9 |
| 10/30/77 | 9 | 2/11/78 | 5 |
| | | 2/18/78 | 3 |
| 11/5/77 | 39 | 2/25/78 | 15 |
| 11/9/77 | 18 | 3/4/78 | –[d] |
| 11/10/77 | 17 | 3/11/78 | 7 |
| 11/11/77 | 28 | 3/18/78 | 10 |
| 11/12/77 | 22 | 3/25/78 | 8 |
| 11/15/77 | 18 | | |
| 11/18/77 | 104 | | |
| 11/25/77 | –[b] | | |
| 12/2/77 | 5 | | |

[a]Sampling times are generally about 24 hours; however, the timer used to control sampling duration has been observed to occasionally run approximately 1 hour fast in a 24-hour period. This could result in a four percent error in the reported results. Sample periods are also occasionally short due to generator failure. Samples collected for periods less than about 20 hours are not reported.

[b]Sampler power supply ran out of fuel during sample collection.

[c]Two samples were taken simultaneously on January 12, 1978, one 3 feet above ground and the other 10 feet above ground.

[d]Missed due to bad weather and flooding.

Table 2.7-12. SUMMARY OF BASELINE SUSPENDED PARTICULATE CONCENTRATIONS FOR MONTEZUMA CASTLE NATIONAL MONUMENT, ARIZONA

| Year | 24-hour Averages Maximum ($\mu g/m^3$) | Second Highest ($\mu g/m^3$) | Geometric Mean ($\mu g/m^3$) |
|---|---|---|---|
| 1971 | 49 | * | 21 |
| 1972 | 111 | * | 26 |
| 1973 | 54 | 54 | 28 |
| 1974 | 72 | 64 | 27 |
| 1975 | 164 | 103 | 27 |
| 1976 | 64 | 59 | 30 |

Source: Arizona Department of Health Services, 1972-1977.

*Not reported.

Table 2.7-13 presents data for sulfate, nitrate, and lead concentrations in nine particulate samples collected at the site. Measured ambient sulfate concentrations ranged from 1.8 to 4.6 $\mu g/m^3$ and averaged 3.1 $\mu g/m^3$. These concentrations are well below the 25 $\mu g/m^3$ standard adopted by California, and one of the only states with a sulfate standard. In 1975, sulfate concentrations reported for Montezuma Castle National Monument averaged 2.5 $\mu g/m^3$ (Arizona Department of Health Services, 1976). Sulfate accounted for as much as 51 percent of the total particulate weight in 1 sample and averaged 26 percent in the 9 samples. It is suspected that native soils in the area are a major contributor to the observed airborne sulfate concentration. However, ambient sulfate levels did not correlate well with ambient suspended particulate levels.

**Table 2.7-13.** TWENTY-FOUR-HOUR AVERAGE CONCENTRATIONS OF PARTICULATE SULFATE, NITRATE AND LEAD AT THE ANDERSON SITE*

| | | Sulfate | | Nitrate | | Lead | |
|---|---|---|---|---|---|---|---|
| Sample Date | Total Particulate ($\mu g/m^3$) | Ambient ($\mu g/m^3$) | Percentage of Particulate Weight | Ambient ($\mu g/m^3$) | Percentage of Particulate Weight | Ambient ($\mu g/m^3$) | Percentage of Particulate Weight |
| 9/16/77 | 20 | 2.4 | 12 | 1.0 | 5 | 0.02 | 0.09 |
| 9/25/77 | 21 | 1.9 | 9 | 0.8 | 4 | 0.02 | 0.08 |
| 9/30/77 | 13 | 2.7 | 21 | 1.6 | 12 | 0.04 | 0.3 |
| 10/7/77 | 6 | 2.7 | 44 | 2.3 | 21 | 0.03 | 0.5 |
| 10/21/77 | 7 | 3.4 | 46 | 0.9 | 12 | 0.02 | 0.3 |
| 10/29/77 | 9 | 4.6 | 51 | 1.3 | 14 | 0.05 | 0.6 |
| 11/4/77 | 39 | 4.6 | 12 | 1.9 | 5 | 0.07 | 0.2 |
| 11/18/77 | 104 | 3.7 | 4 | 2.1 | 2 | 0.05 | 0.04 |
| 12/2/77 | 5 | 1.8 | 36 | 1.0 | 20 | 0.02 | 0.5 |

*Concentrations based on analytical data provided by Union Oil Company, March 1978. Particulates were sampled for approximate 24-hour periods.

Always lower than sulfate, ambient nitrate concentrations ranged from 0.8 to 2.3 $\mu g/m^3$ in the 9 samples and averaged 1.4 $\mu g/m^3$. This value is very close to the 1.3 $\mu g/m^3$ mean reported for 29 non-urban National Air Surveillance Network stations located throughout the country (Williams et al., 1973). Nitrate accounted for as much as 21 percent of the total particulate weight in 1 sample, but ranged as low as 4 percent of the total. As in the case of sulfate, natural soils in the region are suspected of contributing particulate nitrate to the ambient air.

Sulfate and nitrate combined accounted for 6 to 65 percent of the total particulate weight. The highest percentage occurred in two samples with relatively low total particulate concentration. Conversely, the lowest percentage corresponded to the highest ambient particulate concentration of the nine samples analyzed.

Ambient particulate lead concentrations for the 9 samples ranged from 0.02 to 0.07 $\mu g/m^3$. For comparison, particulate lead concentrations averaged 0.1 $\mu g/m^3$ at Montezuma Castle National Monument in 1975 (Arizona Department of Health Services, 1976). These levels are well below the proposed 1.5 $\mu g/m^3$ National Ambient Air Quality Standard for lead. By weight, lead accounted for only 0.04 to 0.6 percent of total suspended particulate matter. As in the case of sulfate and nitrate, the lowest percentage of lead corresponded to the highest ambient particulate concentration.

Sulfur Dioxide

Consecutive 24-hour-average sulfur dioxide ($SO_2$) concentrations were measured on the property during the two 5-day monitoring programs, using the Federal Reference Method (West-Gaeke bubblers). Solutions supplied and analyzed by the Arizona Bureau of Air Quality Control were kept in a temperature-controlled shelter during sampling (approximately 200 ml/min), and were placed on ice immediately following sampling and kept there until delivery for analysis. These precautionary measures were taken to minimize the possibility of sample degradation.

Sampling results (Table 2.7-14) indicate generally low background $SO_2$ concentrations that are well below state/federal standards. However, the observed concentrations are higher then would be expected at such a remote site. Potential reasons for the unexpectedly high results could include influence of emissions from the diesel electric power source located downhill and approximately 200 feet from the monitoring station, and possible analytical error or bias.

Table 2.7-14. TWENTY-FOUR-HOUR SULFUR DIOXIDE CONCENTRATIONS MEASURED ON THE ANDERSON PROPERTY

| Date | Concentration ($\mu g/m^3$) | | Concentration ($\mu g/m^3$) |
|---|---|---|---|
| 7/13/77 | 9 | 11-9-77 | 14 |
| 7/14/77 | 17 | 11-10-77 | 14 |
| 7/15/77 | 11 | 11-11-77 | 25 |
| 7/16/77 | 11 | 11-12-77 | 21 |
| 7/17/77 | 16 | 11-13-77 | 14 |

Photochemical Oxidants

Ozone, a major component of photochemical oxidants in rural air, was monitored continuously with a Bendix 8002 Ozone Analyzer (chemiluminescence method) during both 5-day field studies. The monitor was calibrated against a calibration standard and a calibrated monitor at the Arizona Bureau of Air Quality Control immediately prior to each study. In addition, operational checks were performed daily with an internal ozone generator.

In general, observed ozone concentrations were well below the federal one-hour standard (0.08 ppm). However, levels reached 75 percent of the standard one day during the July, 1977 field study.

A diurnal cycle was observed in hourly average ozone concentrations during both field studies, with higher concentrations occurring during the daytime and lower concentrations during the night. The highest concentrations and greatest daily ranges were observed during the July study as would be expected with greater solar radiation during summer months. Concentrations ranged between 0.025 ppm and 0.062 ppm in July, but were generally below 0.010 ppm during the November study when observed hourly average concentrations ranged between 0.005 ppm and 0.010 ppm. Observed hourly average ozone concentrations are provided in Appendix B-4.

An analysis of synoptic (large-scale) meteorological conditions during each field study indicates that air flow toward the property was generally from a southeasterly direction. Therefore, Phoenix is indicated as a possible source of ozone precursers during both studies. Long range transport of photochemical oxidants in urban air pollution plumes to remote rural areas has been observed in other areas of the country and is a main reason for most areas of Arizona having been tentatively determined to be "unclassifiable" with respect to attainment of the photochemical oxidant standard.

# APPENDIX B

# METEOROLOGY

Appendix B-1. DAILY AND MONTHLY TEMPERATURE DATA

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 12 | 21 | 52.9 | 64.0 | 44.0 |
| 12 | 22 | 48.8 | 63.0 | 39.0 |
| 12 | 23 | 50.2 | 64.0 | 39.0 |
| 12 | 24 | 46.5 | 57.0 | 36.0 |
| 12 | 25 | 49.4 | 62.0 | 38.0 |
| 12 | 26 | 52.3 | 64.0 | 42.0 |
| 12 | 27 | 49.6 | 62.0 | 40.0 |
| 12 | 28 | 51.9 | 68.0 | 39.0 |
| 12 | 29 | 50.7 | 59.0 | 43.0 |
| 12 | 30 | 44.6 | 52.0 | 37.0 |
| 12 | 31 | 41.9 | 43.0 | 41.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 12 | 49.0 | 59.8 | 39.8 | 68.0 | 36.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77 -

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 1 | 1 | 43.4 | 50.0 | 40.0 |
| 1 | 2 | 45.7 | 52.0 | 38.0 |
| 1 | 3 | 45.4 | 52.0 | 40.0 |
| 1 | 4 | 44.5 | 54.0 | 38.0 |
| 1 | 5 | 42.3 | 50.0 | 37.0 |
| 1 | 6 | 46.3 | 55.0 | 40.0 |
| 1 | 7 | 44.0 | 49.0 | 40.0 |
| 1 | 8 | 41.2 | 46.0 | 36.0 |
| 1 | 9 | 39.1 | 48.0 | 33.0 |
| 1 | 10 | 38.8 | 51.0 | 28.0 |
| 1 | 11 | 41.0 | 57.0 | 28.0 |
| 1 | 12 | 47.4 | 60.0 | 40.0 |
| 1 | 13 | 45.4 | 60.0 | 34.0 |
| 1 | 14 | 46.1 | 59.0 | 35.0 |
| 1 | 15 | 47.0 | 62.0 | 33.0 |
| 1 | 16 | 50.9 | 66.0 | 38.0 |
| 1 | 17 | 55.7 | 68.0 | 43.0 |
| 1 | 18 | 60.5 | 73.0 | 51.0 |
| 1 | 19 | 61.9 | 77.0 | 50.0 |
| 1 | 20 | 61.9 | 72.0 | 53.0 |
| 1 | 21 | 55.3 | 61.0 | 51.0 |
| 1 | 22 | 55.1 | 64.0 | 50.0 |
| 1 | 23 | 54.9 | 67.0 | 46.0 |
| 1 | 24 | 53.5 | 67.0 | 43.0 |
| 1 | 25 | 51.3 | 60.0 | 45.0 |
| 1 | 26 | 49.7 | 58.0 | 43.0 |
| 1 | 27 | 49.9 | 62.0 | 39.0 |
| 1 | 28 | 54.0 | 68.0 | 43.0 |
| 1 | 29 | 55.1 | 63.0 | 49.0 |
| 1 | 30 | 55.5 | 70.0 | 45.0 |
| 1 | 31 | 55.3 | 70.0 | 43.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 1 | 49.6 | 60.4 | 41.0 | 77.0 | 28.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 2 | 1 | 51.8 | 63.0 | 43.0 |
| 2 | 2 | 49.9 | 63.0 | 38.0 |
| 2 | 3 | 54.4 | 67.0 | 45.0 |
| 2 | 4 | 54.1 | 68.0 | 43.0 |
| 2 | 5 | 56.8 | 72.0 | 47.0 |
| 2 | 6 | 54.6 | 70.0 | 42.0 |
| 2 | 7 | 59.5 | 73.0 | 51.0 |
| 2 | 8 | 61.2 | 73.0 | 53.0 |
| 2 | 9 | 58.4 | 72.0 | 47.0 |
| 2 | 10 | 57.9 | 73.0 | 45.0 |
| 2 | 11 | 61.0 | 77.0 | 43.0 |
| 2 | 12 | 63.4 | 77.0 | 53.0 |
| 2 | 13 | 60.3 | 77.0 | 44.0 |
| 2 | 14 | 51.8 | 53.0 | 50.0 |
| 2 | 15 | 999.9 | 999.9 | 999.9 |
| 2 | 16 | 71.7 | 82.0 | 58.0 |
| 2 | 17 | 66.6 | 83.0 | 48.0 |
| 2 | 18 | 66.0 | 83.0 | 51.0 |
| 2 | 19 | 70.3 | 85.0 | 59.0 |
| 2 | 20 | 68.0 | 83.0 | 56.0 |
| 2 | 21 | 69.2 | 83.0 | 52.0 |
| 2 | 22 | 60.8 | 67.0 | 49.0 |
| 2 | 23 | 53.7 | 66.0 | 41.0 |
| 2 | 24 | 48.1 | 57.0 | 38.0 |
| 2 | 25 | 43.5 | 52.0 | 31.0 |
| 2 | 26 | 48.9 | 60.0 | 36.0 |
| 2 | 27 | 52.1 | 69.0 | 37.0 |
| 2 | 28 | 59.0 | 74.0 | 49.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 2 | 58.3 | 71.2 | 46.3 | 85.0 | 31.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 3 | 1 | 51.0 | 58.0 | 43.0 |
| 3 | 2 | 46.8 | 56.0 | 37.0 |
| 3 | 3 | 45.8 | 57.0 | 32.0 |
| 3 | 4 | 51.0 | 64.0 | 40.0 |
| 3 | 5 | 53.8 | 67.0 | 44.0 |
| 3 | 6 | 56.3 | 69.0 | 47.0 |
| 3 | 7 | 63.4 | 85.0 | 48.0 |
| 3 | 8 | 67.8 | 84.0 | 57.0 |
| 3 | 9 | 64.8 | 78.0 | 53.0 |
| 3 | 10 | 50.3 | 57.0 | 45.0 |
| 3 | 11 | 55.3 | 66.0 | 44.0 |
| 3 | 12 | 59.9 | 73.0 | 50.0 |
| 3 | 13 | 55.3 | 66.0 | 45.0 |
| 3 | 14 | 48.6 | 58.0 | 38.0 |
| 3 | 15 | 53.1 | 70.0 | 39.0 |
| 3 | 16 | 56.5 | 70.0 | 46.0 |
| 3 | 17 | 50.4 | 60.0 | 41.0 |
| 3 | 18 | 53.0 | 66.0 | 40.0 |
| 3 | 19 | 56.5 | 70.0 | 40.0 |
| 3 | 20 | 59.5 | 72.0 | 42.0 |
| 3 | 21 | 64.0 | 77.0 | 50.0 |
| 3 | 22 | 71.1 | 86.0 | 59.0 |
| 3 | 23 | 67.8 | 80.0 | 55.0 |
| 3 | 24 | 60.5 | 71.0 | 52.0 |
| 3 | 25 | 43.8 | 57.0 | 35.0 |
| 3 | 26 | 46.1 | 58.0 | 34.0 |
| 3 | 27 | 56.3 | 69.0 | 42.0 |
| 3 | 28 | 55.5 | 63.0 | 46.0 |
| 3 | 29 | 50.7 | 61.0 | 42.0 |
| 3 | 30 | 54.8 | 67.0 | 44.0 |
| 3 | 31 | 53.4 | 66.0 | 44.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 3 | 55.6 | 67.8 | 44.3 | 86.0 | 32.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 4 | 1 | 51.8 | 60.0 | 39.0 |
| 4 | 2 | 41.0 | 47.0 | 38.0 |
| 4 | 3 | 49.0 | 63.0 | 32.0 |
| 4 | 4 | 59.1 | 73.0 | 42.0 |
| 4 | 5 | 68.8 | 87.0 | 53.0 |
| 4 | 6 | 77.5 | 94.0 | 66.0 |
| 4 | 7 | 79.6 | 97.0 | 66.0 |
| 4 | 8 | 76.5 | 90.0 | 64.0 |
| 4 | 9 | 74.4 | 89.0 | 63.0 |
| 4 | 10 | 67.0 | 76.0 | 57.0 |
| 4 | 11 | 65.6 | 77.0 | 53.0 |
| 4 | 12 | 72.2 | 84.0 | 57.0 |
| 4 | 13 | 76.1 | 88.0 | 63.0 |
| 4 | 14 | 72.3 | 87.0 | 63.0 |
| 4 | 15 | 68.4 | 77.0 | 55.0 |
| 4 | 16 | 72.7 | 85.0 | 63.0 |
| 4 | 17 | 77.2 | 93.0 | 62.0 |
| 4 | 18 | 76.6 | 89.0 | 63.0 |
| 4 | 19 | 71.5 | 82.0 | 62.0 |
| 4 | 20 | 70.8 | 82.0 | 59.0 |
| 4 | 21 | 74.5 | 91.0 | 59.0 |
| 4 | 22 | 78.0 | 93.0 | 65.0 |
| 4 | 23 | 85.4 | 98.0 | 72.0 |
| 4 | 24 | 79.5 | 88.0 | 70.0 |
| 4 | 25 | 82.0 | 95.0 | 71.0 |
| 4 | 26 | 82.6 | 95.0 | 71.0 |
| 4 | 27 | 79.5 | 89.0 | 72.0 |
| 4 | 28 | 76.1 | 89.0 | 60.0 |
| 4 | 29 | 77.2 | 91.0 | 63.0 |
| 4 | 30 | 78.5 | 90.0 | 66.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 4 | 72.0 | 84.6 | 59.6 | 98.0 | 32.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 5 | 1 | 77.3 | 88.0 | 67.0 |
| 5 | 2 | 77.1 | 90.0 | 63.0 |
| 5 | 3 | 76.5 | 87.0 | 66.0 |
| 5 | 4 | 72.8 | 86.0 | 58.0 |
| 5 | 5 | 70.8 | 80.0 | 62.0 |
| 5 | 6 | 64.5 | 73.0 | 57.0 |
| 5 | 7 | 62.4 | 69.0 | 55.0 |
| 5 | 8 | 69.5 | 81.0 | 60.0 |
| 5 | 9 | 55.4 | 64.0 | 49.0 |
| 5 | 10 | 60.3 | 73.0 | 45.0 |
| 5 | 11 | 67.4 | 78.0 | 53.0 |
| 5 | 12 | 67.0 | 77.0 | 59.0 |
| 5 | 13 | 58.3 | 68.0 | 51.0 |
| 5 | 14 | 62.0 | 74.0 | 50.0 |
| 5 | 15 | 69.4 | 81.0 | 55.0 |
| 5 | 16 | 67.6 | 77.0 | 60.0 |
| 5 | 17 | 62.8 | 71.0 | 50.0 |
| 5 | 18 | 66.2 | 77.0 | 55.0 |
| 5 | 19 | 70.8 | 85.0 | 57.0 |
| 5 | 20 | 77.1 | 89.0 | 63.0 |
| 5 | 21 | 79.3 | 92.0 | 63.0 |
| 5 | 22 | 81.3 | 93.0 | 59.0 |
| 5 | 23 | 76.4 | 89.0 | 69.0 |
| 5 | 24 | 59.5 | 68.0 | 54.0 |
| 5 | 25 | 67.4 | 80.0 | 56.0 |
| 5 | 26 | 72.0 | 84.0 | 57.0 |
| 5 | 27 | 76.5 | 89.0 | 61.0 |
| 5 | 28 | 83.6 | 96.0 | 65.0 |
| 5 | 29 | 999.9 | 999.9 | 999.9 |
| 5 | 30 | 999.9 | 999.9 | 999.9 |
| 5 | 31 | 999.9 | 999.9 | 999.9 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY |
|---|---|---|---|---|---|
| 5 | 69.7 | 80.7 | 57.8 | 96.0 | 45.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 6 | 1 | 999.9 | 999.9 | 999.9 |
| 6 | 2 | 92.8 | 102.0 | 79.0 |
| 6 | 3 | 93.5 | 105.0 | 83.0 |
| 6 | 4 | 89.4 | 100.0 | 82.0 |
| 6 | 5 | 89.8 | 102.0 | 79.0 |
| 6 | 6 | 90.7 | 101.0 | 82.0 |
| 6 | 7 | 89.3 | 100.0 | 81.0 |
| 6 | 8 | 84.4 | 95.0 | 76.0 |
| 6 | 9 | 85.0 | 95.0 | 75.0 |
| 6 | 10 | 82.5 | 93.0 | 71.0 |
| 6 | 11 | 82.5 | 93.0 | 70.0 |
| 6 | 12 | 84.7 | 98.0 | 71.0 |
| 6 | 13 | 85.9 | 99.0 | 70.0 |
| 6 | 14 | 88.2 | 101.0 | 74.0 |
| 6 | 15 | 90.1 | 104.0 | 74.0 |
| 6 | 16 | 90.5 | 103.0 | 75.0 |
| 6 | 17 | 90.8 | 104.0 | 78.0 |
| 6 | 18 | 88.9 | 102.0 | 75.0 |
| 6 | 19 | 85.0 | 97.0 | 70.0 |
| 6 | 20 | 85.7 | 98.0 | 72.0 |
| 6 | 21 | 85.8 | 97.0 | 72.0 |
| 6 | 22 | 89.8 | 101.0 | 77.0 |
| 6 | 23 | 91.5 | 102.0 | 76.0 |
| 6 | 24 | 93.6 | 105.0 | 82.0 |
| 6 | 25 | 94.6 | 105.0 | 82.0 |
| 6 | 26 | 95.5 | 107.0 | 82.0 |
| 6 | 27 | 97.4 | 110.0 | 82.0 |
| 6 | 28 | 99.0 | 110.0 | 84.0 |
| 6 | 29 | 99.4 | 110.0 | 86.0 |
| 6 | 30 | 99.5 | 110.0 | 87.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 6 | 90.2 | 101.7 | 77.5 | 110.0 | 70.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 7 | 1 | 95.0 | 105.0 | 84.0 |
| 7 | 2 | 94.8 | 103.0 | 83.0 |
| 7 | 3 | 88.4 | 93.0 | 80.0 |
| 7 | 4 | 88.9 | 98.0 | 80.0 |
| 7 | 5 | 90.0 | 100.0 | 78.0 |
| 7 | 6 | 93.8 | 105.0 | 80.0 |
| 7 | 7 | 96.1 | 107.0 | 82.0 |
| 7 | 8 | 96.4 | 107.0 | 82.0 |
| 7 | 9 | 97.0 | 107.0 | 82.0 |
| 7 | 10 | 94.4 | 103.0 | 82.0 |
| 7 | 11 | 94.0 | 103.0 | 84.0 |
| 7 | 12 | 94.9 | 105.0 | 82.0 |
| 7 | 13 | 95.2 | 105.0 | 85.0 |
| 7 | 14 | 94.6 | 106.0 | 81.0 |
| 7 | 15 | 92.7 | 107.0 | 85.0 |
| 7 | 16 | 93.4 | 108.0 | 85.0 |
| 7 | 17 | 92.0 | 106.0 | 85.0 |
| 7 | 18 | 83.1 | 86.0 | 77.0 |
| 7 | 19 | 89.3 | 100.0 | 79.0 |
| 7 | 20 | 92.1 | 107.0 | 80.0 |
| 7 | 21 | 92.2 | 101.0 | 83.0 |
| 7 | 22 | 91.8 | 98.0 | 83.0 |
| 7 | 23 | 79.3 | 88.0 | 73.0 |
| 7 | 24 | 85.7 | 100.0 | 70.0 |
| 7 | 25 | 95.6 | 108.0 | 80.0 |
| 7 | 26 | 94.9 | 108.0 | 82.0 |
| 7 | 27 | 96.6 | 108.0 | 83.0 |
| 7 | 28 | 100.3 | 112.0 | 87.0 |
| 7 | 29 | 97.8 | 107.0 | 91.0 |
| 7 | 30 | 95.1 | 102.0 | 86.0 |
| 7 | 31 | 98.9 | 111.0 | 85.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 7 | 93.0 | 103.4 | 82.1 | 112.0 | 70.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/15/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 8 | 1 | 97.6 | 108.0 | 87.0 |
| 8 | 2 | 96.9 | 108.0 | 85.0 |
| 8 | 3 | 97.9 | 109.0 | 87.0 |
| 8 | 4 | 97.2 | 108.0 | 85.0 |
| 8 | 5 | 98.8 | 110.0 | 85.0 |
| 8 | 6 | 96.8 | 108.0 | 85.0 |
| 8 | 7 | 96.3 | 106.0 | 87.0 |
| 8 | 8 | 95.5 | 103.0 | 85.0 |
| 8 | 9 | 92.4 | 103.0 | 84.0 |
| 8 | 10 | 89.0 | 103.0 | 82.0 |
| 8 | 11 | 93.4 | 108.0 | 80.0 |
| 8 | 12 | 90.4 | 104.0 | 83.0 |
| 8 | 13 | 92.8 | 104.0 | 82.0 |
| 8 | 14 | 89.6 | 104.0 | 82.0 |
| 8 | 15 | 80.1 | 91.0 | 72.0 |
| 8 | 16 | 76.0 | 85.0 | 72.0 |
| 8 | 17 | 81.0 | 91.0 | 72.0 |
| 8 | 18 | 87.0 | 98.0 | 73.0 |
| 8 | 19 | 90.6 | 102.0 | 79.0 |
| 8 | 20 | 93.9 | 106.0 | 80.0 |
| 8 | 21 | 91.8 | 102.0 | 82.0 |
| 8 | 22 | 88.2 | 98.0 | 80.0 |
| 8 | 23 | 84.7 | 95.0 | 72.0 |
| 8 | 24 | 86.8 | 98.0 | 76.0 |
| 8 | 25 | 89.1 | 102.0 | 78.0 |
| 8 | 26 | 87.0 | 98.0 | 78.0 |
| 8 | 27 | 84.4 | 97.0 | 72.0 |
| 8 | 28 | 89.0 | 103.0 | 76.0 |
| 8 | 29 | 91.1 | 103.0 | 75.0 |
| 8 | 30 | 91.9 | 103.0 | 80.0 |
| 8 | 31 | 90.1 | 102.0 | 78.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 8 | 90.5 | 101.9 | 79.8 | 110.0 | 72.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 9 | 1 | 91.1 | 102.0 | 78.0 |
| 9 | 2 | 92.5 | 102.0 | 83.0 |
| 9 | 3 | 94.1 | 104.0 | 83.0 |
| 9 | 4 | 95.4 | 106.0 | 83.0 |
| 9 | 5 | 94.3 | 106.0 | 81.0 |
| 9 | 6 | 94.8 | 108.0 | 82.0 |
| 9 | 7 | 97.4 | 110.0 | 86.0 |
| 9 | 8 | 96.8 | 110.0 | 84.0 |
| 9 | 9 | 92.9 | 103.0 | 83.0 |
| 9 | 10 | 83.6 | 94.0 | 73.0 |
| 9 | 11 | 73.8 | 79.0 | 63.0 |
| 9 | 12 | 78.1 | 90.0 | 69.0 |
| 9 | 13 | 82.8 | 97.0 | 72.0 |
| 9 | 14 | 84.5 | 95.0 | 75.0 |
| 9 | 15 | 81.9 | 93.0 | 70.0 |
| 9 | 16 | 77.7 | 87.0 | 70.0 |
| 9 | 17 | 73.8 | 84.0 | 62.0 |
| 9 | 18 | 78.8 | 93.0 | 66.0 |
| 9 | 19 | 80.3 | 93.0 | 68.0 |
| 9 | 20 | 76.7 | 89.0 | 64.0 |
| 9 | 21 | 77.8 | 90.0 | 66.0 |
| 9 | 22 | 77.9 | 89.0 | 70.0 |
| 9 | 23 | 79.3 | 89.0 | 70.0 |
| 9 | 24 | 80.3 | 93.0 | 69.0 |
| 9 | 25 | 84.3 | 97.0 | 72.0 |
| 9 | 26 | 86.0 | 95.0 | 77.0 |
| 9 | 27 | 71.1 | 80.0 | 65.0 |
| 9 | 28 | 76.6 | 90.0 | 65.0 |
| 9 | 29 | 80.8 | 93.0 | 70.0 |
| 9 | 30 | 78.0 | 89.0 | 67.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 9 | 83.8 | 95.0 | 72.9 | 110.0 | 62.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 10 | 1 | 79.3 | 94.0 | 68.0 |
| 10 | 2 | 81.1 | 95.0 | 68.0 |
| 10 | 3 | 83.1 | 96.0 | 72.0 |
| 10 | 4 | 83.3 | 97.0 | 70.0 |
| 10 | 5 | 80.6 | 94.0 | 73.0 |
| 10 | 6 | 67.1 | 70.0 | 63.0 |
| 10 | 7 | 72.9 | 84.0 | 65.0 |
| 10 | 8 | 74.3 | 89.0 | 66.0 |
| 10 | 9 | 75.7 | 86.0 | 64.0 |
| 10 | 10 | 76.3 | 88.0 | 66.0 |
| 10 | 11 | 79.0 | 92.0 | 72.0 |
| 10 | 12 | 79.0 | 90.0 | 71.0 |
| 10 | 13 | 77.4 | 92.0 | 68.0 |
| 10 | 14 | 78.6 | 93.0 | 65.0 |
| 10 | 15 | 83.1 | 95.0 | 74.0 |
| 10 | 16 | 83.1 | 93.0 | 76.0 |
| 10 | 17 | 83.2 | 97.0 | 73.0 |
| 10 | 18 | 80.7 | 94.0 | 72.0 |
| 10 | 19 | 75.3 | 86.0 | 67.0 |
| 10 | 20 | 69.3 | 77.0 | 62.0 |
| 10 | 21 | 67.6 | 78.0 | 60.0 |
| 10 | 22 | 70.7 | 83.0 | 59.0 |
| 10 | 23 | 73.1 | 84.0 | 64.0 |
| 10 | 24 | 72.4 | 86.0 | 64.0 |
| 10 | 25 | 74.7 | 88.0 | 62.0 |
| 10 | 26 | 77.0 | 89.0 | 68.0 |
| 10 | 27 | 74.2 | 84.0 | 65.0 |
| 10 | 28 | 73.7 | 83.0 | 63.0 |
| 10 | 29 | 68.7 | 73.0 | 63.0 |
| 10 | 30 | 63.9 | 75.0 | 53.0 |
| 10 | 31 | 63.5 | 75.0 | 53.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 10 | 75.5 | 87.1 | 66.1 | 97.0 | 53.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 11 | 1 | 64.2 | 77.0 | 53.0 |
| 11 | 2 | 68.6 | 81.0 | 57.0 |
| 11 | 3 | 71.4 | 84.0 | 60.0 |
| 11 | 4 | 69.8 | 82.0 | 59.0 |
| 11 | 5 | 65.8 | 76.0 | 57.0 |
| 11 | 6 | 51.7 | 59.0 | 46.0 |
| 11 | 7 | 51.1 | 59.0 | 44.0 |
| 11 | 8 | 55.2 | 69.0 | 43.0 |
| 11 | 9 | 55.2 | 65.0 | 49.0 |
| 11 | 10 | 62.0 | 75.0 | 50.0 |
| 11 | 11 | 68.7 | 80.0 | 61.0 |
| 11 | 12 | 68.8 | 84.0 | 60.0 |
| 11 | 13 | 69.2 | 82.0 | 59.0 |
| 11 | 14 | 65.5 | 78.0 | 54.0 |
| 11 | 15 | 64.3 | 77.0 | 52.0 |
| 11 | 16 | 65.0 | 78.0 | 52.0 |
| 11 | 17 | 65.0 | 82.0 | 54.0 |
| 11 | 18 | 64.4 | 73.0 | 56.0 |
| 11 | 19 | 59.9 | 65.0 | 52.0 |
| 11 | 20 | 49.3 | 57.0 | 43.0 |
| 11 | 21 | 51.4 | 65.0 | 39.0 |
| 11 | 22 | 57.8 | 70.0 | 49.0 |
| 11 | 23 | 58.6 | 71.0 | 50.0 |
| 11 | 24 | 60.5 | 73.0 | 49.0 |
| 11 | 25 | 62.8 | 81.0 | 50.0 |
| 11 | 26 | 66.1 | 81.0 | 53.0 |
| 11 | 27 | 63.6 | 76.0 | 53.0 |
| 11 | 28 | 62.0 | 73.0 | 49.0 |
| 11 | 29 | 60.4 | 68.0 | 54.0 |
| 11 | 30 | 59.8 | 73.0 | 46.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 11 | 61.9 | 73.8 | 51.8 | 84.0 | 39.0 |

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

| MONTH | DAY | DAILY AVERAGE | DAILY MAX | DAILY MIN |
|---|---|---|---|---|
| 12 | 1 | 57.0 | 69.0 | 47.0 |
| 12 | 2 | 57.1 | 70.0 | 45.0 |
| 12 | 3 | 59.0 | 73.0 | 46.0 |
| 12 | 4 | 59.0 | 73.0 | 48.0 |
| 12 | 5 | 59.1 | 72.0 | 47.0 |
| 12 | 6 | 62.1 | 77.0 | 47.0 |
| 12 | 7 | 61.5 | 76.0 | 50.0 |
| 12 | 8 | 60.4 | 74.0 | 50.0 |
| 12 | 9 | 61.9 | 76.0 | 50.0 |
| 12 | 10 | 63.3 | 73.0 | 56.0 |
| 12 | 11 | 60.7 | 73.0 | 52.0 |
| 12 | 12 | 56.9 | 68.0 | 48.0 |
| 12 | 13 | 57.4 | 69.0 | 49.0 |
| 12 | 14 | 57.1 | 73.0 | 44.0 |
| 12 | 15 | 60.4 | 72.0 | 50.0 |
| 12 | 16 | 48.7 | 55.0 | 44.0 |

| MONTH | MONTHLY AVE | MONTHLY AVE MAX | MONTHLY AVE MIN | MONTHLY MAX | MONTHLY M |
|---|---|---|---|---|---|
| 12 | 58.8 | 71.4 | 48.3 | 77.0 | 44.0 |

Appendix B-2. DIURNAL WIND DIRECTION FREQUENCY TABULATIONS SEASONAL AND ANNUAL

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS
MINERALS - ANDERSON
12/21/76 - 2/28/77
SPEED CLASS ALL MPH

WINTER

| | HOUR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | TOTL |
| N | 12 | 20 | 20 | 13 | 23 | 18 | 17 | 14 | 14 | 16 | 10 | 13 | 3 | 2 | 4 | 2 | 0 | 1 | 1 | 0 | 0 | 3 | 3 | 9 | 218 |
| NNE | 7 | 4 | 8 | 11 | 9 | 8 | 8 | 9 | 9 | 12 | 11 | 5 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 8 | 119 |
| NE | 4 | 10 | 3 | 5 | 1 | 3 | 1 | 3 | 2 | 3 | 6 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 4 | 6 | 60 |
| ENE | 4 | 3 | 3 | 1 | 0 | 2 | 0 | 2 | 2 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 4 | 7 | 40 |
| E | 4 | 3 | 1 | 2 | 1 | 1 | 0 | 2 | 2 | 0 | 2 | 1 | 0 | 2 | 0 | 1 | 2 | 2 | 1 | 1 | 3 | 2 | 10 | 13 | 56 |
| ESE | 5 | 6 | 2 | 0 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 2 | 10 | 18 | 16 | 20 | 11 | 110 |
| SE | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 0 | 2 | 2 | 3 | 3 | 5 | 4 | 6 | 4 | 8 | 9 | 17 | 7 | 1 | 87 |
| SSE | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 3 | 3 | 0 | 5 | 5 | 15 | 11 | 4 | 2 | 58 |
| S | 3 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 1 | 6 | 4 | 14 | 9 | 5 | 2 | 1 | 57 |
| SSW | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 4 | 2 | 1 | 0 | 0 | 1 | 2 | 5 | 4 | 5 | 3 | 1 | 0 | 1 | 37 |
| SW | 3 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 3 | 6 | 3 | 6 | 7 | 4 | 7 | 5 | 2 | 0 | 1 | 1 | 55 |
| WSW | 0 | 0 | 4 | 3 | 1 | 1 | 2 | 3 | 2 | 0 | 6 | 13 | 24 | 19 | 34 | 38 | 38 | 35 | 29 | 11 | 0 | 1 | 0 | 2 | 266 |
| W | 3 | 0 | 2 | 2 | 2 | 2 | 5 | 4 | 5 | 1 | 7 | 9 | 5 | 16 | 13 | 8 | 3 | 5 | 6 | 3 | 2 | 1 | 0 | 0 | 104 |
| WNW | 1 | 3 | 6 | 7 | 6 | 6 | 7 | 5 | 4 | 7 | 1 | 4 | 4 | 4 | 2 | 1 | 1 | 2 | 2 | 2 | 4 | 3 | 4 | 1 | 87 |
| NW | 8 | 5 | 5 | 7 | 6 | 6 | 7 | 3 | 5 | 5 | 5 | 9 | 11 | 5 | 3 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 3 | 3 | 103 |
| NNW | 11 | 9 | 8 | 14 | 11 | 15 | 12 | 16 | 16 | 11 | 7 | 2 | 7 | 3 | 1 | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 4 | 2 | 154 |
| CALM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTL | 68 | 68 | 67 | 67 | 67 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 66 | 67 | 67 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 1611 |

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS

MINERALS - ANDERSON

3/ 1/77 - 5/31/77

SPEED CLASS ALL MPH

SPRING

| | HOUR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | TOTL |
| N | 7 | 13 | 20 | 21 | 22 | 30 | 28 | 31 | 35 | 21 | 10 | 3 | 4 | 2 | 1 | 1 | 2 | 2 | 6 | 2 | 2 | 2 | 4 | 5 | 274 |
| NNE | 10 | 9 | 8 | 19 | 16 | 9 | 16 | 16 | 15 | 6 | 3 | 2 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 2 | 4 | 4 | 147 |
| NE | 6 | 6 | 3 | 5 | 10 | 6 | 3 | 4 | 4 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 59 |
| ENE | 1 | 6 | 6 | 4 | 1 | 3 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 3 | 39 |
| E | 4 | 8 | 8 | 7 | 3 | 4 | 4 | 3 | 5 | 2 | 0 | 2 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 6 | 64 |
| ESE | 20 | 14 | 12 | 5 | 5 | 9 | 11 | 10 | 8 | 6 | 5 | 5 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 8 | 10 | 24 | 162 |
| SE | 11 | 7 | 4 | 4 | 5 | 4 | 1 | 3 | 3 | 8 | 10 | 9 | 7 | 5 | 4 | 3 | 0 | 2 | 1 | 1 | 8 | 10 | 14 | 9 | 133 |
| SSE | 4 | 6 | 5 | 1 | 3 | 2 | 2 | 3 | 3 | 1 | 6 | 10 | 15 | 13 | 9 | 8 | 12 | 8 | 8 | 11 | 11 | 10 | 7 | 7 | 165 |
| S | 5 | 3 | 5 | 6 | 4 | 6 | 1 | 1 | 0 | 4 | 3 | 5 | 10 | 15 | 23 | 20 | 15 | 12 | 11 | 12 | 13 | 12 | 15 | 7 | 208 |
| SSW | 4 | 2 | 3 | 1 | 1 | 3 | 1 | 0 | 0 | 2 | 1 | 5 | 9 | 11 | 11 | 11 | 10 | 14 | 12 | 4 | 9 | 10 | 4 | 4 | 132 |
| SW | 4 | 2 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 3 | 2 | 9 | 8 | 10 | 12 | 8 | 3 | 9 | 7 | 5 | 7 | 4 | 103 |
| WSW | 3 | 3 | 2 | 4 | 2 | 0 | 1 | 1 | 3 | 6 | 15 | 16 | 13 | 13 | 14 | 17 | 19 | 19 | 26 | 23 | 18 | 12 | 7 | 6 | 243 |
| W | 2 | 2 | 1 | 0 | 1 | 2 | 3 | 0 | 0 | 4 | 4 | 10 | 11 | 9 | 12 | 10 | 8 | 11 | 14 | 12 | 8 | 6 | 3 | 1 | 134 |
| WNW | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 4 | 2 | 2 | 5 | 2 | 2 | 2 | 3 | 4 | 3 | 3 | 3 | 4 | 6 | 5 | 1 | 2 | 65 |
| NW | 0 | 1 | 2 | 1 | 5 | 0 | 1 | 2 | 0 | 4 | 8 | 5 | 2 | 2 | 0 | 1 | 1 | 2 | 0 | 3 | 2 | 2 | 3 | 1 | 48 |
| NNW | 3 | 6 | 7 | 7 | 9 | 8 | 11 | 8 | 10 | 19 | 13 | 8 | 3 | 3 | 1 | 0 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 129 |
| CALM | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| TOTL | 87 | 89 | 89 | 89 | 89 | 89 | 89 | 89 | 89 | 89 | 88 | 87 | 86 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 2106 |

SUMMER

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS
MINERALS - ANDERSON
6/ 1/77 - 8/31/77
SPEED CLASS ALL MPH

HOUR

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | TOTL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 0 | 2 | 4 | 2 | 8 | 7 | 9 | 17 | 17 | 11 | 2 | 2 | 0 | 1 | 0 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 0 | 1 | 97 |
| NNE | 5 | 2 | 1 | 2 | 5 | 5 | 4 | 5 | 5 | 1 | 3 | 1 | 3 | 0 | 2 | 2 | 1 | 1 | 2 | 0 | 4 | 2 | 3 | 2 | 61 |
| NE | 0 | 2 | 1 | 5 | 2 | 1 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 4 | 2 | 0 | 1 | 2 | 30 |
| ENE | 2 | 1 | 8 | 10 | 6 | 7 | 8 | 7 | 9 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 4 | 2 | 80 |
| E | 8 | 11 | 16 | 18 | 13 | 18 | 19 | 12 | 12 | 9 | 6 | 4 | 1 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 5 | 0 | 3 | 161 |
| ESE | 20 | 21 | 23 | 15 | 17 | 10 | 12 | 7 | 8 | 11 | 11 | 10 | 9 | 3 | 1 | 2 | 3 | 1 | 0 | 1 | 1 | 3 | 6 | 6 | 201 |
| SE | 19 | 21 | 15 | 10 | 12 | 10 | 9 | 3 | 2 | 4 | 13 | 16 | 9 | 6 | 3 | 0 | 1 | 1 | 2 | 0 | 1 | 3 | 2 | 14 | 176 |
| SSE | 8 | 5 | 4 | 5 | 5 | 7 | 1 | 3 | 2 | 0 | 2 | 13 | 20 | 11 | 10 | 10 | 9 | 7 | 4 | 4 | 2 | 2 | 9 | 14 | 157 |
| S | 18 | 13 | 12 | 13 | 8 | 11 | 12 | 11 | 14 | 23 | 12 | 14 | 11 | 27 | 20 | 17 | 17 | 19 | 15 | 11 | 9 | 9 | 18 | 28 | 362 |
| SSW | 5 | 5 | 4 | 3 | 4 | 1 | 3 | 3 | 1 | 4 | 5 | 7 | 4 | 8 | 13 | 14 | 9 | 11 | 13 | 10 | 8 | 10 | 20 | 7 | 172 |
| SW | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 4 | 5 | 2 | 6 | 5 | 8 | 8 | 14 | 10 | 14 | 2 | 85 |
| WSW | 3 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 8 | 22 | 12 | 14 | 21 | 15 | 16 | 16 | 22 | 15 | 18 | 6 | 2 | 205 |
| W | 2 | 4 | 0 | 2 | 2 | 0 | 0 | 0 | 2 | 3 | 9 | 10 | 10 | 14 | 18 | 16 | 24 | 22 | 22 | 24 | 29 | 22 | 5 | 4 | 244 |
| WNW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 5 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 21 |
| NW | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 4 | 5 | 4 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 28 |
| NNW | 0 | 1 | 0 | 2 | 5 | 12 | 10 | 12 | 11 | 12 | 7 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 81 |
| CALM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTL | 91 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 89 | 89 | 90 | 90 | 90 | 89 | 89 | 91 | 91 | 91 | 91 | 2161 |

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS

MINERALS - ANDERSON

9/ 1/77 - 11/30/77

SPEED CLASS ALL MPH

FALL

| | HOUR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | TOTL |
| N | 12 | 16 | 19 | 22 | 33 | 35 | 38 | 34 | 34 | 34 | 19 | 13 | 6 | 4 | 2 | 2 | 2 | 2 | 1 | 2 | 4 | 2 | 5 | 12 | 353 |
| NNE | 6 | 7 | 13 | 8 | 5 | 11 | 12 | 7 | 11 | 7 | 6 | 3 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 3 | 1 | 2 | 3 | 5 | 115 |
| NE | 3 | 6 | 3 | 7 | 8 | 9 | 7 | 8 | 4 | 4 | 3 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 69 |
| ENE | 6 | 3 | 7 | 2 | 6 | 1 | 3 | 0 | 4 | 2 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 49 |
| E | 12 | 12 | 11 | 6 | 4 | 7 | 1 | 2 | 4 | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 0 | 2 | 1 | 0 | 1 | 2 | 6 | 12 | 90 |
| ESE | 12 | 9 | 7 | 4 | 6 | 5 | 5 | 8 | 6 | 3 | 3 | 6 | 2 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 4 | 10 | 17 | 14 | 126 |
| SE | 15 | 11 | 10 | 8 | 2 | 3 | 3 | 4 | 2 | 2 | 4 | 2 | 6 | 5 | 5 | 4 | 3 | 3 | 9 | 13 | 21 | 25 | 25 | 16 | 201 |
| SSE | 3 | 2 | 2 | 1 | 2 | 3 | 4 | 1 | 1 | 2 | 4 | 12 | 10 | 13 | 11 | 11 | 10 | 10 | 8 | 15 | 11 | 17 | 12 | 10 | 175 |
| S | 6 | 3 | 2 | 0 | 1 | 1 | 2 | 2 | 1 | 1 | 6 | 6 | 9 | 7 | 7 | 9 | 9 | 7 | 10 | 13 | 18 | 14 | 6 | 5 | 145 |
| SSW | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 3 | 2 | 4 | 5 | 9 | 13 | 7 | 8 | 8 | 4 | 4 | 9 | 1 | 6 | 0 | 90 |
| SW | 3 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 2 | 2 | 2 | 4 | 4 | 6 | 5 | 5 | 6 | 9 | 7 | 5 | 7 | 1 | 2 | 77 |
| WSW | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 14 | 15 | 21 | 29 | 39 | 34 | 34 | 33 | 23 | 14 | 7 | 3 | 2 | 281 |
| W | 1 | 3 | 2 | 4 | 2 | 0 | 1 | 0 | 1 | 0 | 3 | 5 | 17 | 17 | 9 | 7 | 14 | 13 | 9 | 8 | 0 | 0 | 1 | 0 | 117 |
| WNW | 1 | 0 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 0 | 0 | 2 | 29 |
| NW | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 2 | 1 | 5 | 3 | 8 | 5 | 3 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 46 |
| NNW | 10 | 16 | 12 | 19 | 16 | 14 | 11 | 20 | 20 | 19 | 28 | 13 | 7 | 3 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 2 | 3 | 221 |
| CALM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTL | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 2184 |

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS
MINERALS - ANDERSON
12/21/76 - 11/30/77
SPEED CLASS ALL MPH

ANNUAL

| | HOUR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | TOTL |
| N | 31 | 50 | 63 | 58 | 86 | 90 | 92 | 96 | 100 | 82 | 41 | 31 | 13 | 9 | 7 | 7 | 7 | 7 | 10 | 6 | 7 | 9 | 12 | 27 | 941 |
| NNE | 28 | 22 | 30 | 40 | 35 | 33 | 40 | 37 | 40 | 26 | 23 | 11 | 7 | 3 | 4 | 3 | 2 | 3 | 4 | 7 | 6 | 7 | 12 | 19 | 442 |
| NE | 13 | 24 | 10 | 22 | 21 | 19 | 12 | 19 | 11 | 8 | 10 | 4 | 2 | 2 | 1 | 0 | 2 | 2 | 4 | 4 | 5 | 4 | 7 | 12 | 218 |
| ENE | 13 | 13 | 24 | 17 | 13 | 13 | 14 | 12 | 16 | 8 | 4 | 2 | 3 | 1 | 1 | 2 | 0 | 3 | 2 | 4 | 3 | 9 | 12 | 19 | 208 |
| E | 28 | 34 | 36 | 33 | 21 | 30 | 24 | 19 | 23 | 12 | 9 | 7 | 3 | 5 | 2 | 5 | 4 | 6 | 3 | 1 | 5 | 9 | 18 | 34 | 371 |
| ESE | 57 | 50 | 44 | 24 | 30 | 25 | 31 | 27 | 24 | 23 | 22 | 21 | 17 | 6 | 4 | 3 | 6 | 1 | 3 | 13 | 23 | 37 | 53 | 55 | 599 |
| SE | 46 | 41 | 31 | 23 | 20 | 18 | 14 | 11 | 10 | 17 | 27 | 29 | 24 | 19 | 15 | 12 | 8 | 12 | 16 | 22 | 39 | 55 | 48 | 40 | 597 |
| SSE | 15 | 13 | 11 | 7 | 13 | 13 | 7 | 7 | 6 | 3 | 12 | 36 | 47 | 38 | 32 | 32 | 34 | 25 | 25 | 35 | 39 | 40 | 32 | 33 | 555 |
| S | 32 | 20 | 21 | 20 | 13 | 18 | 16 | 14 | 15 | 29 | 25 | 26 | 30 | 50 | 50 | 46 | 42 | 44 | 40 | 50 | 49 | 40 | 41 | 41 | 772 |
| SSW | 11 | 10 | 8 | 5 | 7 | 5 | 6 | 5 | 2 | 9 | 12 | 18 | 19 | 28 | 37 | 33 | 29 | 38 | 33 | 23 | 29 | 22 | 30 | 12 | 431 |
| SW | 11 | 4 | 4 | 5 | 4 | 3 | 1 | 1 | 0 | 4 | 7 | 8 | 9 | 23 | 22 | 23 | 30 | 23 | 27 | 29 | 28 | 22 | 23 | 9 | 320 |
| WSW | 7 | 5 | 7 | 13 | 3 | 1 | 3 | 4 | 5 | 13 | 32 | 51 | 74 | 65 | 91 | 115 | 106 | 104 | 104 | 79 | 47 | 38 | 16 | 12 | 995 |
| W | 8 | 9 | 5 | 8 | 7 | 4 | 9 | 4 | 9 | 8 | 23 | 34 | 43 | 56 | 52 | 41 | 49 | 51 | 51 | 47 | 39 | 29 | 9 | 5 | 599 |
| WNW | 4 | 4 | 8 | 9 | 9 | 8 | 12 | 13 | 8 | 15 | 10 | 9 | 8 | 9 | 8 | 7 | 5 | 8 | 8 | 7 | 13 | 8 | 6 | 6 | 202 |
| NW | 8 | 6 | 8 | 11 | 14 | 8 | 11 | 11 | 11 | 18 | 23 | 23 | 18 | 10 | 4 | 3 | 5 | 7 | 2 | 5 | 3 | 4 | 7 | 5 | 225 |
| NNW | 24 | 32 | 27 | 42 | 41 | 49 | 44 | 56 | 57 | 61 | 55 | 24 | 17 | 9 | 4 | 3 | 7 | 2 | 3 | 3 | 2 | 4 | 11 | 8 | 585 |
| CALM | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| TOTL | 337 | 337 | 337 | 337 | 337 | 337 | 336 | 336 | 334 | 336 | 335 | 334 | 334 | 333 | 334 | 335 | 336 | 336 | 335 | 335 | 337 | 337 | 337 | 337 | 8061 |

152

Appendix B-3. ANNUAL RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION AND SPEED BY STABILITY CLASS 12/21/76 - 11/30/77

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS A

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.000372 | 0.002109 | 0.000868 | 0.000124 | 0.0 | 0.0 | 0.003474 |
| NNE | 0.000124 | 0.000620 | 0.000496 | 0.0 | 0.0 | 0.0 | 0.001241 |
| NE | 0.0 | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.000124 |
| ENE | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| E | 0.0 | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000248 |
| ESE | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| SE | 0.0 | 0.000124 | 0.000496 | 0.000124 | 0.0 | 0.0 | 0.000744 |
| SSE | 0.0 | 0.000124 | 0.001613 | 0.000496 | 0.000372 | 0.000248 | 0.002853 |
| S | 0.0 | 0.000620 | 0.002233 | 0.000372 | 0.0 | 0.0 | 0.003225 |
| SSW | 0.000372 | 0.001116 | 0.001613 | 0.000620 | 0.0 | 0.0 | 0.003722 |
| SW | 0.000124 | 0.000868 | 0.000992 | 0.000372 | 0.0 | 0.0 | 0.002357 |
| WSW | 0.0 | 0.000496 | 0.002357 | 0.000248 | 0.0 | 0.0 | 0.003101 |
| W | 0.000372 | 0.000744 | 0.001116 | 0.000248 | 0.0 | 0.0 | 0.002481 |
| WNW | 0.000248 | 0.000496 | 0.000496 | 0.0 | 0.0 | 0.0 | 0.001241 |
| NW | 0.000248 | 0.000992 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.001365 |
| NNW | 0.000372 | 0.001737 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.002233 |
| TOTL | 0.002233 | 0.010545 | 0.012654 | 0.002605 | 0.000372 | 0.000248 | 0.028656 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS A

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 3 | 17 | 7 | 1 | 0 | 0 | 28 | 6.7 |
| NNE | 1 | 5 | 4 | 0 | 0 | 0 | 10 | 7.2 |
| NE | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 9.0 |
| ENE | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 7.0 |
| E | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 6.0 |
| ESE | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 6.0 |
| SE | 0 | 1 | 4 | 1 | 0 | 0 | 6 | 9.8 |
| SSE | 0 | 1 | 13 | 4 | 3 | 2 | 23 | 13.7 |
| S | 0 | 5 | 18 | 3 | 0 | 0 | 26 | 9.6 |
| SSW | 3 | 9 | 13 | 5 | 0 | 0 | 30 | 9.1 |
| SW | 1 | 7 | 8 | 3 | 0 | 0 | 19 | 8.6 |
| WSW | 0 | 4 | 19 | 2 | 0 | 0 | 25 | 9.2 |
| W | 3 | 6 | 9 | 2 | 0 | 0 | 20 | 8.2 |
| WNW | 2 | 4 | 4 | 0 | 0 | 0 | 10 | 6.6 |
| NW | 2 | 8 | 1 | 0 | 0 | 0 | 11 | 5.6 |
| NNW | 3 | 14 | 1 | 0 | 0 | 0 | 18 | 5.6 |
| TOTL | 18 | 85 | 102 | 21 | 3 | 2 | 231 | 8.6 |

NUMBER OF CALMS 0

154

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS B

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.001985 | 0.005210 | 0.003598 | 0.0 | 0.0 | 0.0 | 0.010793 |
| NNE | 0.000868 | 0.001985 | 0.001861 | 0.000248 | 0.000124 | 0.0 | 0.005086 |
| NE | 0.000372 | 0.000496 | 0.000992 | 0.0 | 0.000124 | 0.0 | 0.001985 |
| ENE | 0.000496 | 0.000496 | 0.000620 | 0.000124 | 0.000124 | 0.0 | 0.001861 |
| E | 0.000248 | 0.000620 | 0.000496 | 0.000496 | 0.000124 | 0.0 | 0.001985 |
| ESE | 0.0 | 0.000868 | 0.001116 | 0.0 | 0.0 | 0.0 | 0.001985 |
| SE | 0.000248 | 0.000372 | 0.001365 | 0.000620 | 0.0 | 0.0 | 0.002605 |
| SSE | 0.000248 | 0.001985 | 0.005831 | 0.002233 | 0.0 | 0.0 | 0.010296 |
| S | 0.002357 | 0.007939 | 0.010296 | 0.003225 | 0.000248 | 0.0 | 0.024066 |
| SSW | 0.002853 | 0.004838 | 0.006823 | 0.001116 | 0.0 | 0.0 | 0.015631 |
| SW | 0.000992 | 0.003101 | 0.004838 | 0.000868 | 0.0 | 0.0 | 0.009800 |
| WSW | 0.001985 | 0.007691 | 0.011785 | 0.002977 | 0.000248 | 0.0 | 0.024687 |
| W | 0.003349 | 0.005582 | 0.009676 | 0.001116 | 0.000124 | 0.0 | 0.019849 |
| WNW | 0.000868 | 0.001116 | 0.000992 | 0.000248 | 0.0 | 0.0 | 0.003225 |
| NW | 0.001613 | 0.001985 | 0.000496 | 0.0 | 0.0 | 0.0 | 0.004094 |
| NNW | 0.002481 | 0.006203 | 0.000744 | 0.0 | 0.0 | 0.0 | 0.009428 |
| TOTL | 0.020965 | 0.050490 | 0.061531 | 0.013274 | 0.001116 | 0.0 | 0.147376 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS B

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 16 | 42 | 29 | 0 | 0 | 0 | 87 | 6.4 |
| NNE | 7 | 16 | 15 | 2 | 1 | 0 | 41 | 7.7 |
| NE | 3 | 4 | 8 | 0 | 1 | 0 | 16 | 8.3 |
| ENE | 4 | 4 | 5 | 1 | 1 | 0 | 15 | 8.1 |
| E | 2 | 5 | 4 | 4 | 1 | 0 | 16 | 9.6 |
| ESE | 0 | 7 | 9 | 0 | 0 | 0 | 16 | 8.1 |
| SE | 2 | 3 | 11 | 5 | 0 | 0 | 21 | 9.8 |
| SSE | 2 | 16 | 47 | 18 | 0 | 0 | 83 | 10.2 |
| S | 19 | 64 | 83 | 26 | 2 | 0 | 194 | 8.4 |
| SSW | 23 | 39 | 55 | 9 | 0 | 0 | 126 | 7.7 |
| SW | 8 | 25 | 39 | 7 | 0 | 0 | 79 | 8.3 |
| WSW | 16 | 62 | 95 | 24 | 2 | 0 | 199 | 8.6 |
| W | 27 | 45 | 78 | 9 | 1 | 0 | 160 | 7.9 |
| WNW | 7 | 9 | 8 | 2 | 0 | 0 | 26 | 6.8 |
| NW | 13 | 16 | 4 | 0 | 0 | 0 | 33 | 5.4 |
| NNW | 20 | 50 | 6 | 0 | 0 | 0 | 76 | 5.4 |
| TOTL | 169 | 407 | 496 | 107 | 9 | 0 | 1188 | 8.0 |

NUMBER OF CALMS 0

155

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS C

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.002605 | 0.006327 | 0.002853 | 0.000248 | 0.000124 | 0.0 | 0.012157 |
| NNE | 0.000496 | 0.002481 | 0.000992 | 0.000372 | 0.0 | 0.0 | 0.004342 |
| NE | 0.000372 | 0.000496 | 0.000992 | 0.000372 | 0.000124 | 0.0 | 0.002357 |
| ENE | 0.000620 | 0.000496 | 0.0 | 0.0 | 0.000124 | 0.0 | 0.001241 |
| E | 0.000372 | 0.000620 | 0.000868 | 0.000124 | 0.0 | 0.0 | 0.001985 |
| ESE | 0.000372 | 0.000248 | 0.000992 | 0.000992 | 0.0 | 0.0 | 0.002605 |
| SE | 0.000372 | 0.000372 | 0.002729 | 0.002109 | 0.000620 | 0.0 | 0.006203 |
| SSE | 0.000372 | 0.001241 | 0.004218 | 0.003722 | 0.000868 | 0.0 | 0.010421 |
| S | 0.003722 | 0.003349 | 0.004218 | 0.002605 | 0.000372 | 0.0 | 0.014266 |
| SSW | 0.001116 | 0.001985 | 0.003846 | 0.001116 | 0.0 | 0.0 | 0.008064 |
| SW | 0.000868 | 0.001985 | 0.002977 | 0.000992 | 0.000248 | 0.0 | 0.007071 |
| WSW | 0.002481 | 0.012529 | 0.016375 | 0.005582 | 0.000868 | 0.0 | 0.037836 |
| W | 0.001489 | 0.004714 | 0.007691 | 0.003946 | 0.000248 | 0.0 | 0.017988 |
| WNW | 0.001241 | 0.001116 | 0.000496 | 0.000620 | 0.000124 | 0.0 | 0.003598 |
| NW | 0.001365 | 0.002729 | 0.000248 | 0.000248 | 0.000496 | 0.0 | 0.005086 |
| NNW | 0.002233 | 0.004466 | 0.000992 | 0.000124 | 0.0 | 0.0 | 0.007815 |
| TOTL | 0.020097 | 0.045156 | 0.050490 | 0.023074 | 0.004218 | 0.0 | 0.143034 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS C

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 21 | 51 | 23 | 2 | 1 | 0 | 98 | 6.5 |
| NNE | 4 | 20 | 8 | 3 | 0 | 0 | 35 | 7.1 |
| NE | 3 | 4 | 8 | 3 | 1 | 0 | 19 | 9.4 |
| ENE | 5 | 4 | 0 | 0 | 1 | 0 | 10 | 5.7 |
| E | 3 | 5 | 7 | 1 | 0 | 0 | 16 | 7.7 |
| ESE | 3 | 2 | 8 | 8 | 0 | 0 | 21 | 10.7 |
| SE | 3 | 3 | 22 | 17 | 5 | 0 | 50 | 11.7 |
| SSE | 3 | 10 | 34 | 30 | 7 | 0 | 84 | 12.1 |
| S | 30 | 27 | 34 | 21 | 3 | 0 | 115 | 8.6 |
| SSW | 9 | 16 | 31 | 9 | 0 | 0 | 65 | 8.7 |
| SW | 7 | 16 | 24 | 8 | 2 | 0 | 57 | 8.9 |
| WSW | 20 | 101 | 132 | 45 | 7 | 0 | 305 | 9.1 |
| W | 12 | 38 | 62 | 31 | 2 | 0 | 145 | 9.6 |
| WNW | 10 | 9 | 4 | 5 | 1 | 0 | 29 | 7.6 |
| NW | 11 | 22 | 2 | 2 | 4 | 0 | 41 | 7.5 |
| NNW | 18 | 36 | 8 | 1 | 0 | 0 | 63 | 5.7 |
| TOTL | 162 | 364 | 407 | 186 | 34 | 0 | 1153 | 8.8 |

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
STABILITY CLASS D

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.018112 | 0.038333 | 0.011041 | 0.001116 | 0.0 | 0.0 | 0.068602 |
| NNE | 0.008188 | 0.015135 | 0.008436 | 0.001613 | 0.000248 | 0.0 | 0.033619 |
| NE | 0.002729 | 0.004714 | 0.003474 | 0.000992 | 0.000372 | 0.000372 | 0.012654 |
| ENE | 0.004466 | 0.002853 | 0.002233 | 0.000868 | 0.000248 | 0.000248 | 0.010917 |
| E | 0.005582 | 0.004962 | 0.003598 | 0.001116 | 0.000124 | 0.000124 | 0.015507 |
| ESE | 0.005831 | 0.005334 | 0.003846 | 0.004342 | 0.000124 | 0.0 | 0.019476 |
| SE | 0.003970 | 0.003101 | 0.002853 | 0.004466 | 0.001489 | 0.0 | 0.015879 |
| SSE | 0.007319 | 0.002605 | 0.005210 | 0.003846 | 0.000620 | 0.0 | 0.019601 |
| S | 0.012778 | 0.012033 | 0.008808 | 0.002853 | 0.0 | 0.0 | 0.036472 |
| SSW | 0.005706 | 0.006451 | 0.004714 | 0.001737 | 0.0 | 0.0 | 0.018608 |
| SW | 0.002357 | 0.003722 | 0.007071 | 0.001613 | 0.0 | 0.0 | 0.014762 |
| WSW | 0.002729 | 0.017368 | 0.020469 | 0.004590 | 0.000744 | 0.0 | 0.045900 |
| W | 0.002481 | 0.004466 | 0.011785 | 0.006203 | 0.000744 | 0.0 | 0.025679 |
| WNW | 0.001737 | 0.004218 | 0.000744 | 0.002481 | 0.000992 | 0.000372 | 0.010545 |
| NW | 0.004838 | 0.003598 | 0.001116 | 0.001116 | 0.000372 | 0.000124 | 0.011165 |
| NNW | 0.013770 | 0.017864 | 0.001737 | 0.0 | 0.0 | 0.0 | 0.033371 |
| TOTL | 0.102593 | 0.146756 | 0.097134 | 0.038953 | 0.006079 | 0.001241 | 0.392755 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS D

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 146 | 309 | 89 | 9 | 0 | 0 | 553 | 5.9 |
| NNE | 66 | 122 | 68 | 13 | 2 | 0 | 271 | 6.8 |
| NE | 22 | 38 | 28 | 8 | 3 | 3 | 102 | 8.0 |
| ENE | 36 | 23 | 18 | 7 | 2 | 2 | 88 | 7.2 |
| E | 45 | 40 | 29 | 9 | 1 | 1 | 125 | 6.9 |
| ESE | 47 | 43 | 31 | 35 | 1 | 0 | 157 | 8.1 |
| SE | 32 | 25 | 23 | 36 | 12 | 0 | 128 | 9.8 |
| SSE | 59 | 21 | 42 | 31 | 5 | 0 | 158 | 8.2 |
| S | 103 | 97 | 71 | 23 | 0 | 0 | 294 | 6.5 |
| SSW | 46 | 52 | 38 | 14 | 0 | 0 | 150 | 6.9 |
| SW | 19 | 30 | 57 | 13 | 0 | 0 | 119 | 8.2 |
| WSW | 22 | 140 | 165 | 37 | 6 | 0 | 370 | 8.5 |
| W | 20 | 36 | 95 | 50 | 6 | 0 | 207 | 9.8 |
| WNW | 14 | 34 | 6 | 20 | 8 | 3 | 85 | 10.0 |
| NW | 39 | 29 | 9 | 9 | 3 | 1 | 90 | 7.0 |
| NNW | 111 | 144 | 14 | 0 | 0 | 0 | 269 | 5.0 |
| TOTL | 827 | 1183 | 783 | 314 | 49 | 10 | 3166 | 7.3 |

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS E

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.017258 | 0.002109 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.019491 |
| NNE | 0.009312 | 0.000620 | 0.0 | 0.0 | 0.0 | 0.0 | 0.009932 |
| NE | 0.009436 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.009560 |
| ENE | 0.009684 | 0.0 | 0.000372 | 0.000372 | 0.0 | 0.0 | 0.010429 |
| E | 0.016637 | 0.001737 | 0.001241 | 0.001737 | 0.0 | 0.0 | 0.021351 |
| ESE | 0.017258 | 0.008064 | 0.003970 | 0.004962 | 0.000992 | 0.000124 | 0.035370 |
| SE | 0.011547 | 0.005086 | 0.004590 | 0.005458 | 0.002233 | 0.000248 | 0.029162 |
| SSE | 0.010553 | 0.001985 | 0.003101 | 0.003474 | 0.000868 | 0.0 | 0.019981 |
| S | 0.011547 | 0.001365 | 0.001985 | 0.000620 | 0.0 | 0.0 | 0.015516 |
| SSW | 0.005090 | 0.000744 | 0.000868 | 0.000248 | 0.000124 | 0.0 | 0.007075 |
| SW | 0.003849 | 0.001116 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.005089 |
| WSW | 0.002731 | 0.004466 | 0.003225 | 0.000124 | 0.0 | 0.0 | 0.010547 |
| W | 0.003352 | 0.001985 | 0.001985 | 0.000124 | 0.0 | 0.0 | 0.007446 |
| WNW | 0.004221 | 0.001241 | 0.000372 | 0.000372 | 0.0 | 0.0 | 0.006206 |
| NW | 0.004221 | 0.001241 | 0.000124 | 0.000248 | 0.000248 | 0.0 | 0.006082 |
| NNW | 0.012912 | 0.004342 | 0.000248 | 0.0 | 0.0 | 0.0 | 0.017502 |
| TOTL | 0.149609 | 0.036224 | 0.022330 | 0.017740 | 0.004466 | 0.000372 | 0.230741 |

RELATIVE FREQUENCY OF CALMS 0.000124

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS E

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 139 | 17 | 1 | 0 | 0 | 0 | 157 | 3.3 |
| NNE | 75 | 5 | 0 | 0 | 0 | 0 | 80 | 2.9 |
| NE | 76 | 1 | 0 | 0 | 0 | 0 | 77 | 2.6 |
| ENE | 78 | 0 | 3 | 3 | 0 | 0 | 84 | 3.2 |
| E | 134 | 14 | 10 | 14 | 0 | 0 | 172 | 4.5 |
| ESE | 139 | 65 | 32 | 40 | 8 | 1 | 285 | 6.7 |
| SE | 93 | 41 | 37 | 44 | 18 | 2 | 235 | 8.4 |
| SSE | 85 | 16 | 25 | 28 | 7 | 0 | 161 | 7.1 |
| S | 93 | 11 | 16 | 5 | 0 | 0 | 125 | 4.5 |
| SSW | 41 | 6 | 7 | 2 | 1 | 0 | 57 | 4.8 |
| SW | 31 | 9 | 1 | 0 | 0 | 0 | 41 | 3.9 |
| WSW | 22 | 36 | 26 | 1 | 0 | 0 | 85 | 6.2 |
| W | 27 | 16 | 16 | 1 | 0 | 0 | 60 | 5.5 |
| WNW | 34 | 10 | 3 | 3 | 0 | 0 | 50 | 4.6 |
| NW | 34 | 10 | 1 | 2 | 2 | 0 | 49 | 4.9 |
| NNW | 104 | 35 | 2 | 0 | 0 | 0 | 141 | 3.7 |
| TOTL | 1205 | 292 | 180 | 143 | 36 | 3 | 1859 | 5.3 |

NUMBER OF CALMS 1

158

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS F

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.001365 | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.001613 |
| NNE | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000248 |
| NE | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| ENE | 0.000744 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000744 |
| E | 0.002605 | 0.000620 | 0.0 | 0.000124 | 0.0 | 0.0 | 0.003349 |
| ESE | 0.004218 | 0.003474 | 0.001737 | 0.000744 | 0.0 | 0.0 | 0.010172 |
| SE | 0.003349 | 0.003225 | 0.003225 | 0.002605 | 0.001489 | 0.0 | 0.013894 |
| SSE | 0.001737 | 0.000372 | 0.000372 | 0.000868 | 0.000248 | 0.0 | 0.003598 |
| S | 0.001241 | 0.000372 | 0.0 | 0.0 | 0.0 | 0.0 | 0.001613 |
| SSW | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| SW | 0.000372 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000372 |
| WSW | 0.000372 | 0.000868 | 0.0 | 0.0 | 0.0 | 0.0 | 0.001241 |
| W | 0.000496 | 0.000248 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.000868 |
| WNW | 0.0 | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.000124 |
| NW | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| NNW | 0.000992 | 0.000620 | 0.0 | 0.0 | 0.0 | 0.0 | 0.001613 |
| TOTL | 0.017968 | 0.010172 | 0.005582 | 0.004342 | 0.001737 | 0.0 | 0.039821 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS F

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 11 | 2 | 0 | 0 | 0 | 0 | 13 | 3.5 |
| NNE | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 3.0 |
| NE | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2.0 |
| ENE | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 3.0 |
| E | 21 | 5 | 0 | 1 | 0 | 0 | 27 | 3.9 |
| ESE | 34 | 28 | 14 | 6 | 0 | 0 | 82 | 6.2 |
| SE | 27 | 26 | 26 | 21 | 12 | 0 | 112 | 9.5 |
| SSE | 14 | 3 | 3 | 7 | 2 | 0 | 29 | 8.4 |
| S | 10 | 3 | 0 | 0 | 0 | 0 | 13 | 3.5 |
| SSW | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 6.0 |
| SW | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3.3 |
| WSW | 3 | 7 | 0 | 0 | 0 | 0 | 10 | 5.2 |
| W | 4 | 2 | 1 | 0 | 0 | 0 | 7 | 4.3 |
| WNW | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 10.0 |
| NW | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2.0 |
| NNW | 8 | 5 | 0 | 0 | 0 | 0 | 13 | 3.9 |
| TOTL | 145 | 82 | 45 | 35 | 14 | 0 | 321 | 6.9 |

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS G

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.000496 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000620 |
| NNE | 0.000372 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000372 |
| NE | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000248 |
| ENE | 0.000496 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000496 |
| E | 0.001365 | 0.000124 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.001613 |
| ESE | 0.002233 | 0.001489 | 0.000620 | 0.000248 | 0.0 | 0.0 | 0.004590 |
| SE | 0.001613 | 0.001241 | 0.002357 | 0.000372 | 0.0 | 0.0 | 0.005582 |
| SSE | 0.001489 | 0.000496 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.002109 |
| S | 0.000620 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000620 |
| SSW | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000248 |
| SW | 0.000248 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000248 |
| WSW | 0.0 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| W | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| WNW | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000124 |
| NW | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NNW | 0.000496 | 0.000124 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000620 |
| TOTL | 0.010048 | 0.003722 | 0.003225 | 0.000620 | 0.0 | 0.0 | 0.017616 |

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS G

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 4 | 1 | 0 | 0 | 0 | 0 | 5 | 3.0 |
| NNE | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 2.3 |
| NE | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1.5 |
| ENE | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 3.3 |
| E | 11 | 1 | 1 | 0 | 0 | 0 | 13 | 3.4 |
| ESE | 18 | 12 | 5 | 2 | 0 | 0 | 37 | 5.7 |
| SE | 13 | 10 | 19 | 3 | 0 | 0 | 45 | 7.5 |
| SSE | 12 | 4 | 1 | 0 | 0 | 0 | 17 | 4.1 |
| S | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 3.2 |
| SSW | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 2.0 |
| SW | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 3.5 |
| WSW | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 5.0 |
| W | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| WNW | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1.0 |
| NW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| NNW | 4 | 1 | 0 | 0 | 0 | 0 | 5 | 3.6 |
| TOTL | 81 | 30 | 26 | 5 | 0 | 0 | 142 | 5.3 |

NUMBER OF CALMS 0

165

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS ALL

WIND SPEED (MPH)

| DIRECTION | 0 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL |
|---|---|---|---|---|---|---|---|
| N | 0.042195 | 0.054460 | 0.018464 | 0.001489 | 0.000124 | 0.0 | 0.116751 |
| NNE | 0.019608 | 0.020841 | 0.011785 | 0.002233 | 0.000372 | 0.0 | 0.054839 |
| NE | 0.013279 | 0.005831 | 0.005582 | 0.001365 | 0.000620 | 0.000372 | 0.027049 |
| ENE | 0.016506 | 0.003970 | 0.003225 | 0.001365 | 0.000496 | 0.000248 | 0.025810 |
| E | 0.026806 | 0.008932 | 0.006327 | 0.003598 | 0.000248 | 0.000124 | 0.046034 |
| ESE | 0.029909 | 0.019601 | 0.012281 | 0.011269 | 0.001116 | 0.000124 | 0.074320 |
| SE | 0.021097 | 0.013522 | 0.017616 | 0.015755 | 0.005831 | 0.000248 | 0.074068 |
| SSE | 0.021718 | 0.008808 | 0.020469 | 0.014638 | 0.002977 | 0.000248 | 0.068858 |
| S | 0.032266 | 0.025679 | 0.027540 | 0.009676 | 0.000620 | 0.0 | 0.095782 |
| SSW | 0.015389 | 0.015259 | 0.017864 | 0.004838 | 0.000124 | 0.0 | 0.053473 |
| SW | 0.008811 | 0.010793 | 0.016003 | 0.003846 | 0.000248 | 0.0 | 0.039701 |
| WSW | 0.010300 | 0.043543 | 0.054212 | 0.013522 | 0.001861 | 0.0 | 0.123438 |
| W | 0.011541 | 0.017740 | 0.032378 | 0.011537 | 0.001116 | 0.0 | 0.074313 |
| WNW | 0.008439 | 0.008188 | 0.003225 | 0.003722 | 0.001116 | 0.000372 | 0.025062 |
| NW | 0.012410 | 0.010545 | 0.002109 | 0.001613 | 0.001116 | 0.000124 | 0.027917 |
| NNW | 0.033259 | 0.035355 | 0.003846 | 0.000124 | 0.0 | 0.0 | 0.072584 |
| TOTL | 0.323533 | 0.303064 | 0.252946 | 0.100608 | 0.017988 | 0.001861 | 1.000000 |

RELATIVE FREQUENCY OF CALMS 0.000124

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS ALL

WIND SPEED (MPH)

| DIRECTION | 1 - 4 | 5 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | 25 + | TOTAL | AVG WS |
|---|---|---|---|---|---|---|---|---|
| N | 340 | 439 | 149 | 12 | 1 | 0 | 941 | 5.5 |
| NNE | 158 | 168 | 95 | 18 | 3 | 0 | 442 | 6.1 |
| NE | 107 | 47 | 45 | 11 | 5 | 3 | 218 | 6.2 |
| ENE | 133 | 32 | 26 | 11 | 4 | 2 | 208 | 5.4 |
| E | 216 | 72 | 51 | 29 | 2 | 1 | 371 | 5.6 |
| ESE | 241 | 158 | 99 | 91 | 9 | 1 | 599 | 7.1 |
| SE | 170 | 109 | 142 | 127 | 47 | 2 | 597 | 9.2 |
| SSE | 175 | 71 | 165 | 118 | 24 | 2 | 555 | 8.9 |
| S | 260 | 207 | 222 | 78 | 5 | 0 | 772 | 7.0 |
| SSW | 124 | 123 | 144 | 39 | 1 | 0 | 431 | 7.3 |
| SW | 71 | 87 | 129 | 31 | 2 | 0 | 320 | 7.8 |
| WSW | 83 | 351 | 437 | 109 | 15 | 0 | 995 | 8.5 |
| W | 93 | 143 | 261 | 93 | 9 | 0 | 599 | 8.7 |
| WNW | 68 | 66 | 26 | 30 | 9 | 3 | 202 | 7.7 |
| NW | 100 | 85 | 17 | 13 | 9 | 1 | 225 | 6.3 |
| NNW | 268 | 285 | 31 | 1 | 0 | 0 | 585 | 4.8 |
| TOTL | 2607 | 2443 | 2039 | 811 | 145 | 15 | 8060 | 7.2 |

NUMBER OF CALMS 1
TOTAL CASES 8061

APPENDIX B-4

HOURLY AVERAGE OZONE CONCENTRATIONS

MEASURED HOURLY-AVERAGE OZONE CONCENTRATIONS (ppm).

| Time (MST) | Day 7/13/77 | 7/14/77 | 7/15/77 | 5/16/77 | 5/17/77 | 5/18/77 | 11/9/77 | 11/10/77 | 11/11/77 | 11/12/77 | 11/13/77 | 11/14/77 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:00 | | 0.036 | 0.048 | 0.048 | 0.042 | 0.039 | | 0.005 | 0.006 | 0.006 | 0.006 | 0.006 |
| 2:00 | | 0.036 | 0.048 | 0.044 | 0.043 | 0.040 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| 3:00 | | 0.035 | 0.046 | 0.042 | 0.041 | 0.041 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| 4:00 | | 0.032 | 0.041 | 0.041 | 0.036 | 0.045 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| 5:00 | | 0.031 | 0.038 | 0.040 | 0.035 | 0.050 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.005 |
| 6:00 | | 0.029 | 0.040 | 0.038 | 0.033 | 0.044 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.005 |
| 7:00 | | 0.025 | 0.035 | 0.037 | 0.032 | 0.045 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.005 |
| 8:00 | 0.042 | 0.026 | 0.045 | 0.039 | 0.037 | 0.045 | | 0.006 | 0.006 | 0.006 | 0.006 | 0.005 |
| 9:00 | 0.043 | 0.028 | 0.049 | 0.042 | 0.042 | 0.046 | | 0.006 | 0.006 | 0.006 | 0.006 | |
| 10:00 | 0.044 | 0.030 | 0.050 | 0.044 | 0.050 | 0.048 | 0.006 | 0.008 | 0.006 | 0.006 | 0.006 | |
| 11:00 | 0.045 | 0.033 | 0.052 | 0.048 | 0.050 | 0.048 | 0.006 | 0.006 | 0.008 | 0.008 | 0.008 | |
| 12:00 | 0.047 | 0.034 | 0.053 | 0.053 | 0.050 | 0.049 | 0.006 | 0.006 | 0.008 | 0.008 | 0.010 | |
| 13:00 | 0.046 | 0.033 | 0.053 | 0.053 | 0.049 | 0.050 | 0.006 | 0.008 | 0.008 | 0.008 | 0.008 | |
| 14:00 | 0.050 | 0.034 | 0.055 | 0.054 | 0.048 | 0.053 | 0.006 | 0.008 | 0.008 | 0.008 | 0.008 | |
| 15:00 | 0.052 | 0.037 | 0.054 | 0.050 | 0.048 | | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | |
| 16:00 | 0.053 | 0.039 | 0.054 | 0.049 | 0.049 | | 0.008 | 0.008 | 0.010 | 0.008 | 0.008 | |
| 17:00 | 0.053 | 0.038 | 0.062 | 0.050 | 0.049 | | 0.008 | 0.006 | 0.010 | 0.008 | 0.008 | |
| 18:00 | 0.050 | 0.040 | 0.059 | 0.052 | 0.050 | | 0.006 | 0.006 | 0.010 | 0.008 | 0.008 | |
| 19:00 | 0.049 | 0.040 | 0.058 | 0.051 | 0.052 | | 0.006 | 0.006 | 0.010 | 0.008 | 0.006 | |
| 20:00 | 0.045 | 0.043 | 0.054 | 0.047 | 0.052 | | 0.008 | 0.006 | 0.010 | 0.008 | 0.008 | |
| 21:00 | 0.043 | 0.041 | 0.052 | 0.045 | 0.052 | | 0.006 | 0.006 | 0.008 | 0.008 | 0.006 | |
| 22:00 | 0.038 | 0.041 | 0.052 | 0.042 | 0.052 | | 0.006 | 0.006 | 0.008 | 0.006 | 0.006 | |
| 23:00 | 0.040 | 0.045 | 0.053 | 0.040 | 0.048 | | 0.005 | 0.006 | 0.008 | 0.006 | 0.006 | |
| 24:00 | 0.035 | 0.048 | 0.050 | 0.041 | 0.043 | | 0.005 | 0.006 | 0.006 | 0.005 | 0.006 | |

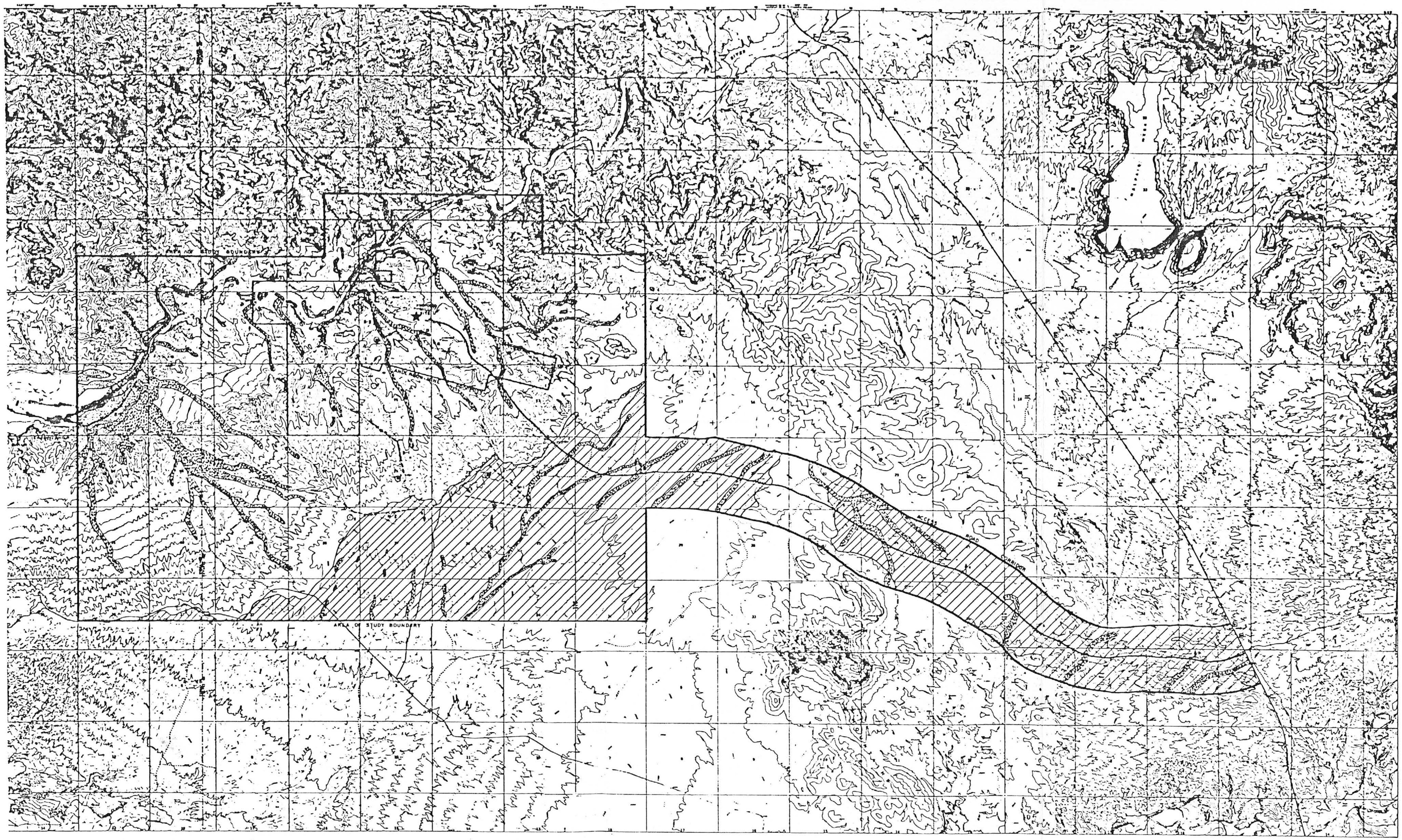
## 2.8 BIOLOGY

Biological field studies were conducted on the Anderson property and in the vicinity of the proposed access road and Palmerita Ranch water pipeline from February through October, 1977 (Dames & Moore, 1978a and b). Both quantitative and qualitative information on the plant and animal communities in the area was collected during these studies. Sampling procedures used during the field program are discussed in Appendix C-1. The locations of sampling sites are given in Figure 2.8-1.

The following discussion is based largely on the results of the these field studies. This information was supplemented by data on the mesquite bosque near Palmerita Ranch collected by personnel from the Arizona Academy of Science (Smith and Bender, 1973).

### VEGETATION

The Anderson property is located within the Sonoran Desert (Lowe, 1964 and Lowe and Brown, 1973). The plant associations on and in the vicinity of the property can be generally classified into two broad subdivisions of this desert; the Lower Colorado Subdivision, which is dominated by creosotebush/bursage communities, and the Upper Arizona Subdivision, which is characterized by palo verde/ saguaro cactus plant communities.




LEGEND

| | | |
|---|---|---|
| Riparian | Vegetation sample site | Bird transect |
| Upland desert | 5 x 5 drop-trap grid | |
| Joshua tree woodland | ★ Proposed mill site | |
| Pseudoriparian | Small mamml assessment line | |

N

0 1 2

miles

Figure 2.8-1. BIOLOGICAL SAMPLE SITES AND VEGETATION TYPES

Source: Domes and Moore, 1978 a

Although most of the species growing in the vicinity of the Anderson property are typical of Sonoran Desert vegetation, there are two, Joshua tree and bladdersage, that are characteristic of the Mohave Desert to the west. The presence of both saguaro cactus and Joshua trees in this area denotes that it is part of a transition zone (or ecotone) between the Sonoran and Mohave deserts (Lowe, 1964).

Four vegetation types were identified in the vicinity of the Anderson property and the proposed access road (Dames & Moore, 1978a and b). These communities are upland desert, Joshua tree woodland, riparian and pseudoriparian (Figure 2.8-1). The species identified in each of these vegetation types are listed in Table C-2, Appendix C-2.

The four types are recognized primarily by those species that are visibly dominant (over six feet tall). It should be noted that a large number of the plants identified during the field studies are common to most of the types.

Upland Desert

Upland desert constitutes the largest vegetation type on the property, covering more than 2/3 of the area. Species composition and density varies considerably within this vegetation type due to microclimatic and edaphic variability across the property; however, the upland desert type is readily definable.

Vegetation over six feet high in the upland desert community is dominated by palo verde and Joshua trees. These two species have an average dominance value (measured in square feet of basal area per acre) of 2494 and 1298.6, respectively (Table 2.8-1). Although less abundant, saguaro cactus and ocotillo (average dominance values of 602 and 752, respectively) are also common in the upper strata of this type.

Below six feet, the basal area cover of upland desert vegetation is relatively low, varying from 0.6 percent (sample site 7) to 14.8 percent (sample site 8) and averaging 5.3 percent (Table 2.8-2). Shrubs constitute most of this lower strata, accounting for an average of 73 percent of the total basal area cover (Table 2.8-2). The most common shrubs throughout the type are creosotebush, brittlebush and white bursage.

Except for sample site 13, cacti, lilies and their allies constitute less than one percent of the cover in the upland desert type. Yucca, a member of the lily family, had a total basal area cover of 57 percent at sample site 13. Grasses and forbs are also relatively sparse, comprising approximately 13 percent of the total basal area cover.

The paucity of desert succulents in the vicinity of the property may be due to soil conditions. Loose gravels or rock crevices where infiltration of precipitation is rapid are necessary for the

TABLE 2.8-1

DENSITY AND DOMINANCE OF UPPER STRATA PLANTS
BASED ON POINT-CENTERED QUARTER DATA

| | | Palo Verde | | Saguaro | | Joshua Tree | | Ocotillo | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Site | Den.[a] | Dom. | Den. | Dom. | Den. | Dom. | Den. | Dom. |
| Upland Desert | 1 | 20 | 5865 | 8 | 202 | 11 | 3142 | 20 | 1071 |
| | 7 | 16 | 965 | 23 | 296 | 59 | 167 | 57 | 668 |
| | 8 | 27 | 652 | 7 | 1308 | 15 | 587 | 19 | 517 |
| MEAN | | 21.0 | 2494.0 | 12.6 | 602.0 | 28.3 | 1298.6 | 32.0 | 752.0 |
| Joshua-tree Woodland | 2 | - | - | - | - | 10 | 7162 | 22 | 719 |
| | 5 | 12 | 1539 | - | - | 20 | 5669 | 17 | 679 |
| | 6 | - | - | - | - | 8 | 4619 | 46 | 283 |
| MEAN | | 4.0 | 513.0 | 0.0 | 0.0 | 12.6 | 5816.8 | 28.3 | 560.3 |

* Density and dominance given as absolute values (Phillips, 1959)

Density given as number per acre.

Dominance given as basal area per acre (in sq ft.).

Source: Dames & Moore, 1978a

# TABLE 2.8-2

## PERCENT BASAL COVER AND PERCENT RELATIVE COVER OF VEGETATION MEASURED ON LINE INTERCEPTS AT FOURTEEN SAMPLE SITES

SAMPLE SITES

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **I. TREES** | | | | | | | | | | | | | | |
| % basal cover | ND[a] | ND | 0.2[c] | 3.0 | ND | ND | ND | ND | -[b] | - | ND | ND | ND | ND |
| Mesquite | | | 100 | 100 | | | | | | | | | | |
| **II SHRUBS, CACTI, LILIES, AND ALLIES** | | | | | | | | | | | | | | |
| % basal cover | 1.1 | 0.6 | 0.2 | 0.4 | 10.1 | 7.6 | 0.6 | 12.9 | 31.7 | 27.0 | 5.7 | 4.8 | 2.5 | 22.0 |
| Agave | | | | | | | | | | | | | 16 | |
| Brittlebush | 21 | | | | | | 46 | | | | | | | |
| Burrobrush | | | | | | | | 9 | 38 | | | | | 13 |
| Cane Cholla | | | | | | | 2 | | 1 | | | | | |
| Catclaw | | | | 3 | | | | | | | | | | 7 |
| Creosotebush | 60 | 41 | | | 38 | 19 | 24 | 32 | | | 69 | 64 | 8 | 5 |
| Englemann Pr. Pear | | | | | | <1 | | | | | | | | |
| Goldenweed | | | | | 20 | | 13 | | | | | | | |
| Hedgehog Cactus | <1 | <1 | | | | | | | | | | | | |
| Joint-fir | | | | | | 5 | | | | | | | | |
| Mesquite | | | 100 | 89 | | | | | 61 | 96 | | | | 75 |
| Paper flower | | | | | 8 | 30 | | 18 | | | | | | |
| Ratany | | | | | | | 2 | | | | | | | |
| Saltbush | 19 | 36 | | | | | | | | | | | | |
| Senecio spp. | | 23 | | | | | | | | 4 | | | 10 | |
| Unidentified spp. | | | | | | | 12 | 9 | | | | | | |
| White Bursage | | | | | 34 | 46 | | 30 | | | 31 | 36 | | |
| Wolfeberry | | | | 8 | | | 1 | 2 | | | | | | |
| Yucca | | | | | | | | | | | | | 66 | |
| **III. GRASSES** | | | | | | | | | | | | | | |
| % basal cover | 0.2 | 0.1 | 0.8 | 0.3 | 1.0 | 0.6 | - | 1.9 | 19.0 | 6.2 | 0.4 | 0.4 | 0.2 | - |
| Bermuda | | | | | | | | | | 15 | | | | |
| Big Galleta | | | | | 51 | 73 | | 18 | | | | | | |
| Bush Muhley | | | | | | | | 24 | | | | | | |
| Dropseed | 48 | | | | | | | | | | | | | |
| Fluffgrass | | | | | 24 | 9 | | 40 | | | | | | |
| Mediterranean Grass | 11 | 18 | 100 | 100 | 6 | | | | | | | | | |
| Muhley spp. | 36 | | | | | | | | | | | | | |
| Red Brome | 5 | | | | | | | | | | | | | |
| Tobosa Grass | | 82 | | | 19 | 18 | | 18 | | | 59 | 100 | 100 | |
| Annual Grasses | | | | | | | | | 100 | 95 | | | | |
| **IV. FORBS** | | | | | | | | | | | | | | |
| % basal cover | 0.2 | 0.2 | - | - | - | - | - | - | - | 0.1 | 0.3 | 0.2 | 0.2 | - |
| Desert Mallow | 18 | | | | | | | | | | | | | |
| Filaree | 26 | 33 | | | | | | | | | | | | |
| Four O'Clock | | | | | | | | | | | | 90 | | |
| Owlflower | 56 | 67 | | | | | | | | | | | | |
| Skeletonweed | | | | | | | | | | | | | 100 | |
| Wild Gourd | | | | | | | | | | 100 | | | | |
| Wooly Indianwheat | | | | | | | | | | | 100 | 10 | | |

a. ND - no data, line intercept (300 ft per line) for the cover used only at sites 3, 4, 9, 10.
b. Dash means no basal cover of the size-class (vertical strata) detected on the intercept
c. % basal cover = sum of basal area intercepted / 300 ft. x 100

% relative cover = sum of species interception / total interception for strata x 100 (rounded to nearest integer greater than one)

* Not identified to species due to absence of specific taxonomic characters.

Source: Phillips (1959)

Source: Dames & Moore, 1978a

prolific growth of these succulents, particularly cacti. While sandy to gravelly soils are present on and in the vicinity of the property, they may not be sufficiently permeable to support large numbers of these plants.

Precipitation in the Sonoran Desert is seldom high enough to support extensive grasslands. While a variety of annual and perennial grasses such as big galleta, tobosa, dropseed, and fluffgrass are adopted to these arid conditions, they seldom constitute a major portion of any of the desert plant communities. Essentially the same is true for forb species. Grasses and forbs on the property may have been further reduced by the drought conditions that prevailed before and during the field study period and by grazing pressure (refer below to the discussion on Range Condition for further description of the effects of grazing).

As can be expected in desert environments, the response of annuals to sporadic precipitation provides seasonal variation in the species composition of the vegetation on the Anderson property. The first four vegetation sites were sampled in April and the remaining sites were sampled in October. Annual grasses were relatively abundant during the spring sampling period and almost nonexistant in the fall (Table 2.8-2). It is apparent that there was sufficient winter rain to stimulate spring germination and growth, but precipitation during the summer was not abundant enough to support these annuals. The composition of the forb component also varied between seasons. Globe mallow, filaree, and owl clover were particularly common in the spring while four o'clock, skeleton weed, wild gourd, and wooly Indianwheat were common in the fall (Dames & Moore, 1978a).

Joshua Tree Woodland

Joshua tree woodland is located on top of the mesa to the south and southwest of the Anderson property (Figure 2.8-1). It generally occurs above the 2000-foot contour. This type is the most prevalent vegetation association along the right-of-way for the proposed access road.

Joshua tree woodland is distinguished from the upland desert type by a lack of saguaro cactus (Table 2.8-1). The paucity of this species may be due to soil conditions. Saguaro cactus is relatively shallow-rooted and top-heavy. In fine soils similar to those on the mesa top, the species is frequently up-rooted by winds and flash flooding. On coarser soils, such as those found on the Anderson property, the species is much more stable.

Species composition of the understory in the Joshua tree woodland is virtually identical to the understory of the upland desert type (Table 2.8-2). However, total basal area cover in the woodland understory is slightly higher than in the understory of the upland desert. Total cover in the Joshua tree woodland averages 6.7 percent compared to 5.3 percent for the upland desert type. If the results from sample site 8 (Table 2.8-2) are deleted, the average basal area cover of the upland desert understory falls to 3.4 percent.

This difference in basal area cover can probably be attributed to soil moisture conditions. Upland desert vegetation is most prevalent on the north facing slopes to the south of the Santa Maria River. Soils on these slopes consist primarily of sands, sandy gravels, and gravels. Soils on the mesa top where the Joshua tree woodland is most prevalent consist largely of silty sands that have a higher moisture retention capacity than the sands and gravels of the north-facing slopes. In addition, the level aspect of the mesa top probably results in a more favorable infiltration to runoff ratio than on the north-facing slopes. Since the mesa top is at a higher elevation than the slopes, it may also receive slightly more precipitation.

Riparian

Riparian vegetation is present along the Santa Maria River in the vicinity of Anderson property (Figure 2.8-1). This vegetation consists largely of mesquite stands. Where undisturbed, these stands (termed mesquite bosques) are typically quite dense.

Sample sites 3 and 4 are representative of the riparian vegetation on the Anderson property (Figure 2.8-1 and Table 2.8-2). Overstory vegetation consists of essentially 100 percent mesquite. The understory shrub component is also composed largely of young mesquite plants. Other shrub species that may be found in the type in low numbers include white-thorn acacia, wolfberry, creosotebush, and burrobush. Forbs and grasses are often not present in the type. Where sufficient light and surface moisture are available, Mediterranean grass was found to be the most common herbaceous species in the riparian vegetation on the property.

A large, relatively undisturbed mesquite bosque is located along the Santa Maria River near the Palmerita Ranch in Sections 14, 15 and 16 of T11N, R11W (Figure 2.8-1). The bosque covers approximately 960 acres and is located on private land. It is quite dense and contains many old trees, some reaching a height of 25 feet. The only major disturbance to this bosque is an unimproved road running along its southern edge (Smith and Bender, 1973). The bosque has been recommended for desig nation as a Scientific Natural Area by the Arizona Academy of Science (Smith and Bender, 1973).

Pseudoriparian

Pseudoriparian vegetation is located along the intermittent streams and washes that drain the property and adjacent areas (Figure 2.8-1). Sample site 14 (Figure 2.8-1) is representative of this association (Table 2.8-2).

The pseudoriparian vegetation type is a transition between the ripa rian vegetation along the Santa Maria River and the upland desert (Dames & Moore, 1978a and b). Mesquite as well as shrub and tree species common to the upland desert are found in the type. Although quantitative data on the overstory component of the pseudoriparian association was not collected, mesquite, Joshua tree, and little-leaf palo verde were observed to be abundant in many of the draws and washes in the area (Dames & Moore, 1978b). The understory vegetation in the type consists largely of mosquite, burrobush, catclaw, and creosotebush (Table 2.8-2) although a variety of other shrubs, cacti, and herbaceous plants are also found in the association (Table C-2, Appendix C). Most of the shrubs observed in the pseudoriparian type were larger and more robust than individuals of the same species growing in adjacent upland areas. This is apparently due to increased soil moisture in the drainages.

Range Condition

Assuming no disturbance, plant communities such as those occurring on the Anderson property and in adjacent areas are described as ephemeral livestock range with the primary forage consisting of annuals such as grasses, filaree, Indianwheat, and mustards (Dames & Moore, 1978a). The growth of these annuals is closely tied to precipitation which is extremely varied from year to year.

Given that the property is not highly productive livestock range, its quality relative to similar habitats can be estimated based on the percentage of regression that has occurred from "climax" vegetation to early successional stages as the result of disturbance. Four range condition classes (excellent, good, fair, and poor) have been recognized (Dames & Moore, 1978a). Each condition class represents a 25 percent reduction in the vegetative potential of a given area of rangeland. The appropriate condition class is generally determined by the abundance of key indicator plant species. These plant indicators are termed decreasers, increasers, and invaders. Decreasers are native plant species such as galleta grass and bush muhley that become less abundant due to grazing pressure. Increasers are native species such as senegio, bursage, and bricklebush that become more abundant due to grazing pressure. Invaders are exotic (nonnative) plant species such as paperflower, buckwheat, and skeleton weed that also become more abundant on disturbed sites.

Point intercepts were taken at three locations in the Joshua tree woodland and one location in the upland desert type (Table 2.8-3). One of the samples (Sample D) was taken in a fenced exclosure constructed by the U.S. Bureau of Land Management (BLM) in the mid-1960's. The vegetation in this exclosure is representative of ungrazed Joshua tree wood land habitat.

As can been seen from the data in Table 2.8-3, the vegetation cover at sample sites A, B, and C was less than half that found in the exclosure. Big galleta grass, which is an important livestock forage plant and a decrea ser, was more than five times as abundant in the exclosure than at the other sample site. Bursage, an increaser, and paperflower, an invader, were found at all of the sample sites except the exclosure. These data, as well as field observations on the low reproduction of palatable forage plants, indicates that the property and adjacent areas are in the "poor" range condition class (Dames & Moore, 1978a).

TABLE 2.8-3

PERCENT RELATIVE COMPOSITION AND PERCENT ABSOLUTE COVER BASED ON POINT INTERCEPT DATA FROM FOUR SAMPLE SITES

| SPECIES | SITES A* | | B* | | C* | | D | |
|---|---|---|---|---|---|---|---|---|
| | % Com | % Cov | % Com | % Cov | % Com | % Cov | % Com | % Cov |
| Annual | | | | | | | 4 | 2 |
| Barrel Cactus | 2 | <1 | - | - | - | - | - | - |
| Beavertail Cactus | - | - | - | - | 1 | <1 | - | - |
| Blackbrush | 2 | <1 | 4 | 1 | 1 | <1 | - | - |
| Big Galleta | 9 | -1 | 6 | 2 | 1 | <1 | 18 | 10 |
| Bladderpod | - | - | 1 | <1 | - | - | - | - |
| Bush muhley | 2 | <1 | 1 | <1 | - | - | 2 | 1 |
| Cane Cholla | 15 | 2 | 8 | 2 | 6 | 2 | 15 | 8 |
| Catclaw | 2 | <1 | 5 | 1 | - | - | 4 | 2 |
| Creosotebush | 25 | 4 | 27 | 10 | 23 | 6 | 18 | 12 |
| Desert Holly | - | - | - | - | - | - | 2 | 1 |
| Desert Trumpet | - | - | 1 | <1 | - | - | - | - |
| Engelmann Pr. Pear | - | - | - | - | - | - | 2 | 1 |
| Eriogonum spp. | 4 | <1 | 3 | 1 | 4 | 1 | - | - |
| Flat-top Buckwheat | 4 | <1 | - | - | 1 | <1 | - | - |
| Fluff Grass | - | - | - | - | 1 | <1 | - | - |
| Globemallow spp. | - | - | - | - | - | - | 2 | 1 |
| Hedgehog Cactus | - | - | 1 | <1 | - | - | 2 | 1 |
| Joint-fir | - | - | 1 | <1 | 1 | <1 | 4 | 2 |
| Joshua tree | - | - | 4 | 2 | - | - | 2 | 8 |
| Little-leaf Palo Verde | 4 | 1 | - | - | 9 | 4 | - | - |

TABLE 2.8-3 concluded

| SPECIES | A* % Com | A* % Cov | B* % Com | B* % Cov | C* % Com | C* % Cov | D % Com | D % Cov |
|---|---|---|---|---|---|---|---|---|
| Little-leaf Ratany | 2 | <1 | 3 | 1 | 1 | <1 | - | - |
| Mediterianean Grass | 2 | <1 | 9 | 2 | 4 | 1 | 5 | 3 |
| Nightshade | - | - | - | - | - | - | 2 | 1 |
| Ocotillo | 4 | <1 | 4 | 1 | 1 | <1 | - | - |
| Paperflower | 4 | <1 | 8 | 2 | 2 | <1 | - | - |
| Red Brome | - | - | - | - | 2 | <1 | 9 | 5 |
| Saguaro | - | - | - | - | 2 | <1 | - | - |
| Squirrel-tail Grass | - | - | 1 | <1 | - | - | - | - |
| White Brittlebush | - | - | -- | - | 4 | 1 | - | - |
| White Bursage | 19 | 3 | 8 | 3 | 19 | 5 | - | - |
| Wild Gourd | - | - | - | - | - | - | 9 | 5 |
| Wool Indiantwheat | - | - | 5 | 1 | 17 | 5 | - | - |
| Total | 100 | 11+ | 100 | 24+ | 100 | 25+ | 100 | 63 |

* Average of three 100-pt. intercept. A) 3 lines near sample site 6 - Joshua tree forest; B) 3 lines near sample site 5 - Joshua tree forest; C) 3 lines 0.2 miles north of sample site 1 - Sonoran Desert ecotone; and D) one line in an exclosure 4 miles west of Hwy. 93 on Alamo Rd. Joshua tree forest (see Plate 3.1.1-1).

$$\% \text{ Relative Composition} = \frac{\text{No. plants intercepted per species}}{\text{Sum plants intercepted for all species}} \times 100$$

$$\% \text{ Absolute Cover} = \frac{\text{No. Plants intercepted per species}}{\text{Total Plants taken}} \times 100$$

Source: Dames & Moore, 1978a

Drought conditions over the last few years and foraging by feral burros appear to be the primary factors causing a deterioration of the range in the vicinity of the Anderson property. Stocking rates for domestic animals can be easily adjusted to prevent range destruction, but drought and feral burros pose a more perplexing problem. The BLM has recently attempted to bring grazing pressure into balance with range production. They have removed a large number of burros from the general area as one means of reducing further deterioration of the range (Dames & Moore, 1978a).

Grazing pressure on the property is regulated by the BLM. The Anderson property is located in the BLM's Santa Maria Community Allotment which encompasses 62,000 acres. The stocking rate for this allotment is currently 198 animal units (defined as one cow or one cow with unweaned calf) per year (Dames & Moore, 1978a).

Threatened, Endangered or Protected Plant Species

The 1974 listing of protected plant species published by the Arizona Commission of Agriculture and Horticulture include the following species identified on the Anderson property or in the adjacent area during the biological field program. It should be noted that none of these species are considered to be endangered or threatened.

- Mescal (Agave deserti). 0.1 mile north of the Anderson Mine at about 1800 feet. Approximately 20 plants.
- Saguaro (Cereus giganteus). Throughout upland desert type.

- Hedgehog cactus (Echinocereus fasciculatus). Throughout upland desert on exposed ridges above washes.

- Engelmann hedgehog cactus (E. englemannii). Same location as hedgehog cactus.

- Barrel cactus (Ferocactus acanthodes). On canyon walls and mesa slopes in Sections 3, 10, and 16, T11N, R10W.

- Ocotillo (Fourquieria Splendens). Throughout upland desert on well drained bajada and mesa.

- Crucifixion-thorn (Halocantha emoryi). SW 1/4 of Section 11, T11N, R10W. About 0.3 mile SW of Anderson Mine at base of rocky slope, elevation 1800 feet. Also on mesa slopes to the east and west.

- Fishhook pincushion (Mammallaria microcarpa). Throughout upland desert on slightly modified exposures or at sites where soils have some water retention capacity such as rock crevices, washes, and shaded areas.

- Bigelow nolina (Nolina bigelovii). Six plants immediately south of Anderson Mine road, SW 1/4 of Section 11, T11N, R10W, elevation 1820 feet.

- Buckhorn cholla (Opuntia acanthocarpa). Throughout upland desert on sandy or gravelly soils of benches, mesa slopes, and washes.

- Beavertail cactus (O. basilaris). Upland desert on well-drained sandy and gravelly soils above 1400 feet.

- Teddy bear cholla (O. bigelovii). On well drained, rocky or gravelly south-facing slopes and mesa tops below 2000 feet.

- Pancake prickly pear (O. chlorotica). A few isolated plants on north-facing rocky slopes of higher mesas facing the Santa Maria River in Section 3, T11N, R10W.

- Christmas cactus (O. leptocaulis). Mesas, bajadas, and arroyos throughout upland desert in sandy soils.

- Englemann prickly pear (O. phaecantha). Rocky, gravelly or sandy soils of higher mesas and bajadas in the upland desert to the east and north of the Anderson Mine.

- Banana yucca (Yucca baccata). Rocky to sandy soils on higher ridges and protected slopes in the upland desert north and east of the Anderson Mine.

- Joshua tree (Y. brevifolia). Throughout upland desert, particularly numerous on arroyo slopes above 1400 feet and in Joshua tree woodland on the mesa south and west of the Anderson property.

- Soaptree yucca (Y. elata). Throughout upland desert in arroyo flats and other locations having sandy alluvial soils above the Santa Maria River floodplain.

WILDLIFE

A total of 95 species of land vertebrates were identified on the Anderson property and in the vicinity of the proposed water pipeline route and access road (Table C-3, Appendix C-2). Of these species, 2 percent were amphibians, 16 percent were reptiles, 63 percent were birds, and 19 percent were mammals. The low number of amphibian species found in the area is due largely to the general lack of surface water. The large proportion of bird species is charcteristic of temperate terrestrial ecosystems. The mammals observed in the area were primarily rodent species.

## Reptiles and Amphibians

Fifteen species of reptiles and two species of amphibians were observed in the vicinity of the Anderson property (Table C-3, Appendix C-3). As would be expected, the amphibian species were found exclusively in the riparian habitat along the Santa Maria River. Of the 15 reptile species, 8 were recorded in the riparian habitat, 6 in pseudo-riparian vegetation, 9 in the Joshua tree woodland, and 13 in the upland desert type.

TABLE 2.8-4

REPTILIAN COMPOSITION AND ABUNDANCE BASED ON NUMBER OF CAPTURES FROM FOUR 5 X 5 DROP-TRAP GRIDS

| | GRID | | | | |
|---|---|---|---|---|---|
| **I. April 21-23** | A* | B | C | C | Total |
| Side-blotched Lizard | - | - | 2 | 1 | 3 |
| Desert Horned Lizard | - | - | 2 | - | 2 |
| Western Whiptail | 2 | 2 | - | 1 | 5 |
| TOTAL | 2 | 2 | 4 | 2 | |
| **II. June 8-10** | | | | | |
| Banded Gecko | 2 | - | 3 | - | 5 |
| Side-blotched Lizard | 1 | - | 8 | 1 | 10 |
| Desert Horned Lizard | - | - | 1 | - | 1 |
| Western Whiptail | - | 3 | - | 1 | 4 |
| TOTAL | 3 | 3 | 12 | 2 | |
| **III. October 21-23** | | | | | |
| Zebra-tailed Lizard | 1 | - | - | - | 1 |
| Side-blotched Lizard | 2 | - | 1 | 1 | 4 |
| TOTAL | 3 | - | 1 | 1 | |

*Grid A - Joshua tree woodland, B- Upland desert, C-Upland desert west of Anderson Mine, and D - Riparian

Source: Dames & Moore 1978a

TABLE 2.8-5

AVERAGE BIRD DENSITY (Per 100 ACRES) BASED ON 3-DAY TRANSECT COUNTS

I. February 25-27

| | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 |
|---|---|---|---|---|---|---|
| | $\bar{N}$ | | | $\bar{N}$ | $\bar{N}$ | |
| Red-tailed Hawk | | | | <1 | | |
| Gambel's Quail | <1 | | | | 10 | |
| White-throated Swift | <1 | | | | 6 | |
| Costa's Hummingbird | | | | | 64 | |
| Gila Woodpecker | 2 | | | | | |
| Ladder-backed Woodpecker | | | | | 5 | |
| Verdin | 3 | | | 3 | 2 | |
| Cactus Wren | 4 | | | 2 | | |
| Rock Wren | | | | 3 | | |
| Bendire's Thrasher | 1 | | | | | |
| Black-tailed Gnatcatcher | | | | 3 | 2 | |
| Phainopepla | | | | | 8 | |
| Loggerhead Shrike | 3 | | | | | |
| House Finch | | | | | 136 | |
| American Goldfinch | | | | | 5 | |
| Brown Towhee | | | | | 2 | |
| Black-throated Sparrow | 12 | | | 7 | | |
| White-crowned Sparrow | 12 | | | | 9 | |
| TOTAL AVERAGE DENSITY | ~37 | | | ~18 | 249 | |
| TOTAL SPECIES | 9 | | | 6 | 11 | |

*Transect M-1, S-2, and R-1 were run in winter census. All transects were run during other seasons.

II. April 6-8

| | $\bar{N}$ | $\bar{N}$ | $\bar{N}$ | $\bar{N}$ | $\bar{N}$ | $\bar{N}$ |
|---|---|---|---|---|---|---|
| Turkey Vulture | <1 | <1 | <1 | <1 | <1 | <1 |
| Sharp-shinned Hawk | | | <1 | <1 | 1 | 2 |
| Red-Tailed Hawk | | | | | | |
| Golden Eagle | | | <1 | | | |
| American Kestrel | 1 | <1 | | | | |
| Gambel's Quail | 9 | 3 | 3 | 7 | 9 | 15 |
| Mourning Dove | 2 | 2 | | | 1 | |
| Roadrunner | <1 | | | | | |
| White-Throated Swift | <1 | | 1 | | <1 | |

# TABLE 2.8-5 (Cont)

| | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 |
|---|---|---|---|---|---|---|
| Black-ch. Hummingbird | | | | | | 9 |
| Costa's Hummingbird | | 2 | 7 | | | |
| Common Flicker | 7 | <1 | | <1 | | |
| Gila Woodpecker | | <1 | | | | |
| Ladder-backed Woodpecker | | | | | | 1 |
| Western Kingbird | 7 | 5 | 4 | | 5 | 4 |
| Ash-throated Flycatcher | 8 | 5 | 4 | | | 12 |
| Violet-gr. Swallow | <1 | | | | 2 | |
| White-necked Raven | <1 | | | <1 | | 1 |
| Verdin | 4 | | 3 | 7 | 5 | 22 |
| Cactus Wren | 7 | 8 | 3 | 10 | <1 | |
| Canyon Wren | | | | | 4 | |
| Rock Wren | | | | 7 | 5 | |
| Mocking Bird | | <1 | 2 | | | |
| Bendire's Thrasher | 5 | 1 | | 2 | | |
| Curved-billed Thrasher | 3 | <1 | | | | |
| Crissal Thrasher | | | | | 2 | 9 |
| Black-tailed Gnatcatcher | | 1 | 11 | 19 | 2 | |
| Ruby-crowned Kinglet | | | | | 18 | |
| Phainopepla | | | 2 | 7 | 25 | 12 |
| Loggerhead Shrike | 1 | | | | | |
| Hutton's Vireo | | | | | | 5 |
| Bell's Vireo | | | | | | 2 |
| Lucy's Warbler | | | | | 7 | 40 |
| Yellow-rumped Warbler | | | | | 5 | |
| Wilson's Warbler | | | | | 5 | 8 |
| Scott's Oriole | <1 | | <1 | | | |
| House Finch | 27 | 10 | 2 | 31 | 14 | 37 |
| Brown Towhee | | | 1 | | 3 | |
| Lesser Goldfinch | | | | | 5 | |
| Black-throated Sparrow | 34 | 12 | 44 | 31 | 5 | 23 |
| Chipping Sparrow | | | 5 | | | |
| Brewer's Sparrow | 59 | 19 | 8 | 7 | 28 | 52 |
| White-crowned Sparrow | 5 | 10 | | | 14 | 31 |
| TOTAL AVERAGE DENSITY | ~179 | ~78 | ~100 | ~129 | ~165 | ~305 |
| TOTAL SPECIES | 21 | 18 | 19 | 14 | 24 | 19 |

III. June 8-10

| | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 |
|---|---|---|---|---|---|---|
| Turkey Vulture | | <1 | | <1 | | |
| Sharp-shinned Hawk | | 2 | | | | |

# TABLE 2.8-5 (Cont)

| | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 |
|---|---|---|---|---|---|---|
| Red-tailed Hawk | | | | | <1 | |
| American Kestrel | <1 | | | | | |
| Gambel's Quail | 2 | 8 | 2 | 7 | 13 | 13 |
| White-winged Dove | 6 | | 1 | <1 | 36 | 21 |
| Mourning Dove | 5 | 3 | 4 | 4 | 21 | 4 |
| Great Horned Owl | | <1 | | | | |
| Elf Owl | | | <1 | | | |
| Lesser Nighthawk | 2 | 2 | <1 | 1 | | |
| White-throated Swift | | | | | | 1 |
| Black-ch. Hummingbird | | | | | 7 | 9 |
| Costa's Hummingbird | 7 | 3 | | 11 | 3 | |
| Common Flicker | 2 | | 5 | 2 | 3 | 1 |
| Gila Woodpecker | | | <1 | | | |
| Ladder-backed Woodpecker | | | | | 2 | 5 |
| Western Kingbird | 10 | 3 | 4 | 1 | 7 | 8 |
| Ash-throated Flycatcher | 6 | 7 | 10 | 6 | 34 | 19 |
| Say's Phoebe | | | | | 1 | |
| Violet-green Swallow | | | | | | |
| Cliff Swallow | | | | | 2 | |
| White-necked Raven | <1 | <1 | <1 | | | <1 |
| Verdin | | | 3 | 10 | 21 | 15 |
| Cactus Wren | 17 | 6 | 5 | 8 | 3 | [illegible] |
| Canyon Wren | | | | | | |
| Rock Wren | | | | | | |
| Mockingbird | 1 | | <1 | | 1 | |
| Curve-billed Thrasher | 7 | 3 | 3 | 1 | | |
| Crissal Thrasher | | | | | 7 | 13 |
| Phainopepla | | | | | 7 | |
| Black-tailed Gnatcatcher | 3 | 8 | 8 | 11 | 34 | 27 |
| Loggerhead Shrike | 3 | <1 | 1 | 3 | | |
| Bell's Vireo | | | | | 38 | 14 |
| Lucy's Warbler | | | | | 48 | 70 |
| Hooped Oriole | | | | | | 1 |
| Scott's Oriole | 5 | | | | | |
| House Finch | 9 | 4 | 6 | 3 | 3 | 7 |
| Lesser Finch | | | | | 3 | 4 |
| Brown Townee | | | | | 3 | 4 |
| Black-throated Sparrow | 37 | 30 | 19 | 22 | 2 | 5 |
| TOTAL /ERAGE DENSITY | ~122 | ~79 | ~71 | ~90 | ~299 | ~241 |
| TOTAL SPECIES | 18 | 16 | 18 | 16 | 24 | 20 |

# TABLE 2.8-5 concluded

IV. October 21-23

| | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 |
|---|---|---|---|---|---|---|
| Red-tailed Hawk | <1 | | | | | <1 |
| American Kestrel | <1 | | | <1 | | |
| Gambel's Quail | 3 | <1 | | 5 | 16 | |
| Mourning Dove | | | 3 | 3 | | 6 |
| Roadrunner | | 2 | | | | |
| White-throated Swift | | | | | 5 | |
| Black-ch. Hummingbird | | | | | | |
| Costa's Hummingbird | | | | | 5 | |
| Common Flicker | | <1 | <1 | | 3 | |
| Gila Woodpecker | | 2 | | | | |
| Ladder-backed Woodpecker | | | | | 1 | |
| Violet-green Swallow | | | | | | 1 |
| Cliff Swallow | | | | | | |
| White-necked Raven | | | | | <1 | <1 |
| Verdin | | | 6 | 1 | 7 | 1 |
| Cactus Wren | 5 | 3 | 3 | <1 | 1 | |
| Canyon Wren | | | | | <1 | |
| Rock Wren | | | 2 | | | |
| Mockingbird | | 2 | <1 | | | 2 |
| Curved-billed Thrasher | | | <1 | | | |
| Sage Thrasher | 2 | | | | | |
| Robin | | | | | | 2 |
| Black-tailed Gnatcatcher | | | 5 | 1 | 14 | 6 |
| Phainopepla | | | 7 | | 3 | 5 |
| Loggerhead Shrike | <1 | | 3 | 1 | | |
| Bell's Vireo | | | | | 14 | 16 |
| Yellow Warbler | | | | | 5 | |
| Yellow-rumped Warbler | | | 2 | | 2 | |
| Brown-headed Cowbird | | | 3 | | | |
| House Finch | | 8 | 2 | 2 | 3 | 12 |
| Lark Bunting | | <1 | | 10 | | |
| Vesper Sparrow | 1 | | | | | |
| Black-throated Sparrow | 10 | 2 | 15 | 7 | | |
| Chippink Sparrow | | | | | | 3 |
| Brewer's Sparrow | 7 | | | | | |
| White-crowned Sparrow | <1 | | | | | 8 |
| TOTAL AVERAGE DENSITY | ~28 | [illegible] | ~51 | ~30 | ~79 | ~63 |
| TOTAL SPECIES | 9 | 10 | 14 | 10 | 15 | 14 |

Source: Dames & Moore, 1978a

Only five reptile species were collected in the drop-trap grids established in the area (Figure 2.8-1 and Table 2.8-4). The data from this sampling program indicate that the greatest reptile activity took place in June, with the sideblotched lizard being the most commonly caught species followed by the western whip-tail and the banded gecko.

No significant difference in the numbers of captures per species or the total captures per season was found among trap grids (Friedmann Test, S = 16.5 in both cases). These results indicate that captured reptile species are widely dispersed in the area and show no selective habitat preferences (Dames & Moore, 1978a).

Birds

Based on census transect data (Figure 2.8-1 and Table 2.8-5), there is a significant seasonal change in the number of bird species and the density of birds on the Anderson property and the adjacent areas (Krushal-Wallis Test, $H = 14.20$, $P \leq 0.01$, and $H = 8.92$, $P \leq 0.05$, respectively). Wintering and breeding bird populations are relatively abundant in the riparian vegetation type (transects R-1 and R-2, Table 2.8-5) compared to the Joshua tree woodland (transects M-1 and M-2) and upland desert vegetation type (transects S-1 and S-2). The mesquite bosques along the Santa Maria River are apparently used heavily by resident species during the winter and by a variety of species that breed in the area during the summer. These bosques also appear to be an important habitat for arborescent birds that migrate through the area (Dames & Moore, 1978a).

Transect counts taken during each of four seasons were analyzed for species similarity and density similarity (Table 2.8-6). None of the transect data collected in February were similar in terms of species or mean densities. This indicates a dissimilarity of bird communities among the different vegetation types of the area during the winter. In April, species similarity was greater than 50 percent for all transects except for one case of Joshua tree woodland and mesquite bosque (Transect M-2 x R-1 and R-2). Density similarity was also greater in April than in February. The April data indicate that there are three distinct groups or communities of birds in the area during the spring; one group utilizes Joshua tree woodland, upland desert, and mesquite bosque (transects M-1 and M-2 x S-2 and R-2), another inhabits upland desert (transect S-1 x S-2), and the third inhabits riparian vegetation (transect R-1 x R-2). This pattern is the result of resident species dispersing throughout the area and migrant birds utilizing pseudoriparian and riparian habitats (Dames & Moore, 1978a). Similarity patterns in species composition for the June data was identical to that of the April data; however, summer density clustered in two groups, desert (Joshua tree woodland and upland desert) and mesquite bosque. The October transect data indicate dispersal of bird species with mutual species occurrence in deserts (Table 2.8-6). Bird distribution was spotty in the fall, suggesting aggregation, as would be expected preceding and during migration (Dames & Moore, 1978a).

A total of 22 bird species were noted to be breeding in the vicinity of the property (Table C-3, Appendix C-2). Nests of white-winged dove,

# TABLE 2.8-6

## SPECIES AND DENSITY SIMILARITY OF BIRDS BASED ON TRANSECT DATA

I February 25-27

% Density Similarity [a]

| | Transect | M-1 | S-2 | R-1 | APPROX. TOTAL MEAN DENSITY |
|---|---|---|---|---|---|
| | M-1 | * | 43 | 8 | 37 |
| % Species | S-2 | 40 | * | 10 | 18 |
| Similarity [b] | R-1 | 40 | 24 | * | 249 |
| TOTAL SPECIES | | 9 | 6 | 11 | |

II April 6-8

% Density Similarity

| | Transect | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 | APPROX. TOTAL MEAN DENSITY |
|---|---|---|---|---|---|---|---|---|
| | M-1 | * | 53 | 44 | 55 | 42 | 55 | 178 |
| | M-2 | 72 | * | 44 | 40 | 44 | 33 | 79 |
| % Species | S-1 | 58 | 56 | * | 54 | 23 | 24 | 100 |
| Similarity | S-2 | 61 | 53 | 61 | * | 36 | 38 | 129 |
| | R-1 | 51 | 45 | 56 | 58 | * | 51 | 165 |
| | R-2 | 53 | 41 | 53 | 56 | 60 | * | 305 |
| TOTAL SPECIES | | 19 | 20 | 19 | 14 | 24 | 19 | |

III June 8-10

% Density Similarity

| Transect | | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 | APPROX. TOTAL MEAN DENSITY |
|---|---|---|---|---|---|---|---|---|
| | M-1 | * | 65 | 59 | 60 | 20 | 23 | 122 |
| | M-2 | 74 | * | 73 | 77 | 21 | 24 | 79 |
| | S-1 | 83 | 69 | * | 74 | 24 | 28 | 69 |
| | S-2 | 82 | 73 | 82 | * | 27 | 30 | 80 |
| | R-1 | 57 | 44 | 55 | 60 | * | 68 | 299 |
| | R-2 | 53 | 43 | 58 | 56 | 77 | * | 241 |
| TOTAL SPECIES | | 18 | 17 | 18 | 16 | 24 | 20 | |

TABLE 2.8-6 concluded

IV October 21-23

% Density Similarity

| Transect | M-1 | M-2 | S-1 | S-2 | R-1 | R-2 | APPROX. TOTAL MEAN DENSITY |
|---|---|---|---|---|---|---|---|
| M-1 | * | 21 | 33 | 35 | 7 | <1 | 28 |
| M-2 | 32 | * | 20 | 17 | 8 | 47 | 19 |
| S-1 | 26 | 42 | * | 37 | 29 | 28 | 51 |
| S-2 | 53 | 50 | 58 | * | 16 | 15 | 30 |
| R-1 | 17 | 32 | 48 | 40 | * | 49 | 80 |
| | 17 | 17 | 43 | 33 | 41 | * | 62 |
| TOTAL SPECIES | 9 | 10 | 14 | 10 | 15 | 14 | |

a. % Density Similarity = (2 Mw/Ma+MB) x 100 where

Mw = smaller density value of a species mutually occuring in two transects.

Ma = total mean density of all species for a transect

Mb = total mean density of all species for the second transect (Motylea et al., 1950)

b. % Species Similarity = (2c/A+B) x 100 where

c = number of species common to two transects

A = total number of species for a transect

B = total number of species for a second transect (Sorensen, 1948).

c. Total mean density rounded to nearest whole number.

d. Matrix values entered as percent rounded to nearest whole number greater than one. Similarity greater than or equal to 50% enclosed in a polygon.

Source: Dames & Moore, 1978a

common flicker, verdin, cactus wren, lesser goldfinch, and black-throated sparrow were found in the area. Juveniles of Gambel's quail, mourning dove, lesser nighthawk, western kingbird, ash-throated flycatcher, black-tailed gnatcatcher, and loggerhead shrike were observed in the area in June and August. Pairs, possibly breeding on or near the property, included redtailed hawk, American kestrel, great horned owl, Costa's hummingbird, canyon wren, rock wren, curvebilled thrasher, crissal thrasher, Bell's vireo, Lucy's warbler, and brown towhee (Dames & Moore, 1978a).

Mammals

A total of 18 species of mammals, primarily rodents, were observed on the Anderson property and in adjacent areas (Table C-3, Appendix C-2). Of these species, 11 were recorded in both the riparian and upland desert vegetation types, 7 were observed in the pseudoriparian type, and 12 were recorded in the Joshua tree woodland.

Small mammals were trapped at seven locations on and near the property during the spring and fall of 1977 (Table 2.8-7). Merriam's kangaroo rat was the most abundant species captured during both sampling periods. The Arizona pocket mouse was also present in relatively large numbers in the spring, but none were captured in the fall (Table 2.8-7). The rock pocket mouse was the third most abundant species captured in the area, being about equally common in both seasons. The other species trapped in the area were not common during either season. As is expected, general breeding activity of these rodents was highest in the spring and sub-adults became increasingly important in the population towards fall (Table 2.8-7).

The simiarlity for captures among trap lines during the spring was greatest in the Joshua tree woodland (trap line A x G, Table 2.8-8). This was due largely to the abundance of Arizona rock pocket mouse. Similarity for captures was greater than 50 percent in most of the trap lines run during the fall. This was due primarily to the wide spread occurrence of Merriam's kangaroo rat.

The black-tailed jackrabbit was the only intermediate-sized mammal species commonly observed in the area, although the presence of desert cottontails was also noted. Road census data (approximately 20 mile route) collected over three day periods after sundown in April, June, and October was as follows:

| Season | Species | Number and Age Class |
|---|---|---|
| Spring | Black-tailed jackrabbit | 16 adults |
| | Desert cottontail | 2 adults |
| Summer | Black-tailed jackrabbit | 8 adults, 12 sub-adults |
| | Desert cottontail | 1 adult, 1 sub-adult |
| Fall | Black-tailed jackrabbit | 3 adults |

Deer have been occasionally sighted in the vicinity of the Anderson property by MINERALS employees and Dames & Moore biologists. Three sets of deer tracks were noted along bird transect M-1 in February. In October, deep pellet groups were found along bird transect S-2. BLM personnel have observed as many as 35 deer near Tres Alamos Peak southeast of the property.

TABLE 2.8-7

SMALL MAMMAL DATA OBTAINED FROM
SEVEN SETS OF LIVE-TRAP ASSESSMENT LINES

I. Capture Success

| | | April 21-23 | October 20-22 |
|---|---|---|---|
| a. | Number of sample site | 7 | 7 |
| b. | Number of trap lines per sample | 2 | 2 |
| c. | Number of live traps per line | 25 | 25 |
| d. | Number of nights traps were set | 3 | 3 |
| e. | Total trap nights (axbxcxd) | 1050 | 1050 |
| f. | Total captures | 98 | 90 |
| g. | Percent capture success | 9.3 | 8.6 |

II. Composition, captures, and biomass

| | N* | B** | $\bar{B}$ | N | B | $\bar{B}$ |
|---|---|---|---|---|---|---|
| Yuma Antelope Squirrel | 10 | 1439 | 143.9 | 4 | 393 | 98.3 |
| Arizona Pocket Mouse | 32 | 390 | 12.2 | - | - | - |
| Rock Pocket Mouse | 14 | 202 | 14.4 | 10 | 132 | 13.2 |
| Bailey's Pocket Mouse | - | - | - | 4 | 73 | 18.3 |
| Merriam's Kangaroo Rat | 33 | 1447 | 43.8 | 71 | 2713 | 38.2 |
| Deer Mouse | 1 | 18 | 18.0 | - | - | - |
| Brush Mouse | 3 | 44 | 14.7 | - | - | - |
| Whitethroated Woodrat | 5 | 708 | 141.6 | 1 | 110 | 110.0 |
| TOTAL | 98 | 4248 | | 90 | 3363 | |

* Number of captures.

** Biomass (B) and average biomass ($\bar{B}$) in grams.

TABLE 2.8-7 concluded

III. Age and Reproductive Status Adults-Reproductively

REPRODUCTIVE STATUS

| | | ACTIVE | | INACTIVE | | SUBADULTS | |
|---|---|---|---|---|---|---|---|
| | | MALES | FEMALES | MALES | FEMALES | MALES | FEMALES |
| Yuma Antelope Squirrel | Apr | 5 | 2 | - | 3 | - | - |
| | Oct | 1 | - | - | 2 | 1 | - |
| Rock Pocket Mouse | Apr | 6 | 4 | - | 4 | - | - |
| | Oct | - | - | 2 | 3 | 2 | 3 |
| Arizona Pocket Mouse | Apr | 11 | 5 | 10 | 4 | - | 2 |
| | Oct | - | - | - | - | - | - |
| Bailey's Pocket Mouse | Apr | - | - | - | - | - | - |
| | Oct | - | - | 1 | 3 | - | - |
| Marriam's Kangaroo Rat | Apr | 15 | 4 | 2 | 10 | - | 2 |
| | Oct | 20 | 1 | 5 | 19 | 4 | 22 |
| Deer Mouse | Apr | 1 | - | - | - | - | - |
| | Oct | - | - | - | - | - | - |
| Brush Mouse | Apr | - | 1 | - | 1 | - | 1 |
| | Oct | - | - | - | - | - | - |
| Whitethroat Woodrat | Apr | - | 5 | - | - | - | - |
| | Oct | - | - | - | - | - | - |

Source: Dames & Moore, 1978a

TABLE 2.8-8

CAPTURES AND PERCENT SIMILARITY FOR CAPTURES AMONG ASSESSMENT LINES

I. Captures (April 21-23):

| | SITE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | TOTAL |
| Yuma Antelope Squirrel | 2 | 1 | 1 | 1 | - | 4 | 1 | 10 |
| Arizona Pocket Mouse | 16 | 1 | - | - | - | 5 | 10 | 32 |
| Rock Pocket Mouse | 1 | - | 7 | 1 | 4 | 1 | - | 14 |
| Merriam's Kangroo Rat | 15 | - | 2 | 1 | - | 1 | 15 | 33 |
| Deer Mouse | - | - | - | 1 | - | - | - | 1 |
| Brush Mouse | - | - | - | 1 | 2 | - | - | 3 |
| Whitethroated Woodrat | - | 1 | 1 | 1 | - | - | 2 | 5 |
| TOTAL | 34 | 3 | 11 | 6 | 6 | 10 | 28 | 98 |

II. Captures (October 20-22):

| | A | B | C | D | E | F | G | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Yuma Antelope Squirrel | - | - | 3 | - | - | - | - | 4 |
| Rock Pocket Mouse | - | - | 6 | - | 1 | 3 | - | 10 |
| Bailey's Pocket Mouse | - | - | - | 3 | 1 | - | - | 4 |
| Merriam's Kangagroo Rat | 17 | 11 | 5 | 9 | 2 | 11 | 16 | 71 |
| Whitethroated Woodrat | - | - | - | - | - | - | 1 | 1 |
| TOTAL | 17 | 11 | 14 | 12 | 4 | 14 | 18 | 90 |

TABLE 2.8-8 concluded

III. Percent Similarity for Capture Among Assessment Lines For Spring and Fall

SPRING

| | Site | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|
| | A | X | 11 | 18 | 15 | 5 | 36 | 84 |
| | B | 79 | X | 29 | 44 | 0 | 31 | 19 |
| | C | 32 | 40 | X | 47 | 47 | 19 | 21 |
| FALL | D | 62 | 78 | 62 | X | 33 | 25 | 18 |
| | E | 19 | 27 | 33 | 38 | X | 13 | 0 |
| | F | 71 | 88 | 57 | 92 | 33 | X | 32 |
| | G | 97 | 81 | 40 | 64 | 20 | 73 | X |

a. % Similarity = (2Mw/MA+MB) x 100 where
Mw = minimum number of mutual captures for a species in two transects
MA = total captures of all species for a transect
MB = total captures of all species for a second transect in the crosswise comparison (Motyka et al., 1947)
% Similarity is rounded to the nearest whole number greater than one.
Similarity greater than, or equal to 50% enclosed in a polygon.

Source: Dames & Moore, 1978a

These observations indicate that deer utilize the Anderson property and adjacent areas in small numbers (Dames & Moore, 1978a).

Feral burros appear to utilize the property extensively. Fourteen burros were observed in the wash east of the Anderson Mine in mid-March. Another 21 animals were seen east of the mine in June and 3 burros were observed approximately 1/2 mile south of the driller's camp in October. Burro tracks were recorded in Section 4, T11N, R10W along the canyons and the Santa Maria River.

Threatened and Endangered Species

None of the species designated by the U.S. Department of the Interior as threatened or endangered were observed on the Anderson property or adjacent areas. There is evidence that two species, the desert tortoise and gila monster (*Heloderma suspectum*), listed by the Arizona Game and Fish Department as "species whose status in Arizona may be in jeopardy in the near future" utilize the area to some extent. Tortoise tracks were observed along the Santa Maria River west of the Anderson property in August and in Section 2, T11N, R10W near the river in October. No gila monsters were observed in the area by Dames & Moore biologists, but unverified sitings of this species have been reported by persons working in the area (Dames & Moore, 1978a).

The Federal Wild Horse and Burro Act of 1971 (Public Law 92-185; 85 Stat. 649) does not recognize the burro as an endangered or threatened species but it does grant the burro protected status. The proliferation of burro populations in the vicinity of Alamo Reservoir has posed a problem for the BLM (Mr. Dean Durfee, Phoenix District Office, BLM, personal communication by Dames & Moore, 1977). As discussed above, feral burros, possibly from the Alamo Reservoir herd, were found to utilize the property, particularly near the Santa Maria River.

ENVIRONMENTAL STRESS

Other than the effects of extensive grazing discussed above, environmental stresses are evident in the vicinity of the Anderson property as a result of past human activity.

Disturbance associated with past mining covers a radius of approximately 0.5 mile from the center of the old Anderson Mine. This disturbance is characterized by a scarified surface and the absence of dominant desert plant species. A number of unimproved roads have been constructed recently in the area to accomodate drilling and other mineral exploration activities. These roads have contributed to an increase in the amount of cleared or scarified land on the property and in adjacent areas.

# APPENDIX C

# BIOLOGY

APPENDIX C-1

BIOLOGICAL SAMPLING PROCEDURES

Sample site locations were stratified to obtain a representative sample of each of the major vegetation types identified on the Anderson property and in adjacent areas. Three major strata were recognized during a reconnaissance of the area: Joshua tree woodland, upland desert and riverine (riparian and pseudoriparian). All sample grids, lines and point transects were selected randomly within each strata. The objective of each sample method was to obtain maximum coverage and provide replication within strata. When a random sampling point fell in an area that had been obviously disturbed, such as areas disturbed by past mining activities, new random sites were selected. The field sampling schedule is provided in Table C-1.

VEGETATION

Vegetation sampling procedures used in the field program are described by Mueller-Dombois and Ellenberg (1974) and Phillips (1959). The line intercept method was used to measure vegetation cover and composition of shrubs, forbs and grasses. Size-class criterion was used in the sampling; measurement of basal area of any intercepted plant

TABLE C-1

VEGETATION AND WILDLIFE FIELD SCHEDULE FOR THE ANDERSON URANIUM PROJECT

| OBJECTIVE/TECHNIQUE | SAMPLE PERIOD | COMMENTS |
|---|---|---|
| 1. Floristics | All Field Visits | General Reconnaissance |
| 2. Vegetation Sampling | | |
| a. Line intercept, and quadrats | 11-15 Apr., 1977 | Sites 1-4 |
| | 31 Oct.-06 Nov, 1977 | Sites 5-14 |
| b. Point-centered quadrats | 13-15 Apr., 1977 | Sites 1 and 2 |
| | 31 Oct.-06 Nov., 1977 | Sites 5,6,7, and 8 |
| c. 100 pt.-line intercept | 17 Aug. 1977 | Near Sites 1,5, and 6 and at Almo Rd Enclosure. |
| 3. Faunistics | All Field Visits | General Reconnaissance |
| 4. Faunal Sampling | | |
| a. Herptiles | | |
| 1) 5x5 drop-trap grids | 21-23 Apr., 1977 | All grids (A,B,C, and D) |
| | 08-10 June, 1977 | All grids |
| | 21-23 Oct., 1977 | All grids |
| b. Birds | | |
| 1) Transect Counts | 25-27 Feb., 1977 | Transects M-1, S-2, and R-1 |
| | 06-08 Apr., 1977 | Tr. M-1, M-2, S-1, S-2, R-1, and R-2 |
| | 07-10 June, 1977 | Same as April |
| | 20-23 Oct., 1977 | Same as April |
| 2) Breeding Data | Mar.-Aug., 1977 | General Reconnaissance |
| 5. Small Mammals | | |
| a. Live trap assessment lines | 20-23 Apr., 1977 | Sites A-G |
| | 19-23 Oct., 1977 | Sites A-G |
| 6. Rabbits | | |
| a. Spring count | 06-08 Apr., 1977 | 20 mi. in and near project site |
| b. Summer count | 07-09 June, 1977 | Same as April |
| c. Fall count | 20-22 Oct., 1977 | Same as April |
| 7. Deer | | |
| a. Track and Pellet | Same as birds | Transects M-1 through R-2 |
| 8. Other Mammals | All Field Visits | General Reconnaissance |

Source: Dames & Moore, 1978a

less than six feet in height was included in the sample. Line intercepts were run at 14 locations (Figure 2.8-1). Twenty square meter quadrats were placed along each line intercept at 15-foot intervals. The density of forbs and grasses was measured in each quadrat.

The point-center quarters method was used to measure absolute density and dominance of large shrubs, trees, and cacti on sample sites 1, 2, 5, 6, 7, and 8 (Figure 2.8-1). At each of the selected sample sites, 20 points were read along a compass transect. Points along the transect were placed at 100-foot intervals to insure that plants were not resampled. At each point a 90° arc was read from true north dividing the full circle into four quadrants. In each quadrant the distance from the point to the nearest plant exceeding six feet in height was measured as well as the plant diameter at ground level.

Ten 100-point intercepts were read in upland areas to measure percent relative composition and cover. The points were read at three foot intervals along the intercepts. All plants intercepting the vertical plane to the point were tallied and the sum of sample plants per species was recorded. Three intercepts were run at each of the following locations: 0.2 mile north of sample site 1, in the vicinity of sample site 5, and in the vicinity of sample site 6. These locations were selected as representative of Joshua tree woodland and upland desert vegetation. One 100-point intercept was read in an established exclosure in Joshua tree woodland vegetation approximately four miles west of Highway 93 on Alamo Road. This site is about 16 miles southeast of the Anderson property. The exclosure has been fenced from livestock since the mid-1960s.

In addition to these samples, six 300-foot line intercepts were run parallel to the proposed access road right-of-way at intervals of approximately 2.2 miles. Plant occurrence was noted along the lines. Plants less than six feet in height that intercepted the vertical plane of the lines were counted. All plants greater than six feet in height within 50 feet of the road were counted. These data are in general agreement with the data presented in this report.

During the field program, floral composition was studied through the use of standard keys and field guides. Kearney and Peebles (1960) was referenced as the authority for scientific nomenclature.

WILDLIFE

Four rectilinear drop-trap grids were used to sample herptiles (reptiles and amphibians) (Figure 2.8-1). Traps consisted of open top, one gallon cans set in the ground so that the rims were level with the surface. The cans were placed at 12 meter intervals along coordinates in a 5 x 5 can grid. Samples were taken on a seasonal basis (Table C-1). During each sample period a one-square-foot masonite board was placed over each can and supported on stones to insure about two inches of clearance between the can rim and the lid. After three days, all traps were inspected for captures.

Birds were surveyed seasonally (Table C-1) by transect counts and general reconnaissance. Six transects were established in the area (Figure 2.8-1). In each season, counts were taken on three consecutive days along each transect. The number of all birds and the distance between the transect and the sighting were recorded. These data were converted to density based on methods described by Emlen (1971). Signs of breeding activity were recorded during all censuses and general reconnaissance. Data on breeding included evidence of breeding pairs, courtship behavior and presence of nests, juveniles, and broods.

Small mammals were sampled in the fall and spring (Table C-1) using the modified Calhoun method (1956). Seven sample sites were established in the area (Figure 2.8-1). Four of these sites (A, B, C and D) coincided with the drop-trap grids. Two traplines were established at each site. These lines were placed 250 feet apart and parallel to each other. Twenty-five Sherman live traps were places at 12-meter intervals along each line. The traps were baited and checked for three consecutive nights. Captured animals were marked, identifed, sexed, aged, and released at the point of capture. These data were used to determine composition, abundance, and reproductive status.

The relative abundance and population trend data for rabbits and other intermediate-sized mammals was obtained by using the roadsite-spotlight method (Lord, 1959). This census was conducted for three consecutive nights during April, June, and October (Table C-1) and involved counting all sightings within the headlight beams of a vehicle driven at less than 10 mph. The routes randomly traversed approximately 20 miles of unimproved road in the area (Figure 2.8-1).

Deer were sampled by noting evidence of tracks and pellet groups along bird transects. Sampling was conducted simultaneously with bird counts.

Other mammals such as predators and bats were noted by sightings and evidence of sign during general reconnaissance.

During the field program, wildlife was identified using standard keys and field guides. Scientific nomenclature follows Stebbins (1966), Blair et al. (1968), American Orithologist Union (1957), Phillips et al. (1964), Robbins et al. (1966), Burt and Gossenheider (1964), and Cockrum (1960).

APPENDIX C-2

# PLANTS AND ANIMALS OBSERVED IN THE VICINITY OF THE ANDERSON PROPERTY

TABLE C-2

PLANTS OBSERVED AT THE ANDERSON URANIUM PROJECT AREA

| | | COMMUNITY/VEGETATION TYPE | | | |
|---|---|---|---|---|---|
| TREES | | 1 | 2 | 3 | 4 |
| Canotia holocantha | Crucifixion Thorn | | X | X | X |
| Cercidium floridum | Blue Palo Verde | X | X | | |
| C. microphyllum | Little-leaf Palo Verde | X | X | X | X |
| Chilopsis linearis | Desert Willow | X | X | | |
| Populus Fremontii | Fremont Cottonwood | X | | | |
| Salix spp. | Willow | X | | | |
| SHRUBS, CACTI, AND LILLIES | | | | | |
| Acacia constricta | White-thorn | X | X | X | |
| A. Greggi | Catclaw | X | X | X | |
| Agave parryi | Agave | | | | X |
| Agave spp. | Mescal | | | | X |
| Aplopappus gracilis | Slender Goldenbush | | X | | |
| Aplopappus spp. | Goldenbush | X | X | X | |

a. Community/Vegetation Type:

1. Riparian
2. Pseudoriparian
3. Joshua Tree Woodland
4. Upland desert

TABLE C-2 (CONTINUED)

| | | | | | |
|---|---|---|---|---|---|
| Atriplex polycarpa | Desert Saltbush | X | X | | |
| Atriplex spp. | Saltbush | X | X | | |
| Baccharis glutinosa | Seep-willow | X | | | |
| B. sarothroides | Desert-broom | X | X | X | |
| Brickellia californica | Brickelbush | | X | | |

| SHRUBS, CACTI, AND LILLIES | | COMMUNITY/VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Cereus giganteus | Saguaro | | | | X |
| Chrysothamnus paniculatus | Black-bark Rabbitbush | X | | | |
| Condalia spp. | Graythorn | | X | | |
| Cowania Stansburiana | Cliff-rose | | X | | |
| Crossosoma Bigelovii | Bigelow Ragged Rock-flower | | X | | |
| Echinocereus fasciculatus | Hedgehog Cactus | | | X | X |
| E. Engelmanii | Englemann Hedgehog Cactus | | | | X |
| Encelia farinosa | Brittlebush | | X | | X |
| Ephedra trifurca | Joint-fir | | X | X | X |
| Ephedra spp. | Joint-fir | | | X | |
| Eriogonum fasciculatum | Flat-top Buckwheat-brush | X | X | X | X |
| Ferocactus acanthodes | Barrel Cactus | | | X | X |
| Fouquieria splendens | Ocotillo | | | X | X |
| Franseria deltoidea | Triangle Bursage | | X | | X |
| F. dumosa | White Bursage | | X | X | X |
| Holocantha Emoryi | Crucifixion-thorn | | X | | X |

TABLE C-2 (CONTINUED)

| | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *Hymenoclea monogyra* | Burrobush | | | | X |
| *H. salsola* | Burrobush | | X | | |
| *Hyptis Emoryi* | Desert Lavender | | X | | |
| *Krameria Grayi* | White Ratany | | | X | X |
| *K. parvifolia* | Range Ratany | | | X | X |
| *Larrea divaricata* | Creosotebush | | X | X | X |
| *Lycium Andersonii* | Anderson Thornbush | | X | | X |

| SHRUBS, CACTI, AND LILLIES | | COMMUNITY/VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *L. pallidum* | Rabbit-thorn | | X | | |
| *Lycium spp.* | Wolfberry | X | X | X | |
| *Mammallaria microcarpa* | Fishhook Pincushion | | X | X | X |
| *Nolina Bigelovii* | Bigelow Nolina | | | | X |
| *Opuntia acanthocarpa* | Buckhorn Cholla | X | X | X | X |
| *O. basilaris* | Beavertail Cactus | | | X | X |
| *O. bigelovii* | Teddy Bear Cholla | | | | X |
| *O. chlorotica* | Pancake Prickly Pear | | | | X |
| *O. englemannii* | Englemann Prickly Pear | | | | X |
| *O. leptocaulis* | Christmas Cactus | | | X | X |
| *O. phaecantha* | Engelmann Prickly Pear | | | | X |
| *Psilostrophe cooperi* | Paper Flower | | | X | X |
| *Prosopis juliflora* | Mesquite | X | X | | |
| *P. pubescens* | Screwbean | X | X | | |
| *Salazaria mexicana* | Baldder-sage | | | X | X |

TABLE C-2 (CONTINUED)

| | | | | | |
|---|---|---|---|---|---|
| *Senecio spp.* | Goldenbush | | | X | X |
| *Tamarix pentandra* | Salt Cedar | X | | | |
| *Yucca baccata* | Banana Yucca | | | X | X |
| *Y. brevifolia* | Joshua Tree | | X | X | X |
| *Y. elata* | Soaptree Yucca | | | | X |
| *Yucca spp.* | Yucca | | | X | X |
| GRASSES | | | | | |
| *Aristida spp.* | Threeawn | X | X | | |
| *Bouteloua aristidoides* | Six Weeks Grama | | X | | X |

| GRASSES | | COMMUNITY/VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *Bouteloua spp.* | Grama Grass | | X | | X |
| *Bromus arizonicus* | Arizona Brome | | | X | X |
| *Bromus rubens* | Red Brome | | | X | X |
| *Cynodon Dactylon* | Bermuda Grass | X | | | |
| *Hilaria mutica* | Tobosa | | X | X | X |
| *H. rigida* | Big Galleta | | X | X | X |
| *Muhlenbergia porteri* | Bush Muhley | | X | X | X |
| *Muhlenbergia spp.* | Muhley | | | X | |
| *Schismus barbatus* | Schismus | X | X | X | X |
| *Setaria spp.* | Bristlegrass | | X | | |
| *Sporobolus cryptandrus* | Sand Dropseed | | X | | |
| *Sporobolus spp.* | Dropseed | | X | | X |
| *Tridens pulchellus* | Desert Fluffgrass | | | | X |

TABLE C-2 (CONTINUED)

FORBS

| | | COMMUNITY/VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *Allionia incarnata* | Trailing Four O'Clock | X | X | | |
| *Allionia spp.* | Four O'Clock | X | X | | |
| *Ambrosia spp.* | Ragweed | X | X | | |
| *Amsinckia spp.* | Fiddle-neck | X | X | X | X |
| *Aster abatus* | Mohave Aster | | | | X |
| *Aster spp.* | Aster | X | X | X | X |
| *Baileya multiradiata* | Desert Marigold | | | X | X |
| *Boerhaavia spp.* | Spiderling | X | X | X | X |
| *Chaenactis stevioides* | Chaenactis | | | X | X |
| *Calochortus Kennedyi* | Mariposa Lily | X | X | X | X |
| *Cassia spp.* | Senna | X | X | X | X |
| *Cucurbita digitata* | Wild Gourd | | | X | X |
| *Datura meteloides* | Western-jimson | X | X | | |
| *Erigeron spp.* | Fleabane | X | X | X | X |
| *Eriogonum deflexum* | Skeletonweed | | | X | X |
| *Eriogonum inflatum* | Desert Trumpet | | X | | X |
| *Eriogonum spp.* | Buckwheat | X | X | X | X |
| *Erodium circutarium* | Filaree | X | X | | X |
| *Euphorbia prostrata* | Spurge | | X | X | X |

TABLE C-2 Concluded

| FORBS | | COMMUNITY/VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *Hymenoxys spp.* | Rubberweed | | | X | X |
| *Lepidium spp.* | Peppergrass | X | X | X | X |
| *Lesquerella gordoni* | Bladderpod | | | X | X |
| *L. palmeri* | Bladderpod | | X | | X |
| *Lupinus sparsiflorus* | Arizona Bluebonnet | | X | | |
| *Lupinus spp.* | Lupine | | | X | X |
| *Mimulus spp.* | Monkey Flower | X | | | |
| *Monoptilon belloides* | Mohave Desert-star | | X | X | X |
| *Nicotiana spp.* | Tobacco | X | X | | |
| *Oenothera brevipes* | Desert Sundrop | | X | | |
| *Oenothera spp.* | Primrose | X | X | | |
| *Orobanche ludoviciana* | Broomrape | X | X | | |
| *Orobanche multiflora* | Broomrape | X | X | | |
| *Orthocarpus purpurascens* | Owl Clover | | X | X | X |
| *Phacelia Fremontii* | Scorpionweed | | X | X | X |
| *Phacelia spp.* | Scorpionweed | | | X | X |
| *Plantago Purshii* | Wooly Indianwheat | | | X | X |
| *Rafinesquia neomexicana* | Desert Chickory | X | X | X | X |
| *Rafinesquia spp.* | Desert Dandelion | | X | | X |
| *Rumex spp.* | Sorrel | X | X | | |
| *Senecio spp.* | Senecio | X | X | | |
| *Sisymbrium irio* | London Rocket | X | X | | |
| *Sphaeralcea ambigua* | Desert Mallow | | | | X |
| *Sphaeralcea spp.* | Globemallow | X | X | X | X |
| *Verbena spp.* | Verbena | | X | | X |

Source: Dames & Moore, 1978a

TABLE C-3

## WILDLIFE OBSERVED AT THE ANDERSON URANIUM PROJECT AREA

| | | VEGETATION TYPE | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| **AMPHIBIANS** | | | | | |
| *Scaphiopus spp.* | Spadefoot | X | | | |
| *Bufo punctatus* | Red-spotted Toad | X | | | |
| **REPTILES** | | | | | |
| *Gopherus agassizi* | Desert Tortoise | X | | | |
| *Coleonyx variegatus* | Banded Gecko | | X | X | X |
| *Sauromalus obesus* | Chuckwalla | | | X | X |
| *Dipsosaurus dorsalis* | Desert Iguana | | X | X | X |
| *Callisaurus draconoides* | Zebra-tailed Lizard | X | X | X | |
| *Sceloporus magister* | Desert Spiny Lizard | | | | X |
| *Uta stansburiana* | Side-blotched Lizard | X | X | X | X |

a. Vegetation Type:

1. Riparian
2. Pseudoriparian
3. Joshua Tree Woodland
4. Upland desert

TABLE C-3 (CONTINUED)

| | | VEGETATION TYPE | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| **REPTILES** | | | | | |
| *Phrynosoma platyrhinos* | Desert Horned Lizard | | | | X |
| *Cnemidophorus tigris* | Western Whiptail | X | X | X | X |
| *Salvadora hexalepis* | Western Patch-nosed Snake | | | | X |
| *Pituophis melanoleucus* | Gopher Snake | X | X | X | X |
| *Arizona elegans* | Glossy Snake | | | X | X |
| *Crotalus atrox* | Western Diamondback | X | X | X | X |
| *C. cerastes* | Sidewinder | X | X | X | X |
| *C. scutulatus* | Mohave Rattlesnake | | | X | X |
| **BIRDS** | | | | | |
| *Cathartes aura* | Turkey Vulture | X | X | X | X |
| * *Buteo jamaicensis* | Red-tailed Hawk | X | X | X | X |
| *Accipiter cooperii* | Cooper's Hawk | | | X | X |
| *Aquila chrysaetos* | Golden Eagle | X | X | X | X |
| *Falco mexicana* | Prairie Falcon | | | | X |
| *F. sparverius* | American Kestrel | X | X | X | X |

* Bird species of which evidence of breeding was noted on the project area.

TABLE C-3 (CONTINUED)

| BIRDS | | Vegetation Type 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| * Lophortyx gambelii | Gambel's Quail | X | X | X | X |
| * Zenaida asiatica | White-winged Dove | X | X | | X |
| * Z. macroura | Mourning Dove | X | X | X | X |
| Geococcyx californianus | Roadrunner | X | X | X | X |
| Otus asio | Screech Owl | | | | X |
| * Bubo virginianus | Great Horned Owl | X | X | X | X |
| Micrathene whitneyi | Elf Owl | | | | X |
| Phalaenoptilus nuttalli | Poorwill | | | X | X |
| * Chordeiles acutipennis | Lesser Nighthawk | | | X | X |
| Aeronautes saxatalis | White-throated swift | X | | X | X |
| Archilochus alexandri | Black-chinned Hummingbird | X | | | |
| * Calypte costae | Costa's Hummingbird | X | | X | X |
| * Colaptes auratus | Common Flicker | X | X | X | X |
| Centurus uropygialis | Gila Woodpecker | | | | X |
| Dendrocopos scalaris | Ladder-backed Woodpecker | X | | | |
| * Tyrannus verticalis | Western Kingbird | X | X | X | X |

TABLE C-3 (CONTINUED)

| BIRDS | | VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| * Myiarchus cinerascens | Ash-throated Flycatcher | X | X | X | X |
| Sayornis saya | Say's Phoebe | X | | | |
| Tachycineta thalassina | Violet-green Swallow | X | | X | |
| Petrochelidon pyrrhonata | Cliff Swallow | X | | | |
| Corvus cryptoleucus | White-necked Raven | X | X | X | X |
| * Auriparus flaviceps | Verdin | X | X | X | X |
| * Campylorhynchus brunneicapillus | Cactus Wren | | X | X | X |
| Catherpes mexicanus | Canyon Wren | | X | | |
| Salpinctes obsoletus | Rock Wren | | X | | |
| Mimus polyglottos | Mockingbird | X | X | X | X |
| Toxostoma bendirei | Bendire's Thrasher | | X | X | X |
| * T. curvirostre | Curve-billed Thrasher | X | X | X | |
| * T. dorsale | Crissal Thrasher | X | X | | |
| Oreoscoptes montanus | Sage Thrasher | | | X | |
| Turdus migratorious | Robin | X | | | |
| * Polioptila melanura | Black-tailed Gnatcatcher | X | X | X | X |
| Regulus calendula | Ruby-crowned Kinglet | X | | | |

TABLE C-3 (CONTINUED)

| BIRDS | | VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *Phainopepla nitens* | Phainopepla | X | X | X | X |
| * *Lanius ludoviciana* | Loggerhead Shrike | X | X | X | X |
| * *Vireo bellii* | Bell's Vireo | X | | | |
| *V. vicinior* | Gray Vireo | X | | | |
| * *Vermivora luciae* | Lucy's Warbler | X | | | |
| *Dendroica petechia* | Yellow Warbler | X | | | |
| *D. coronata* | Yellow-rumped Warbler | X | | | |
| *Wilsonia pusilla* | Wilson's Warbler | X | | | |
| *Icterus cucullatus* | Hooded Oriole | X | | | |
| * *I. parisorum* | Scott's Oriole | | | X | X |
| * *Molothous ater* | Brown-headed Cowbird | | | X | X |
| *Carpodacus mexicanus* | House Finch | X | X | X | X |
| *Spinus tristis* | American Goldfinch | X | | | |
| * *S. psaltria* | Lesser Goldfinch | X | | | |
| *Pipilo fuscus* | Brown Towhee | X | | X | |
| *Calamospiza melanocorys* | Lark Bunting | | | X | X |
| *Pooecetes gramineus* | Vesper Sparrow | | | X | |

TABLE C-3 (CONTINUED)

| | | VEGETATION TYPE | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| **BIRDS** | | | | | |
| * *Amphispiza bilineata* | Black-throated Sparrow | | X | X | X |
| *Spizella passerina* | Chipping Sparrow | | X | | X |
| *S. breweri* | Brewer's Sparrow | | X | X | X |
| *Zonotrichia leucophrys* | White-crowned Sparrow | X | X | X | |
| **MAMMALS** | | | | | |
| *Myotis spp.* | Myotine Bat | X | | | |
| *Bassariscus astutus* | Ringtail | | | X | X |
| *Taxidea taxus* | Badger | | | X | X |
| *Canis latrans* | Coyote | X | X | X | X |
| *Lynx rufus* | Bobcat | X | X | X | X |
| *Citellus tereticaudus* | Mohave Ground Squirrel | | | X | |
| *Ammospermophilus harrisi* | Yuma Antelope Squirrel | | | X | X |
| *Perognathus amplus* | Arizona Pocket Mouse | | | X | |
| *P. intermedius* | Rock Pocket Mouse | | X | | X |
| *P. baileyi* | Bailey's Pocket Mouse | X | X | | |

TABLE C-3 Concluded

| MAMMALS | | VEGETATION TYPE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Dipodomys merriami | Merriam's Kangaroo Rat | X | | X | X |
| Peromyscus maniculatus | Deer Mouse | X | | | |
| P. boylei | Brush Mouse | X | | | |
| Neotoma albigula | Whitethroat Woodrat | | | X | X |
| Lepus californicus | Blacktail Jackrabbit | X | X | X | X |
| Sylvilagus auduboni | Desert Cottontail | X | X | | |
| Odocoileus hemionus | Mule Deer | X | | X | X |
| Equus asinus | Feral Burro | X | X | X | X |

Source: Dames & Moore 1978a

## 2.9 BACKGROUND RADIOLOGICAL CONSIDERATIONS

Generally speaking, the most significant source of ionizing radiation exposure to the general public is from the natural environment. This exposure is not uniform for all individuals, but varies due to a number of factors, including altitude, geological features, and human habitats. Variations in exposure as a result of these natural factors often exceed exposures from man-made sources (e.g., x-ray equipment and nuclear reactors) that receive considerably more publicity. According to the literature, the dose from natural radiation to an individual in the United States ranges from 80 to 250 mrem/yr. [One millirem (mrem) is defined as that quantity of any type of ionizing radiation which, when absorbed by man, produces an effect equivalent to the absorption by man of 0.001 roentgen of x-ray or gamma radiation (400 kilovolts).] The average individual living in the United States in 1964 received an x-ray exposure of 55 mrem/yr for medical purposes. Other sources, such as nuclear reactors account for less than 5 mrem/yr.

In order to determine the significance of the effects of small man-made increments of exposure, it is necessary to determine the larger natural radiation components. Several studies have shown no correlation of background radiation with health effects. However, background radiation exposure is less well defined than exposure to man-made sources, so it may contribute to the deleterious effects that may be associated with low levels of radiation.

Natural background radiation comes from cosmic radiation and from radioactive elements in the earth's crust and in building materials. An additional increment of external exposure, which accounts for less than five percent of the total, is due primarily to the presence of radon isotopes and their radioactive decay products in the atmosphere.

The natural radiation environment is believed to have been relatively constant for at least 10,000 years. However, human living habits have changed in such a way as to increase exposure. Populations have tended to migrate from coastal to inland areas, thus increasing their elevation and exposure to cosmic radiation. Outdoor agrarian society has been largely replaced by indoor work and life in urban centers. Exposure has thus been increased in some instances because of the natural radioactivity of building materials; while in other instances, buildings may attenuate exposure to outdoor terrestrial sources, thereby lowering exposure.

Additional increments of radiation exposure result from ingestion of natural radionuclides. Potassium-40 is the principal contributor of internal doses; other significant internal emitters are carbon-14, radon-222, radium-226 and -228, and their daughter products.

The retention of inhaled radioactive daughter products of radon isotopes is the primary source of lung radiation dose to the general public. The inhalation of radon daughters requires special attention in the case of underground uranium miners (Federal Radiation Council

1967). Exposure to occupants of residential dwellings can also be significant. A potential average lung dose of about 250 mrem/yr to occupants of unventilated wood dwellings and about 1800 mrem/yr to occupants of unventilated concrete buildings has been calculated.

Since the proposed mine and mill will release radioactive materials, it is important to establish baseline radiation levels and concentrations of radioactive materials. Periodic monitoring during project operations can then detect any significant increases by comparison with these baseline levels. To obtain the necessary baseline information, the following sampling programs were conducted:

- atmospheric radon-222 concentrations
- radon-222 daughter analysis
- radon flux determinations
- integrated gamma radiation
- radionuclide content of sediments, water, vegetation, and soils

RADIOACTIVE MATERIALS IN THE AIR

As a general rule, gaseous radon-222 and radioactive constituents of suspended particulate matter account for most of the background airborne radioactive matter. Surface soils and rock, which are the most significant existing sources of airborne particles in the project area, contain traces of radioactive matter, as do most materials of the earth's crust. Gaseous radon-222, a radioactive decay product of radium-226 in the soil and rock, decays to radioactive daughter products that deposit on soil particles and airborne particles that can be ingested by man and animals.

Radon-222

Air samples were collected for two periods of two hours each at roughly 24-hour intervals at the meteorological tower located near the center of the ore body and five satellite locations (Figure 2.9-1). The samples were analyzed for radon-222 content within 48 hours of collection by Eberline Instrument Corporation of Albuquerque, New Mexico. The results of these analyses are presented in Table 2.9-1.

Concentrations of radon-222 ranged from undetectable to nearly 2 pCi/l on the property. The average radon concentration for all samples was 0.35 pCi/l.

The highest radon-222 concentration was observed at the meteorological tower which is located on a ridge above the ore body. This reading was taken in the morning during a light, increasing northwest wind following several hours of very light southeast-east to northeast winds. Considering that on the previous day the winds reached a higher peak than on any other day during the sampling period and that flushing was relatively thorough, this reading probably represents a radon-222 buildup of only a few hours.

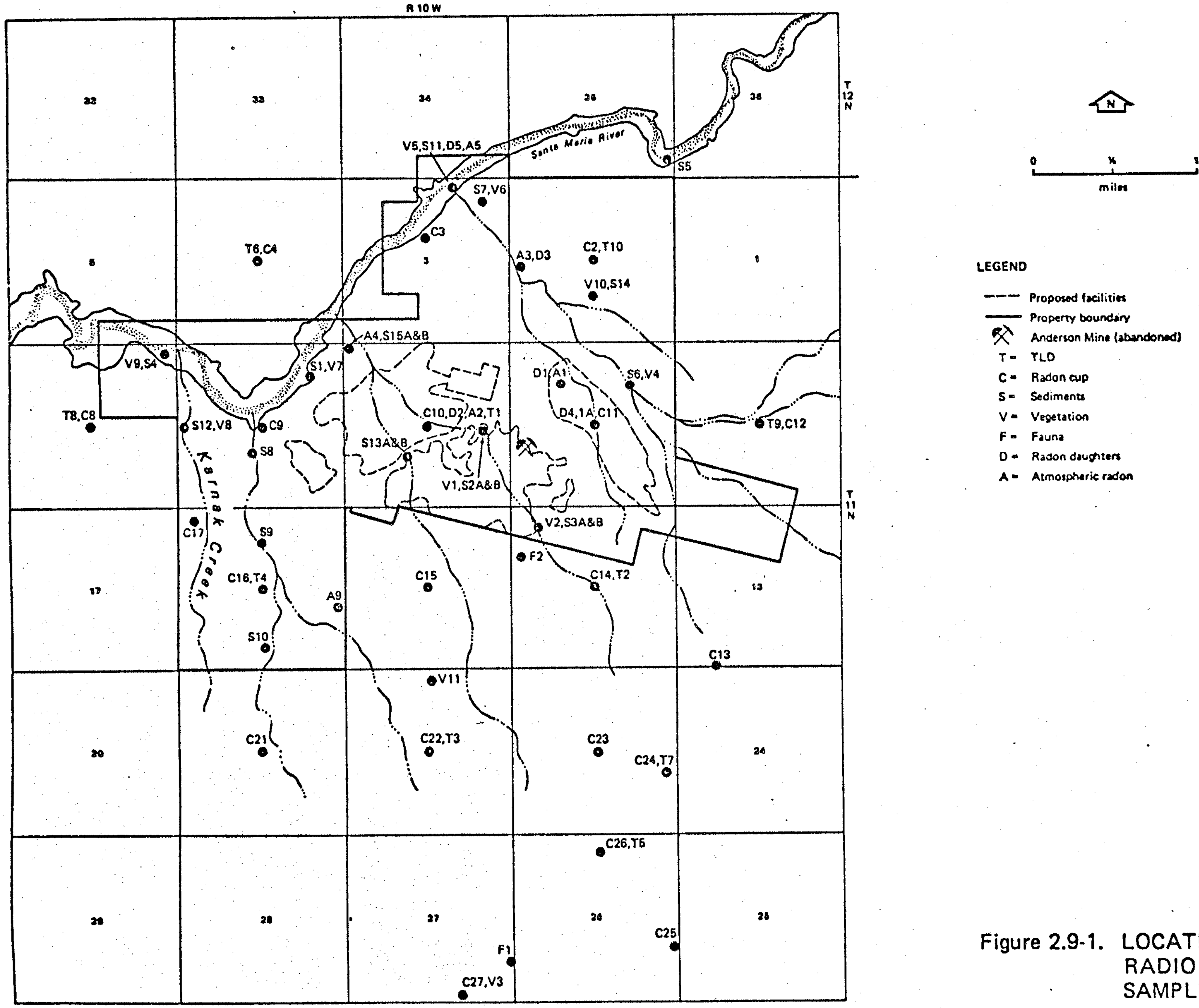



Figure 2.9-1. LOCATION OF RADIOLOGICAL SAMPLE SITES

Table 2.9-1. ATMOSPHERIC RADON CONTEN

| Date of Collection | Time of Collection | Sample A1 (pCi/l) | of C | Sample 1A (pCi/l) | Time of Collection | Sample A9 (pCi/l) |
|---|---|---|---|---|---|---|
| 7-13-77 | 09:12 - 11:15 | 0.00* ± 0.10 | | | | |
| | 13:04 - 15:04 | 0.00 ± 0:20 | | | | |
| 7-14-77 | 07:15 - 09:00 | 0.35 ± 0.23 | | | | |
| | 12:00 - 14:00 | 0.14 ± 0.10 | | | | |
| 7-15-77 | 07:40 - 09:40 | 0.00 ± 0.20 | | 0.00 ± 0.20 | | |
| | 12:21 - 14:21 | 0.29 ± 0.22 | | 0.37 ± 0.19 | | |
| 7-16-77 | 07:17 - 09:17 | 0.44* ± 0.13 | 07:0 | | | |
| | 12:15 - 14:15 | 1.6 ± 0.3 | 12:0 | | | |
| 11-9-77 | | | | | | |
| 11-9-77 | 12:00 - 14:00 | 0.3 ± 0.1 | | | | |
| 11-9-77 to 11-10-77 | 07:30 to 09:30 | 0.00 ± 0.2 | | | | |
| 11-10-77 | 07:30 - 09:30 | 0.3 ± 0.2 | | | | |
| | 12:00 - 14:00 | 0.3 ± 0.1 | | | | |
| 11-11-77 | 07:30 - 09:30 | 0.0 ± 0.2 | | | | |
| | 12:00 - 14:00 | 0.8 ± 0.2 | | | | |
| 11-12-77 | 07:30 - 09:30 | 0.8 ± 0.1 | 07:3 | | | |
| | 12:00 - 14:00 | 0.0 ± 0.2 | 11:5 | | | |
| 11-13-77 | 07:30 - 09:30 | 0.7 ± 0.2 | | | 08:10 - 10:10 | 0.6 ± 0.3 |
| | 12:00 - 14:00 | 0.0 ± 0.2 | | | 12:00 - 14:00 | 0.7 ± 0.3 |

*Sample bag leaked, reading is for total sample re

Radon-222 concentrations at sample sites A3, A4 and A5, located downwind from the ore body (Figure 2.9-1), were not consistantly high during the morning sampling periods (Table 2.9-1). Consequently, overnight drafts from the desert floor did not result in the concentration of radon in canyons and stream channels at lower elevations. Based on these results, there appears to be sufficient winds in the area to disperse radon from the property.

Radon-222 concentrations did not consistantly increase from the morning to the afternoon samples. If such an increase did occur, it would indicate a daytime atmospheric inversion on the property. An inversion would tend to trap the radon-222 emanating from the soil in the lower layers of air where the samples were taken.

Radon Daughters

The presence of radon in the atmosphere is often difficult to detect and/or measure because of its normally low concentration, its character as one of the noble gases, and its transitory presence due to radioactive decay. Radon as a noble gas shows little inclination for concentration on solid surfaces or in liquids because of its inherent resistance to ionization. However, radon gas in the atmosphere breaks down radioactively forming highly ionized polonium, which in turn breaks down forming other ionized isotopes. These highly charged ions are attracted to dust particles in the air and collect on them. In a carefully controlled situation, collection of such dust particles and determination of radon daughter content would provide a measure of radon content in the ambient air. However, in field conditions, drifting air masses dilute or concentrate the daughters. Consequently, the most significant readings reflecting local conditions are those taken during stagnant inversions when air flow is minimal.

Radon-222 has at least 11 daughters (including the final product of stable lead-206), only a few of which are practical to measure. Polonium-218 has a 3.05 minute half-life and its daughter, lead-214, has a 26.8 minute half-life. Both of these radon daughters are commonly measured for direct radon-222 determination where the laboratory apparatus is close at hand or where field conditions support use of a mobile laboratory with this capability. Since the samples collected on the Anderson property for radon daughter analysis were stored for several days, measurement of these isotopes was not meaningful. For the Anderson property samples, the most practical isotopes to measure were lead-210 with a half-life of 21 years and its bismuth and polonium daughters (these daughters should be in equilibrium with lead-210).

Due to its long half-life, lead-210 concentrations reflect only the effective time of dispersion of dust paricles. High winds preceding the sampling may lead to measurements reflecting radon daughter accumulation in regional soils rather than local atmospheric radon or local soil conditions. In any case, it is useful to measure these more stable radon daughters since radioactive material in dust forms a significant portion of atmospheric radioactivity.

Airborne particulate samples were collected at the meteorological tower and four satellite locations (Figure 2.9-1) in 1977. The satellite stations were sampled sequentially and no station was sampled more than once. A total of five samples were collected in July 1977 at the meteorological tower. All samples were analyzed by Eberline Instrument Corporation for total particulates, thorium-230, radium-226, and lead-210. The results of these analyses are presented in Table 2.9-2.

Examination of the data (Table 2.9-2 and Figures 2.9-2 and 2.9-3) indicate that the radioactive composition of the dust is a function of the wind azimuth as well as wind speed. For example, north winds produced the highest dust loads and lowest uranium concentrations, while the highest uranium measurements were taken when the winds were from the east and west. These results may be due to the source of the particulates. Winds from the north cross the Santa Maria River channel and the lower reaches of several tributaries before reaching the sampling sites. Since these drainage channels are covered by loose silts and fine sands, suspended particulates would be relatively high with strong winds. Winds from the east and west cross areas composed of coarser materials; consequently, the dust load of these winds is somewhat lower. North winds cross a minimum of exposed ore deposits in the vicinity of the property so it would be expected that the concentration of radioactive

Table 2.9-2. RADON DAUGHTERS IN THE ATMOSPHERE

| Sample | U µg/g | U pg/l | $Th^{230}$ pCi/g | $Ra^{226}$ pCi/g | $Pb^{210}$ pCi/g | Particle Load g | Wind Speed* mph | Azi-muth Degrees | Wind Speed: Peak of Period mph | Wind Speed: Azi-muth Degrees | Volume Sampled $m^3$ | Temperature* Degrees | Time Hr | Date of Collection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D4 | 29.5 | 1.13 | 5.25 | <0.8 | 328 | 0.061 | 6.5 | 143 | 17 | 110 | 1590 | 94 | 9:07 - 9:07 | 7-13&14-77 |
| D3 | 93.8 | 9.80 | 28.75 | <8 | <581 | 0.016 | 12 | 122 | 17 | 110 | 153 | 94 | 9:05 - 11:30 | 7-13-77 |
| D4 | 40.9 | 2.39 | 2.25 | <0.9 | 237 | 0.093 | 9.9 | 109 | 17 | 100 | 1590 | 95 | 9:15 - 9:15 | 7-14&15-77 |
| D5 | 125 | 8.0 | 66.25 | <6 | 988 | 0.008 | 6.6 | 140 | 16 | 90 | 125 | 88 | 7:10 - 9:00 | 7-14-77 |
| D5 | 90.9 | 14.71 | 32.73 | 19.1 | 1455 | 0.011 | 11 | 110 | 12 | 100 | 68 | 99 | 12:00 - 13:00 | 7-14-77 |
| D3 | 88.9 | 6.72 | 44.44 | 23.3 | <94 | 0.009 | 9.0 | 145 | 10 | 120 | 119 | 104 | 14:13 - 16:00 | 7-14-77 |
| D4 | 12.8 | 0.94 | <0.7 | <0.4 | 154 | 0.117 | 8.5 | 99 | 22 | 40 | 1590 | 93 | 9:18 - 9:22 | 7-15&16-77 |
| D1 | 44.7 | 15.44 | <2 | 7.0 | <206 | 0.047 | 8.1 | 77 | 11 | 80 | 136 | 88 | 7:30 - 9:30 | 7-15-77 |
| D1 | 71.4 | 7.35 | 23.57 | <4 | <643 | 0.014 | 9.0 | 144 | 10 | 150 | 136 | 102 | 12:00 - 14:01 | 7-15-77 |
| D4 | 33.9 | 1.32 | <2 | 2.3 | 258 | 0.062 | 3.8 | 342 | 12 | 210 | 1590 | 93 | 9:31 - 9:34 | 7-16&17-77 |
| D2 | 90.9 | 7.35 | <10 | <5 | 482 | 0.011 | 4.0 | 76 | 4 | 90 | 136 | 89 | 7:30 - 9:03 | 7-16-77 |
| D2 | 45.5 | 7.35 | 24.55 | <2 | 273 | 0.022 | 5.6 | 300 | 7 | 300 | 136 | 101 | 12:07 - 14:07 | 7-16-77 |
| D4 | 6.5 | 0.50 | 5.45 | <0.4 | 195 | 0.123 | 9.4 | 73 | 22 | 30 | 1590 | 89 | 9:37 - 9:37 | 7-17&18-77 |

*Geometric mean

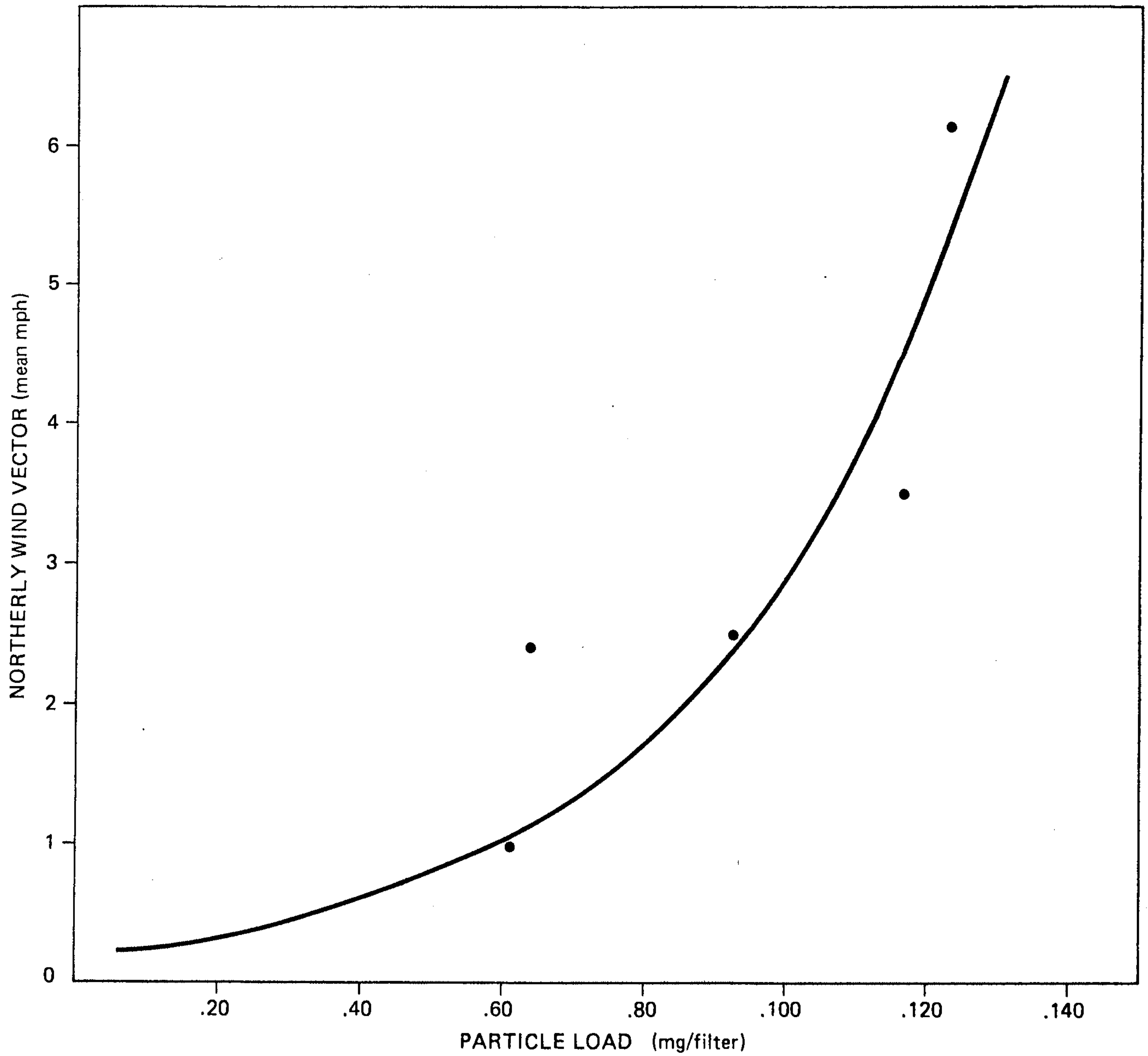



Figure 2.9-2. PARTICULATE LOAD ON THE ANDERSON PROPERTY RELATIVE TO WIND SPEED

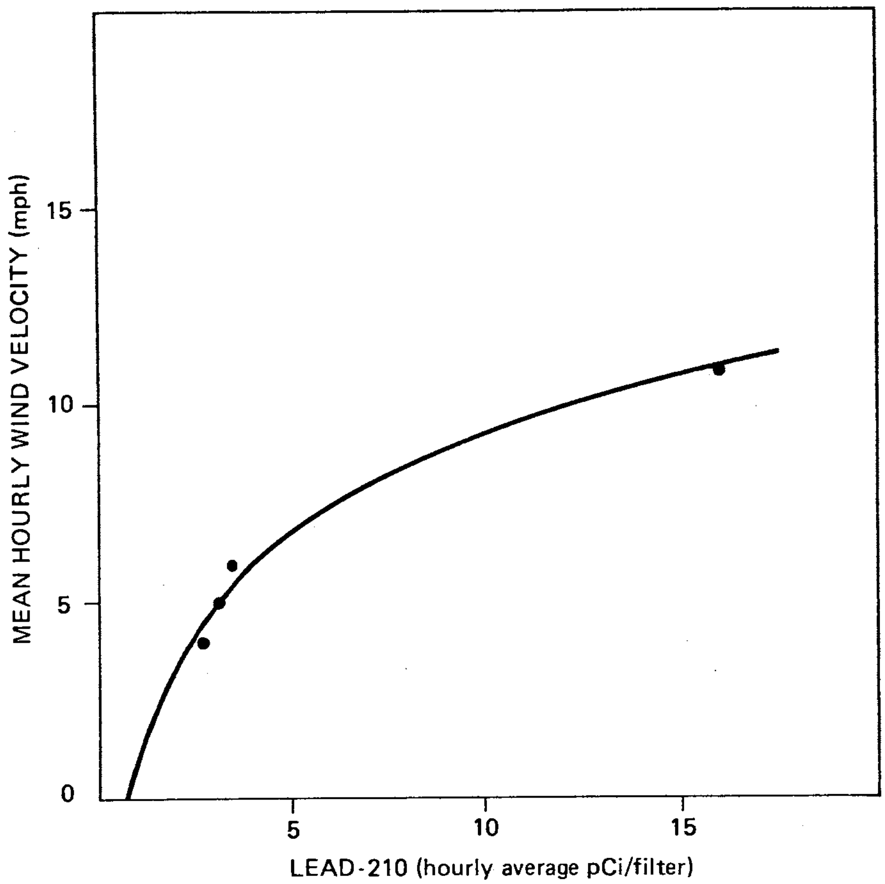



Figure 2.9-3. LEAD-210 CONCENTRATION IN THE ATMOSPHERE RELATIVE TO WIND VELOCITY

materials in the dust would be lower than winds from the east and west which have relatively long sets over exposed ore bodies.

Subsoil Radon Measurements

On a local basis, one of the most significant components of atmospheric radon is provided by radon emanating from the soil. During periods of stable pressure and low winds, radon movement is generally influenced by diffusion coefficients, both in the atmosphere and in the soil. Daily, weekly, and seasonal fluctuations in atmospheric pressure and winds, however, cause migration of radon to and from the surface at accelerated rates; consequently, radon from a considerable depth may find its way to the surface over a period of time. Obviously, with the limited half-life of radon (3.823 days), there is a maximum pepth beyond which no significant quantities of radon could be expected to reach the surface. The factors determining this depth include the rate of movement of radon to the surface, the production rate of radon at the source, the flow path, and the features of the soil or rock and atmosphere interface.

The relative emanation of radon from the Anderson property was determined by use of track etching analyses of alpha-sensitive photographic films mounted in inverted styrene cups (radon cups) and buried two to three feet below the surface of the ground at 20 locations (Figure 2.9-1). Because of their physical characteristics, these cup-mounted films sense only radon gas in their immediate environment* and integrate the levels perceived over time. For this determination, two cups were placed in each hole, covered with a plastic bag, and buried. They were not disturbed again except to remove one of the cups after three months and the other after six months. The results of the rack etching analyses for the cups are presented in Table 2.9-3. Although an empirical method exists for converting these reading to concentrations on the basis of laboratory testing**, it has yet to be affirmed that this conversion is applicable to field data. Consequently, the relative track numbers obtained are presented in lieu of actual concentrations.

Since the two sets of data provided in Table 2.9-3 represent two different seasons, one relatively dry and the other relatively wet, it is possible to obtain a relative evaluation of the exponential term in the diffusion equation incorporating a decay term (presuming the production of radon-222 in the surface soils is negligible compared to the production at depth).

$$C = Co\ e^{-\sqrt{\frac{\lambda}{D/S}}\, x}$$

where: C = concentration of radon gas in interstices of soil/rock at distance x from plane source units (pCi/l)

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*These films also may be affected by radon daughters that plate out on the sides of the cup. The influence of the plating out on the radon levels reported is unknown at this time.

**H.W. Alter, President, Terradex Corportion, Walnut Creek, California personal communication, November 21, 1977.

Table 2.9-3. RADION CUP READINGS ON THE ANDERSON PROPERTY

| Sample Site | First 3-month Average | Second 3-month Average | 6-month Average | k* |
|---|---|---|---|---|
| | Tracks/$mm^2$/Month | | | |
| C2 | 28.4 | 76.0 | 52.2 | 1.215 |
| C3 | 23.2 | 1.4 | 12.3 | 0.3538 |
| C4 | 17.1 | - | - | - |
| C8 | 33.6 | 63.8 | 48.7 | 1.135 |
| C9 | 12.8 | - | - | - |
| C10 | 113.3 | 603.3 | 358.3 | 1.281 |
| C11 | 29.9 | 45.3 | 37.6 | 1.090 |
| C12 | 20.8 | 67.0 | 43.9 | 1.274 |
| C13 | 28.5 | 56.3 | 42.4 | 1.149 |
| C14 | 38.1 | 18.1 | 28.1 | 0.847 |
| C15 | 88.0 | -27.8 | 30.1 | - |
| C16 | 76.3 | 70.5 | 73.4 | 0.986 |
| C17 | 44.5 | 29.5 | 37.0 | 0.918 |
| C21 | 21.9 | 54.9 | 38.4 | 1.213 |
| C22 | 62.1 | 72.1 | 67.1 | 1.028 |
| C23 | 12.6 | 45.2 | 28.9 | 1.339 |
| C24 | 27.6 | 100.8 | 64.2 | 1.285 |
| C25 | 26.4 | 46.8 | 36.6 | 1.127 |
| C26 | 51.4 | 26.4 | 38.9 | 0.871 |
| C27 | 29.4 | 81.2 | 55.3 | 1.220 |

*Where $u_2 = ku_1$, $k = \frac{\ln C_2}{\ln C_1}$

Co = concentration of radon gas in interstices of source material, presumed homogeneous in distribution (pCi/l)

$\lambda$ = activity coefficient ($2.1 \times 10^{-6}$ $sec^{-1}$ for radon-222)

D/S = effective diffusion coefficient divided by porosity

x = distance from plane source (cm)

If $u = \sqrt{\frac{\lambda}{D/S}}$ then a ratio of the equation under the two conditions (dry and wet) allows for computation of the relative "u" values where:

$$u_2 = u_1 \frac{\ln C_2}{\ln C_1}$$

These values were calculated for each location and are tabulated in Table 2.9-3. This information shows that while the soils in general were less permeable in the wet season, this was not uniformly the case. Consequently, an areal distribution that bears on geology and geologic structure may be indicated.

Most of the radon cup data from the first three months (dry period) fell within four distinct groups (Figure 2.9-4). Each group could be described by the general equation:

$$y = ax^b$$

where

y = number of tracks

a,b = empirical constants

x = elevation above a datum

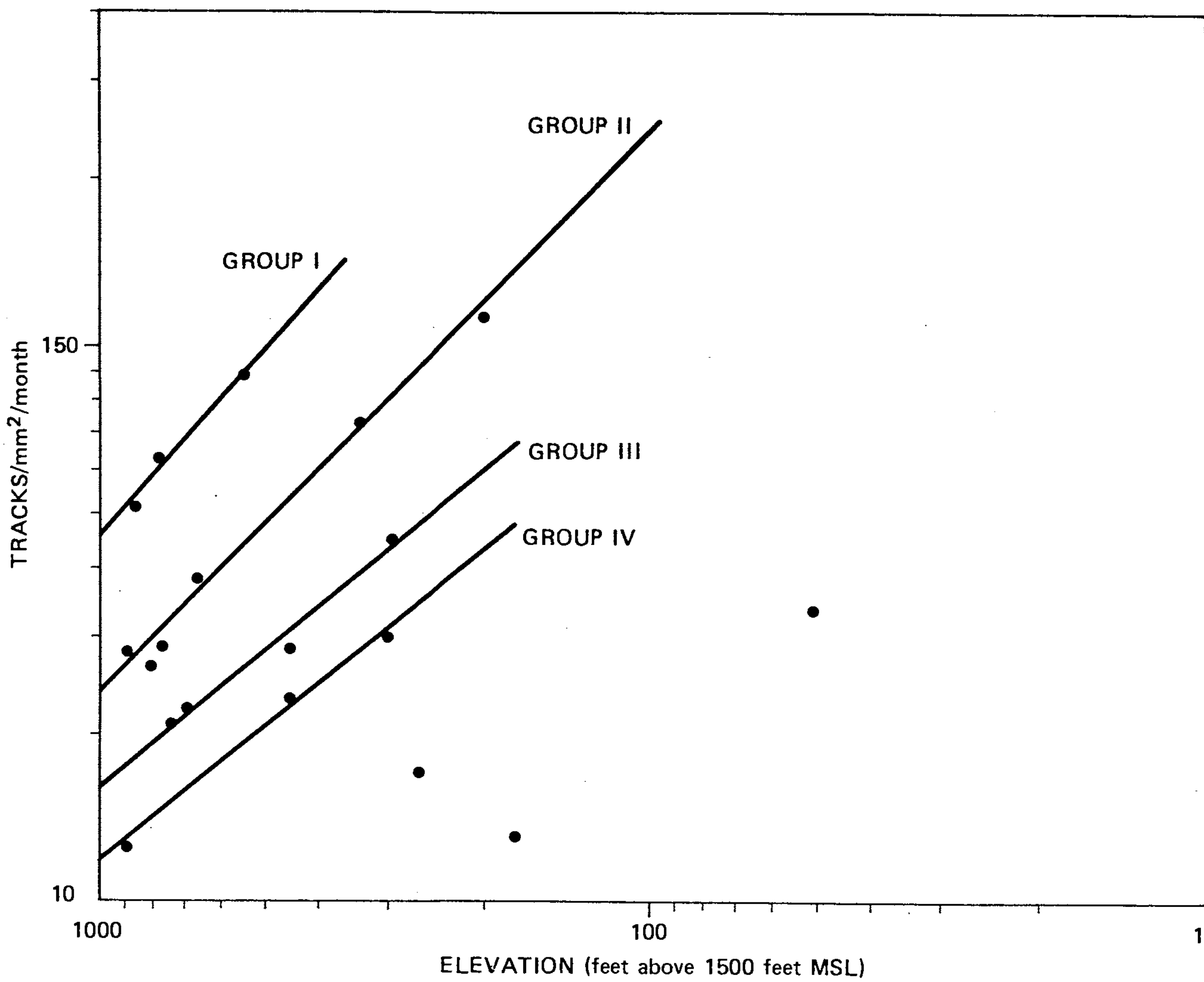


Figure 2.9-4. RADON-222 CONCENTRATIONS RELATIVE TO ELEVATION

The distribution of the data points suggest that the groupings are sensitive to the underlying base rock geology, modified by the relative thickness of the overburden and their proximity to the ore body.

Based on experience, Terradex Corporation has estimated that the overall migration rate of randon-222 through soil and rock on a world wide basis is roughly on the order of 15 to 30 feet per day. Consequently, for the sampling period involved, the radon cups could detect radon emanating from a source at a depth of 100 to 300 feet. This degree of sensitivity allows detection of radioactive materials in the formations beneath the alluvium on the Anderson property.

As Figure 2.9-4 shows, each of the four groups relate to elevation above an arbitrary datum plan (1500 ft msl was used in this analysis). Group I consists of three points on the desert floor south of and stratigraphically above the exposed ore body on the property. Group II consists of seven points that are located progressively further from the central ore body (Figure 2.9-1). Group III consists of four pionts which appear to be marginally beyond the ore bed. Two of these points lie west-southwest of the deposit and the other two lie east-northeast of the deposit. Group IV consists of three points which are located considerably west of the main ore deposit and are stratigraphically below the miocene lake beds that constitute the ore bearing zone.

The groupings appear to provide reference points for the relative position of the ore body. They may also identify the relative transmissivity of uranium daughters through the intervening rock and soil. It would not be justified at this point to assume that all of the radon detected by the radon cups was due to radon-222 migration from the ore body. Dissolved radium moving with moisture upward or laterally in rock and soil may, over time, have also contributed to the readings by providing a closer source. However, it is likely that the primary source of the readings is the radon from the ore bed itself.

TOTAL RADIATION LEVELS

Total natural background ionizing radiation from all sources (air, water, and cosmic radiation) was measured on the Anderson property by means of thermoluminescent dosimetry. Special weatherproof thermoluminescent dosimeter (TLD) packets containing three high-sensitivity fluoride chips were placed at some of the same locations as the radon cups to monitor the general ionizing radiation in the area (Figure 2.9-1). Two TLDs were placed at each selected location. One was collected after three months and the other was collected after six months. One TLD was kept at the Eberline laboratory in Santa Fe, New Mexico, for control purposes. The results of this program are presented in Table 2.9-4.

The geometric mean of the TLD readings was 1.97 mrem/week (excluding sample T1, the geometric mean was 1.85 mrem/week), which was slightly higher than the 1.88 mrem/week registered from the control kept at the Eberline laboratory. Except for one high reading from the TLD located above the ore body, the dose data can be separated into two groups, one

Table 2.9-4. TLD READINGS IN THE VICINITY OF THE ANDERSON PROPERTY

| Sample Site | TLD Reading mrem/wk |
|---|---|
| T1 | 3.40 |
| T2 | 1.99 |
| T3 | 1.74 |
| T4 | 1.76 |
| T5 | 1.70 |
| T6 | 1.54 |
| T7 | 2.06 |
| T8 | 2.07 |
| T9 | 2.12 |
| T10 | 1.76 |

with a mean of 1.74 mrem/week (sample sites T3, T4, T5 and T10) and one with a mean of 2.06 mrem/week (sample sites T2, T7, T8 and T9).

RADIOACTIVE MATERIALS IN THE WATER

Groundwater samples were collected from a total of 10 sources in the vicinity of the Anderson property (Figure 2.6-11). These samples were analyzed for total uranium, radon-222, radium-226 and -228, thorium-228, -230 and -232, gross alpha, and gross beta (Table 2.6-20). As discussed in Section 2.6, no surface water samples were taken on the property since surface flows did not occur during the field studies.

The following discussion is based on the analyses conducted on samples collected in April and May, 1977. These results are considered to be more accurate than the results from the analyses conducted on the September 1977 samples since they correlate well with nonradiological constituents. It is probable that the analytical procedures used for the September samples were not sensitive enough to detect the small amounts of radioactive materials present in the water.

The assumption that the distribution of uranium isotopes is "normal" in the water on the Anderson property does not appear to be warranted based on the results of the groundwater sampling program. Gross alpha values were too low in all of the samples to account for normal uranium isotope distribution, let alone equilibrium between uranium and its daughters (Table 2.6-20). While gross alpha determinations are often inaccurate for water with a high total dissolved solids content, analytical error does not necessarily account for the mismatch between gross alpha readings and the uranium content of the water on the Anderson property. The results indicate the absence of uranium daughters which suggests a disequilibrium in the uranium parents (uranium-238 and uranium-234).

This disequilibrium may have been brought about by geochemical processes resulting in a differential movement of uranium-234 relative to the other isotopes in the uranium series. The beginning of the uranium decay series is as follows:

| Isotope | Half-life |
|---|---|
| Uranium-238 | $4.5 \times 10^9$ years |
| ↓ | |
| Thorium-234 | 24.1 days |
| ↓ | |
| Protactinium-234 | 1.2 minutes |
| ↓ | |
| Uranium-234 | $2.5 \times 10^5$ years |
| ↓ | |
| Thorium-230 | $8 \times 10^4$ years |
| ↓ | |
| Radium-226 | $1.6 \times 10^3$ years |

If uranium-238 is in the +4 valence state it does not differ significantly in solubility from the thorium isotopes. Protactinium-234 has too short a half-life to account for any significant change in solubility. Uranium-234, on the other hand, is commonly produced in an oxidized state (+6 valence) which readily forms complexes with bicarbonate ions and is, in essence, solubilized.

Most of the groundwater samples contained few alpha-emitters other than uranium (Table 2.6-20). Consequently, most of the gross alpha readings should be attributed to uranium-238, uranium-235, and uranium-234. By determining the portion of the gross alpha values that can be accounted for by uranium-238 and uranium-235 (uranium-235 does not commonly dissociate from uranium-238 by geochemical processes), it is then possible to estimate the uranium-234 content of the water. Table 2.9-5 provides the expected concentrations of uranium-234 given the gross alpha values for the water samples.

Comparison of the total uranium concentrations to gross alpha readings for the samples suggests a general depletion of uranium-234 in the groundwater of the area (Table 2.6-20). At least two of the samples (AM-28 and Grapevine Springs) had gross alpha readings too low to account for the uranium-238 content alone, indicating analytical problems. Samples from well DC-5, Palmerita Ranch well, Pipeline Ranch well, Santa Maria Highway, and Tres Alamos Spring had gross alpha counts slightly above the level that could be attributed to the presence of uranium-238 and uranium-235. If this difference was due only to uranium-234, approximately 22 percent of the expected concentration of this isotope is present in the samples. Accounting for the thorium and radium isotopes present in two of those samples (Palmerita Ranch well and Santa Maria well #1) would make this fraction even smaller.

Table 2.9-5. EXPECTED CONCENTRATIONS OF URANIUM 234

| Total Uranium μg/l Observed | Activity Due to Non-differentiated $U^{238}$ Plus $U^{235}$ @ 0.346 pCi/μg | Alpha (Gross) Observed pCi/l | Difference Assumed to be $U^{234}$ pCi/l | Percentage $U^{234}$ in U Total |
|---|---|---|---|---|
| 7.6 | 2.63 | 2 ± 1 | <0 | - |
| 46.0 | 15.92 | 21 ± 5 | 5.08 | 1.79E-3 |
| 11.1 | 3.84 | <2 | <0 | - |
| 5.0 | 1.73 | 2 ± 2 | 0.27 | 0.87E-3 |
| 7.2 | 2.49 | 3 ± 2 | 0.51 | 1.15E-3 |
| 11.5 | 3.98 | 4 ± 3 | 0 | - |
| 18.8 | 6.51 | 8 ± 5 | 1.495 | 1.29E-3 |
| 16.9 | 5.85 | 7 ± 4 | 1.15 | 1.10E-3 |

Except for the sample from the Palmerita Ranch well no significant concentrations of radium-226 or radium-228 were found in the groundwater samples. The water from the Plamerita Ranch well contained a significant quantity of radium-228 (Table 2.6-20). In contrast, this water contained the lowest concentration of total uranium of all the samples. The Palmerita Ranch well water also contained significant quantities of thorium-228 and -230, but no significant concentration of thorium-232 was found. The only other sample with significant thorium levels was taken from Santa Maria Well No. 1. Significant quantities of all three thorium isotopes were found in the water from this well. The total uranium content of the Santa Maria Well No. 1 water was approximately twice that of the Palmerita Ranch well water, but no significant levels of either radium isotope (226 or 228) were found in the water.

In evaluating the relative concentrations of thorium-232 daughters (radium-228 and thorium-228) and the thorium daughter of uranium-234 (thorium-230) in the samples from Santa Maria Well No. 1 and the Palmerita Ranch well, it was noted that these two groundwater sources have several features in common. Water from both sources contain relatively high concentrations of calcium along with low carbonate and were among the lowest in pH (Table 2.6-17). Both wells are also located in the alluvial plain of the Santa Maria River near outcrops or near-surface deposits of basalt, which inherently contains large quantities of calcium. Since calcium and radium are chemically similar, the sampling results imply a coordinated movement of the radium with calcium.

The presence of relatively high levels of radium-228 in the Palmerita Ranch well water with no significant concentration of thorium-232 may be the result of differences in solubility. Thorium is much less soluble in water than radium. Consequently, the results suggest a chemical separation of the two elements, perhaps as a direct result of infiltration of precipitation in a nearby recharge area. If this is the case, then the radium-228 would have moved free of thorium-232 to its present position. The presence of thorium-228 in the water would result from the decay of radium-228.

The water from Santa Maria Well No. 1 contains essentially the same amount of thorium-228 as the water from the Palmerita Ranch well plus the only thorium-232 observed in any of the samples, but no radium-228. In an area lacking significant rainfall for many months and assuming a nominally low rate of groundwater movement, this situation may be due to analytical error.

The apparent lack of radium-226 in any of the groundwater samples may also be due to analytical problems. However, its continuous and conspicuous absence would infer a circulation of the groundwater in the area as opposed to the presence of ancient stagnant waters that have been in place for thousands of years.

Analysis of the uranium content of groundwater in the vicinity of the Anderson property relative to other water quality constituents provides some information on the mobilization mechanisms of the groundwater system in the area. While other radioactive components of the water could also provide this information, only uranium was present in sufficient quantities to provide a reasonably reliable analysis of all the samples.

Uranium appears to be mobilized, i.e., free to enter water, in essentially two forms. One of these forms is a complex of the uranyl ion and the other is when uranium is in the form of or associated with particulates, especially particulates of colloidal size.

Ferruccio (1975) found that dissolution of uranium from carbonate rocks is appreciably influenced by cationic components of the water according to the following series:

$$Mg^{++} > Ca^{++} > Na^{+}$$

Carbonate rocks are neither characteristic of the country rock nor the ore in the vicinity of the Anderson property, although calcareous chert constitutes a large portion of the upper layer of the Miocene lake beds in which the uranium ore is found.

In the noncarbonate rocks typical of the area, the solubility of uranium appears to be a function of cation concentrations in essentially the inverse of the relationship described by Ferruccio. There is a very high correlation between the uranium content of the groundwater and the concentration of sodium (Figure 2.9-5). The presence of calcium, magnesium, and potassium appears to decrease the solubility

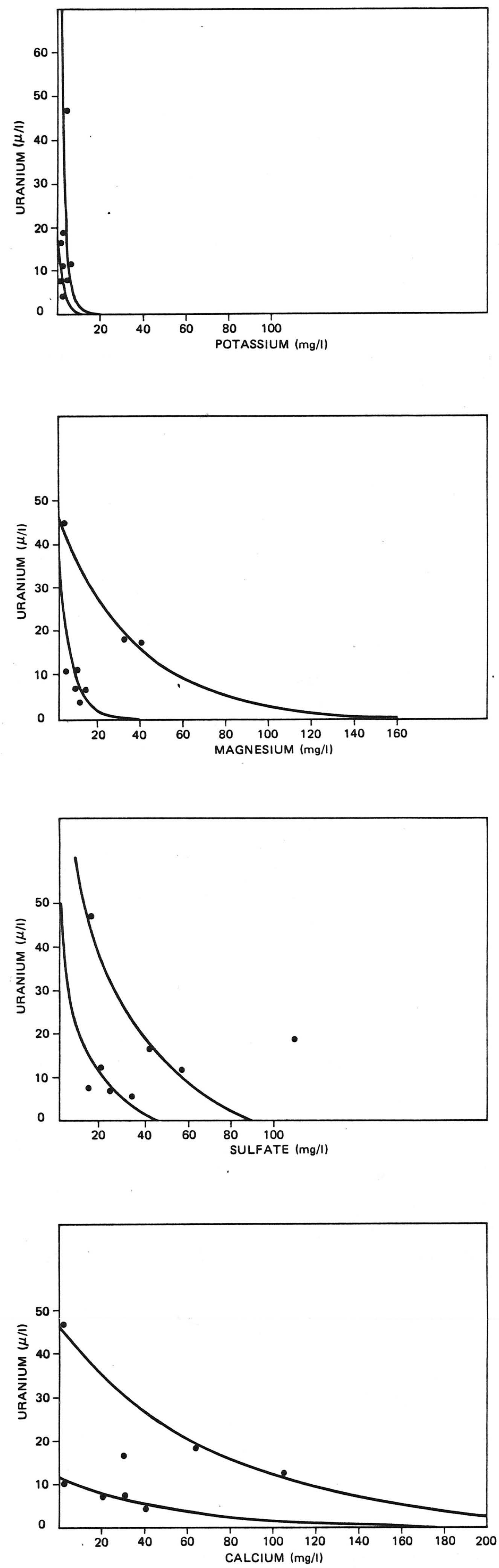


Figure 2.9-5. URANIUM CONCENTRATIONS IN GROUNDWATER RELATIVE TO OTHER MAJOR WATER QUALITY CONSTITUENTS

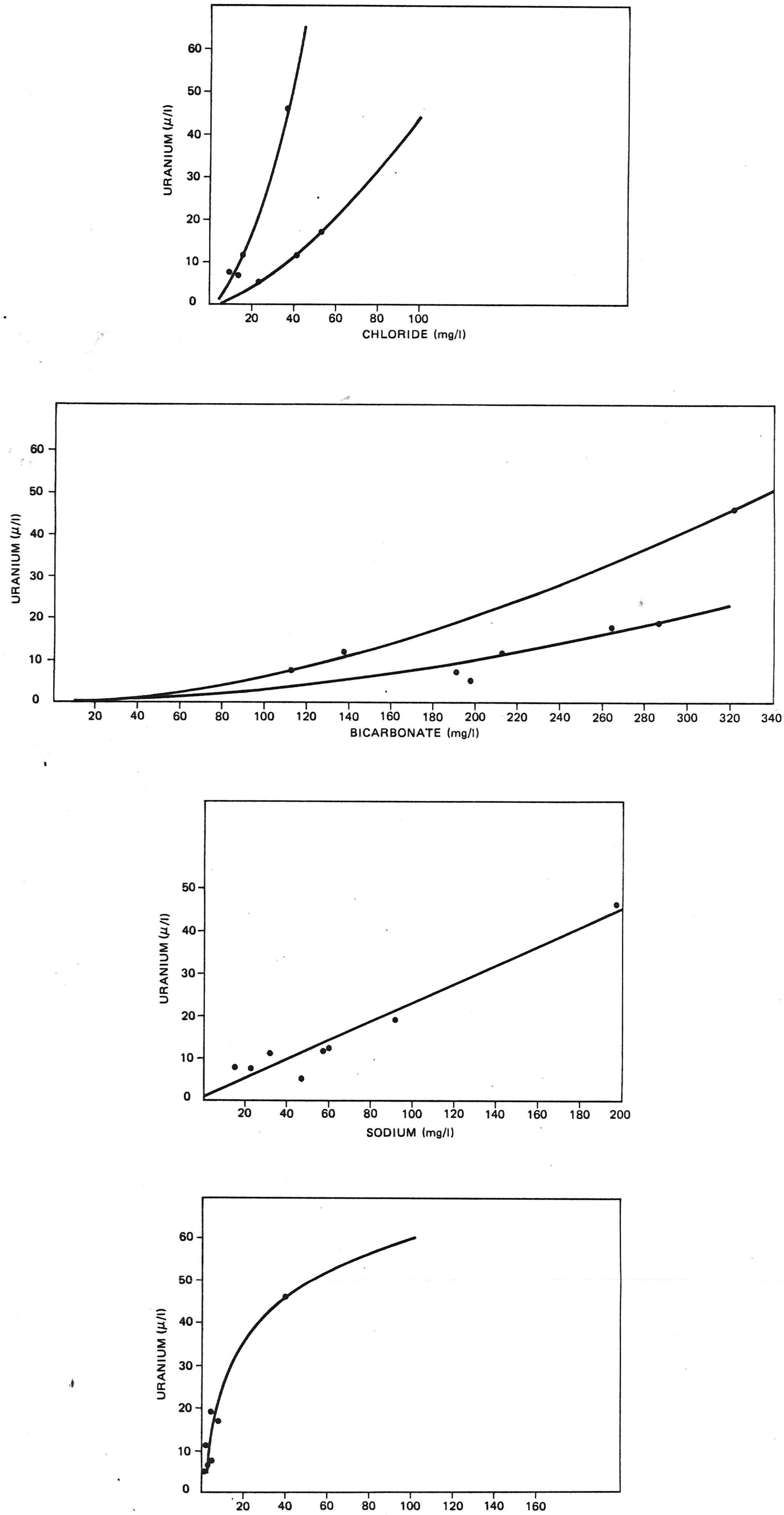


Figure 2.9-5-1. URANIUM CONCENTRATIONS IN GROUNDWATER RELATIVE TO OTHER MAJOR WATER QUALITY CONSTITUENTS

of uranium. Consequently, solubilization would not appear to be the mechanism of uranium mobilization on the Anderson property; rather ion exchange or possibly mobilization of colloids containing uranium appears to be the more likely method.

Examination of anion concentrations in the groundwater clarifies this observation to some degree. The presence of sulfate seems to retard the movement of uranium into the water while chloride and bicarbonate appear to encourage it. Although somewhat similar to the effect of sodium at lower concentrations, the data show that at higher bicarbonate levels the movement of uranium into the water accelerates (Figure 2.9-5). This appears to be the result of two reactions. One is the effect of ion exchange, which is relatively linear to bicarbonate concentration, while the other is apparently the result of uranium (probably the uranyl ion) and bicarbonate complexing. A similar, if accelerated, reaction may be seen between uranium and chloride (Figure 2.9-5).

The relationship between uranium content in the groundwater and silica is particularly interesting and reflects the importance of colloidal behavior in uranium mobility. At the pH levels encountered in the sampling program (7.3 to 8.9), colloidal silica must be present to account for the silica concentrations in the groundwater (Table 2.6-19). Therefore, the curve in Figure 2.9-5 relating uranium to silica is essentially Langmuirian and probably relates to the surface area of the silica colloids.

In summary, there appears to be a geochemical situation in the general area of the Anderson property in which certain constituents of the groundwater, namely sodium, chloride, silica, and bicarbonate, encourage the presence of uranium in the water while other constituents are antagonistic to it. The antagonistic constituents include the principal ions calcium, magnesium, sulfate, and potassium.

## RADIOACTIVE MATERIALS IN SOILS, PLANTS AND ANIMALS

### Soils

As discussed above, migration of uranium and its daughters occurs in the groundwater on and in the vicinity of the Anderson property. Since uranium mining was conducted on the property in the past and radioactive materials were largely left exposed after termination of these activities, direct particulate displacement due to erosion of the exposed ore beds may have provided another significant source of uranium migration in the area. For this reason, 19 sediment samples were collected along the drainage channels on the property (Figure 2.9-1). These samples were analyzed for uranium-238 and 6 of its 14 daughters (uranium-234, thorium-230, radium-226, lead-214, bismuth-214, and polonium-210). These six daughters were chosen on the basis of their sensitivity to geochemical separation. In addition to these isotopes, the samples were analyzed for thorium-232 and its daughter lead-212, gross alpha, gross beta, cesium-137 (a fallout product), and potassium-40. The results of these analyses are presented in Table 2.9-6.

In order to identify the origin of sediments and erosion mechanisms, an analysis of particle size distribution was also conducted on the samples. Particle sizes ranged in diameter from about 4 to approximately 12,000 microns with distinct peaks at 4 to 40 microns, 111 microns, 220 microns, and 800 to 900 microns. Each peak appears to represent a separate material source. The 4 to 40 micron particles represent wind-blown dust typical of the project region and the other semi-arid and arid regions of the west. On the Anderson property, these particles have been transported to the site by winds largely from the south-southwest. The particles 111 microns in diameter have been generated from the exposed ore deposits on the property. These particles are agglomerative in nature, generally forming aggregates too large to be carried by the wind; consequently, this material is normally transported by surface runoff. Particles in the 220 micron class appear to be derived from the Tertiary volcanic series in the vicinity of the property. These particles are also transported primarily by water. The 800 to 900 micron particles originate from the fluvial material typical of the river alluvium that borders the Anderson property. These particles were moved to the sample sites primarily by strong north-northeast winds.

A good correlation between uranium-238 and uranium-234 concentrations was observed in the sediment samples; however, the uranium-234

Table 2.9-6. RADIOACTIVE MATERIALS IN THE SEDIMENTS ON THE ANDERSON PROPERTY

| Sediment Sample | $U^{238}$ | $U^{234}$ | $Th^{230}$ | $Ra^{226}$ | $Pb^{214}$ | $Bi^{214}$ | $Pb^{210}$ | $Th^{232}$ | $Pb^{212}$ | Gross Alpha | Gross Beta | $K^{40}$ | $Cs^{137}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 | | | | | .5 ± .9 | .3 ± .5 | | | .5 ± .4 | 5 ± 3.2 | 8.5 ± 1.2 | 22 ± 4 | .2 ± .1 |
| S2A | 0.82 ± 0.11 | .81 ± .11 | .45 ± .11 | .54 ± .02 | 1.0 ± .5 | .2 ± .5 | .5 ± .4 | .54 ± .13 | .9 ± .5 | 6.4 ± 3.4 | 11 ± 2 | 23 ± 5 | .3 ± .2 |
| S2B | 0.62 ± 0.11 | .60 ± .11 | .33 ± .06 | .32 ± .01 | .6 ± .4 | .3 ± .5 | .6 ± .4 | .48 ± .08 | .7 ± .4 | 8.7 ± 3.8 | 12 ± 2 | 29 ± 5 | .2 ± .2 |
| S3A | 0.90 ± 0.22 | .83 ± .21 | .48 ± .10 | .36 ± .01 | .6 ± .5 | .3 ± .5 | .6 ± .4 | 1.04 ± .18 | .9 ± .5 | 8.4 ± 3.7 | 14 ± 3 | 31 ± 5 | <.3 |
| S3B | 0.38 ± 0.11 | .38 ± .11 | .23 ± .06 | .23 ± .01 | .3 ± .5 | .3 ± .4 | <0.4 | .53 ± .11 | .2 ± .5 | 6.2 ± 3.4 | 4.7 ± 1.0 | 31 ± 6 | <.2 |
| S4 | | | | | .9 ± .5 | .2 ± .5 | | | .5 ± .4 | 5.0 ± 3.3 | 5.8 ± 1.0 | 33 ± 6 | <.2 |
| S5 | | | | | .3 ± .4 | .2 ± .5 | | | .5 ± .4 | 11 ± 4 | 10 ± 2 | 29 ± 6 | <.3 |
| S6 | | | | | 1.0 ± .5 | .2 ± .5 | | | .9 ± .5 | 5.9 ± 3.3 | 8.5 ± 1.2 | 19 ± 4 | <.2 |
| S7 | | | | | 1.2 ± .5 | .5 ± .4 | .8 ± .4 | | 1.0 ± .4 | 9.8 ± 3.9 | 11 ± 2 | 20 ± 5 | <.3 |
| S8 | | | | | .7 ± .5 | .2 ± .4 | | | .8 ± .4 | 9.2 ± 3.8 | 8.2 ± 1.1 | 26 ± 5 | <.2 |
| S9 | | | | | .9 ± .4 | .2 ± .4 | | | 1.1 ± .4 | 12 ± 4 | 8.0 ± 1.1 | 26 ± 5 | <.2 |
| S10 | | | | | .2 ± .5 | .2 ± .5 | | | .6 ± .4 | 11 ± 4 | 11 ± 2 | 28 ± 5 | <.2 |
| S11 | | | | | .2 ± .5 | .2 ± .4 | | | .7 ± .4 | 8.4 ± 3.7 | 13 ± 2 | 32 ± 5 | .2 ± .1 |
| S12 | | | | | .8 ± .4 | .4 ± .4 | | | 1.1 ± .4 | 7.6 ± 3.6 | 11 ± 2 | 24 ± 5 | <.2 |
| S13A | 0.68 ± .14 | .64 ± .13 | .35 ± .07 | .33 ± .01 | .9 ± .1 | .7 ± .4 | .8 ± .4 | .37 ± .07 | .9 ± .4 | 5.0 ± 3.2 | 11 ± 2 | 24 ± 4 | .2 ±.1 |
| S13B | 0.46 ± .10 | .45 ± .09 | .30 ± .11 | .33 ± .01 | .9 ± .5 | .2 ± .5 | .9 ± .4 | 0.70 ± .17 | .6 ± .4 | 7.6 ± 3.6 | 5.7 ± 1.0 | 20 ± 5 | .2 ±.2 |
| S14 | | | | | 1.1 ± .5 | .9 ± .6 | .7 ± .4 | | .4 ± .4 | 3.9 ± 3.0 | 8.8 ± 1.2 | 22 ± 5 | <.2 |
| S15A | 0.43 ± .10 | .43 ± .10 | .26 ± .07 | .22 ± .01 | .9 ± .4 | .2 ± .4 | .7 ± .4 | .33 ± .08 | .8 ± .4 | 4.5 ± 3.1 | 8.1 ± 1.1 | 28 ± 5 | <.1 |
| S15B | 0.32 ± .08 | .30 ± .07 | .16 ± .02 | .28 ± .01 | .9 ± .5 | .2 ± .4 | .6 ± .4 | .26 ± .03 | .5 ± .4 | 8.4 ± 3.7 | 14 ± 3 | 25 ± 5 | <.2 |

values were equal to or slightly lower than the uranium-238 values, suggesting that uranium-234 may not yet have reached equilibrium since deposition of the uranium-238. No significant separation of the two uranium isotopes has occurred in the sediments, which indicates that both are oxidized. This is not unexpected in a region with a relatively depressed water table(s).

The thorium-230 concentrations in the samples were approximately half of the value to be expected if this daughter was in equilibrium with its parent, uranium-234. This implies a relatively recent (in geologic time) separation of oxidized uranium and thorium. On the assumption that the transfer of the uranium parent took place without thorium-230 accompanying it, then the separation took place roughly 77,000 years ago.

Comparison of radium-226 data to that of lead-214 showed the latter to be abnormally high relative to the radium content of the sediment samples. Two trends can be seen in the relationship between these isotopes. In samples S2 and S3, the concentration of lead-214 is about twice that of radium-226. In samples S13 and S15, the lead-214 concentration is about three times greater than the concentration of radium-226. This difference in concentrations is possible because of the presence of the highly mobile intervening daughter of radium-226, radon-222. As a gas, radon has the capability of migrating from below the surface of the ground and depositing its daughters, of which lead-214 is one, on or near surface soils.

Lead-214 decays by beta emission to bismuth-214 which has a half-life of less than 30 minutes. Consequently, the concentrations of these two isotopes should be in a 1:1 ratio, but they are not in the sediment samples taken on the Anderson property. Due to the short half-life of lead-214 and bismuth-214 (26.8 minutes and 19.7 minutes, respectively), analysis for these isotopes should be done in the field to obtain accurate results. Because of a high dependence on rapid analysis, ventilation, careful handling, and possibly analytical procedures, the lead-214/bismuth-214 results obtained for the Anderson property may represent procedural bias.

Since lead-210 has a half-life of 22 years, the results of analysis for this isotope should be more pertinent than the lead-214 results for samples transported from the field to a laboratory for analysis. Except for sample S2A which was unaccountably high in lead-214 and sample S3B which had no significant lead-210 concentration, the data verify the lead-214 readings on close to a 1:1 basis.

If uranium-238 is in equilibrium with its daughters and no thorium is present, the gross alpha measured in a sample should be equal to the total activity of the uranium-238 plus its alpha-emitting daughters or roughly eight times the activity of uranium-238 (Faul, 1954). Calculations based on the sediment analyses result in a uranium (plus daughters) to gross alpha ratio of 1:1 to 1:3.3. Allowing for error in the measurement of both variables, these calculations indicate that the alpha levels are slightly higher than can be accounted for by the uranium series.

The only alpha-emitting isotope in the uranium-238 series that would not be expected to be in equilibrium in the sediments is polonium-210. Polonium-210 is a daughter of radon-222. As discussed above, radon migrating to the surface of the soil could deposit its daughters there, resulting in higher than normal concentrations of polonium-210 and other isotopes. This could account for the excess gross alpha readings.

A potential exists for the differential accumulation of polonium-210 in the surface soils compared to its daughter, lead-210. Polonium is relatively insoluble in the alkaline environment typical of the groundwater and soils of the property; consequently, differential migration by groundwater movement seems unlikely. However, polonium-210 is relatively volatile, particularly at the high temperatures experienced in the Arizona desert. Concentrations of polonium-210 relative to lead-210 in the near surface soils could result from "random walk" of polonium atoms.

Thorium-232 concentrations in the sediment samples ranged from 0.26 to 1.04 pCi/g with a geometric mean of 0.48 pCi/g (Table 2.9-6).

Concentrations of lead-212, a thorium-232 daughter, ranged from 0.2 to 1.1 pCi/g with a geometric mean of 0.67 pCi/g. Since the concentrations of these two isotopes should be equal in equilibrium conditions, the results indicate geochemical separation. The highest values for thorium came from samples taken near basalt outcrops. The highest values for lead-212 came from the basalt outcrop areas and the stream course along the western side of the property.

The decay chain for thorium-232 is shown in Figure 2.9-6. The figure includes the primary decay modes (alpha or beta emission) and half-lives of each of the major intermediate products between thorium-232 and stable lead-208. Compared to the uranium series, the time required for thorium-232 to decay to lead-208 is short, taking slightly less than nine years. The most stable nuclides in the series are radium-228 (half-life of 6.7 years) and thorium-228 (half-life of 1.9 years). With the exception of radium-224 (half-life of 3.64 days), all the other intermediate isotopes have half-lives of considerably less than one day. Consequently, after the production of radon-220 (half-life 54.5 seconds), the only nuclides in the series that are reasonable to analyze for in field samples analyzed in a laboratory are lead-212 (half-life of 10.6 hours) and bismuth-212 (half-life of 60.5 minutes).

Due to the short half-life of the intermediate isotopes between thorium-228 and lead-212 and the length of time between sample collection and analysis, thorium-228 and lead-212 should have been in equilibrium at the time laboratory tests were conducted. The only nuclide

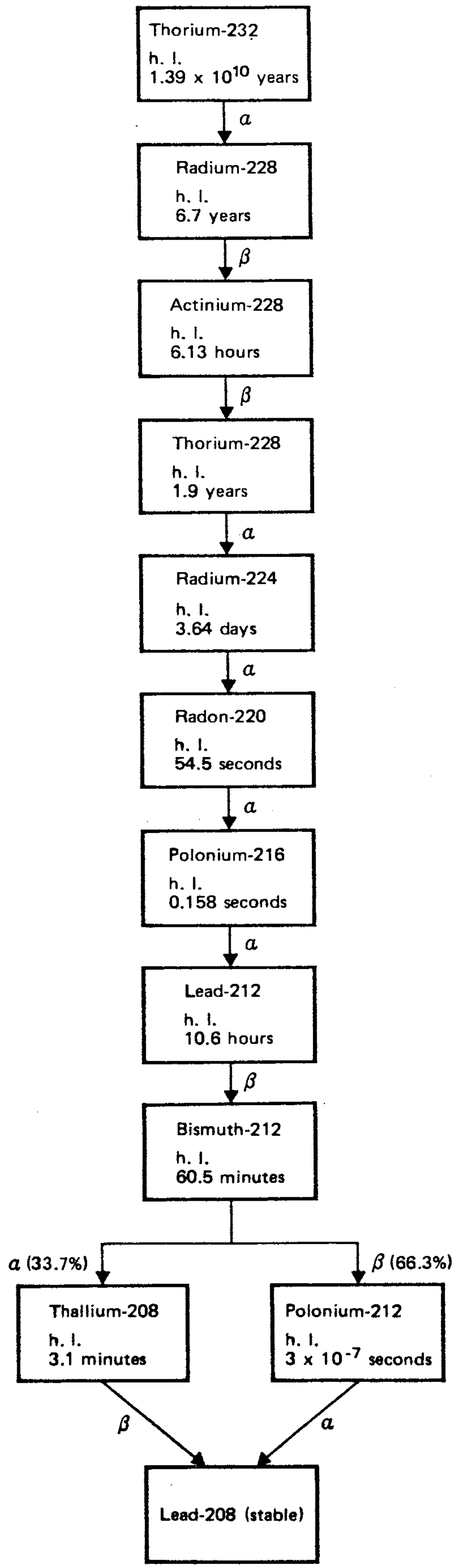


Figure 2.9-6. DECAY CHAIN FOR THORIUM- 232

between thorium-232 and lead-212 that has a sufficiently long half-life, as well as different chemistry, that would permit significant differentiation is radium-228 (half-life of 6.7 years). Therefore, the only plausible explanation for the results is a physical-chemical separation of thorium-232 and radium-228 in the sediments.

An evaluation of the samples for which both thorium-232 and lead-212 concentrations were determined provides some information on the possible mechanisms causing this differentiation. Sample locations S2, S3, and S15 lie along the same stream course (Figure 2.9-1), with sample S3 closest to the basalt that appears to be the primary source of thorium in the area. As may be seen, the average of the thorium-232/lead-212 ratios for the two samples collected at each of the three locations is a continuous function with distance along the stream course (Figure 2.9-7):

$$R = 1.91 - 0.157 \ln D$$

where

$R$ = thorium-232/lead-212 ratio

$\ln$ = log to the base e

$D$ = distance in feet from the source along the stream course

Although the number of locations examined is limited, the correlation is good. Since the function is log-linear, the differentiation is probably due to differences in solubility between thorium and radium.

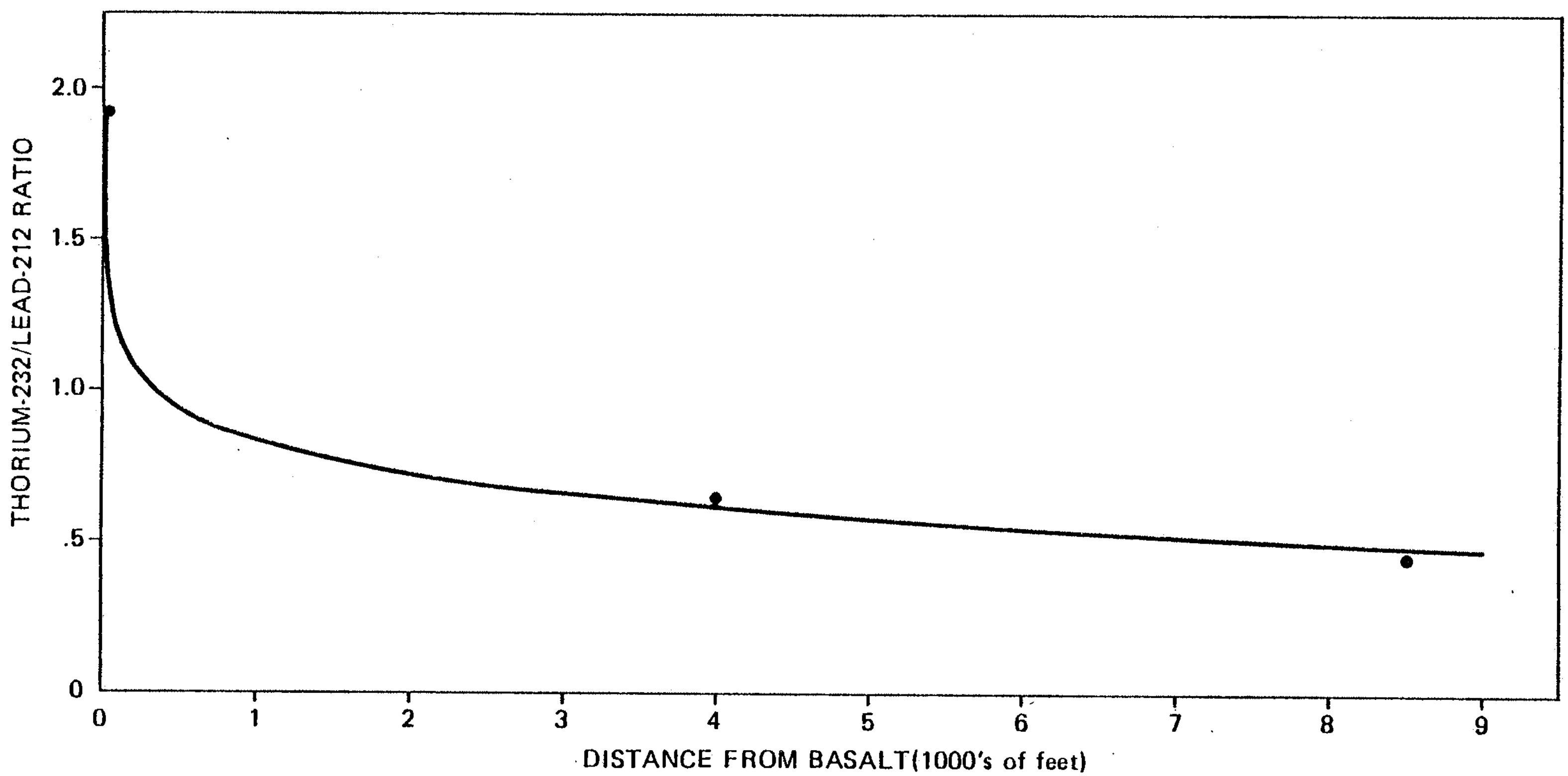


Figure 2.9-7. THORIUM-232/LEAD-212 RATIO AS A FUNCTION OF DISTANCE FROM BASALT DEPOSIT

Evaluation of the uranium-238 and thorium-232 concentrations in the sediments shows two relationships between these isotopes. The upper curve on Figure 2.9-8 represents samples starting at the ore bed and proceeding along the given stream course. The second curve represents samples starting at the basalt outcrop and proceeding downstream; however, all of the samples were not taken from the same stream course. It is interesting to note that both curves have the same zero thorium intercept on the uranium axis, about 0.14 pCi/g.

Cesium-137 levels in the sediment samples were at or below the detection limits of the analysis. Because the values were so low compared to the potential error, it is not possible to determine any distribution relationships for this isotope. However, it should be noted that the locations where cesium-137 may have accumulated correspond with deposition of sediments by southwest winds (Table 2.9-6 and Figure 2.9-1).

Potassium-40 concentrations were generally four to six times the probable analytical error, representing significant levels of this radionuclide in the sediments on the property (Table 2.9-6). Distribution of the potassium appears to be relatively uniform, although higher values were associated with basalt areas and one position in the river bottom roughly at the confluence of Karnak Creek (Figure 2.9-1).

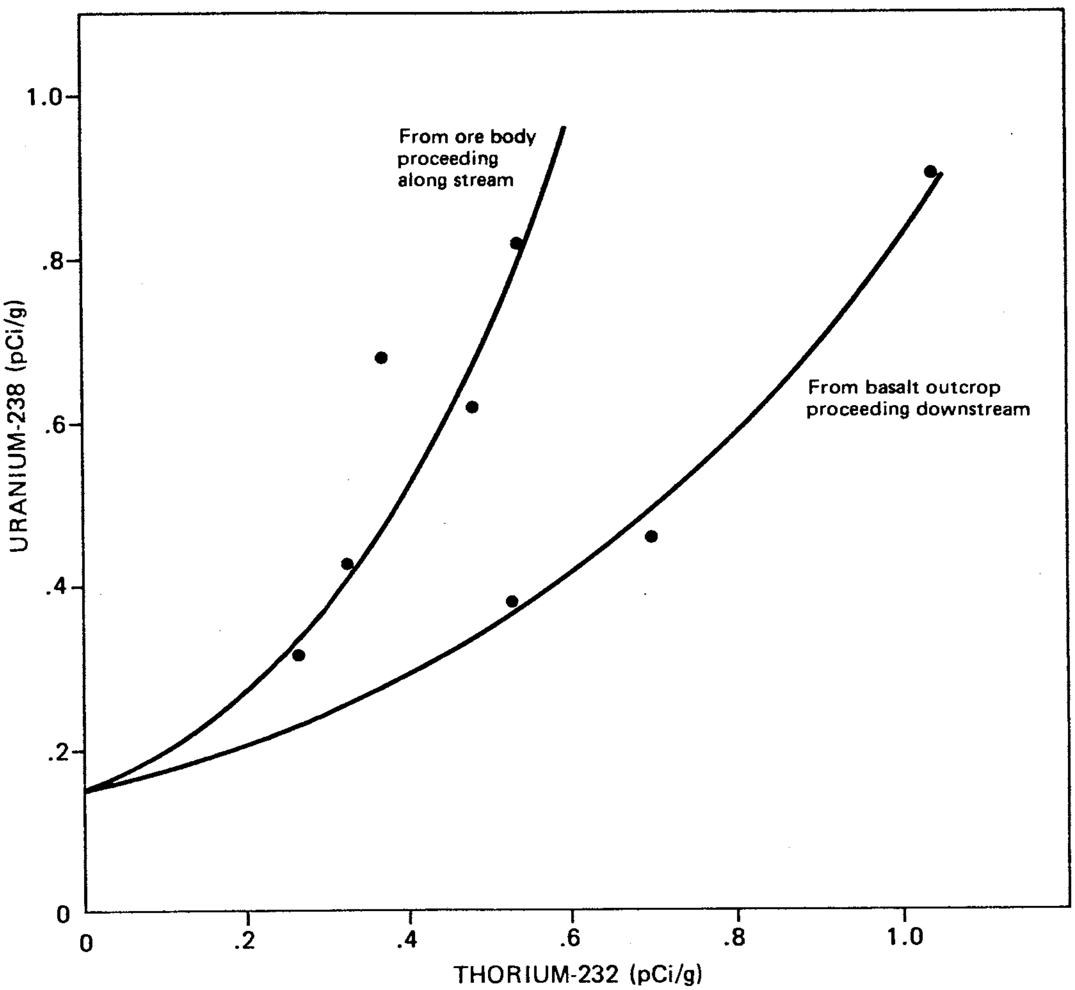


Figure 2.9-8. RELATIONSHIP BETWEEN URANIUM-238 AND THORIUM-232 CONCENTRATIONS IN THE SEDIMENTS ON THE ANDERSON PROPERTY

Comparison of uranium-238 and thorium-232 concentrations with potassium-40 on the property is of interest due to the intense igneous activity that occurred in the area during the Tertiary. Potassium, like uranium and thorium, is commonly rejected to a late crystallizing phase in melted rock. Consequently, associations between the three elements are commonly sought in geochemical analyses. As can be seen in Figure 2.9-9, thorium and uranium are at minimum levels when potassium-40 concentrations are on the order of 26 to 27 pCi/g. Below this concentration, uranium and thorium decrease as potassium increases while above this concentration uranium and thorium increase as potassium increases. The "null" value on the uranium-238/potassium-40 curve in Figure 2.9-9 is close to the value of uranium-238 at the thorium-uranium intercept on Figure 2.9-8. This suggests a baseline concentration of uranium for the area in an earlier geologic time which has subsequently increased due to concentration through altered geochemical conditions.

Vegetation

Vegetation samples were collected at 11 locations encompassing the area exposed to the ore deposits on the Anderson property (Figure 2.9-1 and Table 2.9-7). These samples were composited and analyzed for total uranium, gross alpha, gross beta, potassium-40, beryllium-7 (a natural radioactive isotope found in the atmosphere), the uranium daughters lead-214 and bismuth-214, and five beta-emitting fallout

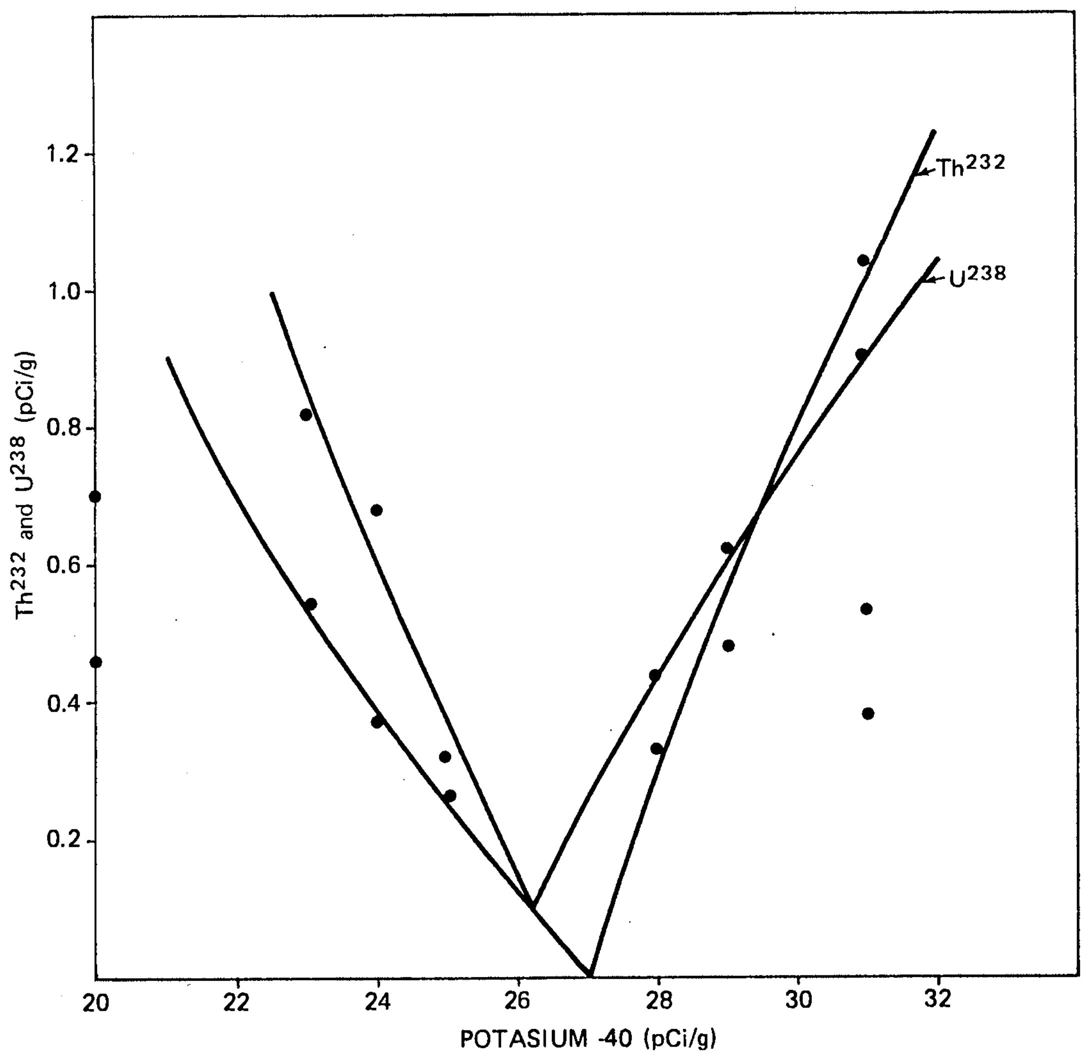


Figure 2.9-9. RELATIONSHIP BETWEEN URANIUM -238/THORIUM -232 AND POTASIUM -40 CONCENTRATIONS IN THE SEDIMENTS ON THE ANDERSON PROPERTY

Table 2.9-7. VEGETATION SAMPLES COLLECTED ON THE ANDERSON PROPERTY FOR RADIOLOGICAL ANALYSIS

| Sample | Location | Elevation | Contents (In Descending Order by Weight) |
|---|---|---|---|
| V1 | NE 1/4 Sec. 10<br>Coincides with soil sample #2 | 1760 ft | Brittlebush (Encelina farinosa)<br>Catclaw (Acacia greggii)<br>Wolfberry (Lycium Spp.) |
| V2 | NW 1/4 Sec. 14<br>along wash, coincides with soil samples #3 A & B | 2120 ft | White Bursage (Franseria dumosa)<br>Globemallow (Sphaeralcea spp.)<br>Joint-fir (Ephedra trifurca)<br>Bladdersage (Salazaria mexicana) |
| V3 | Near tank at South Border Sec. 27 | 2320 ft | White Ratany (Kamaria Grayi)<br>Beavertail Cactus (Opuntia basilaris)<br>Cane Cholla (O. acanthocarpa)<br>Paperflower (Psilotrophe cooperi)<br>Tabosa Grass (Hilaria mutica) |
| V4 | NE 1/4 Sec. 11, at confluence two washes 1/2 mi. ENE of Anderson Mine. Coincides with soil sample #6 | 1760 ft | White Bursage<br>Ratany (Kamaria spp.)<br>Catclaw<br>Paperflower<br>Tabosa Grass<br>Globemallow |
| V5 | S. side Santa Maria R. at confluence with wash near north edge Sec. 3, coincides with soil sample #11 | 1520 ft | Mesquite (Prosopis juliflora)<br>Catclaw<br>Seep-willow (Baceharis glutinosa) |
| V6 | East edge Sec. 3 upslope from confluence of two washes; soil sample #7 taken downstream in wash below this sample | 1600 ft | Brittlebush<br>White Bursage<br>Palo Verde (Cercidium microphyllum) |
| V7 | NE 1/4 Sec. 9, south side mesquite bosque at south side Santa Maria River. Coincides with soil sample #1 | 1580 ft | Mesquite<br>Catclaw<br>Seep-willow<br>Black-bark Rabbitbrush (Chrysothamaus paniculatus) |
| V8 | West edge of Sec. 9 along wash | 1600 ft | White Bursage<br>False Palo Verde (Holocantha emoryi)<br>Bladder-stem |
| V9 | South side Santa Maria River at north border Sec. 8, about 0.2 mi. west of NE Sec. corner | 1480 ft | Catclaw<br>Mesquite<br>Cane Cholla |
| V10 | Southwest facing slope of Black Mtn., SE 1/4 Sec. 2, about 0.1 mi northwest soil sample #14 | 1750 ft | Brittlebush<br>White Bursage |
| V11 | Near road junction at north edge Sec. 22. | 2268 ft | Brittlebush<br>Beavertail Cactus |

isotopes (ruthenium-103, niobium-95, zirconium-95, cesium-137 and cerium-144) (Table 2.9-8).

Total uranium content was low in all the samples with less than half having concentrations greater than the limit of detection (approximately 0.05 μg/g). The highest concentration of uranium (0.3 μg/g) was detected in the vegetation growing on the ore deposits. Of the four other vegetation samples that contained detectable levels of uranium, two were taken downstream of the ore deposits, one was taken in the vicinity of the basalt outcrops on the property, and one (the lowest detectable concentration) was taken on the desert floor approximately one mile south of the exposed ore deposits (Table 2.9-8 and Figure 2.9-1).

The highest uranium concentration in vegetation was only about 10 percent of the uranium concentration found in the sediments at the sample sites. The other vegetation samples also contained far less uranium than the soils where they were growing. This may be due to rejection of the heavy uranium isotopes by the plants and/or the uranium may not be in a chemical form available for plant uptake.

Gross alpha counts for the vegetation averaged about 1.2 pCi/g. Three samples had a zero reading for gross alpha and the count for the remaining 8 samples ranged from 1.1 to 2.5 pCi/g with analytical error ranging from 0.9 to 1.5 pCi/g, respectively (Table 2.9-8).

Table 2.9-8. RADIOACTIVE MATERIALS IN PLANTS AND ANIMALS ON THE ANDERSON PROPERTY

| Vegetation Sample | U Tot µg/g | Gross Alpha | Gross Beta | $K^{40}$ | $Zr^{95}$ | $Nb^{95}$ | $Ru^{103}$ | $Pb^{214}$ | $Bi^{214}$ | $Cs^{137}$ | $Ce^{144}$ | $Be^{7}$ | Weight (Grams) Wet | Weight (Grams) Dry | $Pb^{212}$ | $Ra^{226}$ | $Th^{230}$ | $Th^{232}$ | $Pb^{210}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | 0.3 | 2.5 ± 1.5 | 25 ± 2 | 43 ± 13 | 3.6 ± 0.8 | 2.0 ± 0.7 | 1.0 ± 0.5 | - | <2.1 | <0.6 | 6.3 ± 5.4 | 5.7 ± 4.7 | 500 | 154 | | | | | |
| V2 | 0.07 | 1.6 ± 1.3 | 10 ± 1 | 11 ± 5 | 1.4 ± 0.5 | 1.0 ± 0.4 | <0.6 | 1.4 ± 1.2 | - | 0.3 ± 0.2 | - | 4.3 ± 2.4 | 500 | 362 | | | | | |
| V3 | <0.05 | 1.4 ± 1.3 | 14 ± 1 | 16 ± 4 | 0.9 ± 0.3 | 0.7 ± 0.3 | - | - | <0.8 | <0.2 | 2.2 ± 1.9 | - | 500 | 293 | | | | | |
| V4 | <0.05 | 0.0 ± 1.0 | 12 ± 1 | 10 ± 5 | 0.9 ± 0.4 | 0.5 ± 0.3 | - | <1.6 | <0.5 | <0.4 | <4.6 | 3.1 ± 2.2 | 400 | 376 | | | | | |
| V5 | <0.05 | 0.0 ± 1.0 | 16 ± 1 | 21 ± 10 | 1.2 ± 0.6 | 1.2 ± 0.6 | - | - | - | <0.6 | - | - | 400 | 204 | | | | | |
| V6 | <0.05 | 1.4 ± 1.3 | 20 ± 2 | <6.3 | - | - | 0.6 ± 0.5 | - | - | <1.4 | - | - | 400 | 330 | | | | | |
| V7 | <0.05 | 1.4 ± 1.3 | 13 ± 1 | 10 ± 5 | 0.7 ± 0.3 | 0.5 ± 0.3 | 0.3 ± 0.2 | <1.3 | <1.3 | <0.2 | 2.6 ± 2.3 | <2.8 | 300 | 244 | | | | | |
| V8 | 0.08 | 1.8 ± 1.3 | 16 ± 1 | 17 ± 6 | 1.2 ± 0.4 | 0.5 ± 0.3 | 0.5 ± 0.3 | <1.5 | - | <0.4 | 2.9 ± 2.8 | - | 400 | 222 | | | | | |
| V9 | <0.05 | 0.0 ± 1.0 | 11 ± 1 | 8.1 ± 4.2 | 0.9 ± 0.4 | 0.5 ± 0.3 | - | <1.5 | <1.2 | <0.3 | 0 | 3.7 ± 2.0 | 500 | 343 | | | | | |
| V10 | 0.08 | 1.4 ± 1.3 | 25 ± 2 | 15 ± 4 | 0.7 ± 0.3 | 0.6 ± 0.3 | 0.3 ± 0.2 | - | <1.5 | 0.3 ± 0.1 | 2.1 ± 1.9 | < 2.1 | 500 | 276 | | | | | |
| V11 | 0.06 | 1.1 ± 0.9 | 21 ± 2 | 25 ± 10 | 0.9 ± 0.5 | <1.0 | 0.4 ± 0.3 | - | - | <0.4 | - | - | 500 | 189 | | | | | |
| | avg. | 1.15 | 16.6 | 16.6 | 1.13 | 0.75 | | | | | | | | | | | | | |
| **Fauna Sample** | | | | | | | | | | | | | | | | | | | |
| Biomass 1 | <0.05 | 0.6 ± 0.2 | 8.9 ± 0.3 | 14 ± 7 | | | | | | <0.5 | | | | | <1.5 | 0.00 ± 0.05 | <0.02 | <0.02 | <0.1 |
| Skeleton 1 | <0.05 | 0.0 ± 0.1 | 1.7 ± 0.2 | 27 ± 8 | | | | <0.2 | | <0.1 | | | | | <0.2 | 0.00 ± 0.05 | 0.02 ± 0.01 | <0.02 | <0.1 |
| Biomass 2 | <0.05 | 0.6 ± 0.2 | 8.6 ± 0.2 | 9.2 ± 4 | | | | | | <0.2 | | | | | <0.7 | 0.00 ± 0.05 | <0.02 | <0.02 | <0.1 |
| Skeleton 2 | <0.05 | 0.0 ± 0.1 | 2.1 ± 0.1 | 28 ± 6 | | | | <0.1 | | <0.1 | | | | | <0.1 | 0.00 ± 0.05 | <0.02 | <0.02 | <0.1 |

In the vegetation sample with the highest gross alpha reading, approximately 80 percent of the count can be attributed to uranium, thorium, and their daughters. In the other samples with significant alpha readings, the uranium and thorium series accounts for only about 25 percent of the gross alpha activity. This suggests that the lower error limit (i.e., 1.6 - 1.3 = 0.3 pCi/g for sample V2) may be the actual gross alpha reading in these samples.

Gross beta counts for the vegetation averaged 16.6 pCi/g and ranged from 10 to 25 pCi/g. In most cases, these readings can be attributed primarily to potassium-40. In fact, in samples V1, V2, V3, V5, V8, and V11, potassium-40 levels were higher than the gross beta counts, indicating self-absorption during the laboratory tests.

Of the fallout isotopes, only niobium-95 and zirconium-95 were measured at reasonably detectable levels in most of the vegetation samples (Table 2.9-8). Concentrations of the other fallout nuclides (rubium-103, cesium-137, cerium-144, and beryllium-7) were relatively low (Table 2.9-8). For most of these nuclides, the higher concentrations were measured in samples taken in the vicinity of the ore deposits. This is apparently due to the drop off from the desert platform at this location, providing a deposition point for winds from the southwest.

No significant concentrations of lead-214 and bismuth-214 were found in the vegetation samples (Table 2.9-8).

Fauna

Two jackrabbits were collected on the Anderson property for radionuclide analyses (Figure 2.9-1). Both total biomass and skeletal tissue was analyzed for total uranium, gross alpha, gross beta, potassium-40, lead-212, lead-214, lead-210, radium-226, cesium-137, thorium-230, and thorium-232 (Table 2.9-8).

None of the radionuclides were found in significant concentrations except for potassium-40. Both jackrabbits contained higher levels of potassium-40 in their skeletal tissue than in all the tissue as a whole. The potassium-40 levels observed in the skeletal tissue were approximately the same as the concentrations measured in the sediment samples taken on the desert floor in the general vicinity of the fauna collection sites (Table 2.9-6) and close to the "null" value of uranium in the uranium/potassium curve shown in Figure 2.9-9.

Assuming that the relationship of uranium and thorium to potassium observed in the sediment samples is correct, then a concentration of 26 to 27 pCi/g of potassium in the jackrabbit tissue should be accompanied by 0.2 to 0.4 pCi/g of uranium-238 and 0 to 0.3 pCi/g of thorium-232. Neither uranium-238 nor thorium-232 were found above the limits of detection in the animal tissue. One skeletal sample did contain 0.02 ($\pm$0.01) pCi/g of thorium-230. If it is assumed that the thorium-230 was in equilibrium with uranium-238, then biochemical rejection of uranium relative to potassium has occurred in the jackrabbits by at least a factor of 10.

The gross alpha counts for the total biomass of the jackrabbits, while subject to many variables, are on the same order as the radon-222 levels measured in the general area of collection for roughly a comparable volume of material. Since no heavy isotopes were reported for the jackrabbit biomass, equilibration of radon-222 content between the atmosphere and the tissue (assumed to be mostly water) may be a factor attributing to the gross alpha readings.