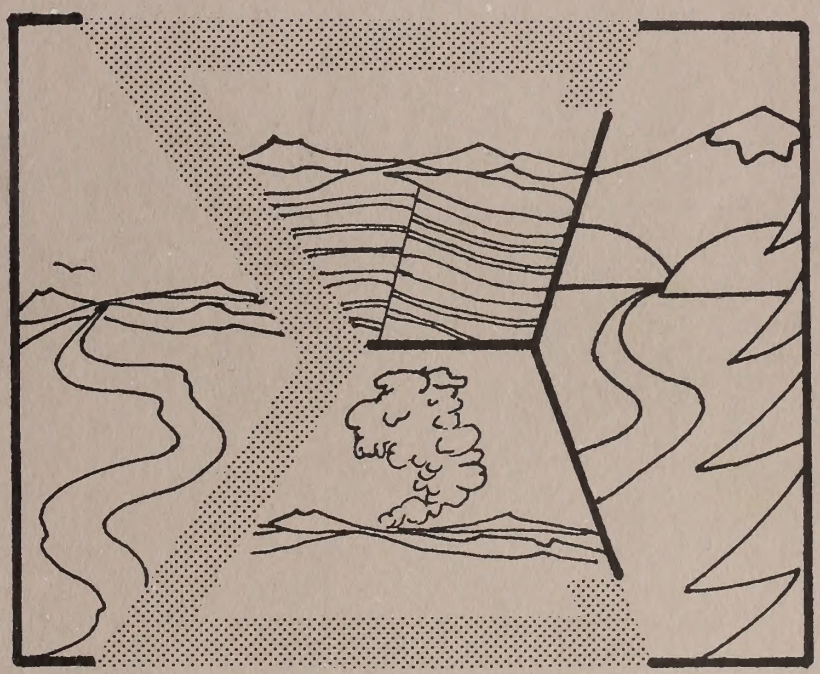
Environmental Assessment Record and Technical Examination on Proposed Geothermal Leasing in the Silver City Area



UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

LAS CRUCES DISTRICT

EAR No. NM-030-78-17

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
P. O. Box 1420
Las Cruces, New Mexico
88001

ENVIRONMENTAL ASSESSMENT RECORD
and
TECHNICAL EXAMINATION
ON PROPOSED GEOTHERMAL LEASING
IN THE SILVER CITY AREA

Las Cruces-Lordsburg Resource Area
Las Cruces District
December 1977

ENVIRONMENTAL ASSESSMENT RECORD
and
TECHNICAL EXAMINATION

ON PROPOSED GEOTHERMAL LEASING

IN THE SILVER CITY AREA

PREPARED BY:

Tom Birch, Range Conservationst
John Castellano, Wildlife Biologist
Gary Marsh, Outdoor Recreation Planner
Walter Nowak, Geologist, Team Leader
Karen Way, Archaeologist

Staff Support:

Dave Coss, Wildlife Technician
Cathy Fernandes, Typist
Evelyn Horst, Writer-editor, and Typist
Elizabeth Hummer, Environmental Assistant
Marvin James, Planning and Environmental Coordinator
Lulu Smith, Typist
William Tipton, Geologist
Gilbert Valencia, Draftsman and Cartographer

Daniel C. B. Rathbun, District Manager

TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

FIGURES (Cont'd) Page

I. DESCRIPTION OF THE PROPOSED ACTION

A. The Proposal

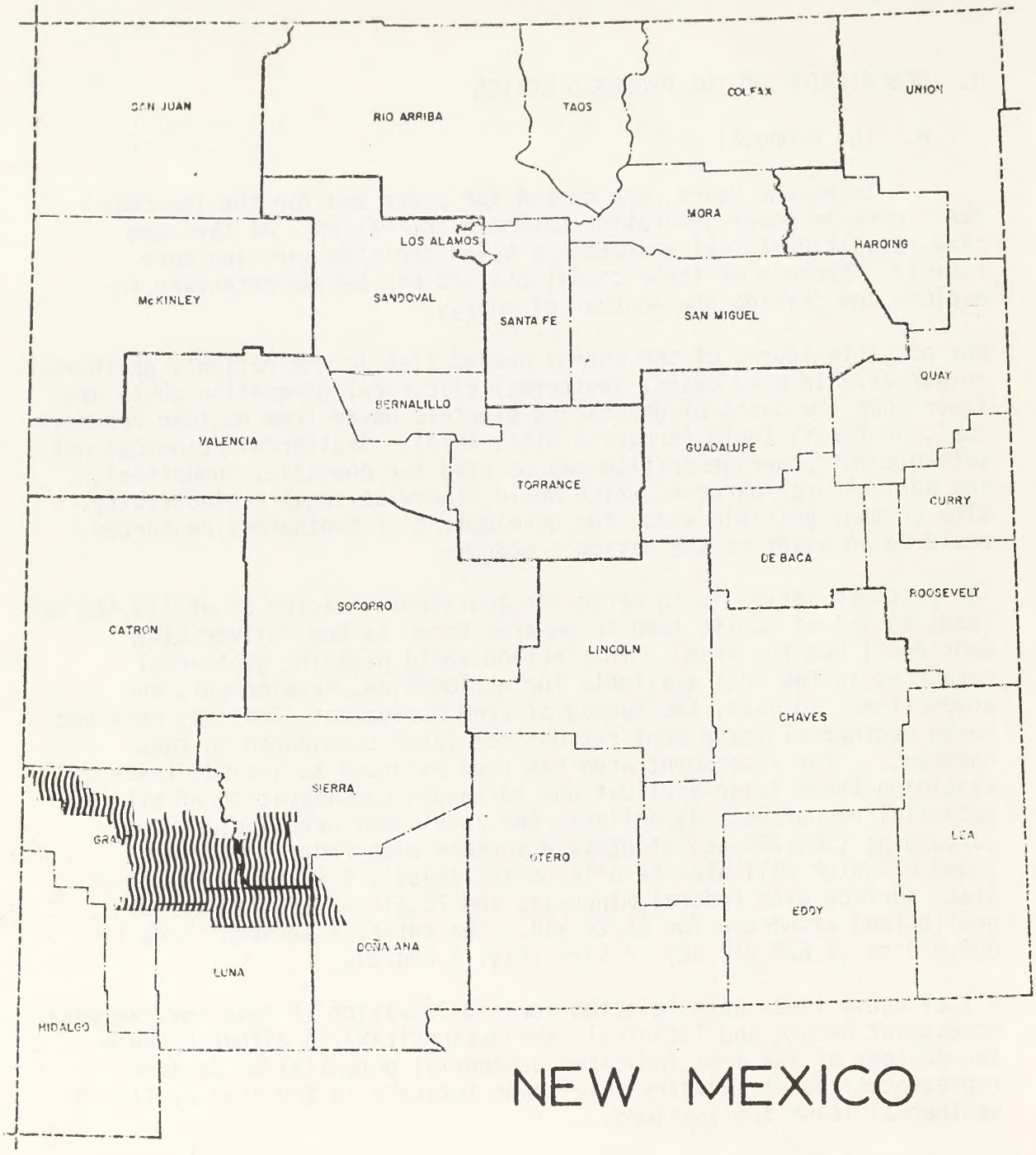
In recent years, the demand for power and for the low cost fuels used in power generation has been increasing. At the same time, traditional fuel sources are being depleted more and more rapidly. Because of these conditions, it has become necessary to explore and develop new sources of energy.

One possible source of the energy needed lies in the nation's geothermal resources. In many cases, geothermal electrical generating costs are lower than the costs of generating electric power from nuclear reactors, coal, or fossil fuels (Kruger & Otte, 1973). Geothermal resources not suitable for power generation may be used for domestic, industrial, and agricultural purposes which would otherwise require electricity. With so many possible uses, the development of geothermal resources could be an asset to the nation's economy.

The proposed action is to offer for geothermal leasing about 113,440 ha (280,300 ac) of public land in an area known as the "Silver City Geothermal Leasing Area". This action would make the geothermal resources in the area available for exploration, development, and production. To date, the Bureau of Land Management (BLM) has received seven geothermal lease applications for lands considered in this document. The assessment area has been expanded to include lands adjoining these lease applications to insure consideration of all potential resources. As defined, the assessment area includes 237,070 ha (585,790 ac) of private surface with Federal minerals (some of which will also be offered for lease), 470 ha (1,160 ac) of State surface with Federal minerals, and 22,510 ha (55,620 ac) of public land withdrawn for State aid. The entire assessment area is 659,620 ha (1,629,910 ac) in size (Fig. 1 and 2).

All of these lands were selected for consideration in this Environmental Assessment Record and Technical Examination (EAR/TE) either because the geology of the area indicates geothermal potential or because representatives of industry have shown interest in the area by filing geothermal lease applications.

A systematic field inventory of resources has not been conducted for most of the assessment area, and inventory is not scheduled until Fiscal Year 82. As additional data is collected through the BLM's land use planning process, additional values will be identified. Management Framework Plan decisions will be made concerning these resources in FY 86.



Proposed Leasing Area

FIGURE 1 PROPOSED SILVER CITY GEOTHERMAL LEASING AREA IN RELATION TO NEW MEXICO

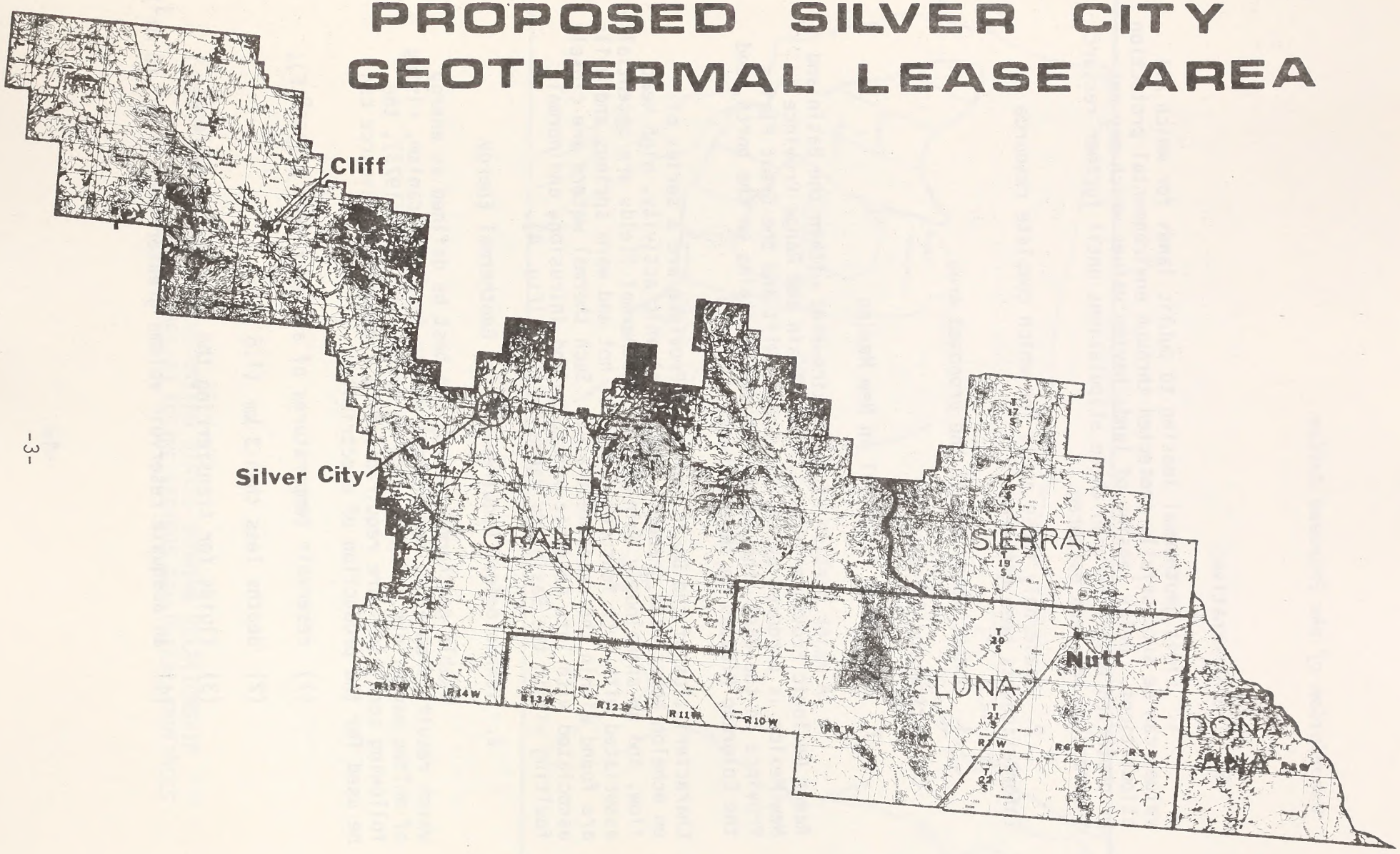


FIGURE 2 SILVER CITY LEASE AREA SHOWING COUNTIES

B. The Alternatives

1. Limit geothermal leasing to public lands for which all values can be successfully protected through environmental protection stipulations. Delay leasing of lands having values which may not be protected easily through these stipulations until further resource information has been gathered.

2. Lease only those areas for which complete resource information has been gathered.

3. Do not lease any of the proposed area.

C. Background Information

1. Geothermal Potential in New Mexico

A major portion of New Mexico lies within the Basin and Range Geologic Province (Fig. 3). The Basin and Range Province in New Mexico is bordered by the Rio Grande Rift and the Great Plains Province on the east, the southern Rocky Mountains on the north, and the Colorado Plateau on the northwest.

Characteristics of the Basin and Range Province are a series of en echelon horsts and grabens, recent volcanic activity, high heat flow, and an anomalously thin crust. Geothermal fields are potentially associated with such features. Several hot and warm springs and wells are found within the assessment area. Such thermal waters are closely associated with late Cenozoic volcanism and intrusion, and normal faulting within the Basin and Range Province (Fig. 4).

2. Technological Requirements for Geothermal Energy

Usable geothermal energy can best be defined as energy which results from anomalous thermal events (e.g., volcanism, rising of molten magma, etc.). According to Kruger and Otte (1973), the following conditions are required before a geothermal resource can be used for the production of electricity:

(1) reservoir temperatures of at least 180^{o} C (356^{o} F);

(2) depths less than 3 km (1.8 mi);

(3) fluids for transferring the heat to the surface;

(4) an adequate reservoir volume greater than 14 km^3 (3 mi^3);

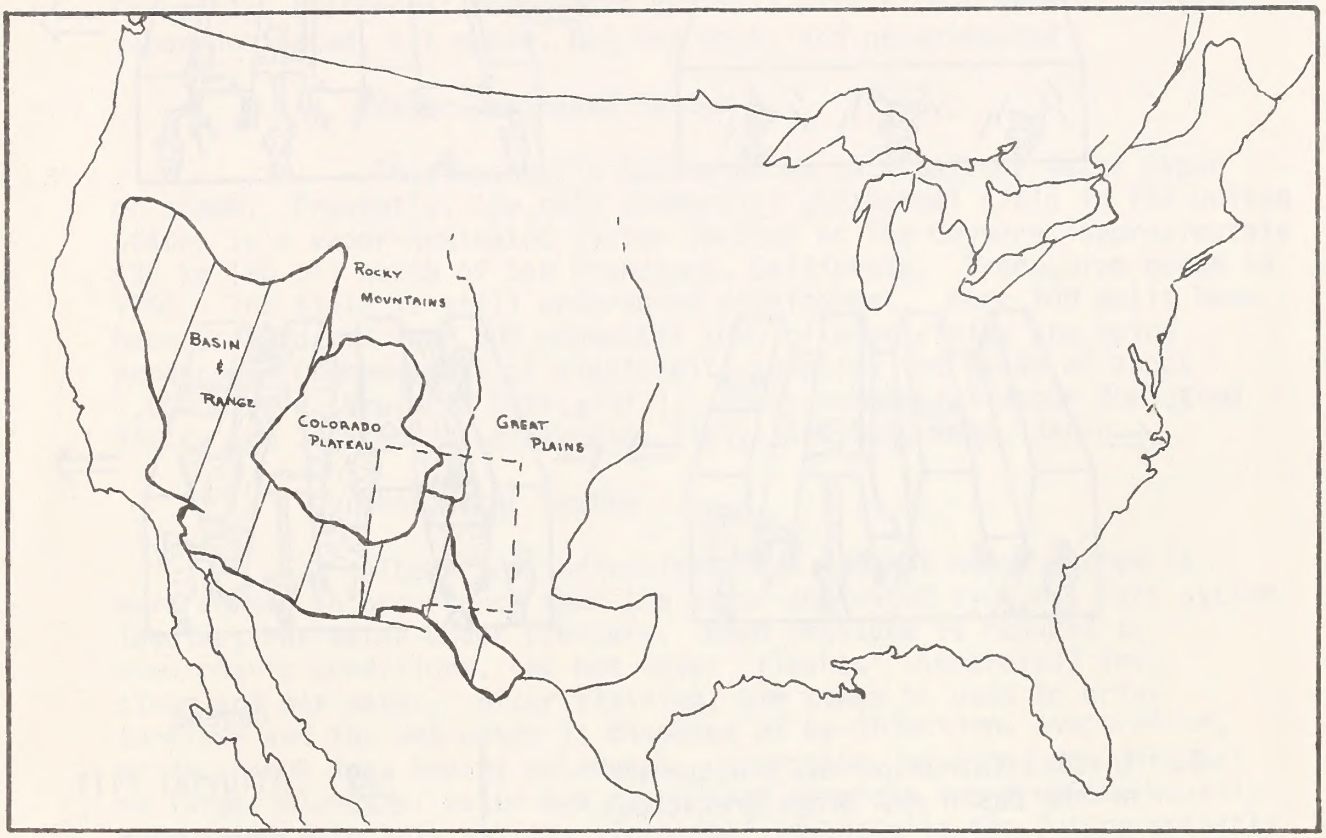
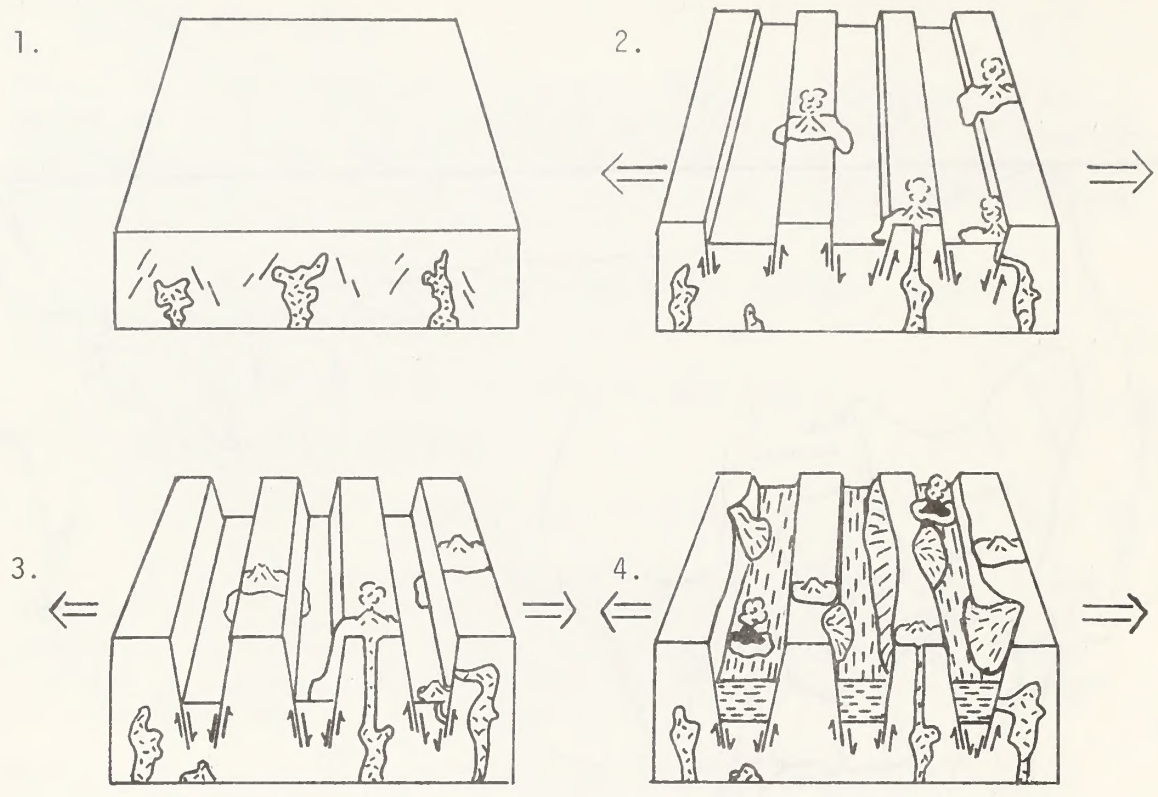


FIGURE 3 MAP OF THE UNITED STATES SHOWING RELATIONSHIP OF NEW MEXICO TO THE VARIOUS GEOLOGICAL PROVINCES



1. Initial intrusion and fracturing of the Basin and Range Cretaceous.
2. Continued extension with initial explosive volcanism - Early Tertiary
3. Continued faulting forms deep basins Mid to Late Tertiary
4. Erosion of the ranges fills basins with alluvial material. Magma type becomes predominantly basaltic Quaternary

Legend

- Alluvial fill
- Silicic Magma
- Rhyolitic volcanoes
- Basaltic volcanoes
- Normal faults
- Extensional Forces

FIGURE 4 SCHEMATIC ILLUSTRATING THE FORMATION OF BASIN AND RANGE STRUCTURES

(5) sufficient reservoir permeability to ensure sustained delivery of fluids to wells at adequate rates (Kruger and Otte, 1973) (refer to Table 1 for producible reserves).

Presently, geothermal reservoirs can fall within four general systems: vapor-dominated, hot water, hot dry rock, and geopressured.

a. Vapor-Dominated System

This system is dominated by hot, gaseous water vapor or steam. Presently, the only commercial geothermal field in the United States is a vapor-dominated system located at The Geysers, approximately 130 km (80 mi) north of San Francisco, California. Production began in 1960. The field is still undergoing development. Over 100 wells have been drilled and over 800 megawatts (MW) of electricity are being produced. One megawatt of electricity supplies the needs of about 1,000 people (Kruger & Otte, 1973). Other commercial vapor dominated fields are located at Larderello, Italy, and Matsukawa, Japan.

b. Hot Water System

There are indications that the hot water system is more common in occurrence than the vapor-dominated system. This system involves hot water under pressure. When pressure is reduced to atmospheric conditions, the hot water "flashes" (separates) into steam and hot water. After flashing, the steam is used to drive turbines and the hot water is disposed of by injection, evaporation, or discharge into nearby waterways. Corrosion, scaling, and disposal of large volumes of water and associated minerals are problems usually associated with this system. Technical advances in the future probably will result in a much more efficient use of the hot water system.

Many nations throughout the world are developing hot water systems (i.e., New Zealand, Japan, Iceland, Mexico, and the Soviet Union). One system being developed within the United States is the Valles Caldera Field (Baca Ranch Location) in north central New Mexico.

c. Hot Rock System

The hot rock system is presently in the experimental stage. The Los Alamos Scientific Laboratory (LASL) is currently conducting an experimental program for this system in the Valle Grande area in northern New Mexico. The purpose of this experimental program is to design a working model to determine the feasibility of the system.

TABLE 1 AMOUNT OF PRODUCIBLE GEOTHERMAL ENERGY IN THE UNITED STATES 1/
(MWCEN* of ELECTRICITY)

Energy Price (Mill/kwhr)[a]	Known Reserves Amount	Areas	Probable Reserves Amount	Areas	Undiscovered Amount	Areas
2.90 - 3.00	1,000	1	5,000	1	10,000	1
3.00 - 4.00	30,000	1-2	400,000	1-4	2,000,000	1-5
4.00 - 5.00	---	-	600,000	1-6	12,000,000[b]	1-7
5.00 - 8.00	---	-	---	-	20,000,000[c]	d
8.00 -12.00	---	-	---	-	40,000,000[c]	d

1/ Taken directly from Kruger, Paul, and Carel Otte, 1973; Geothermal Energy, Resources, Production, Stimulation; Stanford University Press, Stanford, California, 360 pgs.

Areas: 1 - Clear Lake, The Geysers, Ca; 2 - Imperial Valley, Ca; 3 - Jemez area, N.M.; 4 - Long Valley, Ca.; 5 - remainder of Basin and Range area of western U.S.; 6 - Hawaii; 7 - Alaska.

a. In 1972 dollars
b. Hot, dry rock at less than 6.1 km (20,000 ft) depth
c. Hot, dry rock at less than 10.7 km (35,000 ft) depth
d. Development of hot, dry rock energy is assumed over 5 percent of the area of the western third of the U.S. Hot, dry rock systems development is based on hydraulic fracturing or cost-equivalent technology. Present drilling technology is assumed; new, low-cost deep drilling could substantially improve these economics.

* Megawatt-century. . . a megawatt of electrical energy produced for a century.

The model for this system involves drilling into hot rock, fracturing the rock if necessary, and drilling a second well into the fractured area. Then water is circulated down one well, through the hot fractured rock, and pumped from the second well to a generating plant to produce electricity.

Currently, the experimental project at Los Alamos has achieved circulation between the two wells with 92 percent recovery rate. Heat exchangers have been installed and are functioning. This system will be tested for several months to check whether the temperature decreases in the closed circulation system and to see what problems, if any, might be encountered from mineral precipitation.

d. Geopressured Reservoir System

Geopressured reservoirs lie within sedimentary basins which receive continuous accumulations of sediment, such as the Gulf of Mexico. Deep water-bearing sediments are under increasing pressure because of continuous deposition of additional overlying sediments. Although these systems are thought to contain a significant geothermal resource, economic recovery is complicated by depths of more than 3 km (2 mi) and by the presence of methane in the systems. At this time, emphasis is placed on the capture of methane (natural gas) while the separated steam is allowed to vent to the atmosphere, wasting the geothermal resource.

3. Geothermal Lease Status in New Mexico

Leases for geothermal development are currently being granted on Federal, State, and private lands within New Mexico. At present, the U.S. Geological Survey (USGS) has designated nine "Known Geothermal Resource Areas" (KGRA's). These areas are: Baca No. 1, Gila Hot Springs, Kilbourne Hole, Kilbourne Hole Addition, Lightning Dock, Lower Frisco Hot Springs, Radium Springs, San Ysidro, and Socorro Peak. Baca No. 1 and Socorro Peak were designated KGRA's by USGS because of geologic evidence (43 CFR 3200.0-5(k) (1 & 2). The others were designated KGRA's because of competitive interest as defined by the simultaneous filing of lease applications where the lands applied for in two separate applications overlapped each other by half or more (43 CFR 3200.0-5(k)(3)). Each KGRA (leased by competitive bid) along with its buffer zone of marginal interest (noncompetitive) may contain Federal, State, or private lands.

Presently, all but two of these KGRA's have been opened for leasing of the Federal geothermal resources. Lower Frisco Hot Springs and Gila Hot Springs KGRA's are presently closed to Federal leasing. The U.S. Forest Service will soon complete an Environmental Statement on geothermal leasing in these areas and will make a decision to lease the area or to withhold it from leasing.

To date, 29 competitive leases covering 20,480 ha (50,610 ac) and 58 noncompetitive leases on 43,220 ha (106,790 ac) have been let on public lands. In addition, 169 noncompetitive lease applications are still pending in New Mexico on approximately 139,150 ha (343,840 ac) of Federal lands and on State and private lands with minerals reserved to the Federal government.

The State of New Mexico also has issued geothermal leases. The State conducted lease sales in August, 1974 and March, 1975; however, bids were received only for lands within or near indicated thermal anomalies, and these lands were subsequently leased.

The Federal government does not keep records concerning the leasing of geothermal resources on private lands. Although some private holdings have been leased, many landowners are refraining from leasing to see what develops on leased lands adjacent to their property.

4. Legal Provisions for Development

The Geothermal Steam Act of 1970 provides for the orderly development of Federally owned geothermal resources. In 1973, the Department of the Interior completed a four-volume Environmental Statement (ES) for the Geothermal Leasing Program. This document promulgated regulations for leasing. On January 1, 1974, 43 CFR 3200, and 30 CFR 270 and 271 became effective to implement the "Steam Act". Since then, six Geothermal Resource Operation (GRO) Orders have been issued under the "Steam Act". These GRO Orders were formulated by USGS pursuant to 30 CFR 270.11. GRO Order #5 is now being prepared and will be published in the Federal Register when completed and approved. Copies of the "Steam Act" and the GRO Orders are available from most BLM and USGS offices.

5. The Process of Acquiring the Right to Develop and Produce Federal Geothermal Resources

a. Environmental Assessment Record and Technical Examination

When an area is selected for geothermal leasing, the Director of BLM or his authorized representative requests that other interested Federal agencies prepare reports describing known resources in the area and the potential effect of geothermal development on these resources (43 CFR 3200.0-6(a)). BLM then writes an Environmental Assessment Record (43 CFR 3200.0-6(b)) and Technical Examination (43 CFR 23.5), incorporating the information supplied by the other agencies. This EAR/TE is an evaluation of the impacts which could occur during a geothermal development program. If the area is to be leased, special stipulations which are not covered in the lease contract, the Code of Federal Regulations (CFR) or the GRO Orders will be recommended through the EAR/TE.

Geothermal development of an area is divided into pre-lease exploration, leasing, post-lease exploration, development, production, and close-out. A discussion of each phase will follow, explaining the procedures and regulations associated with each phase (Table 2). The sequential steps involved in the exploration and development of geothermal resources are presented in Figure 5.

b. Pre-lease Exploration

Pre-lease exploration is divided into "Casual Use" and "Exploration Operations."

(1) Casual Use

"Casual Use" as defined in 43 CFR 3209.0-5(d) means "activities that involve practices which do not ordinarily lead to any appreciable disturbance or damage to lands, resources, or improvements." The activities do not involve use of heavy equipment or explosives and do not involve vehicular movement except over established roads and trails. Casual use does not require a permit, EAR, or TE. Casual use generally includes the following:

(a) Research

Initial research starts with a literature review. Included along with this is a study of available maps, charts, aerial photographs, and geologic publications of the selected area.

(b) Geological Reconnaissance

Usually one or more persons on foot accomplish this survey using a Brunton compass and maps to obtain and record data. The study consists of obtaining information on structure, stratigraphy, and the distribution of volcanic and hydrothermally altered rock.

(c) Geochemical Survey

This survey is accomplished by sampling springs, surface waters, well waters, and volatiles which are present in the area. Temperature, rate of flow, water migration, and chemical analysis of water and gases can be determined through this survey.

(d) Airborne Survey

Airborne surveys are conducted over the selected area to locate fault structures, surface alteration, and other geological indicators. No surface disturbance occurs during these surveys.

TABLE 2 STAGES OF IMPLEMENTATION, AGENCY RESPONSIBILITIES AND REGULATIONS ASSOCIATED WITH GEOTHERMAL DEVELOPMENT

Stage of Implementation	BLM Responsibilities	USGS Responsibilities	Regulations
Pre-lease Exploration	Environmental Assessment Record and Technical Examination (EAR&TE) Review of Notice of Intent	Input	43 CFR 23.5 Cooperative Agreement 43 CFR 3209
Leasing	Environmental Assessment Record and Technical Examination (EAR&TE)	Input Plan of Exploration	43 CFR 23.5 43 CFR 3200
Post-lease Exploration	Input	Plan of Operation Environmental Analysis (EA) Permit to Drill	43 CFR 3200 30 CFR 270-271 GRO Orders
Development	Input	Plan of Development Plan of Utilization EA Permit to Drill	43 CFR 3200 30 CFR 270-271 GRO Orders
Production	Input Permit for Powerlines, Pipelines, Power Plants and Roads.	Plan of Production Plan of Injection EA Permit to Drill	43 CFR 3200 30 CFR 270-271 GRO Orders
(Certificate of Public Convenience and Necessity from Public Utility Commission of New Mexico to construct power plant)			
Close-out	Input	Input	43 CFR 3200 30 CFR 270-271 GRO Orders

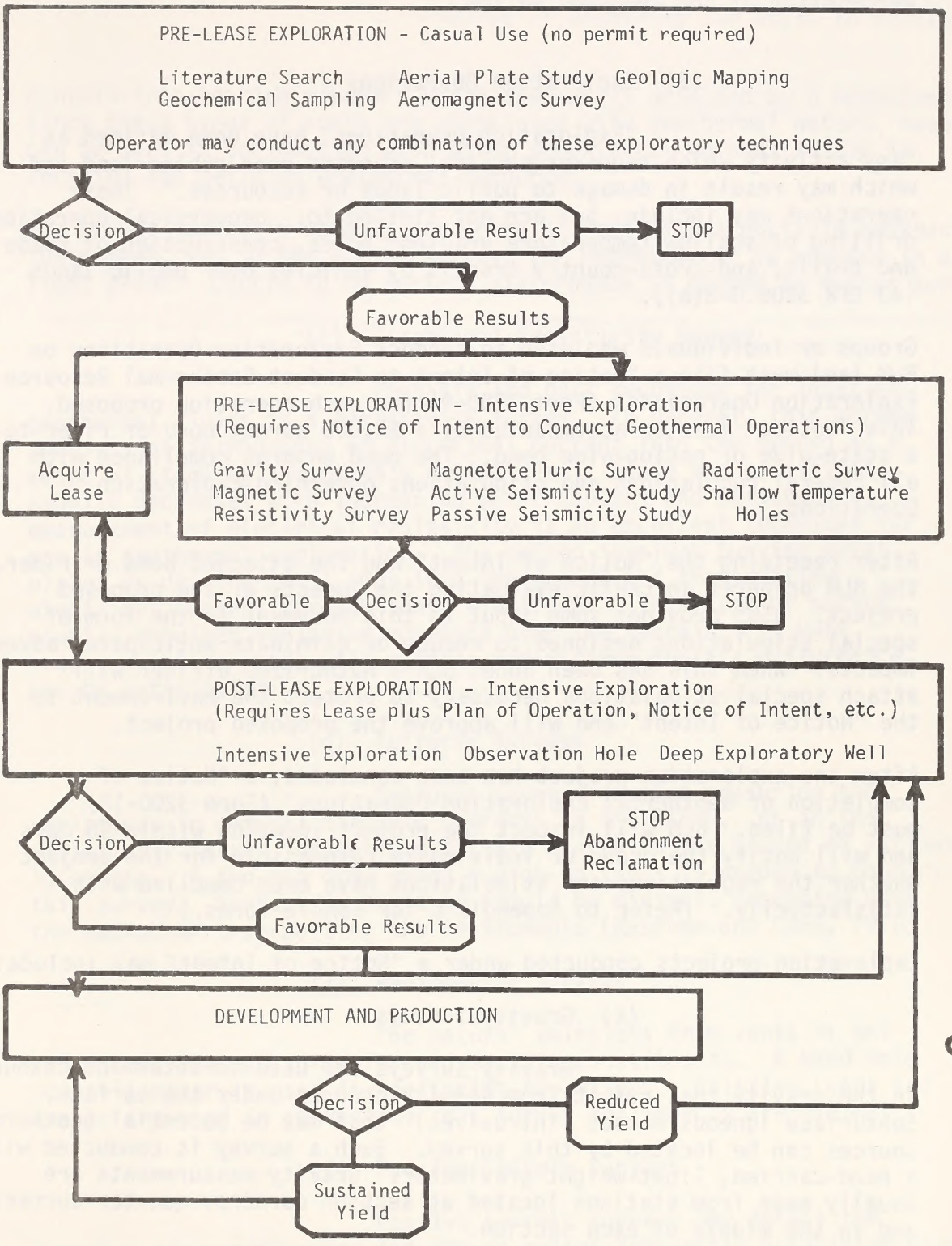


FIGURE 5 TYPICAL EXPLORATION AND DEVELOPMENT SEQUENCE
(Raschen and Cook, 1976)

(2) Exploration Operations

"Exploration Operations" have been defined as "any activity which requires physical presence upon public land and which may result in damage to public lands or resources." These operations may include, but are not limited to: geophysical operations, drilling of shallow temperature gradient holes, construction of roads and trails, and cross-country transit by vehicles over public lands (43 CFR 3209.0-3(a)).

Groups or individuals who wish to conduct Exploration Operations on BLM land must file a "Notice of Intent to Conduct Geothermal Resource Exploration Operations" (Form 3200-9) for each operation proposed. This "Notice" must be accompanied by a $5,000 surety bond or rider to a state-wide or nation-wide bond. The bond ensures compliance with all Federal regulations and stipulations governing Exploration Operations.

After receiving the "Notice of Intent" and the attached bond or rider, the BLM prepares an EAR/TE evaluating the impacts of the proposed project. USGS provides some input to this document in the form of special stipulations designed to reduce or eliminate anticipated adverse impacts. When this has been done, BLM's Authorized Officer will attach special stipulations necessary to protect the environment to the "Notice of Intent" and will approve the proposed project.

After the exploration project has been concluded, a "Notice of Completion of Geothermal Exploration Operations" (Form 3200-10) must be filed. BLM will inspect the project location within 90 days and will notify the group or individuals responsible for the project whether the regulations and stipulations have been complied with satisfactorily. (Refer to Appendix C for sample forms.)

Exploration projects conducted under a "Notice of Intent" may include:

(a) Gravity Surveys

Gravity surveys are used to determine changes in the gravity that result from density changes under the surface. Subsurface igneous masses (intrusives) that may be potential geothermal sources can be located by this survey. Such a survey is conducted with a hand-carried, light-weight gravimeter. Gravity measurements are usually made from stations located at section corners, quarter corners, and in the middle of each section.

(b) Magnetic Surveys

Magnetic surveys are conducted either in the air or on the ground. The survey is used to determine whether anomalous magnetic material exists in the subsurface. Igneous rocks commonly

contain iron-bearing minerals which are easily detected by a magnetometer. Since these types of rocks are associated with geothermal waters, magnetics can be used in conjunction with other geophysical methods to aid in locating and defining geothermal resources.

The ground survey is usually conducted on foot with a portable backpack instrument, and in the aerial survey, the magnetometer is mounted in a light plane. Little to no surface disturbance is caused by either survey.

(c) Electrical Resistivity Survey

Probably the best technique for locating geothermal fluids is a resistivity survey. In general, this survey consists of introducing an electrical current into the ground as a means of studying the earth's resistivity. Since the resistivity usually decreases with increasing water content and temperature, measurement of electrical resistivity is an excellent technique for use in geothermal exploration. The method involves burying metal plates or driving metal rods into the ground and transmitting electrical current through these electrodes. This type of survey usually requires vehicular movement over the terrain. In most areas, existing roads will suffice and minimum surface disturbance can be anticipated.

(d) Telluric Surveys

Telluric surveys involve measuring the variations in natural electric currents in the earth. As in the resistivity survey, potentiometers are placed in the ground at various locations. A two-man crew using a pick-up truck is needed to conduct this survey. Surface disturbance should be minimal, depending upon the method of transporting the instruments (Raschen and Cook, 1976).

(e) Radiometric Surveys

The natural emissions from vents or hot springs may be monitored for radioactive constituents. A hand-held scintillometer is used in monitoring the waters. Existing roads and trails are used in conducting this survey and impacts are minimal.

(f) Passive Seismic Surveys

Passive seismic surveys may detect the numerous microearthquakes and ground noises frequently associated with geothermal areas. Several small geophones are placed in the ground, each connected by cable to recorders about the size of a small suitcase. The geophones pick up seismic events and transfer the information to the recorder. The study can last from two to four weeks. Usually, one to

two men are required to conduct this survey. The sensitivity of the geophones may restrict the use of vehicles which generate extraneous vibrations (Raschen and cook, 1976).

(g) Active Seismic Surveys

Active seismic surveys may be used to obtain information on subsurface geology. Vibroseis* is one of the most popular forms of active seismic surveys because of its minimal adverse effects on the environment (Jiracek, 1974, pers. comm.). This method involves using a truck-mounted vibrator to create seismic waves of controlled frequencies.

Dinoseis*, although not as popular as Vibroseis, is also an efficient method of producing seismic waves. In this technique, an explosion confined within a truck-mounted drum forces a plate against the ground to produce the necessary vibrations. Dinoseis produces about the same minimal surface disturbance as Bivroseis.

Detonation of explosives (shot holes) in drill holes to generate seismic energy is a technique which is not normally used because of the surface disturbance and the lack of frequency control. Weight drop seismics are nearly nonexistent in industry. This technique uses a small, portable, heavy weight attached to a pulley on a truck. When the weight is released, the impact creates seismic vibrations.

(h) Shallow Temperature Gradient Holes

Drill holes involved in exploration to determine geothermal potential of an area can be used to obtain a variety of information. These shallow exploration holes are used mainly for determining temperature gradients, heat flow, lithology, and shallow geologic structures. Geothermal and geological test holes are limited to 152 m (500 ft) unless otherwise authorized under a Pre-lease "Notice of Intent". They are drilled by portable, truck-mounted drills and usually require only a short time to complete. These holes will be periodically visited, using pickup mounted equipment, to gather data.

c. Leasing

The process of leasing Federal geothermal resources is separated into competitive (43 CFR 3200) and noncompetitive (43 CFR 3210) leasing. (Refer to Appendix C for sample lease forms.)

(1) Competitive Leasing

Competitive leases are issued to the highest qualified bidder on designated tracts of land within a KGRA. These

*Trademark

tracts of land are selected by surface and subsurface geological features, drill log data, chemical analysis of water, or by competitive interest in the area.

When a lease sale is to be conducted, notice is published weekly in one or more papers of general circulation for four consecutive weeks. The notice specifies time, place, bidding requirements, land descriptions, royalty, rental terms, and any special stipulations. An application, accompanied by one-half of the bonus bid, is filed pursuant to 43 CFR 3220.5(a-b). The bids are opened and displayed at the time and place previously advertised. Then the lessor has 30 days to accept or reject the bids. When a bidder is successful, he is required to sign three copies of the lease contract, pay the first year's rental, pay the balance of the bonus bid, file the required bond or bonds, and submit a proposed "Plan of Exploration". If these requirements are met in the specified time frame, a geothermal lease contract is issued. Failure to comply with the time allowed will result in rejection of the bid, and money submitted with the bid will be forfeited (43 CFR 3220.6(d-3)). If a bidder is unsuccessful, money tendered with the bonus bid is returned to the applicant with information about the lease sale.

(2) Noncompetitive Leasing

Noncompetitive leases may be issued for any available Federal resources outside of a KGRA, since geothermal potential is supposedly lower in these areas. The entire "Silver City Geothermal Leasing Area" will most likely be leased under noncompetitive leasing regulations because it is not within a defined KGRA. Limitations concerning available lands are described in 43 CFR 3201.1-2--5; however, certain lands are, or may be, withheld from leasing (43 CFR 3201.1-6).

A noncompetitive lease is acquired in a manner similar to a competitive lease. An application, bond(s), an application fee, and a proposed "Plan of Exploration" are sent to the proper BLM office (43 CFR 3210.2-1(a-3)) No bonus bids are required on noncompetitive geothermal leases. When the application is approved, three copies of the lease contract are sent to the applicant. The applicant must sign the lease contract and return them with the first year's rent (43 CFR 3205.3-5).

(3) Lease Terms

The "Plan of Exploration" is required by Federal regulations. This plan describes briefly the activities that will be conducted on the lands described in the application.

The "Geothermal Resource Lease Contract" (Form 3200-21) allows the Federal government to lease geothermal resources and at the same time provides protection for other natural resources. Provisions within the contract require protection of the natural environment, prehistoric and historic resources. etc., in compliance with Federal regulations (43 CFR 3000 and 3200, and 30 CFR 270 and 271, GRO Orders, and written and oral orders of the Geothermal Supervisor). In addition, special stipulations needed to protect unique values of a particular area may be incorporated into the lease contract and compliance becomes mandatory.

d. Post-lease Exploration

After a lease is issued, Federal regulations under 30 CFR 270.34 and 43 CFR 3206.6 require that a "Plan of Operation" be filed and approved by the land management agency and the USGS before any activity other than "casual use" may begin. The "Plan", accompanied by maps, will describe all exploration activities that will be conducted on the leased lands. USGS, the lead agency, studies the "Plan" and sends copies to the surface managing agency and other interested agencies for comments.

The USGS must prepare an Environmental Analysis (EA) covering the specific site of the "Plan of Operation." A discussion of the proposed exploration, such as gravity, resistivity, and temperature gradient surveys, may be included in the "Plan." Generally, the proposal is to drill one or more exploratory wells. An on-site inspection with representatives of the lessee, USGS, and the land management agency is then conducted to assess the potential impacts of the proposed operation. After considering the effects upon the environment and developing the special conditions or stipulations deemed necessary to protect the environment, the Area Geothermal Supervisor and the appropriate land management agency jointly approve the "Plan of Operation."

If the activity is to take place in a new geologic or geographic area, the "Plan" and the draft EA are subject to review by the Geothermal Environmental Advisory Panel (GEAP). The GEAP then advises the Supervisor on environmental aspects of the "Plan" and recommends mitigating measures to protect the environment. After these recommendations are obtained from the GEAP, the EA is completed. The Supervisor or the Authorized Officer also may request this review.

Upon approval of the lessee's application for a "Permit to Drill" (Form 9-331C), a permit which includes GRO Order No. 2 and any special stipulations is issued. Then the lessee may commence the operations authorized under the approved "Plan of Operations." The lessee's authorized operations are continuously monitored and inspected by the Area Geothermal Supervisor to ensure that the

lessee complies with the applicable regulations and stipulations. Any additional exploratory operation proposed by the lessee requires an additional "Plan of Operation" pursuant to 30 CFR 270.34, resulting in a procedure essentially the same as the preceding steps.

Pre-lease exploration methods have been defined previously; however, post-lease exploration uses many of these methods on a more intensive basis. For example, exploratory drilling methods, geological information holes and deep exploration wells requiring depths of more than 152 m (500 ft) may be used.

(1) Geological Information Holes

These holes are similar to those drilled for temperature gradient purposes. Larger equipment may be employed. Other than access, the maximum surface area that should be disturbed at the drilling site is 23 m x 31 m (75 ft x 100 ft). Drill cuttings are examined and the hole is probed with geophysical instruments to acquire data on rock types, structure and reservoir conditions. Because these holes can extend to 610 m (2,000 ft) or more, a large mud pit may be necessary. Typically, a mud pit is scooped out with a bulldozer to a depth of 1 to 2 m (3 to 6 ft), a length of 9 to 15 m (30 to 50 ft), and a width of 3 to 6 m (10 to 20 ft). The pit dimensions are dependent upon the terrain and the depth of the hole (volume of mud and cuttings). Drilling an information hole takes from several days to weeks, depending on depth and hardness of the subsurface strata.

(2) Exploration Wells

Once the probable location of the resource is determined, an exploration well is drilled. If a reservoir is discovered, a series of tests are performed to determine temperatures, flow rates, and chemical content of the fluid. The purpose of these tests is to ascertain the potential of the well's productivity. The testing also provides an insight into possible production problems. Noxious gases, such as ammonia, carbon monoxide, hydrogen sulfide, etc., can be toxic if present in sufficient quantities. The steam and water may also contain other minerals which would precipitate at reduced pressures and temperatures.

In drilling an exploratory well, the hole may be bored up to 61 cm (24 in) in diameter and to depths of 1,525 to 3,050 m (5,000 to 10,000 ft). Mud is used where water flows are encountered; otherwise, compressed air is used as a circulation medium. Noise levels are intense during drilling and can approximate those produced by an unmuffled diesel truck.

A drill pad .4 to .8 ha (1 to 2 ac) is cleared of vegetation and leveled. A reserve pit of 93 to 930 sq m (1,000 to 10,000 sq ft) and 1.8 to 2.4 m (6 to 8 ft) deep is dug to contain waste fluid and cuttings during drilling operations.

The well is cased and cemented, and a blow out preventer is installed to control sudden surges of pressure. Blow outs are uncommon, but may occur due to a lack of knowledge of the characteristics of a specific geothermal field. When a blow out does occur, water, steam, and other gases are wasted and spread to the surrounding environs until controlled. Blow outs cause no fire hazard and are usually controlled by slant drilling and then sealed with concrete.

During testing and venting, steam, fluids, and gases are produced at the surface and proper precautions are necessary to prevent surface pollution. The odor of hydrogen sulfide is often present at this point of exploration.

After the testing is completed, the drilling rig is removed, a "Christmas tree" (series of valves) is attached to the casing head, and the disturbed area is rehabilitated. If the well is abandoned, it must be plugged and the area rehabilitated according to GRO Order No. 3. All drilling operations must comply with GRO Orders No. 2 and 4.

e. Development

Once a successful exploratory well is drilled, plans are made to develop the geothermal resource. A new plan, called a "Plan of Development," must be filed pursuant to the requirements of 30 CFR 270.34 and .35. No development operations may begin until the "Plan" is approved by USGS and the appropriate land managing agency. Another EA covering the activites described in the "Plan of Development" is prepared by USGS. The GEAP again recommends mitigating measures for protection of the environment, which may result in additional stipulations imposed upon the lessee. The lessee may then commence the development operations authorized by the "Plan of Development."

Six discrete operations, as they relate to surface disturbance, are recognized. Many of these operations will normally be taking place concurrently.

(1) Road Development

During development, roads to drill sites, to power plant sites, and along transmission lines may be constructed. Roads to producing wells and power plants are usually permanent and

may be surfaced and stabilized. Culverts may be used to avoid erosion of the road beds. Temporary roads to drill sites or along powerlines will probably be built to lower standards.

(2) Drill Site Development

The information obtained during the exploratory phase is very helpful in planning field development and well locations. Additional geophysical work may be conducted in order to gain more detailed information. Development wells are drilled and completed in basically the same manner as the exploratory wells, and require the same considerations.

During this stage of development, somewhat larger equipment often may be used. Drill sites require a pad directly surrounding the well head, approximately 9 x 9 m (30 x 30 ft), which is leveled and cleared of vegetation. Generally, less than .4 to .8 ha (1 to 2 ac) is disturbed. A reserve pit (sump) 93 to 930 sq m (1,000 to 10,000 sq ft) and 1.8 to 2.4 m (6 to 8 ft) deep is dug to contain waste fluids. The sump can be fenced while in use to keep animals out. After the well is drilled, the reserve pit is generally dried out, covered with dirt, and graded. The pit and the remaining area of the drill site is rehabilitated and revegetated.

The number of development wells drilled in an area will depend on a number of factors, including the type of geothermal resource (steam or hot water), temperature, capacity of the wells, and reservoir conditions.

Since the development phase is the critical time from the standpoint of environmental impacts and surface disturbance, the program may be modified as new data becomes available. For instance, if the development wells are drilled with 4 ha (10 ac) spacing, rather than 8 ha (20 ac) spacing, the surface disturbance will be greater. There will be more service roads, pipelines, surface facilities, and general activity. However, if the wells are slant drilled (directionally drilled) from central locations, the impacts will be significantly less. The capability of a company to conduct slant drilling depends on economical, technical, and geological considerations. The variability of these factors from area to area may make slant drilling impractical.

At Cerro Prieto, 18 wells (3 are standby) service a 75 MW generating plant. They were drilled with 4 ha (10 ac) spacing (1 well per 4 ha). A 16 ha (40 ac) well spacing is being used at The Geysers, but future drilling with 8 ha (20 ac) spacing is planned in order to maintain steam production to plant capacity.

(3) Production Testing

To determine the sustained flow characteristics of a well, and to clean out the hole, each new well is vented to the atmosphere for a period of time. Steam, water, and noise accompany production testing. The water is generally directed into the reserve pit, while the steam is released into the atmosphere. Noncondensible/ noxious gases and vapors are often contained in the steam. These vapors and gases generally make up less than 3 percent of the total steam. When present in excessive amounts, some of these gases and vapors are toxic.

Where any of these gases or vapors are present in unacceptable amounts, monitoring devices and special precautions will be necessary as safety measures. Additionally, very small amounts of hydrogen sulfide, as small as 0.025 parts per million (ppm) can be detected by smell ("rotten egg" odor).

High noise levels accompany production testing. Because of this, muffling devices are usually installed. At The Geysers, measurements of noise from a muffled testing well indicated a noise level slightly less than that of an unmuffled diesel truck. Noise levels from other geothermal fields, both vapor-dominated and water-dominated, may not be of similar magnitude.

Blow outs have occurred in 1 to 3 percent of the wells drilled in four commercially developed geothermal areas throughout the world; The Geysers, California (USA), Larderello (Italy), Wairakei (New Zealand), and Cerro Prieto (Mexico). These blow outs occurred mostly during the exploratory, or early stages of development drilling with fewer occurring in later stages as experience was gained and local drilling techniques were perfected. Although some of these blow outs were temporarily spectacular, none resulted in any significant or lasting environmental damage.

(4) Geothermal Pipelines

Pipelines 25 to 76 cm (10 to 30 in) in diameter will be used to transmit steam or hot water from the production wells to the power plants. The pipelines are typically insulated with fiberglass or asbestos to minimize heat loss. Expansion loops or joints are placed at frequent intervals, either vertically or horizontally, to provide for the extreme expansion and contraction of the pipes after production start up (heating up) and shut down (cooling down). Under present technology, pipelines are constructed above ground to provide for expansion and contraction and to allow for easier maintenance and detection of leaks. The lines form a radiating pattern on the

surface, connecting wells with the power plant. They may be painted to blend with the surroundings, and any disturbed areas not needed for access may be revegetated. This arrangement has been used in commercial fields with essentially no loss of land productivity. So far, underground installation is not economically feasible and it may, also, present some safety hazards. (Refer to Figure 6.)

(5) Plant Construction

A "Plan of Utilization" must be filed with USGS prior to starting plant construction. Generating plants are centrally located to minimize the length of the steam lines or water pipes from the servicing wells. The largest plants in current use consist of two 55 MW generators housed together so that production is 110 MW per power plant. Power plant spacing is about one plant per 259 ha (1 sq mi) throughout the productive area. At The Geysers, the average 110 MW plant building is about 30 x 60 m (100 x 200 ft) and three stories high. The adjacent cooling towers are about one-third larger than the generating plant building. The entire generating plant - cooling tower complex occupies an area of about 2 ha (5 ac).

Areas disturbed by construction of the generating plant and cooling towers will be rehabilitated and revegetated. The buildings may be painted to blend with the surroundings. Some cooling towers are architecturally attractive and may be intentionally painted to contrast with the surroundings to heighten the visual experience.

(6) Transmission Lines

Power generated by the plant is transmitted via conventional powerlines to the area of use. The size and location of the lines is dependent upon the power output and destination. The lines will tend to be large since 1 MW of plant capacity can service the power needs of about 1,000 people. To express this another way, one 110 MW power plant can supply the needs of the City of Reno, Nevada.

Rehabilitation will be possible on disturbed areas not needed for continued production, and should be commensurate with the terrain, climate, and significance of the damage.

f. Production

A number of procedures must be followed before production begins within a geothermal field. Prior to placing the subject wells on prolonged production, the lessee, pursuant to 30 CFR 270.34(k), must collect data concerning existing air and water quality, noise, seismic and land subsidence activities, and the ecosystem of the leased lands for at least one year prior to the submission of a

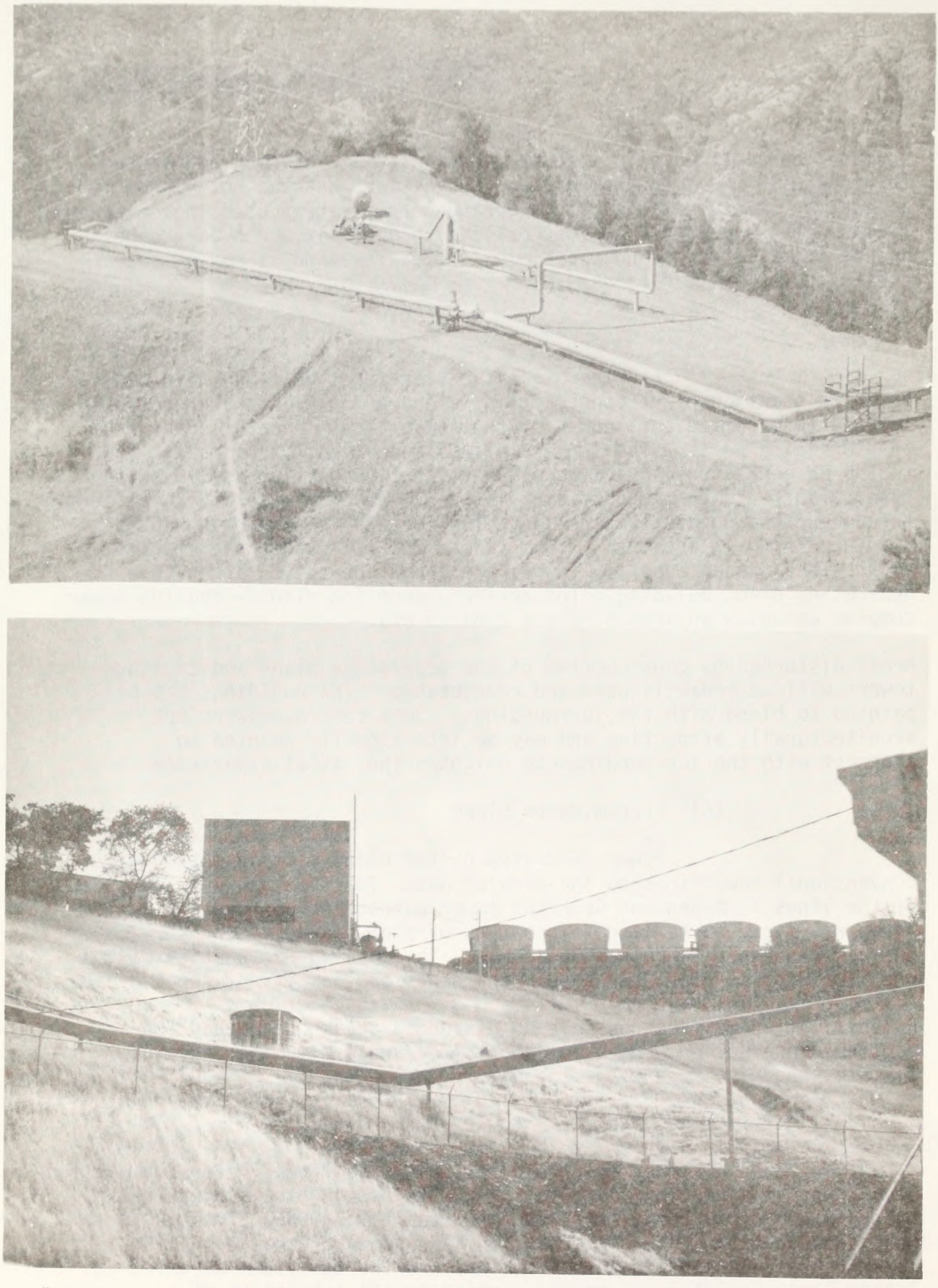


FIGURE 6 GEOTHERMAL FIELD DEVELOPMENT - THE GEYSERS, CALIFORNIA

Steam or hot water from the well (top photo) is transmitted through pipelines to the power plant (bottom photo)

"Plan of Production." Additionally, the lessee, pursuant to 30 CFR 270.76, must submit an annual report of compliance with environmental protection requirements, giving a full account of the actions taken. The use of the leased lands, or other Federal lands, for geothermal production will be authorized only under a separate permit issued by the appropriate agency (43 CFR 3200.0-8(a)).

An EAR is a prerequisite to the issuance of a permit for the use of the leased lands or other Federal lands for a power generation plant, pipeline, transmission line, or other facility. Granting of a permit pursuant to 43 CFR 3200.0-8(a) is not a license to construct a power generation plant. The construction, operation, and maintenance of a power generation plant can only be accomplished by obtaining a "Certificate of Public Convenience and Necessity." This certificate is granted by the Public Utilities Commission of the state having jurisdiction and regulatory authority over the company making application.

The Production phase begins when a generating plant has reached commercial power production capacity. Exploration and development normally continue in parts of the geothermal field which have not yet reached commercial production capacity. The Production stage can be divided into the following discrete operations:

(1) New Drill Sites

Geothermal fields may be long-lived resources. The Larderello Field has been in production since 1904, and The Geysers since 1958. The Geysers is estimated to have a minimum productive life of 30 years or more. Nonetheless, production slowly diminishes the heat flow, and additional wells must be drilled and completed to keep the generating plant operating at full capacity.

Additional wells may be required to replace production wells that have become inoperative. If the waste waters are disposed of by injection, injection wells also may be drilled, or the old, inoperative wells may be utilized for this purpose. The drilling techniques and environmental effects will be the same as for development wells. On a major producing field, it can be expected that one or two drilling rigs will be operating continuously throughout the life of the field.

(2) Maintenance

Repair, maintenance, and monitoring of an operating field will require the periodic use of access roads to service the equipment. Existing wells will require occasional repair work or cleaning. The amount of this remedial work needed will depend upon

the production characteristics of the field; for example, severe scaling and corrosion will make frequent remedial work necessary. Normally, one medium-sized drill rig will be required full time for each 20 to 30 wells (one 110 MW power plant).

(3) Waste Disposal

The most significant waste disposal problem relates to handling the excess geothermal fluids. In vapor-dominated systems, as at The Geysers, about 75 to 80 percent of the water from the spent steam is consumed in the cooling towers, leaving 20 to 25 percent for disposal. In water dominated systems, such as Cerro Prieto, the reverse is true, with 80 percent or more of the total well production requiring disposal. Solid wastes will be disposed of in a dump developed at the site or trucked to the nearest established dump site. Disposal techniques vary depending on the quality and quantities involved. One or more of the following techniques may be employed:

(a) Evaporation Ponds

Waste water at Cerro Prieto is piped to evaporation ponds. Where water quality is satisfactory, such ponds may provide new aquatic habitat. Where water quality is toxic, special measures may be required to protect the groundwater supply, livestock, and wildlife.

(b) Natural Drainage Systems

At Wairaikei, New Zealand, waste water is discharged into a large river. Disposal of high quality water in this manner provides additional resources for agriculture, wildlife and other uses. Low quality water may require extensive treatment before it is suitable for release into natural drainages.

(c) By-product Development

In some instances, it may be economical to extract useful minerals or gases from the geothermal fluids. This could increase the quality of the waste water enough to make it usable for other purposes. Desalinization may be feasible in some areas, providing additional fresh water for other uses.

(d) Injection

At The Geysers, excess water is injected into nonproductive zones of the geothermal field. Successful injection is dependent on the quality of the waste water and the geological

characteristics of the geothermal field. Items to be typically considered in a "Plan of Injection" submitted to USGS can include: whether plugging and scaling problems will prevent the reservoir from accepting the fluid; whether fresh water aquifers can be adequately protected from contamination by hot saline waste water; and whether the subsurface rock structure will adequately hold the injected fluids.

g. Generation of Electricity

Production from a geothermal field will generally require two to five people per plant to inspect, adjust, and service the wells, pipelines, cooling towers, turbines, etc. Their inspections might involve making the rounds about once each day on the existing road network.

The life of an average geothermal field is impossible to estimate at this time because Production information is very limited. Only two fields have been subjected to high rates of drawoff for periods measurable in decades: the Wairakei Field in New Zealand, and the Larderello Field in Italy. At the Wairaikei Field, aquifer pressures declined during the first few years (1957-1964) of Production, and at the same time there was appreciable ground subsidence. By 1970, the ground subsidence and pressure drop had diminished greatly, and by 1973, there was no further net loss of mass from the aquifer. Apparently, the drawoff is being replaced by natural recharge. The production wells in Wairakei are relatively shallow in depth, approximately 1040 m (3,400 ft), and the excess hot water is not being returned to the geothermal reservoir. During the Production period, the water temperature dropped, apparently due to lower pressure; however, there was no marked fall in the enthalpy of hot fluid produced from the wells. Other effects of production on the general area have been complete cessation of hot spring and geyser activity in the Wairakei Valley, and an increase in the size and number of fumaroles in a natural steam area 5 km (3 mi) away. At Larderello, Italy, studies over the last few years indicate that average source steam temperatures have increased between 30^{o} and 40^{o} C (86^{o} and 104^{o} F), while pressures have stabilized after an initial falling period (Kruger and Otte, 1973).

h. Other Uses

There are many possible uses for geothermal energy other than for power generation. Although this seems to be the primary concern of industry and government, many of the discovered reservoirs will not have high enough temperatures to be used for this purpose with present technology. However, lower temperature reservoirs may be used in a variety of ways, such as: space heating, product processing and canning, agricultural heating, mineral recovery, air conditioning, desalinization, sugar processing, fermentation

processes, freeze-drying of food, production of heavy water, mineral extraction from brines, production of alumina from bauxite, gasification of coal, carbonaceous textile processing, and production of ethyl alcohol, butanol acetone, and citric acid (refer to Tables 3, 4, and 5).

A fair portion of the assessment area is presently under cultivation. Geothermal resources may provide substantial support for agricultural industries. Desalinated water may be used to irrigate additional acreage. Hothouses and greenhouses may be constructed to enhance food production by increasing the annual growing season to 365 days.

Geothermal energy can also be used in the processing of the various crops. Food processing industries require steam at 140° C (285° F). These industries may benefit from geothermal development.

Farmers have used natural gas or propane for crop drying; however, escalating fuel costs are causing financial problems. Geothermal steam or hot water heat may be used as a more economical source of energy for crop drying (Raschen and Cook, 1976).

Water from geothermal reservoirs may be used for freeze-drying operatings, using standard ammonia absorption refrigeration methods to freeze-dry coffee, tomatoes, onions, or other vegetables (Raschen and Cook, 1976).

Mimbres Hot Springs and Faywood Hot Springs are locally known for naturally occurring hot water used for mineralized baths. The temperatures of these hot spring vary from approximately 43° C to 60° C (110° F to 140° F). Both of these hot springs are located on private lands and neither has been commercially developed.

i. Close Out

The exhausted production wells may be revitalized before they are abandoned. If these wells are strategically located, fluids injected into the reservoir through the exhausted wells may lengthen the life of the remaining field. If the wells are shut in, tests may reveal that the bottom hole temperatures and fluids have recharged after a period of time. If exhausted, a sizeable geothermal field could be gradually abandoned; an abrupt cessation of operations might be more likely in a smaller field.

Close Out, or abandonment, of all or part of a geothermal field will take place in three phases: (1) abandonment of the subsurface; (2) removal of the surface installations; and (3) rehabilitation of the surface (30 CFR 270.45, 43 CFR 3204.1(1), and GRO Order No. 4).

TABLE 3 TEMPERATURES REQUIRED FOR VARIOUS GEOTHERMAL APPLICATIONS

TEMP. °C	APPLICATION	
200		
190		Temperatue range of conventional power production
	Evaporation of Highly Concentrated Solutions	
180	Refrigeration by Ammonia Absorption	
	Digestion in Paper Pulp	
170	Heavy Water via H_2S Processing	
	Drying of Diatomaceous Earth	
160	Drying of Fish Meal	
	Drying of Timber	
150	Alumina Via Bayers Process	
		Present expected temperature range for binary power plants
140	Drying Farm Products at High Rates	
	Canning of Food	
130	Evaporation in Sugar Refining	
	Extraction of Salts by Evaporation and Crystallization	
120	Fresh Water by Distillation. Most Multiple Effect Evaporations,	
	Concentration of Saline Solutions. Refrigeration by Medium	
110	Temperatures	
	Drying and Curing of Light Aggregate Cement Slabs	
100	Drying of Organic Materials, Seaweeds, Grass, Vegetables, etc.	
	Washing and Drying of Wool	
90	Drying of Stock Fish	
	De-Icing Operations	
80	Space Heating	
	Greenhouses by Space Heating	
70	Pasteurization (harmful bacteria killed at 74.4°C or 166° F)	
	Refrigeration by Low Temperatures	
60	Animal Husbandry	
	Greenhouses by Combined Space and Hotbed Heating	
50	Mushroom Growing	
	Balneological Baths	
40	Soil Warming	
30	Swimming Pools, Biodegrading, Fermenting	
	Warm Water for Year-around Mining in Cold Climates. De-Icing	
20	Hatching of Fish. Fish Farming.	

Saturated Steam

Water

1/ Source: Raschen, Rory, and William S. Cook, 1976 Exploration and Development of Geothermal Resources, Conservation Division, Office of the Area Geothermal Supervisor, US Geological Survey, Menlo Park, California. 29 pages and 14 plates

TABLE 4 APPLICATIONS OF GEOTHERMAL ENERGY IN THE UNITED STATES 1/

Application	Location				
	Alaska	California	Idaho	Nevada	Oregon
Present Applications					
Swimming pools	x		x		
Bath houses	x				
Greenhouses	x	x	x	x	x
Space heating	x	x	x	x	x
Power generation		x			
Heating water for domestic use		x	x	x	x
Spas and recreation		x		x	
Lumber mill drying kilns		x			
Fish propagation			x		
Irrigation			x		
Animal husbandry			x		
Forest campgrounds			x		
Safe heat source for processing explosives				x	
Pasteurization					x
Industrial cleaning					x
Refrigeration					x
Coils under pavement to prevent accumulation of ice and snow					x
Tree seedling nurseries					x

1/ Source: Raschen, Rory and William S. Cook, 1976, Exploration and Development of Geothermal Resources, Conservation Division, Office of the Area Geothermal Supervisor, U.S. Geological Survey, Menlo Park, California,29 pages and 14 plates.

TABLE 5 APPLICATIONS OF GEOTHERMAL ENERGY

OUTSIDE OF THE UNITED STATES 1/

Hungary

1. Greenhouses
2. Animal Husbandry
3. Space Heating
4. Crop Drying

Iceland

1. Space heating on a large scale (40% of population)
2. Hot houses for flowers and vegetables
3. Industrial utilization
4. Power generation
5. Drying of seaweeds
6. Curing cement building slabs
7. Mining of diatomaceous earth
8. Fish breeding (Salmon)

Italy

1. Power generation
2. Chemical production
3. Ore Processing

Japan

1. Space heating
2. Melting road snow
3. Sewage heat treating
4. Livestock barn heating
5. Egg hatching and poultry
6. Power generation
7. Tropical animal breeding
8. Tropical and food fish breeding, eels
9. Greenhouses
10. Sapling growing
11. Soil disinfecting
12. Heating irrigation water
13. Cooking
14. Bathing
15. Heating swimming pools and fire fighting water
16. Salt making or desalting sea water
17. Tropical

Japan (Continued)

18. Food drying
19. Mineral water and medicinal use
20. Rice processing
21. Extraction of gases
22. Production of sulfuric acid
23. Brewing and Distillation
24. Raising alligators and crocodiles
25. Sinter extraction (alum)

Mexico

1. Power generation

New Zealand

1. Process heat for newsprint, pump and lumber mills
2. Space heating
3. Power generation
4. Space cooling by lithium bromide absorption unit powered with geothermal heat
5. Biodegradation of wastes from pigsties
6. Washing and drying of wool
7. Soil and bulb sterilization
8. Tree seedling nurseries
9. Cooking and sterilizing garbage feed
10. Alfalfa drying

USSR

1. Domestic hot water
2. Space heating
3. Greenhouses
4. Soil Heating (permafrost)
5. Industrial Uses
6. Mining uses
7. Dairy farming
8. Power generation (experimental)
9. Iodine recovery

1/ Ibid.

The method of abandonment of equipment in the wells will depend on several factors including the condition, age, method of installation, and type of equipment. The well must be properly plugged to protect the subsurface fresh water zones. Cement plugs are usually set at various levels, the casing is cut off below the ground surface, and a steel cap is welded over the top of the casing. A marker of the well's location may also be installed. The plugging and abandonment of geothermal wells must be accomplished in accordance with GRO Order #3.

Removal of the surface installations, such as buildings, roads, foundations, and equipment, will be accomplished over a period of time. Many of the installations may be used at other locations, or may have salvage value.

Rehabilitation of the field area will probably take considerable time, depending on the topography and the size of the developed area. The obliteration of access roads will be difficult to accomplish, particularly where there are cuts and fills in rough terrain. Pits and sumps will be filled, steep areas will be sloped and contoured, and all disturbed areas will be revegetated, if feasible.

6. Economic Nature of the Proposed Action and Economic Demand Analysis

Leasing of the area in this study will allow interested companies to investigate the geothermal potential of the area more thoroughly than they have been able to do on a pre-lease basis. Each interested company will decide how much time and money it wishes to invest in the area at each stage of implementation. Consequently, the economic scale of activity which may take place at any one stage of a geothermal program is uncertain.

The BLM can make a few general statements about the basic nature of the activities which might take place in the earliest stages of implementation. Pre-lease exploration has already taken place in the area to some extent. Operations at this stage usually consist of a few people visiting the area for a short time. These people might be expected to spend money in hotels, restaurants, stores, bars, etc. The amount of money added to the local economy in this way will vary depending on the intensity of exploration. Post-lease exploration will similarly consist of a few people entering the area temporarily. People conducting post-lease exploratory operations might be expected to stay in the area somewhat longer than during pre-lease activity. Each will add an undetermined amount of money to the economy, primarily for services and supplies.

At any stage of operations, a company may decide to continue or to abandon its efforts. Figure 5 shows a typical exploration and development sequence, including points at which a company might discontinue or abandon its efforts. If a geothermal field is ultimately developed in the proposed leasing area, the local economy will benefit from still more incidental expenditures and from capital investments.

It should be remembered that the Federal government does not make the decision to develop a geothermal field; interested businesses make the decision and provide the capital. The scale of development activities will probably depend on how profitable development of the field promises to be. Since uses chosen for a geothermal resource may vary depending on the quality of that resource, it is not possible to discuss even the basic economic nature of the development or production stages of implementation.

a. Present and Anticipated Demands

In recent years, the national demand for all forms of energy has been high. Regional demand for power in the southwest has been increasing rapidly as evidenced by the recent construction of conventional power plants in Arizona, Texas, and New Mexico. The transfer of industry to the southwest and the region's continued population growth both suggest that the regional demand for power of all kinds will continue to rise in the future.

Although the demand for power continues to rise, fuels traditionally used to generate that power are being depleted rapidly. Recent petroleum shortages have promoted general recognition of the limited and irreplaceable nature of our traditional fuels. As a result, efforts to develop alternate, economically feasible sources of power have increased.

The use of geothermal energy may provide one alternative to traditional power generation. Geothermal energy can be converted to electricity for regional use or used directly for its heat in the area of origination. Any practical application of geothermal energy will help meet the demands for power and reduce the strain on our traditional power sources.

b. Geographic Distribution of Demand

The demand for energy is nation-wide, but distribution of geothermal energy in most forms is limited by geological occurrence of the resource. Electricity is the only form in which geothermal energy may be economically distributed from its area of origin. Consequently, distribution of geothermally produced electricity might be expected throughout the southwest, while other uses will be confined to the locale near the origin.

c. Economic Feasibility of Extraction

The potential worth of any one geothermal well can vary greatly. For example: steam which can produce 1.4 kg cm^2 (20 lbs/in^2) of pressure per hour is capable of generating one kilowatt (kw) of electricity worth about 3.5 mills on today's market. A geothermal well which produces 265° C (510° F) steam is capable of providing 92,720 kg (200,000 lb) of steam per hour, or 10,000 kw of electricity. This quantity of electricity is worth 10,000 times $0.0035, or $35.00 per hour. During the course of a year, continuous operation could generate electricity worth $306,600. On the other hand, many wells may cost more to develop than their resource is worth.

Extensive exploration will allow energy-related industries to evaluate the potential of a geothermal field. The economic feasibility of development and production of New Mexico fields may be determined as a result of extensive exploration and evaluation by interested industries.

d. Alternate Sources

Alternate sources of power include coal, petroleum, natural gas, nuclear energy, solar energy, and wind. Use of coal, petroleum, and natural gas is limited by finite reserves and the nonrenewable nature of these resources. The comparative costs, advantages and disadvantages of the alternatives remaining are beyond the scope of this document.

e. Transportation Networks

Current energy transportation networks handle adequately the energy produced in the area today. The production of geothermal energy will require construction of additional transportation facilities including transmission lines, pipelines, and service roads.

II. DESCRIPTION OF THE EXISTING ENVIRONMENT

A. Nonliving Components[1]

1. Air

a. Air Movement Patterns

Generally, winds blow from the west during the winter and from the southeast during the remainder of the year. The winter winds, usually associated with cold fronts, are generally light and occasionally yield snow. Wind speeds are normally less than 16 kph (10 mph). The greatest yearly movement of air occurs during the late winter and spring when winds change direction and prevail from the southeast. During this period, high, gusty winds cause severe dust storms with gales up to 80 kph (50 mph). The prevailing summer and fall winds, originating from the Gulf of Mexico, are usually light and variable. From July through September, about half of the average annual precipitation falls. It takes the form of brief, intense thunderstorms preceded by moderately high, gusty winds and dust devils. (Maker, et al., 1970; Maker, et al., 1971; Maker et al., 1971; Maker, et al., 1972)

b. Temperature and Humidity

The mean annual temperature varies from 13.8° C (55° F) to 15.5° C (60° F) in areas below 1800 m (6,000 ft). Some places in the assessment area have had extreme highs of more than 38° C (100° F) during the summer and lows of less than -23° C (-10° F) during the winter. The average frost-free season is more than 200 days at lower elevations. About 3,600 hours of sunshine occur annually (ibid).

Relative humidity is 45 to 55 percent throughout the year. The annual evaporation rate (as based on the evaporation pan method) varies from approximately 227 cm to 254 cm (90 to 100 in). The evaporation rate can be as much as ten times the precipitation rate (ibid).

c. Particulate Matter

Most of the particulate matter suspended over the assessment area is caused by gusty winds acting on sparsely vegetated areas, unpaved roads, and land bared for agricultural or construction purposes. The highest seasonal concentration of this matter occurs during the spring months and the lowest concentrations occur during the rainy summer season. Smoke and dust from mining, milling and

1 The material presented in this section has been generalized to afford a regional picture of the climate in the assessment area. Reference: Maker, et al, 1970/1971/1971/1972.

smelting operations in the assessment area may add to the total suspended particulate matter; but this condition is temporary and usually confined to lower elevations (ibid).

d. Noxious/Noncondensible Gases

Carbon monoxide, hydrocarbons, carbon dioxide, hydrogen sulfide, nitrogen oxides, and sulfur oxides are present in minute quantities throughout the proposed lease area. Major sources of these gases are: agricultural machinery, mining, milling, and smelting operations, and vehicle exhausts. Concentration of these gases depends upon wind speed and direction as well as air temperatures. Local concentrations over urban and industrial areas may temporarily exceed National Ambient Air Quality Standards (ibid).

e. Radiological Contaminants

No man-caused sources of radiological contaminants which might degrade air quality are believed to exist within the assessment area.

f. Nonionizing Radiation

Nonionizing radiation is man-made electromagnetic energy created by radio transmitters and high voltage power transmission lines. These sources of nonionizing radiation do exist in the assessment area; however, no problems in air quality are known to exist at the present time.

2. Land

a. Soils

Twenty-four different soil associations have been defined on the lands within the assessment area (ibid). Information pertaining to soil characteristics and qualities of major soils in each soil association, engineering soil groups, estimated soil properties, and interpretation of soil properties for engineering uses is available in the cited publications. The locations of the 24 soils associations are shown in Figure 7.

(1) Mimbres-Verhalen Association

This association occupies the nearly level to very gently sloping valley bottoms and basin floors. The soils, which are moderately fine and fine-textured, are developing in alluvial sediments of mixed origin. These areas are used for farming and grazing.

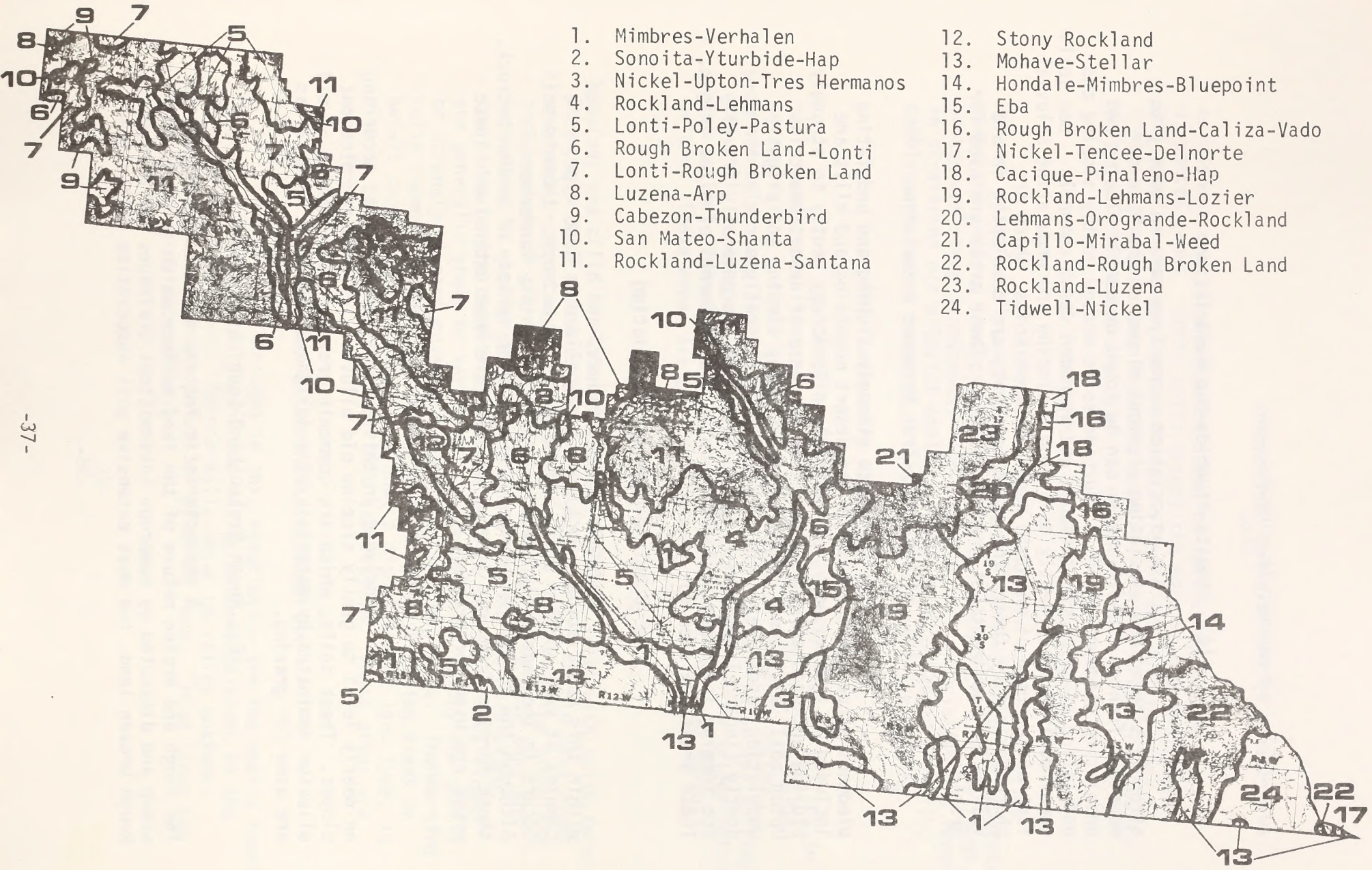


FIGURE 7 SOIL ASSOCIATIONS 1/

1/ Maker, et al., 1970; Maker et al., 1971(2); Maker, et al., 1972.

(2) Sonoita-Yturbide-Hap Association

This association commonly occurs on gently to strongly sloping and undulating piedmont slopes at the base of mountain fronts. Sonoita soils can be found on gently sloping and undulating piedmont slopes. Yturbide soils occupy gently sloping and undulating alluvial fan surfaces and aggraded steam channels. Hap soils occur dominantly on gently to strongly sloping and undulating alluvial fans at the base of mountain ranges. These soils, which are characterized by their fine gravel content, are developing in old valley fill sediments of granitic origin. These areas are used for grazing.

(3) Nickel-Upton-Tres Hermanos Association

The gently to strongly sloping and undulating piedmont slopes at the base of the desert mountains and hills are included in this association. Nickel soils occupy gently to strongly sloping and undulating landscapes at the base of desert mountains. Upton soils also occur on gently to strongly sloping and slightly undulating landscapes. Tres Hermanos soils usually occur on the more gently sloping landscapes. The soils, which are generally gravelly, are forming in coarse-textured alluvial fan sediments of mixed origin. These areas are used for grazing.

(4) Rockland-Lehmans Association

Mountain ranges, ridges, and hills are included within this association. Rockland, a miscellaneous land type, is a complex of very shallow soils and exposures of bedrock. Lehmans soil occurs in the moderately steep and rolling to hilly landscapes. Although the soils are developing from a wide variety of eroded bedrock, those forming from acid igneous material are most extensive. These areas are used for grazing.

(5) Lonti-Poley-Pastura Association

Included in this association are soils occurring on nearly level to gently sloping old alluvial terraces and piedmont slopes. These soils, which are commonly gravelly, are forming in old alluvium dominated by materials of acid igneous origin. These areas are used for grazing.

(6) Rough Broken Land-Lonti Association

A characteristic feature of this association is the rough and broken nature of the land surface, which is steep to very steep and dissected by numerous intermittent drainages and arroyos. Rough broken land, the most extensive soil association within the

assessment area, includes the steep to very steep and severely dissected lands. Lonti soils occupy the more stable landscapes and occur on the gently to strongly sloping and rolling ridge crests. The soils are forming, generally, in material of alluvial origin. These areas are used for grazing.

(7) Lonti-Rough Broken Land Association

This association occurs on rolling to hilly upland. Lonti soils, which are the most extensive, occur on moderately steep and rolling landscapes. Rough broken land occurs on the rough, broken and steep landscapes. The soils in this association are forming in stratified old alluvial sediments that are dominantly gravelly, cobbly, and coarse-textured. These areas are used for grazing.

(8) Luzena-Arp Association

This association is characterized by rolling to hilly landscapes interspersed with nearly level to gently sloping narrow valley bottoms and terraces. Luzena soils occur on the moderately steep and hilly landscapes. Arp soils also occupy rolling and hilly landscapes. Manzano soils occur in the narrow valley bottoms and swales. The soils are developing in material of acid igneous origin. These areas are used for grazing.

(9) Cabezon-Thunderbird Association

This association includes areas with soils forming in materials of volcanic and basic igneous origin on old lava flows and basalt-capped mesas. A characteristic feature is the stony and rocky nature of the soils. The land surface on the mesa tops and lava flows is mostly gently to strongly sloping and undulating. The sides of the basalt-capped mesa and the fronts of lava flows are generally steep or very steep. Cabezon soils occupy the gently to strongly sloping mesa tops and fronts of lava flows. Thunderbird soils commonly occupy the nearly level to gently sloping areas on basalt capped mesa. Basalt rockland, a miscellaneous land type, is also an important component of this association. These areas are used for grazing.

(10) San Mateo-Shanta Association

Included in this association are the nearly level to gently sloping flood plains and valley bottoms adjacent to the Gila and Mimbres Rivers. Shanta soils occur on valley bottoms, depressions, and terminal points of alluvial fans. These lands are used for farming and grazing.

(11) Rockland-Luzena-Santana Association

This association includes the hilly to very steep mountain foothill and intermediate mountain areas. The relatively narrow valley floors and upland summits are commonly separated by steep canyon walls, escarpments, and steep side slopes. Luzena soils are forming dominantly on acid igneous bedrock or conglomerate. These areas are used for grazing.

(12) Stony Rockland Association

This association is characterized by rough, broken topography, very steep slopes and rock outcrops. The exposed rock consists of conglomerates, andesite, rhyolite, and shaley sediments, with lesser amounts of basalt and granite. These areas are used for grazing.

(13) Mohave-Stellar Association

This association occupies the lower parts of the piedmont slopes or plains between the desert mountains and nearly level basin floors. The Mohave soils commonly occur on gently sloping piedmont surfaces. Stellar soils occur on the nearly level to gently sloping areas. These soils are forming in old valley-filling sediments dominated by materials of acid igneous origin. These areas are used for grazing.

(14) Hondale-Mimbres-Bluepoint Association

Included in this association are broad, sloping basin floors and valley bottoms. Bluepoint soils commonly occur on the slightly elevated and gently sloping ridges. These soils are developing in basin-fill sediments of mixed origin. These areas are primarily used for grazing, but a small acreage has been used for crop production. The alkali-affected soils have presented operators with many difficult soil management problems.

(15) Eba Association

The soils in this association, which are usually gravelly and cobbly, are forming in alluvial fan sediments that are dominantly of acid igneous origin. Sonoita soils occur on the gently sloping landscapes. These lands are used for grazing.

(16) Rough Broken Land - Caliza-Vado Association

This association includes rough broken lands characterized by moderately steep sloping landscapes that are dissected

by many drainage-ways. The rough broken land component occupies the steep and rough lands that are dissected by many intermittent stream channels. Caliza soils usually are on the gently sloping crests of narrow ridges. The soils, which are often gravelly, are forming in coarse-textured alluvial fan sediments of mixed origin. These areas are used for grazing.

(17) Nickel-Tencee-Delnorte Association

This association includes the soils on the gently to strongly sloping piedmont slopes contiguous to the base of desert mountains and hills. It is generally dissected by numerous ephemeral streams and arroyos originating in the adjacent mountains. The soils, which are usually gravelly or cobbly, are forming in alluvial fan sediments of mixed origin. These areas are used for grazing.

(18) Cacique-Pinaleno-Hap Association

Included in this association are the broad, nearly level to gently sloping remnants of old alluvial fans that extend from the mountain fronts. Cacique soils occupy nearly level to very gently sloping landscapes and often occur in broad, very slightly depressed areas. The Pinaleno soils occur near the base of adjoining mountain foothills. Hap soils also occur dominantly on gently to strongly sloping and undulating alluvial fans at the base of the mountain ranges. The soils, which are forming in moderately coarse to medium textured alluvial sediments, are usually gravelly. These areas are used for grazing.

(19) Rockland-Lehmans-Lozier Association

Included in this association are mountain ranges, isolated peaks and hills. Rockland, a miscellaneous land type, is a major component of this association. It is a complex of very shallow soils and rock outcrops. Lehmans soils occur on the moderately steep and rolling to hilly landscapes. Lozier soils are extensive on the moderately steep and rolling limestone hills and upland ridges. These areas are used for grazing.

(20) Lehmans-Orogrande-Rockland Association

This association includes rolling to hilly mountain foothill country. Interspersed with the rolling and hilly landscapes are steep to very steep canyon walls and breaks, gently to strongly sloping valley bottoms. Lehmans soils occur on the moderately steep and rolling to hilly landscapes. Orogrande soils

generally occur only on the north slopes and at higher elevations. Rockland is also an extensive component of this association. It consists dominantly of outcrops of igneous bedrock and very shallow soils that occur in a very complex pattern. These areas are used for grazing.

(21) Capillo-Mirabal-Weed Association

This association includes the mountainous landscapes which occur at elevations ranging from about 2,100 to 2,600 m (7,000 to 8,500 ft), and are gently sloping and undulating to moderately steep. The Capillo soils occur on gently rolling uplands and the moderately steep side slopes of the upland ridges. Mirabal soils occur on rolling to hilly uplands and moderately steep mountain side slopes. Weed soils occur on gently rolling uplands. Rockland, a miscellaneous land type, is also an important component of this association. It commonly occurs on steep slopes and consists of a complex of shallow soils. The soils in the association are underlain by mixed igneous and conglomerate rocks. These areas are used for grazing and forestry.

(22) Rockland-Rough Broken Land Association

Included in this association are mountain ranges, isolated mountain peaks, ridges, and hills. Rockland, a miscellaneous land type, is a major component of this association. It is a complex of very shallow soils and outcrops or exposures of bedrock. Lehmans soils occur on the moderately steep and rolling to hilly landscapes. These areas are used for grazing.

(23) Rockland-Luzena Association

This association includes the hilly to very steep mountain foothill and intermediate mountain area. Rockland is characterized by numerous outcrops of bedrock that usually occur on steep to very steep slopes. Shallow soils with variable characteristics are intermingled in complex patterns. Luzena soils are forming dominantly on acid igneous bedrock or conglomerate. These areas are used for grazing.

(24) Tidwell-Nickel Association

A characteristic feature of this association is the undulating to gently rolling hills dominated by shallow and moderately deep gravelly and cobbly soils developing over andesite bedrock. Interspersed with the rolling uplands and hills are nearly level to gently sloping narrow swales and valley bottoms. Tidwell soils occur on gently rolling and hilly uplands. Nickel soils occupy

the gently to strongly sloping and undulating landscapes at the base of the desert mountains. Mohave and Stellar soils occupy the nearly level to gently sloping swales and drainage-ways. These areas are used for grazing.

Soil Erosion

Soil erosion conditions are variable over the assessment area. For the most part, erosion is directly correlated to the type of vegetation present. Erosion ranges from slight on areas with good grassland vegetative ground cover to critical in the dune type mesquite areas.

Gully erosion is prevalent in some locations where large volumes of run-off accumulate in draws or drainage-ways. Sheet erosion occurs on most of the creosotebush areas where very little ground-level vegetation is present to provide soil surface protection. Wind is the primary cause of soil movement in the dune type mesquite areas. Soils with severe erosion susceptibility and where the vegetative ground cover has been depleted have greater amounts of erosion occurring than those areas where a good vegetative ground cover has been maintained.

b. Geology

The Silver City Assessement Area can be considered structurally complex. Most of the assessment area lies within the Transition Zone between the Colorado Plateau structures to the north and Basin and Range structures to the south and east. The area is characterized by widespread normal faulting and local folding. Along with the folding and faulting, widespread volcanic extrusions and local igneous intrusions have take place (Trauger, 1972).

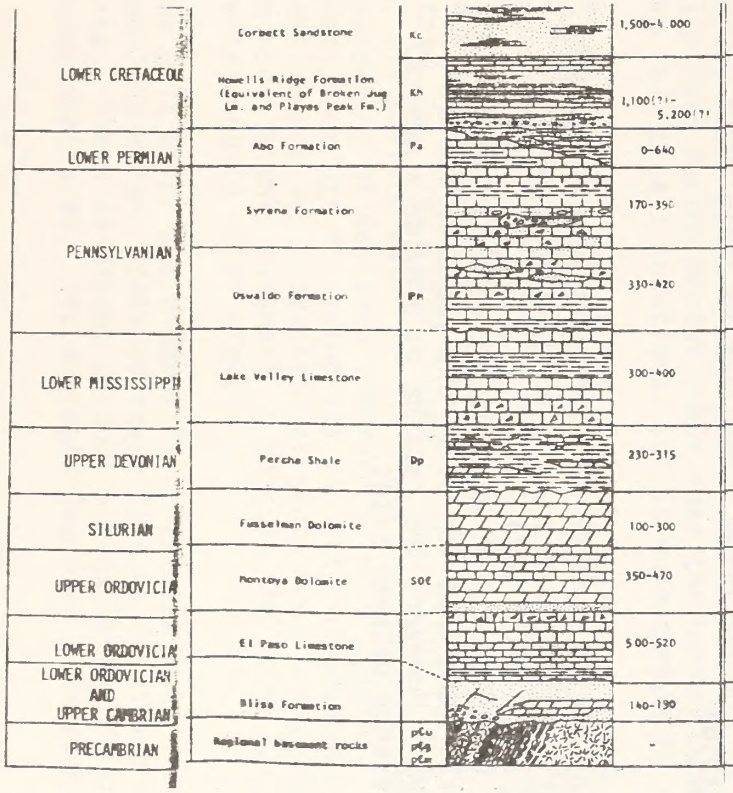
The Basin and Range and Rio Grande Rift structures (to the south and east, respectively) are tectonically separated by steeply dipping faults that appear as horsts and grabens (see Figure 4). These horst and graben structures generally trend northward throughout southwestern New Mexico, but are deflected to the northwest in the assessment area. It appears that this deflection was probably caused by the Colorado Plateau to the north acting as a relatively rigid block (Elston, et al., 1976).

Topographically, Duck Creek and Mangas Creek form a structurally controlled linear feature referred to as the Mangas Trench. The Trench is defined on the west by the Big Burro Mountains and on the east by normal faulting along the western edges of the Mogollon Plateau and the Silver City Range (Trauger, 1972). Another structurally controlled

TABLE 6 .

Generalized Section of Rock Formation in Grant County 1/

SYSTEM OR SERIES	FORMATION OR TYPE OF ROCK	SYMBOL ON MAP		APPROXIMATE RANGE IN THICKNESS (FEET)	CHARACTER (Thickness of beds is approximate)	WATER SUPPLY
QUATERNARY (holocene and upper Pleistocene)	Alluvium	Qal		0-50	Alluvium--boulders, gravel, sand, silt, and clay under flood plains; as much as 75 feet thick in the Gila River valley and about 25 to 35 feet thick in the Mimbres River valley. Terrace gravel, mostly on slopes bordering the Gila and Mimbres Rivers and the Lordsburg valley, is thin and largely composed of rocks derived from the immediate vicinity. Bolson deposits, known from drill holes to be at least 1,600 feet thick, include unconsolidated gravel, sand, silt, and clay in the Lordsburg and Hachite valleys and San Vicente basin. The bolson deposits are heterogeneous mixtures of all rocks found in the surrounding uplands, mostly unconsolidated but locally cemented with carbonate, iron, or silica to form beds of caliche and "herdpan".	Alluvium along main streams yields as much as 2,200 gpm but generally less than 500 gpm to wells; bolson deposits yield as much as 1,500 gpm to wells locally and have potential for higher yields; terrace gravels generally not water bearing but locally yield as much as 300 gpm to wells along main stream channels; basalts are not known to be water bearing.
	Terrace gravels	Qtg		0-125		
	Alluvium and bolson deposits	Qab		0-1,600		
	Basalt	Qb		0-500		
QUATERNARY AND UPPER TERTIARY (Middle Miocene to Pleistocene)	Gila Conglomerate	QTg		0-1,900+	Sedimentary deposits of continental origin as much as 1,900 feet thick, broadly distributed, and, in general, nonconformably to disconformably overlying all older rocks but locally intertongued and interbedded with the uppermost facies of the Tertiary volcanic sequence. Incoherent to strongly cemented fanglomerate, conglomerate, sandstone, and silt, some thick deposits of clay, especially in valley of Duck Creek where beds of diatomite also are found. Rapid lateral changes in composition due to local derivation of sediments. Nearly flat-lying to vertically dipping beds; locally faulted, particularly in the lower parts, and containing pronounced intraformational disconformities, particularly between what is referred to in this report as the lower and upper parts of the Gila; upper part of Gila is generally less consolidated and less deformed than the lower, contains interbedded flows of basaltic andesite.	Yields range from less than 1 gpm to 2,000 gpm to wells, depending upon the degree of consolidation and the locality. Yields generally are less than 20 gpm from the more consolidated beds of the lower part of the formation. Larger yields are mostly from local poorly consolidated beds in the upper part of the formation.
MIDDLE TERTIARY (lower Oligocene to upper Pliocene)	Volcanic rocks of wide variety ranging in age from 6 to 38 million years, and interbedded sediments. Includes all rocks previously referred to the Datil Formation, the Sugarlump Tuff, Kneeling Nun Tuff, Rubio Peak Formation, other named units in central Grant County, and similar rocks of equivalent age in the southern part of the county	Ta Tba Td Tl Tr Trp Ts Tsc		0-10,000+	Flows and sediments that include andesite (Ta), rhyolite (Tr), latite (Tl), dacite (Td), and basaltic andesite (Tba), their pyroclastic equivalents, interbedded water-deposited tuffs (Ts), and fine- to coarse-grained sediments including beds of boulders; widely distributed over northern and southern Grant County. A thick sequence of andesitic-rhyolitic-basaltic rocks has been recognized in broad areas and has been shown conclusively (Elston, 1965, 1968 a, b) to be cyclic and to have been repeated at least three times. The bulk of the eruptive rocks are rhyolitic and the most conspicuous and widespread types are rhyolite and quartz latite ash flow tuffs, such as the Kneeling Nun Tuff and Sugarlump Tuff (well exposed in southeast part of county). The Kneeling Nun is a welded tuff, as much as 400 feet thick, dense, compact, greyish purple weathering to buff and tending towards columnar jointing. The Sugarlump consists of as much as 1,400 feet of sandy, crossbedded water-laid tuffs, crystal tuffs, flows and breccias, most of which are white to green and pink. The Rubio Peak Formation (Trp) consists of as much as 3,200 feet of andesite and latite flows, agglomerates, breccias, tuffs, and tuffaceous sandstones and conglomerates, mostly dark gray to purple or black and known from drill holes to be at least 1,900 feet thick but probably much thicker.	The basalt, basaltic andesite, andesite, rhyolite, latite, and related volcanic and sedimentary rocks generally are locally water bearing and the yields commonly range from ½ to 10 gpm; a few wells yield as much as 40 gpm from sediments interbedded with the flow rocks. Coarse-grained sediments of the sequence may be the aquifer that yields as much as 500 gpm to wells in the Apache Tejo and Faywood area.
LOWER TERTIARY AND UPPER CRETACEOUS	Volcanic rocks in Summit Mountains, Pinos Altos Mountains, and Steeple Rock area	TKa TKab		0-3,000	Andesite flows, tuffs, and flow breccias (TKa) as much as 3,000 feet thick; some flows vesicular, interbedded with rhyolite tuffs and latite flows, underlain locally by a sequence of porphyritic rhyolite flows and welded tuffs (TKr) as much as 200 feet thick; underlying the andesites and rhyolites is a sequence of grayish green to darker green dacite flows, tuffs and flow breccias (TKd); the dacite is host to most of the mineralization in the Steeple Rock mining district. Virden Formation of Elston (1960) in Steeple Rock area and Wimsattville Formation of Harmon and others (1953) in the Santa Rita area--local deposits of conglomerate, fanglomerate, sandstone, and shale as much as 4,000 feet thick near Steeple Rock and at least 1,100 feet thick near Santa Rita. Andesite breccia (TKab) in Pinos Altos Mountains.	The volcanic rocks in general yield less than ½ gpm to wells but locally as much as 25 gpm. The sedimentary rocks also are locally water bearing and yields generally are less than 10 gpm.
	Wimsattville and Virden Formations	TKs		0-4,000		
		TKd TKr				
	Hidalgo Volcanics	TKh		0-5,000	In Little Hatchet Mountains: Mostly basalt flows and pyroclastic rocks; some andesite; in the upper part locally includes as much as 200 feet of limestone, shale, and conglomerate.	Locally water bearing; yields to wells generally less than 2 gpm from volcanic rocks, 1 gpm from sedimentary beds.
	Intrusive rocks	TKi		-	Dikes, sills, plugs, stocks, and laccoliths of varied composition; quartz diorite, monzonite, granodiorite, gabbro, near Silver City and Santa Rita, quartz monzonite and latite near Tyrone, rhyolite and latite dikes and rhyolite plugs near White Signal, monzonite porphyry in Blackhawk area, monzonite and diorite in Little Hatchet Mountains. These rocks have intruded and cut across or displaced older rocks in all areas of intrusive activity.	Locally water-bearing; yields range from 1/5 to 20 gpm.
UPPER CRETACEOUS	Ringbone Shale	Kr		25-650	Black and green fissile shale, some sandstone and black limestone; 25 to 100 feet of volcanic rocks lie between lower and upper shale units.	Not known to be water bearing.
	Skunk Ranch Cgl.	Rs		3,400	Mostly red and maroon conglomerate; includes much red clay-shale, some soft sandstone, locally a layer of augite basalt 0-200 feet thick.	Locally water bearing; yields to wells commonly less than ½ gpm.
	Colorado Formation	Kc		0-1,000	In central Grant County: Lower 200 feet gray-to-black fissile shale containing a few thin sandy layers and, locally, about 50 feet above the base, a 25 foot bed of sandstone overlain by beds containing oyster (gryphea) shells. Upper 800 feet tan, greenish-brown and white sandstone and orkose beds alternating with dark-green, brown, and black shale beds, some thin beds of brown to gray limestone, locally fossiliferous. Intensely intruded by dikes in the area between Silver City and Central.	Locally water bearing, occurrence highly unpredictable, yields generally range from less than 1/10 to 5 gpm; a few wells have yields of about 15 gpm.
	Beartooth Quartzite	Kb		65-140	Thin bedded to massive, vitreous, fine- to very fine-grained sandstone containing thin shale partings, locally crossbedded, light-gray, weathering to reddish-brown; locally conglomeratic within upper 10 feet.	Not known to be water bearing.



LOWER CRETACEOUS	Corbett Sandstone	Kc		1,500–4,000	In Little Hatchet Mountains: Mostly sandstone, locally quartzitic and massive, commonly ripple marked and crossbedded, locally thinly laminated; sandstone beds alternate with sandy shale beds 1 to 15 feet thick; includes several shely and sandy limestone units.	Locally water bearing; yields to wells generally less than 4 gpm and commonly less than 2 gpm.
	Howells Ridge Formation (Equivalent of Broken Jug Lm. and Playas Peak Fm.)	Kh		1,100(?)–5,200(?)	In Little Hatchet Mountains: In the lower part, as much as 4,700 feet of conglomerate, sandstone, red and green shale, and limestone; in middle part, as much as 400 feet of volcanic rocks--augite andesite flows and purple breccias; in upper part, 200-545 feet of massive and thin-bedded black limestone and massive crystalline creamy white limestone, locally fossiliferous and reeflike.	Locally water bearing; yields to wells generally less than 2 gpm, commonly less than 1 gpm. Water from the shales and volcanic rocks is likely to have high concentrations of dissolved solids.
LOWER PERMIAN	Abo Formation	Pa		0–640	Red beds (mostly red shale), siltstone, and limy mudstone containing lenses of limestone and chert conglomerate and thin local beds of olive-green to brown limestone.	Not known to be water bearing.
PENNSYLVANIAN	Syrena Formation			170–390	Bottom 35 to 40 feet of blocky to fissile, black, fetid silty limestone and lenses of limestone conglomerate, overlain by 30 feet of dense dark-gray silty limestone containing 3 to 4 inch nodules of blue-gray limestone, in turn overlain by 10 to 40 feet of olive-green to brown shale. Upper 100 to 280 feet alternating beds of pure gray limestone, silty limestone, and brown, yellow, and red shales.	Locally water bearing; yields to wells range from less than 1 to about 5 gpm.
	Oswaldo Formation	IPm		330–420	Bottom 20 to 40 feet of gray to reddish shale (locally called Parting Shale Member); middle 250 to 300 feet of blue-grey dense, thick-bedded cherty limestone containing shale partings and local small to large lenses of coarse-grained sandstone 70 to 125 feet above the base; Upper 50 to 80 feet of alternating beds of pure limestone and silty limestone overlain by 3 to 5 feet of dense cherty limestone.	Locally water bearing; yields to wells range from less than 1 to about 25 gpm.
LOWER MISSISSIPPIAN	Lake Valley Limestone			300–400	Lower 15 to 40 feet thin-bedded, slabby, fossiliferous gray limestone and thin shale partings, overlain by 20 to 50 feet of light to dark-gray, thick-bedded, fine-grained, fossiliferous, cliff-forming limestone containing masses of black chert, middle part is 200 feet of alternating fossiliferous limestone and shely limestone; the upper 110 feet is massive white to light-gray fossiliferous (crinoidal) limestone and marble containing white to light-gray nodules of chert.	Locally water bearing; yields to wells range from less than 1 to about 150 gpm.
UPPER DEVONIAN	Percha Shale	Dp		230–315	Lower 130 to 215 feet is black fissile shale containing very thin interbeds of blue-gray argillaceous limestone, tan calcareous shale, and white calcite layers near the base. Upper 100 feet is gray shale and limy shale beds containing abundant 1- to 4-inch fossiliferous limestone nodules and several beds of limestone.	Generally not water bearing but locally yields as much as 1 gpm to wells.
SILURIAN	Fusselman Dolomite			100–300	Fine-grained massive dolomite containing sparse chert nodules; brownish-gray to grey on fresh surface, weathering to tan; fossiliferous but most fossils destroyed by dolomitization and local alteration as a result of mineralization.	Locally water bearing; yields to wells range from less than 1 to about 5 gpm.
UPPER ORDOVICIAN	Montoya Dolomite	SOe		350–470	Lower beds (0 to 40 feet) commonly medium- to coarse-grained sandstone containing grains of milky-white opalescent quartz; middle 200 feet mostly dark-gray to black (weathering light-gray to brown), fine-grained massive dolomite containing chert zones; upper 200 feet mostly white to light-gray finely crystalline thin-bedded limestone, some chert.	Locally water bearing; yields to wells range from less than 1 to about 50 gpm.
LOWER ORDOVICIAN	El Paso Limestone			500–520	Lower 400 feet mostly thin- to medium-bedded light-gray to gray-tan limestone and dolomite containing abundant thin crinkled and reticulated siliceous layers; some shale beds; numerous fossils in lower 150 feet. Upper 100 feet massive to thick-bedded finely crystalline light-gray limestone; nodular chert abundant in top few feet.	Locally water bearing; yields to wells range from less than 1 to about 200 gpm.
LOWER ORDOVICIAN AND UPPER CAMBRIAN	Bliss Formation			140–190	Conglomerate (locally) overlain by generally dense glauconitic and hematitic crossbedded sandstone and quartzite; contains some dolomite and limestone.	Not known to be water bearing.
PRECAMBRIAN	Regional basement rocks	pCu pCg pCm		-	Granite, gneiss, mica schist, greenstone; the granitic and gneissic rocks in the Burro Mountains are deeply weathered locally.	Locally water bearing, yields to wells range from less than 1/10 gpm to about 15 gpm.

1/ Trauger, F. D., 1972. Water Resources and General Geology of Grant County, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 2, p. 26, 27.

linear feature is the Mimbres Valley. It is structurally bound on the west by the Pinos Altos Range and topographically on the east by the Black Range and Mimbres Mountains (ibid). Just east of the Black Range is the Cuchillo-Animas Trough, also referred to as the Winston-Hillsboro graben. This structural low is a series of narrow, irregular grabens that extend into the assessment area from the north (Kelley, 1955).

Rocks within the assessment area range from Precambrian to Holocene in age and are represented by various igneous, metamorphic and sedimentary fractions. As is common throughout the southwest, exposures of all but the very youngest stratigraphic units are confined to uplifted areas, since relatively recent alluvial fill and volcanics have covered the intermontane basins. This intermontane fill makes up the surficial deposits in most of the Silver city Assessment Area. Refer to Table 6 for a generalized stratigraphic section covering most of the EAR/TE area (Durham, John, 1977).

Potential geologic hazards for the assessment area, as outlined by the USGS, are: earthqakes, liquifaction, subsidence, flash floods, slope stability, and volcanism. These hazards represent existing geologic conditions that may aggravate or be aggravated by geothermal development. An excellent in-depth document prepared by the Area Geothermal Supervisor's Office, USGS, discusses these hazards, their relationship to geothermal development in the Silver City area. impacts to the environment and measures to mitigate those impacts. This document is available for reference at the Las Cruces District Office, BLM, and from the Area Geothermal Supervisor's Office, USGS, Menlo Park, CA (ibid).

3. Water

Precipitation varies considerably over the assessment area. Amounts received at various locations within or near the area are shown below (Maker, et al., 1970, Maker, et al., 1971 (2), and Maker, et al., 1972). One site cannot be compared directly with another since thr records were kept for different years or for a different period of time. However, the records do provide a general indication of the difference between sites.

Location	Elevation Ft.	Elevation mm	Average Annual Precipitation Inches	Average Annual Precipitation mm	Years Recorded
Hatch	4042	1232	8.96	228	30
Cliff	4900	1494	12.16	309	17
Fort Bayard	6152	1875	15.28	388	92
Santa Rita	6312	1924	16.84	428	21
Silver City	5895	1797	16.38	416	58
Buckhorn	4900	1494	12.07	307	14
Mimbres Ranger Station	6247	1904	17.11	435	47
Pinos Altos	7000	2134	21.29	541	49
White Signal	6070	1850	12.98	330	12
Whitewater	5150	1570	8.74	222	12
Florida	4450	1356	9.77	248	23
Hillsboro	5270	1606	11.53	293	56
Lake Valley	5412	1650	13.25	337	22

Yearly precipitation amounts can vary from only a few inches to nearly double the average. Individual storms will vary from only tracts to several inches of rain during a 24 hour period. Summer thunderstorms of high intensity are generally localized in small areas. Most of the precipitation normally comes during the months of July, August, and September. However, it is not unusual to receive some rain or snow during every month of the year. Heavy amounts of precipitation occasionally fall during months other than the normal summer rainy season. Snow can fall at all locations, but is more common at the higher elevations.

The assessment area is situated in parts of the Mimbres River drainage system, the Gila-San Francisco River drainages systems, the Mimbres Underground Water Basin, and the Nutt-Hackett Underground Water Basin. Under the New Mexico Constitution and case law, the surface water and underground water are subject to appropriation in accordance with State law. The State Engineer has jurisdiction over the appropriation of all surface water in the State and the groundwater within the boundaries of declared underground water basins. The Oil Conservation Commission has the authority and duty of regulating the drilling, development and production of geothermal resources. No attempt will be made in this document to discuss the legal aspects of anything pertaining to water rights.

The Gila River and Mimbres River are the only drainages which have yearlong water. Both of these streams originate outside the assessment area. The Gila passes through approximately 24 km (15 mi) of the assessment area. The average flow over a 48-year period near the

town of Gila is 3823 l (1,010 gal) per second daily or 12,065 ha m (97,810 ac ft) per year.

The Mimbres River, which is a much smaller stream, has had an average flow over a 45-year period of 317 l (84 gal) per second, or 1,000 ha m (8,110 ac ft) per year. Most of this water is used for irrigation within the assessment area. Only during periods of excessive run-off does any appreciable amount of water from this river leave the assessment area. There is presently no water available for appropriation from either the Gila or Mimbres River.

The following is taken from "Water Quality Standards for Interstate and Intrastate Streams in New Mexico" as adopted by the Water Control Commission under the authority of Paragraph C, Section 75-39-4 of the New Mexico Water Quality Act (Chapter 326, Laws of 1973), as amended. Adopted August 22, 1973; Revised September 29, 1975, January 13, 1976, and February 8, 1977.

> Water quality standards for interstate and intrastate streams in New Mexico are consistent with Section 101(a)(2) of the Federal Water Pollution Control Act Amendmenst of 1972 (P.L. 92-500). These standards identify the uses of surface water in the State of New Mexico, and prescribe the water quality standards necessary to sustain those uses.
>
> The following general standards apply at all times (unless otherwise specified) to all surface waters which are suitable for recreation and support of desirable aquatic life presently common in New Mexico waters.
>
> > Stream Bottom Deposits - The stream shall be free of water contaminants from other than natural causes that will settle and adversely inhibit the growth of normal flora and fauna or significantly alter the physical or chemical properties of the bottom.
> >
> > Siltation resulting from the reasonable operation of irrigation and flood control facilities is not subject to these standards.
> >
> > Floating Solids, Oil and Grease - Receiving water shall be free of objectionable oils, scum, grease, and other floating material resulting from other than natural causes.
> >
> > Color - Color producing materials resulting from other than natural causes shall not create an aesthetically undesirable condition nor should color impair the use of the water by desirable aquatic life presently common in New Mexico waters.

Odor and Taste of Fish - Water contaminants from other than natural causes shall be limited to concentrations that will not impart unpalatable flavor to fish, or result in offensive odor arising from the stream or otherwise interfere with the reasonable use of the water.

Plant Nutrients - Plant nutrients from other than natural causes shall not be present in concentrations which will cause undesirable productivity in receiving waters.

Hazardous Substances - Toxic substances, such as, but not limited to pesticides, herbicides, heavy metals, and organics shall not be present in receiving waters in concentrations which will change the ecology of receiving waters to an extent detrimental to man or other organisms of direct or indirect commercial, recreational, or esthetic value. Toxicities of substances in receiving waters will be determined by appropriate bioassay techniques, or other acceptable means, for the particular form of aquatic life which is to be preserved, with the concentrations of toxic materials not to exceed 5% of the 96-hour median tolerance limit, provided that:

> Toxic substances which, through uptake in the aquatic food chain and/or storage in plant and animal tissues, can be magnified to levels which are toxic to man or other organisms, shall not be present in concentrations which result in this biological magnification.

Water used for drinking water supplies shall be protected from hazardous substances in amounts which exceed drinking water standards established by the U.S. Public Health Service.

Radioactivity - The radioactivity of surface waters shall be maintained at the lowest practical level and shall in no case exceed the standards set forth in Part 4 of New Mexico Environmental Improvement Board Radiation Protection Regulations, adopted June 16, 1973.

Pathogens - The stream shall be virtually free of pathogens, in particular, waters used for irrigation of table crops, such as lettuce, shall be virtually free of *Salmonella* and *Shigella* species.

Temperature - Maximum temperatures for each stream reach have been specified. However, the introduction of heat by other than natural causes shall not increase the temperature, as measured from above the point of introduction, by more than

2.7° C (5° F) in a stream, or more than 1.7° C (3° F) in a lake or reservoir. In no case will the introduction of heat be permitted when the maximum temperature specified for the reach, generally 20° C (68° F) for cold water fisheries and 32.2° C (90° F) for warm water fisheries, would thereby be exceeded. These temperature standards shall not apply to impoundments constructed offstream for the purpose of heat disposal. High water temperatures caused by unusually high ambient air temperatures or the reasonable operation of irrigation and aquacultural facilities are not violations of these standards.

Turbidity - Turbidity attributable to other than natural causes shall not reduce light transmission to the point that desirable aquatic life presently common in New Mexico waters is inhibited or that will cause substantial visible contrast with the natural appearance of the water. Turbidity attributable to natural causes or the reasonable operation of irrigation and flood control facilities is not subject to these standards.

Salinity - Where existing information is sufficient, numerical standards for total dissolved solids (or conductivity), chlorides and sulfates have been adopted.

Stream use designations and standards for the Mimbres and Gila Rivers have been developed as follows:

1. The Mimbres River below Mimbres and all perennial reaches of tributaries thereto:

   Designated Uses - Coldwater fisheries; irrigation; livestock and wildlife watering; secondary contact recreation.

   Standards: In any single sample:

   Dissolved oxygen shall be greater than 6.0 mg/l; pH shall be within the range of 6.6 to 8.8; Temperature shall be less than 20° C (68° F).

   The monthly logarithmic mean of fecal coliform bacteria shall be less than 100/100 ml, and no more than 10% of the samples shall exceed 200/100 ml.

2. The Mimbres River above Mimbres and all perennial tributaries thereto:

   Designated Uses: Irrigation, domestic water supply, high quality coldwater fishery, livestock and wildlife watering, secondary contact recreation.

Standards: In any single sample:
Ammonia nitrogen shall be less than 0.2 mg/l
Conductivity shall be less than 300 umhos
Dissolved oxygen shall be greater than 6.0 mg/l or 85% of saturation, whichever is greater
Nitrate nitrogen shall be less than 0.8 mg/l
pH shall be within the range of 6.6 to 8.8;
Temperature shall be less than 20^{o} C (68^{o} F)
Total chlorine residual shall be less than 0.002 mg/l
Total organic carbon shall be less than 7 mg/l
Total phosphorus shall be less than 0.1 mg/l
Turbidity shall be less than 10 FTU

The monthly logarithmic mean of fecal coliform bacteria shall be less than 100/100 ml, and no more than 10% of the samples shall exceed 200/100 ml.

GILA RIVER BASIN

3. The main stem of the Gila River from the New Mexico-Arizona line upstream to Red Rock.

Designated Uses - Irrigation; limited warmwater fishery; livestock and wildlife watering; secondary contact recreation.

Standards: In any single sample:
Dissolved oxygen shall be greater than 5.0 mg/l
pH shall be within the range of 6.6 to 8.8
Temperature shall be less than 32.2^{o} C (90^{o} F)

The monthly logarithmic mean of fecal coliform bacteria shall be less than 1,000/100 ml, and no more than 10% of the samples shall exceed 2,000/100 ml.

4. The main stem of the Gila River from Red Rock upstream to Gila Hot Springs.

Designated Uses: Industrial water supply; irrigation; livestock and wildlife watering; marginal coldwater fishery; secondary contact recreation; warmwater fishery.

Standards: In any single sample:
Dissolved oxygen shall be greater than 5.0 mg/l
pH shall be within the range of 6.6 to 8.8
Temperature shall be less than 28^{o} C 82.4^{o} F)

The monthly logarithmic mean of fecal coliform bacteria shall be less than 1,000/100 ml, and no more than 10% of the samples shall exceed 2,000/100 ml.

5. The main stem of the Gila River from Gila Hot Springs upstream to the headwaters and all tributaries thereto, and all other perennial tributaries to the Gila River above the Town of Cliff.

   Designated Uses: Domestic water supply; high quality coldwater fishery; irrigation; livestock and wildlife watering; secondary contact recreation.

   Standards: In any single sample:
   Ammonia nitrogen shall be less than 0.2 mg/l
   Conductivity shall be less than: 300 umhos for the main stem of the Gila River above Gila Hot Springs; 400 umhos for other reaches
   Dissolved oxygen shall be greater than 6.0 mg/l or 85% of saturation, whichever is greater
   Nitrate nitrogen shall be less than 0.8 mg/l
   pH shall be within the range of 6.6 to 8.8
   Temperature shall be less than 20^{o} C (68^{o} F) except in the East Fork of the Gila River and Sapillo Creek below Lake Roberts where the temperature shall be less than 32.2^{o} C (90^{o} F)
   Total chlorine residual shall be less than 0.002 mg/l
   Total phosphorus shall be less than 0.1 mg/l
   Total organic carbon shall be less than 7 mg/l
   Turbidity shall be less than 10 FTU

   The monthly logarithmic mean of fecal coliform bacteria shall be less than 100/100 ml, and no more than 10% of the samples shall exceed 200/100 ml.

GROUNDWATER

Groundwater is one of the most important natural resources in the region. It is much more abundant than surface water and has been the principal source of water in the historic past. The need for large volumes of water for mining and minerals processing, municipal use and agriculture makes groundwater a valuable commodity. Competition for the groundwater is the principal reason for State control and adjudication.

Three declared underground water basins cover most of the assessment area. See Figure 8. There is presently no additional water available for appropriation for any purpose including water for domestic and stock watering purposes within the Gila-San Francisco Underground Water Basin. New appropriations of ground water, except for domestic and stock watering purposes, generally are not permitted within the Mimbres Underground Water Basin unless the State Engineer determines the new appropriation will not impair existing rights.

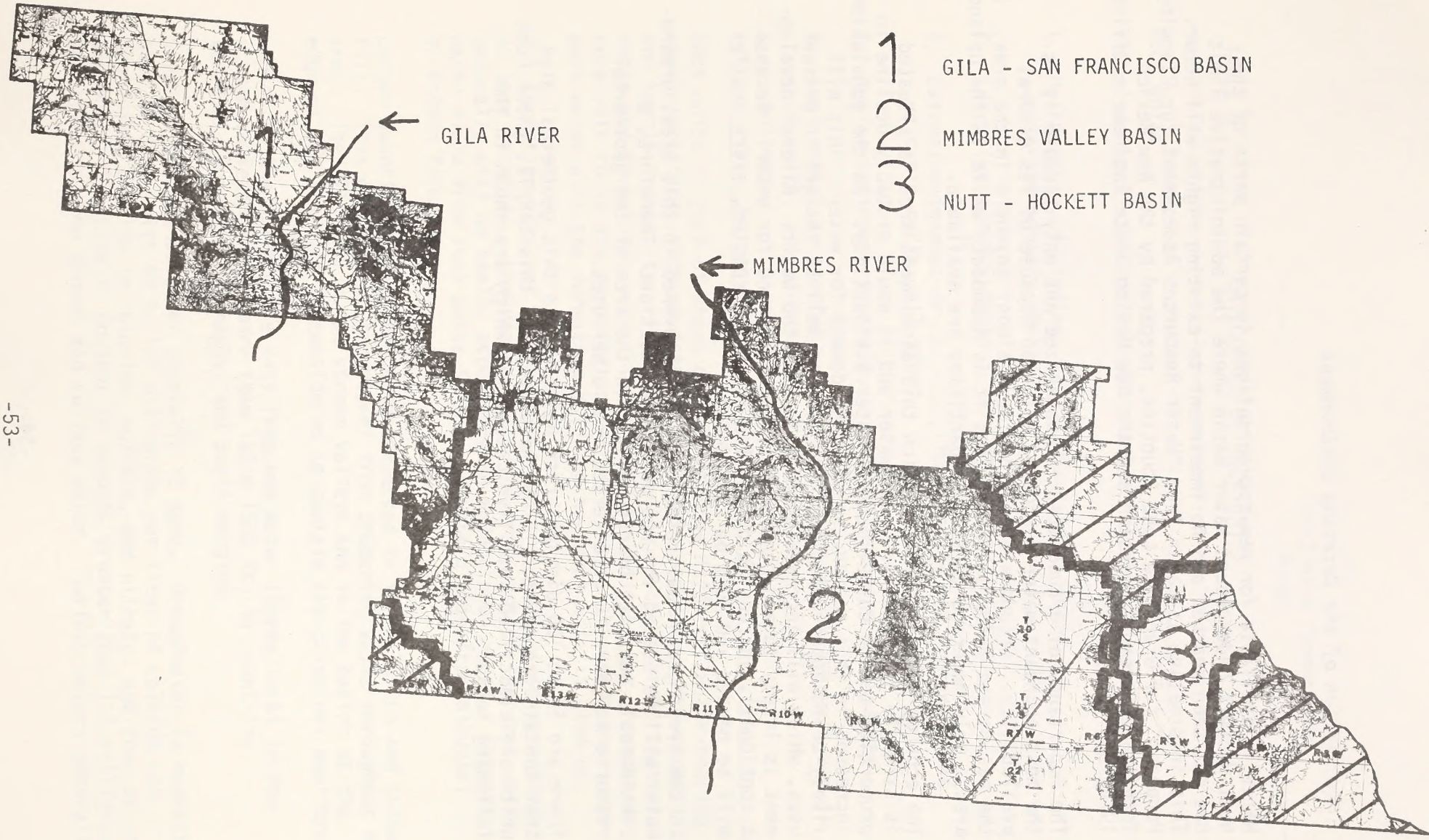


FIGURE 8 - UNDERGROUND WATER BASINS

Water is available for new appropriations in certain parts of the Nutt-Hackett Underground Water Basin where the administrative limit has not been reached and no impairment to existing rights will occur. This information is taken from "Water Resources Assessment for Planning Purposes" for Grant and Luna Counties, prepared by the New Mexico Interstate Stream Commission and the New Mexico State Engineer's Office, 1974, and 1975.

The importance of groundwater is emphasized not only because it is the most abundant water resrouce, but also because of its general availability. Groundwater can be found almost anywhere in the area. In the basins and major stream valleys it is abundant; while in the upland areas, only moderate to meager quantities are available.

The economy of the region in which this assessment area is situated is strongly dependent on groundwater and it would probably decline in proportion to any curtailment of water availability. As the population increases in this region, so will the demand for water. This will likely bring about additional new uses as well as changes in present uses, which will increase competition for the water. Mineral development is likely to add considerably to the demand for water. Because a continually increasing demand for water is expected, every aquifer will be needed and must be considered.

In the event geothermal resources are discovered in this area, groundwater will be needed for operational production. Therefore, a considerable quantity of groundwater in the area of the geothermal resource may have to be diverted from other uses.

There are 50 to 100 distinct rock units within this geothermal area that contain groundwater. For the purpose of this EAR/TE, these rock units are classified into five categories which are shown in the following table.

TABLE 6 CATEGORIES OF ROCK UNITS

Rock Units	Occurrences
1. Metamorphic, including meta-sedimentary rocks	Mountainous areas
2. Intrusive igneous rocks	Mountainous areas
3. Extrusive igneous or volcanic rocks, all types	Mountainous and lowland areas, mostly mountainous
4. Marine Sedimentary strata	Mountainous and basin areas
5. Continental sedimentary deposits, alluvium and bolsoms	In upland stream channels and in basins

Rock units in each of these categories have different water-bearing characteristics, such as intake (recharge), porosity and permeability, and specific capacity. This is because the physical properties of the rocks and formations vary. The important qualities for groundwater reservoir rocks are porosity and permeability. The question is how much water will the formation hold and how much will it give up.

All formations present in the geothermal area will yield groundwater at some location. However, water yeild from most of the rock units generally will be small, especially in mountainous areas. Groundwater yield from rock units is more uncertain than from alluvial or bolson formations.

Larger quantities of water can be expected in the alluvium and bolson fill. This correlation is evident from producing wells throughout the area. The alluvium in the stream valleys and in the basins at the edge of the area can be considered to contain the principal aquifers.

Depths to the water table vary from one meter (three feet) in the stream valleys down to more than 152 m (500 ft) in mountains terrains, mountain pediments, and basin margins.

Chemical quality of water generally is good. Groundwater is moderately hard to hard, with 60 to 120 milligrams per liter of calcium and magnesium, but low in chloride, sulfate, and nitrate, and free of color and odor. Fluoride is present in amounts greater than 1.5 milligrams per liter in some ground and surface water. Surface waters generally

contain about the same, or slightly more, dissolved solids than groundwater. Analyses of water from the principal hot springs indicate that the fluoride content of some of the spring waters is somewhat higher than is considered optimum for domestic use (Trauger, 1972).

The need for groundwater varies greatly throughout the area. The support of wildlife and domestic livestock requires only small quantities of water. These requirements are constant throughout the area. Urban use is greater, and can reach 7570 l (2,000 gal) per minute in communities such as Silver City. These demands are localized. The mineral industry requires large volumes of water within specific localized areas such as in Hurley or Tyrone. Farming also requires large quantities of water for localized use in the larger stream valleys (Gila and Mimbres Valleys).

Data for the period 1960 to 1965 for Grant County show that the mining industry used about 11,000 acre-feet of water, agriculture used about 9,500 acre-feet for irrigation, and the cities used about 1,500 acre-feet (ibid).

The importance of groundwater within this assessment area is illustrated by more than 1,600 water wells that are presently in use. Moreover, the large number of wells and numerous springs, including about a dozen large ones, are indicators of a copious supply of available groundwater. Further information on well depths, water levels, etc., can be obtained from "Water Resources and General Geology of Grant County," New Mexico, Trauger, 1975.

In summary, groundwater can be found almost everywhere in the unit. However, since most of the water resources have already been appropriated, the availability of water for use is limited. Compliance with all State laws by obtaining permits required by the Oil Conservation Commission or State Engineer will be necessary before drilling for or using any ground or surface waters for any purposes.

B. Living Components

1. Vegetation

The vegetation found within the assessment area varies considerably. Primary factors causing difference are elevation, rainfall, and soils. Variations within a vegetative type are also prevalent. The differences found in plant composition and density from one location to another have been caused by past grazing use. The major vegetative types as shown in Figure 9 will be discussed with regard to major species. Since most of the area is private or State land, very little inventory data is available. Vegetative types outlined are: grassland, pinon-juniper-grassland, oakbrush-grassland, creosotebush, mesquite-mesquite-grassland, desert shrub, and riparian-farmland.

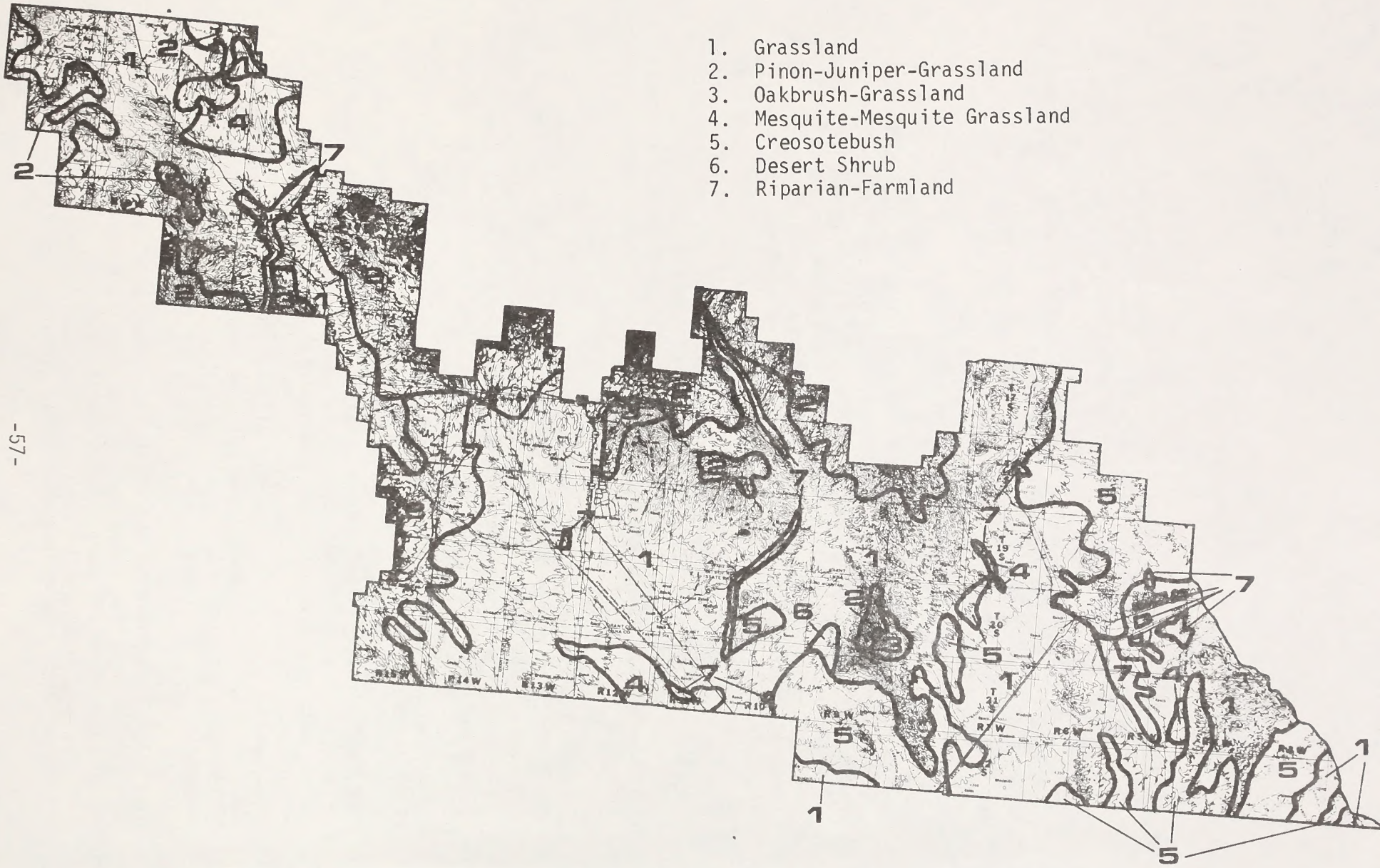


FIGURE 9 VEGETATIVE TYPES

a. Aquatic Vegetation

No attempt was made to identify locations where aquatic plants may be found. No doubt this vegetation will be found in many of the stockwater and irrigation reservoirs as well as in some locations along the Gila and Mimbres Rivers. Species typical of these sites are cattails, *Typha spp.*, sedges, *Carex spp.*, rushes, *Juncus spp.*, as well as some floating vascular plants. Phytoplankton and species of algae may also be present.

b. Terrestrial Vegetation

(1) Grassland Type

This vegetative type is found on nearly two-thirds of the assessment area. Different species are dominant at the various elevation levels. Tobosa, *Hilaria mutica*, is the predominant species on the lower flat lands. The gramas, blue grama, *Bouteloua gracilis*, hairy grama, *Bouteloua hirsuta*, black grama, *Bouteloua eripoda*, and sideoats grama, *Bouteloua curtipendula*, are the dominant species found in the higher elevation sites of the foothills and mountains.

The tobosa flats or draws, so called because of the dominance of this vegetative species, are normally found on the sites of the heavier soils. These may be nearly pure stands of tobosa or a dominance of this species in association with numerous other species, depending upon the location.

Tobosa range in excellent condition will also have a substantial amount of blue grama, sideoats grama, and vine mesquite, *Panicum obtusum*, in the lower-lying areas. Black grama and sand dropseed, *Sporobolus cryptandrus*, are found on the higher, sandier sites within this vegetative type. Tobosa range that is in poorer condition has been invaded by species such as burrograss, *Scleropogon brevifolius*, three-awns, *Aristida spp.*, ring muhly, *Muhlenbergia torreyi*, and fluffgrass, *Tridens puchellus*.

The more alkaline sites within the type normally have an abundance of alkali sacaton, *Sporobolus airoides*. Overflow areas, or sites which receive extra moisture from run-off, quite often have good stands of sacaton, *Sporobolus wrightii*. Soaptree yucca, *Yucca elata*, is commonly found in association with tobosa grass. Shrub or brush species which have invaded include snakeweed, *Xanthocephalum microcephalum*, mesquite, *Prosopis juliflora*, and tarbush, *Flourensia cernua*.

The grass type found in the foothill or mountain terrain is primarily short-grass species, but also includes many species which are in the mid-grass category. Range in excellent condition includes numerous species, but is dominated by blue grama, hairy grama, sideoats grama, and black grama, depending upon soil, aspect, or elevation. Two grama

species found, which are limited in occurrence, are slender grama, *Bouteloua filiformis,* found in the extreme northwest part of the assessment area, and rothrock grama, *Bouteloua rothrockii,* found in the southwest part of the area. This latter species is an indicator of range condition; as it increases, the more desirable species decrease.

Two other grass species which can be found on the wetter sites are little bluestem, *Andropogon scoparius,* and cane bluestem, *Andropogon barbinodis.* Pine dropseed, *Blepharoneuron tricholepis,* needlegrass, *Stipa spp.,* muhlys, *Muhlenbergia spp.,* and plains lovegrass, *Eragrostis intermedia,* can be found at the higher elevations. Three species which occur to a limited extent at various locations are curly mesquite, *Hilaria belangeri,* wolftail, *Lycurus phleoides,* and Arizona cottontop, *Digitatia californica.*

Range which is in poorer condition has an abundance of the less desirable species which include the three-awns, fluffgrass, burrograss, and ring muhly. Numerous shrubs or bush species are found in association with these grasslands. Some are found because of invasion, and are indicators of range condition, while others occur as a part of the natural vegetation found on these sites. If a more intensive analysis of vegetative types were made, these would probably be delineated as a desert shrub-grassland type. Major species which are indicators of range condition are snakeweed, creosotebush, *Larrea tridentata,* mesquite, sacahuista, *Nolina microcarpa,* and, in the southwest part of the assessment area, burroweed, *Haplopappus tenuisectus.* Shrubs and brush included in the natural vegetation of the area are numerous, and their occurrence is usually dependent upon soils, rainfall, aspect, and elevation. These include: crucifixion thorn, *Koeberlina spinosa,* Mormon tea, *Ephedra trifurca,* white thorn, *acacia constricta,* catclaw, *Acacia greggii,* false mesquite, *Calliandra eriophylla,* Spanish dagger, *Yucca baccata,* sotol, *Dasylirion wheeleri,* ocotillo, *Fouquieria splendens,* skunkbush, *Rhus spp.,* agave, *Agave spp.,* cholla, *Opuntia imbricata,* and desert spice bush, *Aloysia wrightii.*

Winterfat, *Ceratoides lanata,* four-wing saltbush, *Atriplex canescens,* and sand sage, *Artemisia filifolia,* also grow in the assessment area. These brush species indicate range in good condition when found in association with grassland.

(2) Pinon-juniper-grassland Type

This vegetative type is found on slightly less than 15 percent of the assessment area. For the most part, this type occurs at the higher elevations. On some sites, junipers, *Juniperus spp.,* grow in nearly pure stands. Other sites have junipers

in association with pinon pine, *Pinus edulis,* or pinon and grassland. The grass species found are similar to those previously described for the grassland type. Some ponderosa pine, *Pinus ponderosa,* are found on the north facing slopes at the higher elevations.

Some of the other species found in this type include oakbrush, *Quercus spp.,* cliff rose, *Cowania spp.,* wolfberry, *Cycium spp.,* mountain mohagany, *Cercoparpus montanus,* and most of the shrub and brush species mentioned previously. Several brush species found mainly in the draws or drainage-ways are rabbitbrush, *Chrysothamnus nauseosus,* desert willow, *Chilopsis linearis,* Apache plume, *Fallugia paradoxa,* and burrobush, *Hymenoclea mongyra.* Many of these species are also found at the lower elevations growing in association with the grassland species.

(3) Oakbrush-grassland Type

This vegetative type covers slightly more than 5 percent of the total area. It is found on terrain which is slightly lower in elevation than the pinon-juniper-grassland type, and it frequently adjoins the latter. The species occurring on this type are nearly identical to those found in pinon-juniper-grassland. The primary difference is that oakbrush is the dominant species on these sites.

(4) Mesquite-mesquite Grassland Type

This vegetative type covers less than 3 percent of the assessment area. It has been delineated as the mesquite-mesquite grassland type because of a distinct difference. Although all the area has an aspect of mesquite being dominant, there is considerable variation within the type. The mesquite in the northwest part of the assessment area has a good understory of grass species. The grass species found here are similar to those on the adjoining grassland type. The undesirable grass species are more prevalent, however, and range condition is deteriorating as a result of the invasion of mesquite.

The rest of the mesquite is located in the southern and eastern part of the assessment area. Here, dune-type mesquite is present along with such species as four-wing saltbush, snakeweed, soaptree yucca, and Mormon tea. Grass species growing include black grama, tobosa, mesa dropseed, *Sporobolus flexuosus,* and spike dropseed, *Sporobolus contractus.*

(5) Creosotebush Type

This vegetative type makes up over 10 percent of the total area. It is found primarily in the southeastern part of

the assessment area on nearly flat to moderately sloping sites. The flatter sites tend to be nearly pure stands of creosotebush. However, other species are present, including: bush muhly, *Muhlenbergia porteri,* tobosa, black grama, burrograss, mariola, *Parthenium incanum,* and range ratany, *Krameria parvifolia.* On the sites with steeper slopes, most of the above mentioned species are also present along with fluffgrass, and, in isolated areas, ocotillo, whitethorn, catclaw, and prickleaf, *Dyssodia acerosa,* soaptree yucca, Spanish dagger, and numerous species of cacti.

(6) Desert Shrub Type

There is only one small area which was delineated as a desert shrub type, and it makes up less than 1 percent of the total area. This site is located west of Cook's Peak. It contains numerous shrubs, none of which are dominant, including soaptree yucca, Mormon tea, mesquite, creosotebush, snakeweed, and desert willow. What was probably once good grassland has only a few scattered black grama and tobosa plants remaining.

All the above described vegetative types have numerous annual grasses and forbs which grow at various times of the year, depending upon available moisture. Various species of cacti and other plants not listed also occur over most of the area.

(7) Riparian-Farmland

This type makes up between 1 and 2 percent of the total area. No attempt was made to differentiate between the riparian vegetation and the farmland which occurs along the Gila and Mimbres Rivers. Other farmland has been delineated and shown in Figure 8. Some isolated small sites are not shown because the scale of the map used is too small.

Most of the native vegetation along the Gila and Mimbres Rivers is deciduous trees, such as cottonwood, *Populus fremontii,* velvet ash, *Fraxinus velutina,* and box elder, *Acer negundo.* Other species which are probably present at some locations include seepwillow, *Baccharis glutinosa,* Goodding willow, *Salix gooddingi,* walnut, *Juglans spp.,* oak, *Quercus spp.,*and numerous species of grasses, forbs, and shrubs.

Most of the farmland along the Gila and Mimbres Rivers is used for growing forage crops, and is then either grazed or harvested for livestock feed. Other land is used for growing apples and vegetable crops. A completely different type of farming operation is found in the Uvas Valley and at other scattered locations. In the Uvas Valley, the primary use of the land is for growing cash crops, which

include cotton, lettuce, tomatoes, chili peppers, grain sorghum, alfalfa, and corn. Much of the corn is harvested for silage, and, along with alfalfa and grain crops, is used in nearby livestock feeding operations. Some land which was once farmed, but has not been tilled in recent years, supports nearly pure stands of Russian thistle, *Salsola kali*.

c. Endangered and Threatened Plants

A proposed list of endangered and threatened plant species, prepared by the Smithsonian Institute, was published in the Federal Register on July 1, 1975 (Vol. 40, No. 127, Part V). As a result of comments on this list, the U. S. Fish and Wildlife Service published a second proposed list of endangered or threatened plant species in the Federal Register on June 16, 1976, (Vol. 41, No. 117, Part IV). The proposed rules for protection of these species were published in the Federal Register June 7, 1976, (Vol. 41, No. 110, Part III).

An inventory of endantered and threatened plant species within the assessment area has not been completed. Information furnished by the New Mexico State Heritage Program shows the following species have been found. The approximate locations are shown on Figure 10.

1. *Aletes filifolius*
2. *Mammillaria orestera*
3. *Pediocactus papyracanthus*
4. *Eriogonum densum*
5. *Scrophylariaceae macrantha*
6. *Helianthus laciniatus spp. crenatus*
7. *Draba mogollonica*

Several species occurring on a suggested State list may be found at various locations. These are listed below:

Agastache mearnsii	Burro and Pinos Altos Mtns.
Agastache cana	Santa Rita area
Brickellia chenopodina	Near Cliff
Encelia scaposa	Hills, between Mimbres & Rio Grande
Hymenoxys olivacea	Hanover Hills
Impomopsis pringlei	Santa Rita area
Senecio oresbius	Pinos Altos Mountains
Senecio thurberi	Santa Rita area

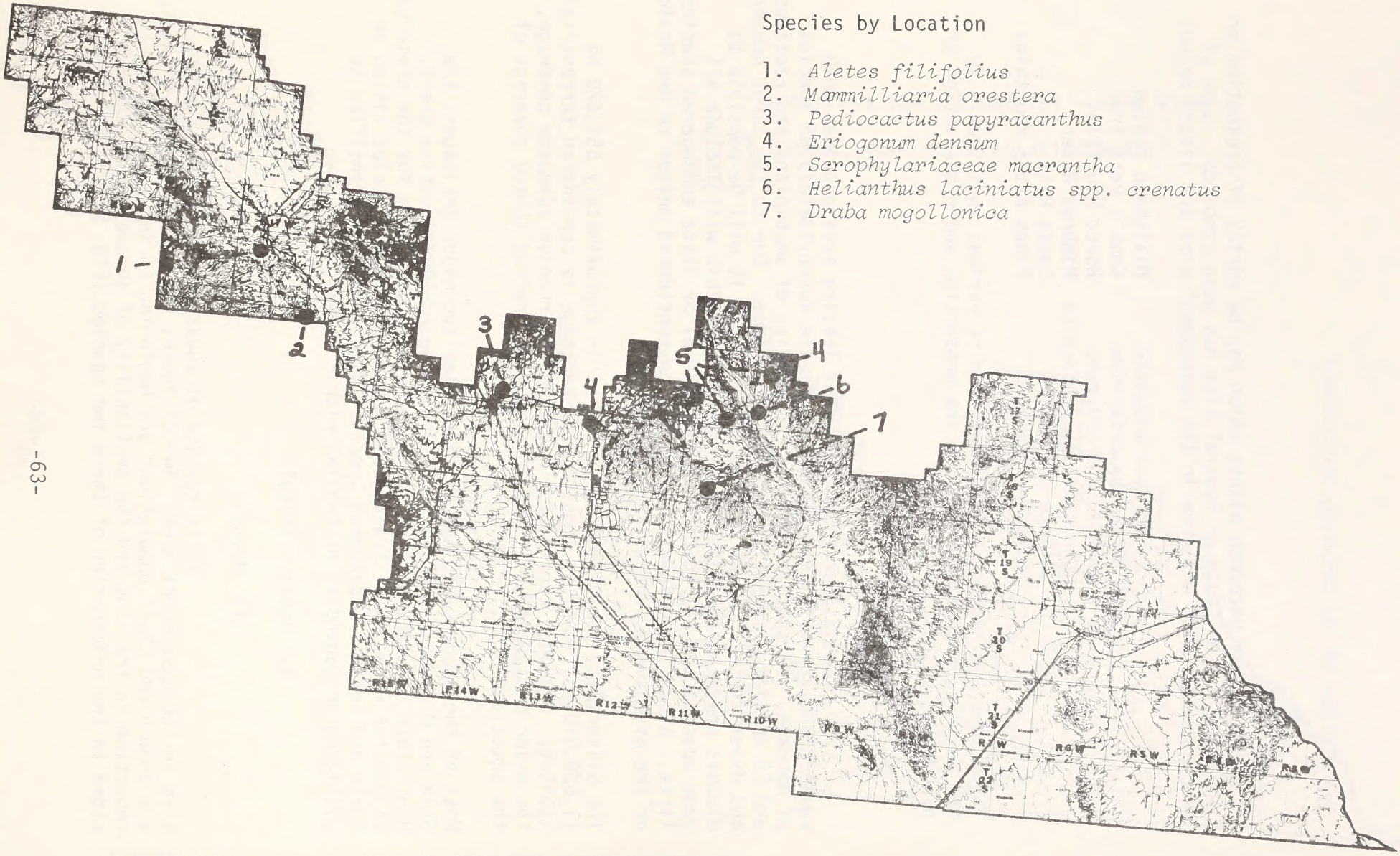


FIGURE 10 ENDANGERED AND THREATENED PLANTS

Also, a list of uncommon plants which may be worthy of protection or inclusion on the State or Federal list has been compiled. Some of these plants which may grow in the assessment area are listed below:

Andropogon wrightii	Hillsboro region
Cupressus arizonica	Cook's Peak area
Mamillaria orestera	Burro Mountains
Oenothera amplexicaulis	Mimbres River
Silene wrightii	Santa Rita
Talinum humile	Pinos Altos Mountains

These last two lists have been compiled by various individuals in New Mexico who are interested in the protection and preservation of plants.

2. Animals

The Silver City geothermal leasing area provides both aquatic and terrestrial habitat. There are approximately 85 species of mammals, 293 species of birds, 62 species of amphibians and reptiles, and 15 species of fish in the assessment area. Due to the large number and diversity of species present in the area, it will be possible to discuss only those species of significance. This will include all game species and all species on the Federal or State endangered species lists. Also, those species which may be considered unique to New Mexico or the assessment area will be discussed.

The Silver City geothermal leasing area is approximately 659,620 ha (1,629,910 ac) in size. Most of this acreage is considered terrestrial habitat. Although terrestrial habitat will receive adequate coverage, the major portion of this section will be directed toward coverage of the aquatic habitat.

Most of the aquatic habitat is within the two major drainages, the Gila and Mimbres River Valleys. These are highly sensitive areas. Many State and Federal agencies have expressed concern for the preservation of habitat along these drainages. Approximately 32 species listed on State and Federal endangered species lists have been identified as utilizing or depending on habitat within these drainages.

a. Aquatic Animals

(1) Mammals

Three species of aquatic mammals are known to live in the assessment area. Two of these, the beaver and the muskrat, are common and their populations are beginning to increase. The reduction in trapping and the availability of adequate habitat have aided in the propagation of these two species.(Fig. 11).

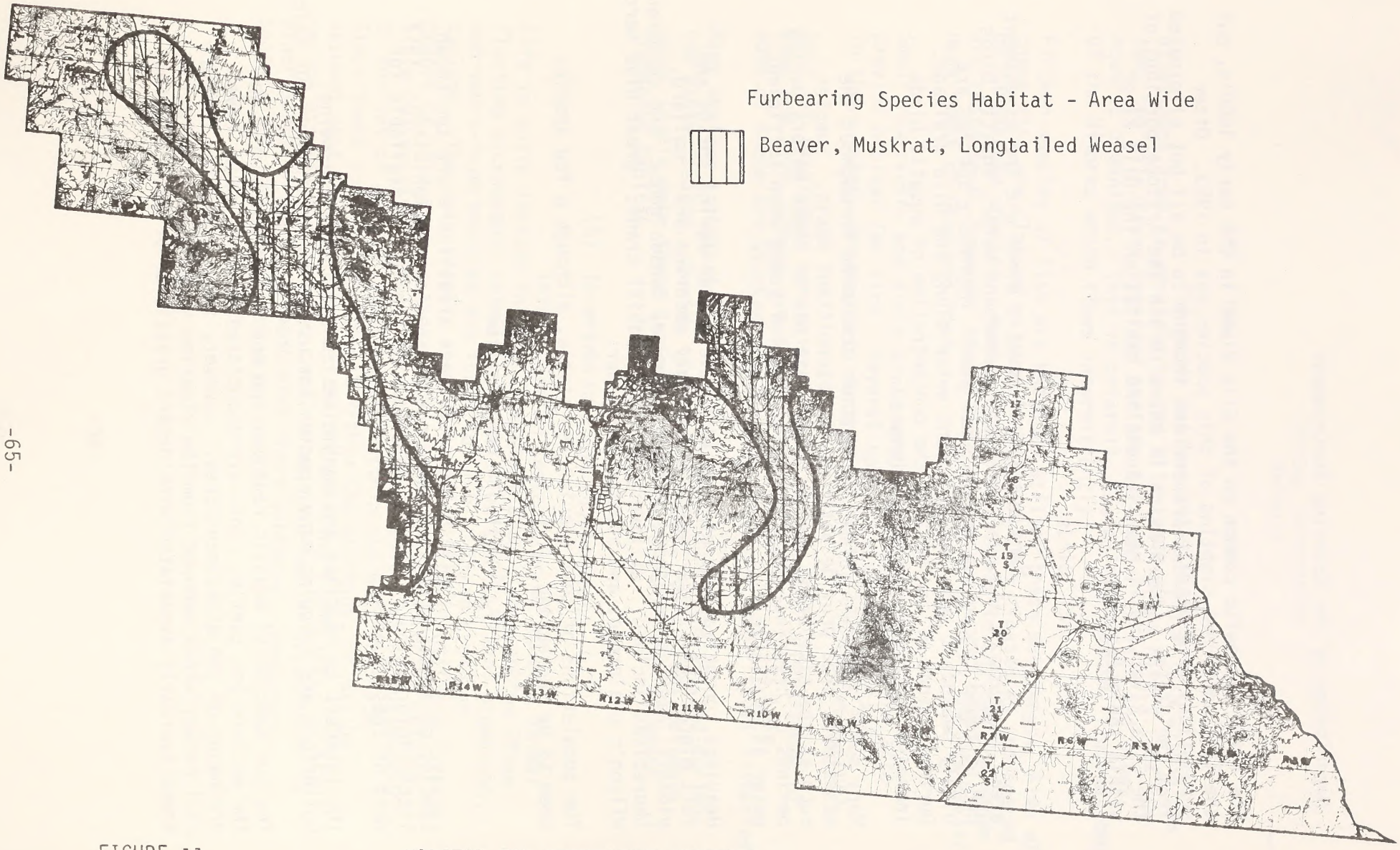


FIGURE 11 HABITAT FOR FURBEARING MAMMALS

The otter was quite common on the Gila River in the early 1900's, but the last confirmed sighting of this species was in 1953. Otter populations were heavily trapped and thought to be all but eliminated from the State. This species is known to use the Arizona portions of the Gila River and it may also utilize habitat on the Gila River within the assessment area.

(2) Birds

Many species of aquatic birds use the assessment area. Because of the availability of permanent water, aquatic birds can be found throughout the area all year. Migratory species are highly dependent upon the permanent water along the Gila drainage. During periods of irrigation, the concentration of aquatic birds increases within the major drainages.

Many small drainages, creeks, and ponds scattered throughout the assessment area provide water on an intermittent basis. Species such as the blue heron, and killdeer make use of these waters during periods of breeding, nesting, and rearing of young when sufficient water is available.

Heaviest concentrations of aquatic species occur during spring and fall migrations. Waterfowl most commonly observed are: mallard, pintail, American widgeon, common goldeneye, Canada goose, and cormorant. Shorebirds include: killdeer, greater sandhill crane, great blue heron, Wilson's phalarope, and spotted sandpiper.

The populations of most species are stable, although a few species seem to be increasing.

(3) Amphibians and Reptiles

Within the assessment area, there are two known species of aquatic reptiles and about 12 species of amphibians. Very little information on population status or density is available for most of these species.

The interest in reptiles and amphibians is continuously growing. Collectors are trapping many species for use in collections or for sale.

The two species of aquatic reptiles are the Sonora mud turtle and the western box turtle. Both are associated with the major river drainages of the assessment area. However, the western box turtle will occupy areas removed from the riparian vegetative association, areas typically associated with desert grasslands or open woodlands.

(4) Fish

The major habitat available for fish within the assessment area is provided by the Gila and Mimbres Rivers. Of the two, the Gila River provides the greater number of fish and other aquatic organisms. This is priarmily due to the seasonal fluctuations of the Mimbres which flows intermittently.

Fifteen species of fish are known to utilize these waterways. Five of these fish are classed as game fish and six are classed as endangered or threatened species. Most of the fish present in the two drainages are indigenous, however, others have been introduced by the New Mexico Department of Game and Fish.

Small reservoirs and stock tanks within the assessment area also provide habitat for fish. Several species have been stocked in these waters for mosquito control or aquatic vegetation control.

Only two reservoirs are maintained by the New Mexico Department of Game and Fish. These are Bear Canyon Dam and Bill Evans Lake. Both of these are stocked on a regular basis to supply sport fisheries.

Many smaller tributaries of the Gila and Mimbres are stocked during the winter season. During the summer season, lower, less reliable water levels make these drainages very questionable for adequate fisheries habitat.

(5) Invertebrates and Zooplankton

Information on these forms of aquatic animal life is quite limited for the assessment area. Zooplankton (free floating microscopic animals), benthic (bottom dwelling) organisms, and macro-invertebrates are known to live in these drainage systems. The only readily available publication identifying invertebrates of this area is an inventory which was prepared by Arizona State University in 1972. This inventory identifies approximately 35 species of aquatic invertebrates within the Gila drainage. Since these species are present within the drainage, it may be assumed that they are utilized by the existing fisheries. It also may be assumed that aquatic communities have become established in other parts of the assessment area where ephemeral, temporary, seasonal, or semi-permanent water exists.

b. Terrestrial Animals

(1) Mammals

There are approximately 84 species of terrestrial mammals known to occur within the assessment area. Many of the species occurring within this Upper Sonoran area have special xeric adaptations. Some are of the burrowing type and some restrict their activities to early morning, late evening, and night.

The distribution of mammals within the assessment area is directly related to habitat availability or the availability of a specific habitat feature. Some species are restricted in their distribution while others are more wide-ranging. Soils, vegetation, topography, water availability, and other factors are all involved in the regulation of species distribution.

(a) Game Mammals

Mammals inhabiting the area that are considered of special interest include those classified as "game." A discussion of these follows:

i. Mule Deer

Mule deer are native to the area and may be found in any of the major biotic communities identified. Areas that provide the most suitable habitat are: the Burro Mountains, Santa Rita Mountains, the western slope of the Black Range, and that portion of the assessment area that borders the Gila National Forest. Mule deer habitat within these areas is considered fair to good. Population numbers are considered stable in most areas except in the Black Range where the population is decreasing.

Certain portions of the previously mentioned areas provide crucial habitat for deer. The Black Range is an area of special concern due to the importance of the area as winter range. The major drainages of the Gila and Mimbres Rivers are also important wintering areas, especially during periods of high snowfall (Fig. 12).

ii. Coues' Whitetail

Coues' or Sonoran whitetail occur throughout the Gila drainage and are scattered along the Mimbres drainage as far east as the Black Range and as far south as the border. Very little information is currently available on the population; however, the population is believed to be stable.

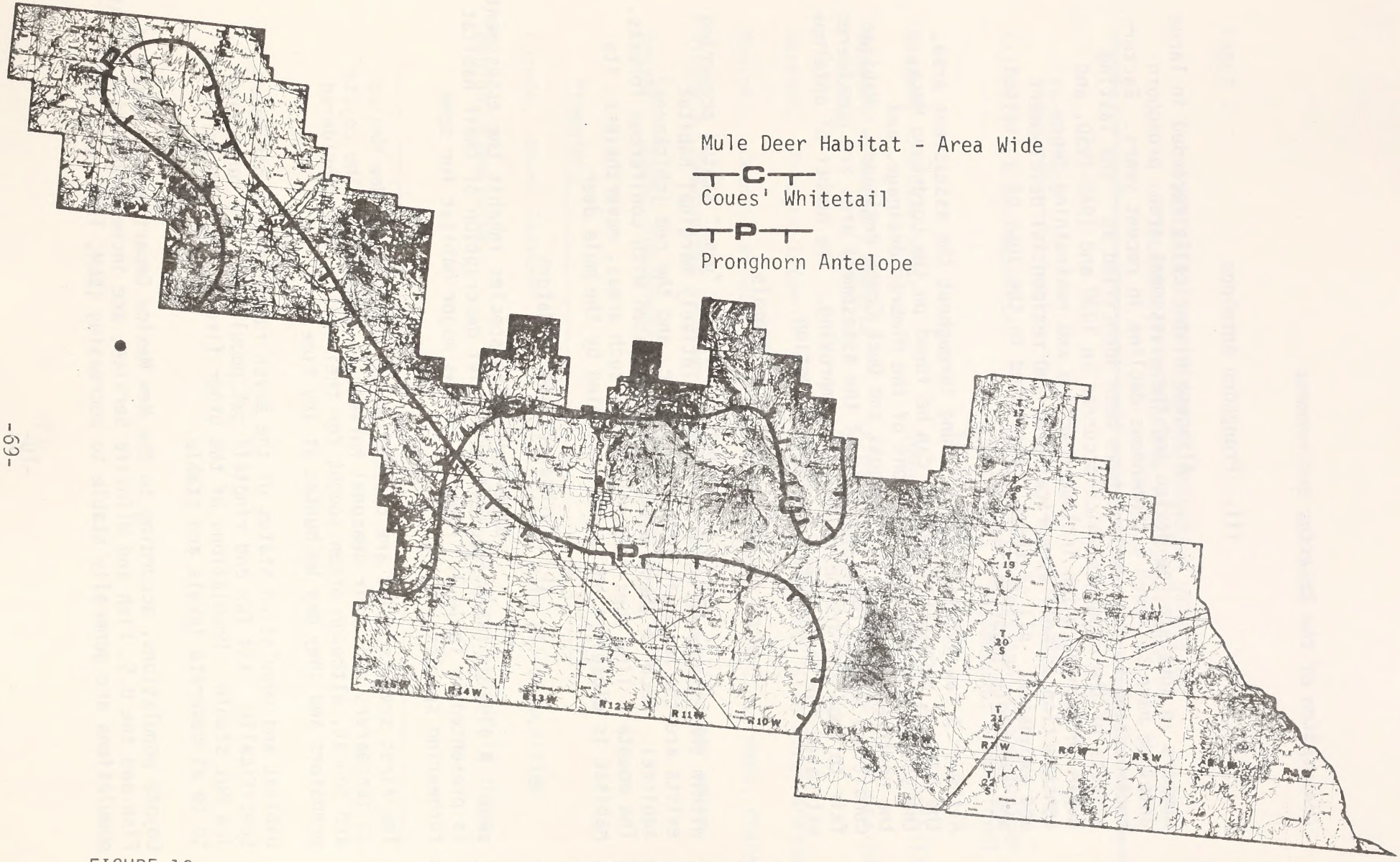


FIGURE 12 HABITAT FOR IMPORTANT GAME MAMMALS

iii. Pronghorn Antelope

Although historically recorded in large numbers in southern New Mexico and the assessment area, pronghorn antelope have suffered a tremendous decline in recent years. Factors contributing to this decline have been identified as the lasting effects of the droughts which occurred in 1930 and 1949-1950, and human influences which include poaching and restraining fence construction as well as agricultural and residential development and expansion. All of these contributed to the loss of a limited and extremely important habitat.

Although a few antelope can be found throughout the assessment area, the highest population density can be found on the Lordsburg Mesa, the southern and eastern portions of the Mimbres drainage, and the northwestern portion of Mangas and Duck Creek drainages. Habitat conditions within these portions of the assessment area are considered fair to good and are believed to be improving. The number of antelope estimated for these areas is one per section.

iv. Other Game Mammals

Other mammals of "game" status occurring within the assessment area for which relatively marginal habitat exists are the mountain lion, black bear, and the red (chickaree) squirrel. Each of these animals is associated with coniferous forests. The mountain lion does range away from such areas; nevertheless, its habitat is closely tied to that occupied by the mule deer.

(b) Furbearers and Predators

Nine furbearing species inhabit the assessment area. A list of these species and a brief description of their habitat is presented in Table 7. Figure 12 shows major habitat for some furbearing species.

The first seven species are classified by the State of New Mexico as furbearers and their seasonal harvest is regulated. The coyote and bobcat, although often sought for their pelts, are considered predators and they may be hunted at any time.

Habitat and population status of the seven furbearers is not known specifically. Kit fox and ringtail cat populations are considered low but stable. Populations of the other five species are believed to be at moderate levels and stable.

Coyote populations, according to the New Mexico Department of Game and Fish and the U.S. Fish and Wildlife Service, are increasing, while bobcat populations are generally stable to decreasing (BLM, 1974, and 1975).

TABLE 7

FURBEARERS AND PREDATORS OCCURRING WITHIN THE SILVER CITY GEOTHERMAL ASSESSMENT AREA

Furbearers	Habitat
Kit Fox, *Vulpes macrotis*	Low desert vegetation; pinon-juniper grassland; creosotebush; open, level sandy ground
Badger, *Taxidea taxus*	Open grasslands and mountain foothills
Longtailed Weasel, *Mustela frenata*	Riparian woodlands, Gila River drainage Mimbres River drainage
Raccoon, *Procyon lotor*	Riparian woodlands, Gila River drainage
Muskrat, *Ondatra zibethica*	Marshes, ponds, lakes, streams, channels
Ringtail, *Bassariscus astutus*	Rocky ridges and cliffs near water
Beaver, *Castor canadensis*	Gila River Drainages
Predators	**Habitat**
Coyote, *Canis latrans*	Associated with all communities
Bobcat, *Lynx rufus*	Rimrock, chaparral, mountain shrub

(c) Other Mammals

In addition to the previously mentioned animal species, numerous other terrestrial mammals inhabit the assessment area. Those commonly observed include the cottontail rabbit, blacktailed jackrabbit, bannertailed kangaroo rat, and striped skunks. Others common to the area but not so frequently observed include the spotted skunk, several species of bats, ground squirrels, mice, and other rodents.

Several species of livestock are raised in the area. Cattle and horses are the most common livestock in the assessment area. A few domestic sheep, goats, and swine are raised on private lands.

(2) Birds

Terrestrial birdlife of special significance includes those of "game" status and resident and wintering birds of prey (raptors). The wintering populations of other species of migratory birds are highly dependent upon habitat provided within the assessment area (refer to Figure 13).

(a) Game Birds

i. Quail

Gambel's quail and scaled (blue) quail are abundant in the assessment area (Fig. 13). Each carries game status and is highly sought by hunters. The Gamel's and scaled quail are well distributed on terrain below 2,100 m (7,000 ft) elevation, and are quite numerous throughout the assessment area. Mearns' quail are found associated with the hither elevations, generally above 1,500 m (5,000 ft), in the foothill areas of the Black Range.

Gambel's and scaled quail populations within this area are high. A combined estimate of population density for both species is 29 birds/km^2 (80 birds/section) during high years and 3.6 birds/km^2 (10 birds/section) during low years.

Estimates of population density for Mearns' quail have not been indicated. State Game and Fish personnel believe that population densities may be higher than estimated because of the remote nature of the habitat they occupy and because of the instinctive "freezing" (not flushing) behavior of this species. Since they are difficult to see, they give the impression of being scarce (BLM, 1974 and 1975).

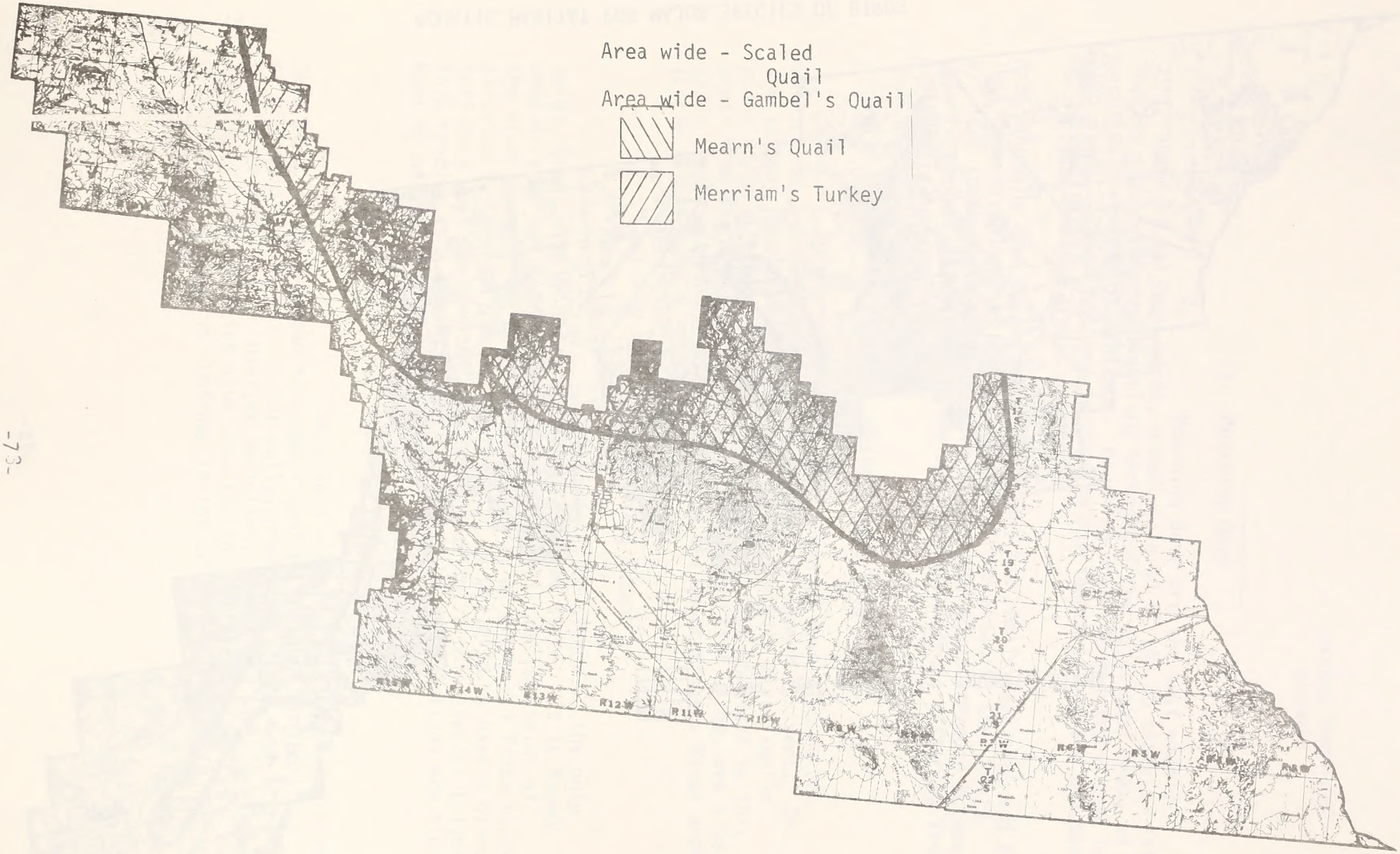


FIGURE 13 TERRESTRIAL HABITAT FOR MAJOR SPECIES OF BIRDS

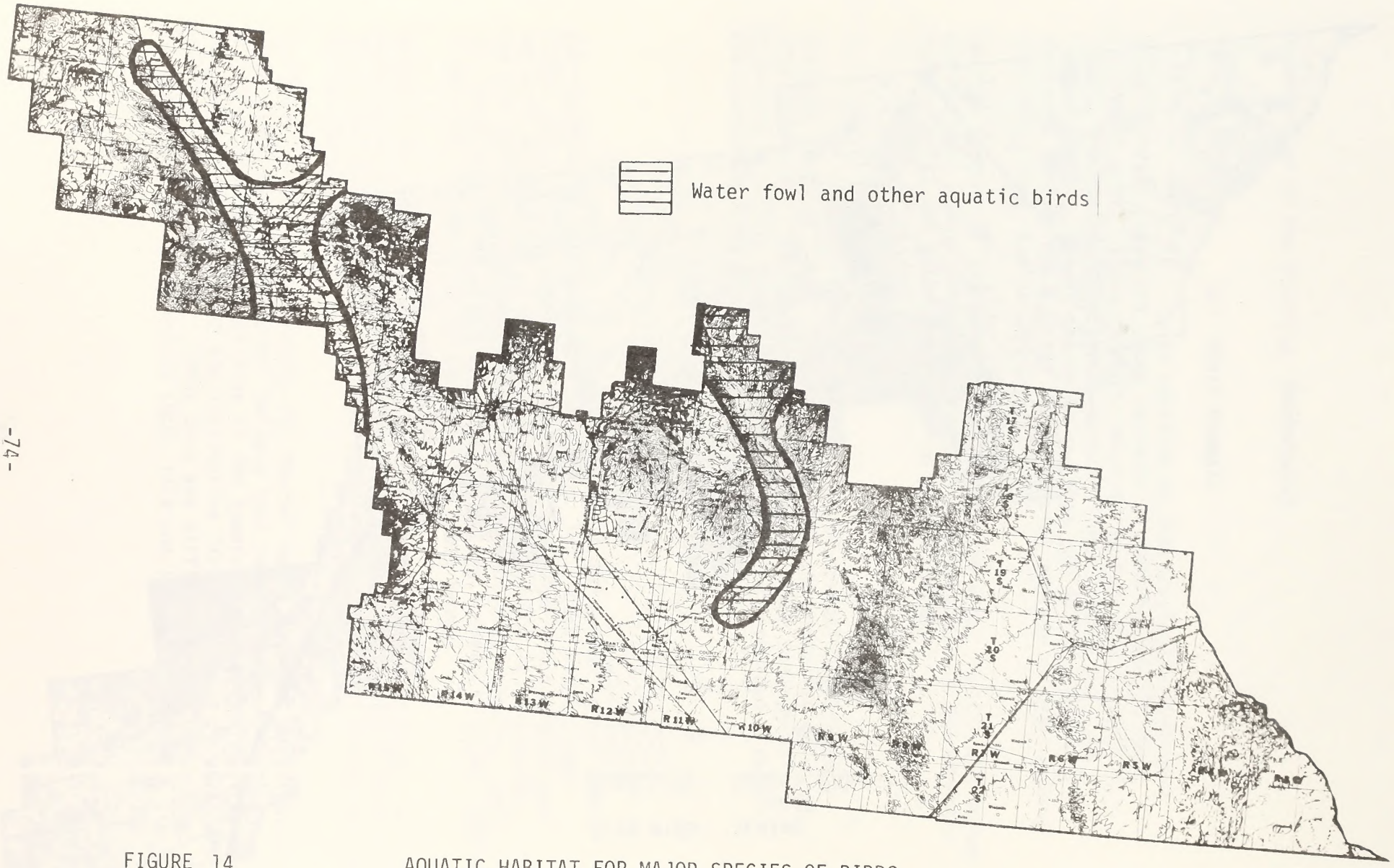


FIGURE 14 AQUATIC HABITAT FOR MAJOR SPECIES OF BIRDS

ii. Mourning Dove

Mourning dove are the most widely distributed of all game birds, breeding in 48 of the 50 states. This species may be observed yearlong throughout the assessment area, as it occupies a variety of habitats. Mourning dove are migratory, and in the spring, warmer days and increasing day length stiumulate movement to northern nesting areas.

Many mourning dove do not leave the area, but remain yearlong, and those leaving are replaced by others migrating from areas further south. A sudden increase in mourning dove occurs from August through October. This represents the return of the adult dove and their offspring from northern regions.

iii. White-winged Dove

The white-winged dove also occurs within the assessment area, but it is only a summer resident. This species may be sighted occasionally along the Gila River and in other riparian habitat. They are considered most abundant in this state from the Mexican border north to beyond Cliff. They are also quite common within the Silver City and the upper Mimbres River area (Ligon, 1961).

iv. Band-tailed Pigeon

The band-tailed pigeon is the only large, true, wild pigeon occurring within the state. It is found around farms and orchards and in the foothills and mountains of the Black Range. The abundance or scarcity of preferred foods (acorns, pinon nuts, cherries, mulberries, etc.,) is believed to have a direct influence upon the abundance and distribution of this species (Ligon, 1961). This species is a highly sought game bird. When populations are high, hunting of this species is permitted.

v. Merriam's Turkey

Merriam's turkey, the largest American game bird, is wide-spread throughout most of the northern portions of the assessment area. Historically, populations were much higher than in present years. Habitat depletion, predation, and uncontrolled hunting are factors which have resulted in a critical situation. Much of the turkey's range is confined to the conifer-oak mountain forests of the southwest.

Due to disruption of winter range as a result of excessive grazing by livestock, the Merriam's turkey has periodically become a species with the problem of scarcity or lack of sustained winter food supplies. The lack of good food supply and water will often bring the turkey down into the lower elevations along the major drainages.

(b) Raptors

Thirty-three species of raptors (birds of prey) have been identified within the assessment area. The most abundant species are the red-tailed hawk, golden eagle, American kestrel, Swainson's hawk, prairie falcon, ferruginous hawk, and marsh hawk (information gathered during 1973 and 1974 by the Public Service Company of New Mexico).

Though little information is available concerning population densities, it is known that the entire area is utilized extensively by these birds of prey all year. Large increases in overall raptor densities occur from October through March as migrants enter the area for the winter (BLM, 1974 and 1975).

(3) Reptiles

Over 50 species of reptiles have been identified as inhabitants of the assessment area. Currently, no consolidated documentation exists for the occurrence and distribution of reptiles in southwestern New Mexico. The Las Cruces District Office of the BLM will soon complete a literature search and museum review for the class *Reptilia* which will consolidate and make available in one document the locations of collections and records of observed species of this class.

(4) Invertebrates

Because numerous varieties of invertebrates occupy the assessment area with little information available on these species, no attempt will be made to discuss numbers or species in this document.

c. Game Species Harvest

Deer (mule deer and Coue's whitetail) harvest and hunter success show steady declines, suggesting declines in population levels. Such declines have been experienced in other areas of New Mexico as well. The establishment of a stratified deer season in 1975 should have benefited deer populations. A more balanced distribution of hunters has been achieved, reducing initial hunting pressures.

Antelope populatons are low in all portions of the assessment area. For this reason, the State Wildlife Agency has closed the region included in the assessment area to antelope hunting.

Quail (Gambel's scaled, and Mearns') harvest statistics reflect fluctuations customarily associated with these species. Current population levels are at or near optimum. Mourning dove harvest statistics also reflect population fluctuations.

d. Endangered and Threatened Animal Species

A "high sensitivity" rating has been given to large portions of this area by both Federal and State agencies, as well as others considered authorities in the field of endangered species. A BLM document is being prepared by the District Wildlife Staff to address the status of species listed by the State of New Mexico or by the Federal government as endangered or threatened. This document entitled Endangered Species of Grant County, consists of a review of literature pertinent to the distribution and status of endangered or threatened faunal species in the assessment area. In addition, people with specific knowledge of endangered species of the same area are being consulted for unpublished data or undocumented information.

Species considered include those classified by Federal and State governments as endangered or threatened. These lists of species were compiled from the list published in the Federal Register on September 26, 1976 by the U. S. Fish and Wildlife Service, and from the list in the New Mexico State Game Commission's Regulation No. 563, adopted January 24, 1975 and amended May 21, 1976.

The completion of this document, "Endangered Species of Grant County," will provide a primary source of information concerning endangered species within the assessment area. The document being prepared does not address critical habitat but does identify regions where these species occur, which undoubtedly defines the habitat for these species.

To determine "essential habitat" for a given species, specific information relative to the vital needs of that species is required. Needs which are most relevant are: space for normal growth; movement, or territorial behavior;nutritional requirements, such as food, water, and minerals; sites for breeding, reproduction, and rearing of offspring; cover or shelter; and other biological, physical, or behavoiral requirements that are deemed vital to the continued existence of endangered or threatened animal species.

It is obvious that comprehensive studies are needed to define, locate, and delineate "essential habitat". These studies are needed most urgently for the species classified endangered and threatened on Federal lists, and then for those classified by the State of New Mexico as endangered or threatened.

C. Ecological Interrelationships

Robert L. Smith (1966) summarizes the basic structure and function of community and ecosystem, and the intricate relationships associated with each, in the following quotation:

> "However the community may be classified, or what methods may be employed to distinguish one community from another, the basic concept remains unchanged. A biotic community is a naturally occurring assemblage of plants and animals living in the same environment, mutually sustaining and interdependent, constantly fixing, utilizing, and dissipating energy. Interacting populations are characterized by constant death and replacement and usually by immigration and emigration of individuals.
>
> The biotic community is a part of a larger whole, the ecosystem, in which the living and the non-living interact to bring about the circulation, transformation, and accumulation of energy and matter. In the non-living, this is accomplished by the physical processes of evaporation, precipitation, erosion and deposition, and the gaseous cycles. In the living, it is accomplished by two components, the autotrophic, which fixes energy by photosynthesis, and the heterotrophic which utilizes and circulates energy and matter through herbivory predation in the broadest sense, and decomposition.
>
> Each organism in the community occupies a particular functional niche at which it arrived by a long process of natural selection and evolution. The more niches there are to occupy, the more complex the community, the greater the diversity of species and the more stable the ecosystem.
>
> Among these species, a few may exert a dominant role over the rest of the community. Usually, plants govern its development and influence the total species composition. The make-up of any one community is determined in part by the species that happen to be distributed on the area and can grow and survive under the prevailing conditions. Thus, an element of chance is involved. The exact species that settle on an area and the number that survive are rarely repeated in any two places at a time, but there is a certain recurring pattern of more or less similar groups.

> Rarely can different groups or communities be sharply delineated, for they blend together to form a sequence of communities gradually changing in composition, known as a continuum. A place where two major communities meet and blend together is called an ecotone.
>
> All communities exhibit some form of layering or stratification, which largely reflects the life form of the plants and which influences the nature and distribution of animal life in the community. Communities most highly stratified offer the richest variety of animal life, for they contain a greater assortment of microhabitats and available niches."

A discussion of the three key processes at work (succession, food relationships, and community relationships) will follow. This discussion will relate the living and non-living components identified in the previous sections. Special consideration will be given to significant relationships whose environmental components might be affected by the proposed action.

1. Succession

Succession is the orderly development of an ecosystem from a pioneer or primary stage to climax. Primary succession is when development begins on an area that has not been previously occupied in a community, and secondary succession is developed in an area where a community did exist and was removed (Odum, 1959).

The following text will consider the present stages of succession, principle changes, invading species, trend, and climax. The discussion will deal primarily with the major biotic communities previously described in the vegetation section.

a. Aquatic Ecosystem

Many of the stock ponds within the assessment area contain water yearlong. These waters contain biota that have evolved through the successional stages.

In the initial stage of succession, the bottoms were barren of plant life. Soon various species of phytoplankton began to inhabit the waters As the microscopic plants and animals died, they settled to the bottom and formed a layer of muck. The muck, once built up, could support rooted submerged aquatic plants. These plants may have included branching green algae, pondweeds, and waterweeds. The rooted plants produced a firm matrix at the bottom of the lake. Sediment from soil erosion reduced the depth of the water, creating a substrate for other

rooted aquatic plants. The succession of many of the dirt tanks which contain a permanent source of water consists of many of these stages, depending on their age and amount of siltation (Smith, 1966).

Other ponds in the assessment area are dry during certain times of the year. Both aquatic and terrestrial succession take place within these ponds, but the stages vary from tank to tank.

Generally, all of the aquatic systems found in the assessment area are influenced by tremendous fluctuations in water levels and large amounts of suspended and deposited sediment. In addition, periodic mechanical maintenance of water edges (i.e., phreatophyte control) and complete reconstruction or maintenance of many dirt stock tanks result in a continuous shifting between secondary succession and regression stages of development.

The Gila River maintains an adequate depth to produce zooplankton, benthic organisms, macro-vertebrates, mussels, and crayfish, as well as algae and other aquatic plants which support other forms of animal life, including fish, waterfowl, shorebirds, mammals, reptiles, and amphibians.

The Mimbres River is dry, or nearly dry, at some times of the year. As a result, aquatic plant and animal life are continually fluctuating, and, again, reflect some stage of secondary succession or regression.

b. Terrestrial Ecosystem

(1) Grassland Ecosystem

The grasslands within the assessment area have undergone some drastic successional changes. The original grasslands have been invaded by creosotebush and mesquite, so that what once was grassland is now composed of all three types of vegetation.

The grassland community develops slowly through primary succession. The successional stages are mainly xeroseres (dry stages) that start on rocky outcrops, sand, or similar strata. The occurrence and plant composition of each stage in the succession is determined largely by the type of soil and its associated habitat factors. Each stage builds up the humus content and water-holding capacity of the soil, thus preparing it for the next stage, until the climax is reached (Campbell, 1931). The climax vegetation of this ecosystem is composed of grama grasses.

In the normal process of succession, annual forbs are the first vascular plants to occupy the sites. Then annual grasses and perennial forbs replace the existing vegetation. Genera represented

in this process include: grama grass, *Bouteloua;* threeawns, *Aristida;* fescues, *Festucae; Pectocarya; Cryptantha;* and lupine, *Lupinus.* Short-lived perennial grasses replace the annual grasses as the ecosystem develops. Rothrock grama, *Bouteloua rothrockii,* and burrograss, *Scleropogon brevifolius,* are important short-lived perennials. These grasses are eventually replaced by long-lived perennials such as broom snakeweed, *Gutierrezia sarothrae;* burroweed, *Aplopappus hartwegii,* brittlebush, *Encelia farinosa;* paper daisy, *Psilostrophe cooperi;* sacaton, *Sporobolus arroides;* tobosa, desert saltgrass, *Distichlis stricta;* and various species of buckwheat, *Eriogonus spp.* The final stage of succession, climax, is represented by plant species such as black grama, tobosa, sideoats grama, and Arizona cottontop. Distribution of these species varies depending on the sites and soil types which they inhabit. Many other plant species occupy small areas within the ecosystem. These consist of creosotebush, four-wing saltbush, blackbrush, *Coleogyne ramosissima,* Mormon tea, mesquite, catclaw, *Acacia greggii,* sotol, *Dasylirion wheeleri,* shrub oak, *Quercus spp.,* mountain mahogany, pinon pine, manzanita, *Arctostaphylos pungins,* squawberry, *Rhus trilobata,* and buckbrush,*Ceanothus spp.* (Whitfield and Beutner, 1938).

The original grassland ecosystem has been greatly altered within the assessment area. Factors such as changes in climate, intensive grazing by domestic livestock, plant competition, rodent competition, soil erosion, and fire have resulted in a successional regression of vast acreages of grassland to a vegetative community now comprised of creosotebush and mesquite (Humphrey, 1958; Norris, 1974, Dick-Peddie, 1961; and Campbell, 1931).

Changes in the ecosystem began to occur with the exploration and settlement of these lands. Cattlemen took advantage of the lush grama grasslands, and deterioration began. The grass plants became weakened from over-utilization and were not able to recover. Overgrazing was not entirely to blame for the deteriorating grassland ecosystem; drought also played an important part. Jardine and Forsling (1922) reported that a severe two-year drought killed 40 percent of the best grazing plants. This reduced the quantity of forage by half. Plants lost were replaced by less desirable plants, causing regression. Valuable cover was lost and did not become re-established immediately because succession requires many years, or even decades, to take place (Campbell, 1931). During the regression, several plants were present that were able to spread and adapt to the conditions within the deteriorated areas (Buffington and Herbel, 1965). Two of these plants were creosotebush and mesquite.

Once a regressive colony was established, its density increased and it gradually spread. The combination of drought, grazing, competition between plants, and soil erosion through wind and water resulted in the steady decline of grass species and an increase in the density of

the hardier creosotebush. The invasion of broom snakeweed, the complete disappearance of grass, the presence of erosional pavement, and the dominance of this shrub over large areas are characteristic of complete takeover of an area by creosotebush. The final results of creosotebush invasion is loss of a grassland climax, loss of many inches of soil through wind and water erosion, and the loss of productive land (habitat) for domestic livestock and wildlife (Gardner, 1951). Drastic changes would have to take place in most areas for grass species to reoccupy these sites. In isolated sites, if the area were protected from grazing, the climatic conditions were favorable, and a source of seed were available, grass species might become reestablished. This is a long, slow process which occurs today in isolated areas where soil erosion was minimal in the past (ibid).

On the other hand, Muller (1940) said that once a creosotebush community is established, a climax is formed. Muller based his belief on the fact that creosotebush is the domiant shrub which occupies a large area even though many other xeric shrubs and herbs are present. A large amount of soil was lost through erosion, and desert pavement now helps protect the soils. The microhabitat which supports the grassland has been destroyed and replaced by a new microhabitat.

Creosotebush is still an active invader of some southern deserts (Gardner, 1951). The process is slow, but valuable acres of grassland are being replaced by creosotebush. This invasion will continue unless measures are taken to halt it (Anderson, 1956).

Mesquite also invades deteriorated rangelands. Mesquite was once confined more to sandy soils of the mesas and heavy soils in the valleys, while creosotebush was found on all soil types (Buffington and Herbel, 1965). Mesquite was already established in isolated areas and had spread into the sites occupied by the early Indian camps (Dick-Peddie, 1961).

Domestic livestock and many wildlife species began utilizing the mesquite beans as the range deteriorated. The plants are now usually found around watering places and along trails due to the fact that the animals ingested the seeds and subsequently dropped them in their feces as they moved from watering to grazing areas. The reduced competition of the dominant grasses released the young mesquite plants, and hastened deterioration of the grassland and dominance by mesquite.

The formation of the mesquite dunes was caused by the breaking up of grasslands by trampling livestock on overstocked ranges. The plants were reduced in size and the soil was loosened. This allowed the wind to pick up the soil from around the grass roots and deposit it around the mesquite shrubs forming dunes (Jardine and Forsling, 1922; and Campbell, 1929). Once range has reached the dune stage, it

is very hard to bring it back to grassland; however, during a three-year period of conservation grazing and ample rainfall, Campbell (1929) was able to trace the stages in recovery of sand dune country.

The mesquite shrub occupies the top of the sand dune. Many plants may be found growing within the protection of the shrub. In years of above average moisture, the plants associated with mesquite begin to revegetate from the north (or sun-protected) side of each dune. The plants become established, produce seed, and may spread into unstable areas of the dune.

Black grama, even though it is a climax species, is very susceptible to grazing. The plant spreads mostly by vegetative reproduction; it is slow to recover because of poor seed production. Broom snakeweed may take over some of the black grama range, but with good moisture and conservative grazing, the black grama range will recover (Campbell and Bomberger, 1934).

Of all the factors causing a change in vegetation within the grassland ecosystem, climate has had the least effect. Fires that were formerly frequent and widespread played a large part in restricting shrub invasion. Since fires have been controlled, the introduction of domestic livestock, plant competition, and rodents have been very effective in enhancing the habitat for woody species at the expense of grasses. Humphrey (1958) indicates that if fire had not been controlled, the grassland would still occupy about the same area as it did in the past.

Dick-Peddie (1961) summarizes the succession of grasslands by saying. . .

> "It may be valid to assume that grass occupied mesa sites on which creosotebush now dominates. However, it would not likely be correct to assume that the present microhabitat is identical or even similar to that which existed under grass. Therefore, a creosotebush site today may be so modified that it will not support grass successfully. The mesquite occupied sites may further deteriorate and eventually be occupied by creosotebush. And finally, the invasion of grasslands by creosotebush, mesquite, juniper, or cholla is most likely a sympton of an already deteriorated site. It may be more explicit to say that these shrubs have become established upon sites which had been suitable for grass at some earlier time."

Plants generally govern the development and influence the composition of an entire ecosystem. As the plant species changes, so does the animal life. Studies conducted on the Jornada Experimental Range in Dona Ana County indicate an animal species biomass of over 35 kg per km^2 (200 lbs per section) in grassland, as high as 148 kg per km^2 (840 lbs per section) in mesquite, and less than 17 kg per km^2 (100 lbs per section) in creosotebush communities.

Animal species typical of the desert region are much like the plant life in that they are either drought resistors or drought evaders (Smith, 1966). Many of the animals have evolved in such a way that they are capable of circumventing the aridity and high temperatures. Other species that are more mobile (i.e., large mammals and birds) utilize desert regions during the cooler periods of the year. Migrations of other animal species to and from the area occur annually.

Animal species inhabiting grasslands show various traits. Common locomotion is by hopping or leaping, such as with the grasshopper, jackrabbit, and kangaroo rate. Speed is also a trait common to a few of the grassland dwellers, such as the antelope and gray fox.

Invertebrates, particularly insects, are extremely abundant. All of the strata within the grassland community are utilized by them. The ground and litter strata are utilized by the scavengers or hunters, and the herbaceous strata by abundant and diverse invertebrate life.

Mammals are the most conspicuous form of animal life within the assessment area. Various rodents, (i.e. ground squirrel), lagamorphs (i.e., jackrabbits, cottontails), and carnivorous species (i.e., badgers, fox, weasel), can be found. These species are generally burrowers or use vegetation, where adequate, for cover.

Various sparrow species (including the endangered Baird's sparrow), meadowlark, horned lark, and Gambel's and scaled quail are associated with these grasslands when cover is adequate. Nesting and feeding activities are prominent life functions of these and other birds in their association with grasslands. Birds of prey frequent such communities because of the ease with which prey is sighted and caught.

Reptiles are not common, but may be seen occasionally. Gopher snakes, whiptails, and others have been observed.

At one time, the distribution of animal species associated with grasslands extended over much of the assessment area; but now, the grassland ecosystem is greatly reduced. The areas invaded by creosotebush exhibit the fewest niches for animal species. Some creosotebush communities exhibit better soil conditions than others and contain other vegetal species. In these areas there are niches for invertebrates, mammals, birds, and reptiles. Generally, less than 17 kg per km^2 (100 lbs per section) of animal biomass are produced by the creosotebush communities.

Mesquite ecosystems which have dunes of various sizes established around the mesquite plants provide the greatest number of habitat sites. Invertebrates and rodents are of the greatest abundance and diversity. The dune provides a substrate highly suitable for burrowing, and each will contain numerous burrows. Reptiles, including lizards

and snakes, will frequent these areas in search of food and cover. The mesquite bush also is used extensively by various ground and aerial nesting birds.

(2) Pinon-juniper Ecosystem

The pinon-juniper ecosystem is a higher moisture belt than the ecosystems previously discussed (25-50 cm or 10-20 in annual rainfall), and reflects increases in vegetation diversity where the pinon-juniper is scattered or sparse. Where dense stands of pinon-juniper occur, a greatly reduced vegetal diversity exists as the result of competition. The pinon-juniper ecosystem represents a belt, or transition zone, between grasslands, desert shrubs, and the coniferous forests.

These pinon-juniper vegetal communities are extremely important to animal species within the desert southwest. The occurrence of a diversity of other vegetal species results in a well-stratified community because of the scattered or sparse cover. Pinon nuts and cedar berries provide an important food source for residents and wintering migrants into the area. The pinon jay, plain titmouse, Harris' sparrow, red crossbill, black-headed grosbeak, and others commonly inhabit the pinon-juniper community. This community also provides mule deer and mountain lion habitat. Species of both the grassland-desert shrub ecosystems and the coniferous forest ecosystem occur.

(3) Oakbrush Ecosystem

The oakbrush ecosystem is a transition between the grassland and pinon-juniper life forms. The ecosystem seems to be stable and supports a number of valuable plant species important to both livestock and wildlife. The specific successional stages of this ecosystem are not described by literature. The oakbrush communities are essentially an extension of the pinon-juniper ecosystem since they adjoin it at the lower elevations. These ecosystems are used by the same animal species as a source of food and cover.

(4) Riparian-Farmland Ecosystem

The riparian-farmland ecosystem contains a large number of annual crops. Very little successional development occurs within this ecosystem until fields are abandoned.

As a result of the agricultural development, vast acreages of important habitat for animal species such as the antelope have been destroyed.

With the extensive agricultural development and the introduction of plant species, habitat for other animal species has developed. Especially abundant are insects, birds, and various mammals.

2. Food Relationships

a. Aquatic Ecosystem

The food chain typical of aquatic ecosystems is represented in the assessment area. The ecosystem provides food for different plant and animal species during all stages of succession. The decaying plankton provide nutrients for the bottom dwelling aquatic plants. The plankton also supply nutrients for various species of fish and other aquatic animals (i.e., fairy shrimp). The dead organisms decompose and provide nutrients for the floating and emergent vegetation (Smith, 1966). The emergent vegetation, algae, and other aquatic plants provide a source of food for surface dwelling aquatic animals which have generally herbaceous food habits (i.e., waterfowl, beaver, muskrat, etc.). These species are then preyed upon by carnivorous species (i.e., osprey, skunk, raccoon, bullfrog, gopher snake, etc.). Some of these species are omnivorous and are generally represented at the top of the food chain.

b. Terrestrial Ecosystems

(1) Grassland Ecosystem

The grassland ecosystem is a very productive natural ecosystem within the assessment area. The climax grasses and forbs supply high value forage for both livestock and wildlife species.

A number of wildlife populations are present in this area. Most of the species are ground dwellers and survive on the seeds and insects associated with this ecosystem. Birds of prey are also common in these grasslands and the small ground dwellers supply food for these species.

The antelope are restricted almost entirely to the grassland ecosystem. They depend greatly on the annual and perennial forbs when they are green and succulent in addition to the grasses.

(2) The Pinon-juniper Ecosystem

The pinon-juniper ecosystem contains, in addition to pinon and juniper, a variety of other trees, shrubs, and grasses. Many of these plant species provide valuable forage and cover for livestock and wildlife. Where a dense canopy cover of pinon and juniper exists, it limits the forage production of many valuable grass and shrub species. In addition to providing important cover for

nesting, resting, and protection from the elements, the pinon pine produces a nut that is highly sought by mule deer, wild turkey, and many kinds of birds and rodents.

The juniper, usually found in conjunction with pinon, is of equal importance, as it also provides food and cover for many species of wildlife (i.e., mule deer, turkey, quail, and many species of songbirds). The foliage is eaten by deer, antelope, and livestock, and the seeds are eaten by fox, bear, squirrel, chipmunk, songbrids, deer, and turkey.

(3) Oakbrush Ecosystem

The oakbrush ecosystem contains many desirable shrubs which supply browse vegetation for livestock and wildlife species. These plants are used at all times of the year. The shrubs provide food and cover for many small wildlife species that, in turn, supply food for predator species such as the raptors, bobcat, coyote, and mountain lion.

(4) Mesquite Ecosystem

The mesquite ecosystem supplies a large amount of forage for its inhabitants and produces the highest animal biomass of the ecosystems. Mesquite is desired by grazing animals in the early spring before the leaves form on the shrubs. The tender branches are very nutritious. The plant's flowers attract bees and other insects to these shrubs. Once the plant has flowered and produced the seed pods, the seed pods are sought by domestic livestock and many wildlife species. Livestock eat the pods and disperse many of the undigested seeds throughout the area in their feces. Many small wildlife species, such as rodents and rabbits, collect and store the seed in their burrows. This action further enhances the spread of the mesquite shrub. Many plant species associated with the mesquite dunes are palatable to livestock and wildlife. Some of these species are four-wing saltbush, mesa dropseed, sand dropseed, spike dropseed, black grama, and many other forbs and shrubs.

Plant species growing directly in association with mesquite shrubs are higher in protein than plants out away from the shrubs. The mesquite plant produces nitrogen in its roots; this nitrogen is released in the soil and utilized by associated plants.

The mesquite dunes support very large wildlife populations of rodents and rabbits. Large numbers of rodents and rabbits burrow into the dunes. These provide food for the many birds of prey associated with this ecosystem. Many songbirds nest in the shrubs and survive on the various seeds and insects within the ecosystem.

(5) Creosotebush Ecosystem

The creosotebush ecosystem produces little forage for its inhabitants. Creosotebush is unpalatable and offers no forage value to domestic livestock and only limited forage value to a few wildlife species. Many of the plant species which are associated with the creosotebush ecosystem do not supply additional forage of any value. A very low population of wildlife species inhabits this area because of the low forage production. The change which has taken place on these lands has reduced its value from a highly productive grassland to a relatively worthless shrub ecosystem.

(6) Desert Shrub Ecosystem

The desert shrub ecosystem, which was probably a good grassland at one time, has now been invaded by numerous brush species. It provides very little forage or cover for any animal species.

(7) Riparian-Farmland Ecosystem

The riparian-farmland ecosystem is perhaps the most productive within the assessment area. Most of the annual crops within the valley supply food for man as well as livestock and wildlife species. Large populations of songbirds, rodents, and insects inhabit the valley and utilize the available food. Birds of prey and various predatory mammals also rely on these valley populations for subsistence.

Farmlands are essentially under the full control and management of man and will continue to be cultivated, planted, and harvested. Riparian ecosystems are of immediate concern and importance. Riparian woodlands are so unique, rare, and important within the desert southwest that every effort should be made to protect them from destruction and unnecessary disturbances. A diversity of animal species is associated with these highly stratified vegetal communities. An abundance of invertebrates occur, of which some are herbivorous, some are carnivorous, and some are omnivorous. The invertebrates, in addition to vegetal species, provide an essential food source for numerous vertebrates, especially amphibians, reptiles, and birds. Fewer mammals feed strictly on invertebrates. Various reptiles, amphibians, birds, and mammals rely on other vertebrates for subsistence. Of special significance are the birds of prey which utilize the areas, not only for food, but also for nesting, resting, and protective cover.

3. Community Relationships

a. Aquatic Ecosystem

The aquatic ecosystem relies upon each species within the system in order to maintain itself. The various seral stages within the aquatic ecosystem provide nutrients for subsequent stages. The plants and animals provide food and habitat for each other. A large number of wildlife species, such as fish, aquatic invertebrates, shorebirds, and waterfowl, are totally dependent on these communities. Numerous terrestrial species also are dependent upon aquatic ecosystems. The water and adjacent vegetation provide essential life-sustaining components for antelope, deer, quail, dove, and numerous songbirds.

b. Terrestrial Ecosystem

(1) Grassland Ecosystem

The grassland ecosystem is dominated by grama grasses in association with numerous other species. Many of these grasses are adaptive to certain soils, while others inhabit all sites. The grasses produce a specific microclimate that must persist if the plants are to survive. Under such conditions, the soils are cooler and contain more moisture than those in areas which do not have a developed microclimate. Many of the grass plants are capable of producing seed, but are more apt to spread by vegetative reproduction through rhizomes and stolons (Jackson, 1928).

Shrubs like creosotebush are able to invade the grasslands when the vigor of the grass has been reduced by drought and heavy grazing because of the lack of grass seed in the soil. The shrub seeds germinate and grow with little interference from the deteriorating grass plants. Once creosotebush invades grassland and becomes established, its physiological characteristics provide competion which grasses cannot withstand. If these areas are provided proper protection, however, the grasses do have the ability to compete and they will eventually re-establish themselves over the area. The grassland community is basically comprised of three strata: the roots, the ground cover, and the plant foliage. Most of the animal life associated with this community is directly dependent upon one or more of these strata. Species occupying the soil or root stratum may be decomposers that help in maintaining the fertility of that stratum, or they may be simply residents (i.e., ants, overwintering pupae, or eggs). Ground stratum inhabitants include such predatory scavengers as spiders, beetles, and scorpions, which prey upon other invertebrates. The

foliage stratum is inhabited by a diversity of insects, including grasshoppers, aphids, bees, and flies. Populations of rodents will utilize all three strata, feeding on roots and foliage, and constructing dens in the soil. Various species of birds, some of which have developed loud, specific songs or calls by which they define their territory (i.e., meadowlark), utilize the ground and foliage strata. These strata are used for feeding where insects and seeds are taken; and in addition, the foliage stratum is used for nesting and for loafing cover.

Another prominent animal species of the grasslands is the pronghorn antelope. This animal is especially dependent upon the green, succulent grasses which appear following early spring precipitation and during the rainy season. During the remainder of the year, forbs and weeds, along with various palatable shrubs (i.e., wild buckwheat, sand sage, and mariola) comprise the antelope's diet. The scattered dry lake beds are frequented by the antelope during both moist and dry periods, since these areas provide the most available source of food.

(2) Pinon-juniper Ecosystem

Pinon and juniper species are able to displace associated plant species through competition where grasses and shrubs have been reduced and soils lost. The conifer species have stabilized most of the soils, but through competition for nutrients, the associated species are inhibited.

The pinon-juniper ecosystem is especially attractive to animal species because of the abundant food source provided. It is most important during the fall and winter months, when numerous migratory birds, mammals, and insects enter the area in need of food and cover. Birds which have specialized beaks for cracking seed (i.e., Clark's nutcracker, red crossbill, blackheaded grosbeak) are common visitors. Other species dependent upon the seeds include mule deer and antelope. In addition, the foliage of these trees, as well as the foliage and seeds of the grasses, forbs, and shrubs associated with this community, provide essential food.

(3) Oakbrush Ecosystem

The oakbrush ecosystem has a diversity of associated shrub species and an understory of grasses, forbs, and litter. Its subsurface root stratum provides a somewhat "upper class" desert ecosystem. Abundant populations of invertebrates and vertebrates live in this ecosystem. Often these isolated ecosystems may be over-utilized by grazing livestock. Even a small amount of destruction or prolonged disturbance could be devastating to this ecosystem because of the diversity of animal species that are dependent upon the areas for food and cover and because of its relatively small acreage.

(4) Mesquite Ecosystem

Mesquite is generally the dominant shrub in the mesquite ecosystem. The shrub is usually low-growing, and the spines on the shrub protect many of the underlying grasses from being overgrazed by livestock. The shrub does not protect these associated plants from all the small wildlife species utilizing the areas under the shrubs.

The roots of the mesquite shrub are long and branching. They provide stabilization of the dune as reinforcement-bar does in concrete. This stabilization allows many other plants to become established on the dune. They also release nitrogen into the soil, which enhances the growth, development, and palatability of associated plant species. While mesquite enhances other vegetation, it also takes a lot of water out of the soil, increasing the competition among other plants within the ecosystem.

The majority of the animal species associated with the mesquite ecosystem is dependent upon the dunes that are common to many of these ecosystems. Antelope will utilize forbs and other succulent plants associated with this ecosystem in addition to utilizing the mesquite bean. The pyrrhuloxia and other birds are especially dependent upon mesquite for nesting and protection. Numerous reptiles (lizards and snakes) hold an important position in this ecosystem because of the abundance of invertebrates and rodents which they eat.

(5) Creosotebush Ecosystem

Creosotebush populations in the assessment area have stabilized. The plants are of uniform height and distribution. Usually, very little additional vegetation is associated with the shrub. Went (1955) indicated that the reason for the lack of other plant species in the ecosystem was that creosotebush contains a water-soluble growth inhibitor which remains in the soil. If the area receives above average rainfall, the inhibitor is washed away and other plant seeds germinate and grow. Knipe and Herbel (1966) also studies the growth inhibitors in creosotebush. Both Went and Herbel concluded that creosotebush does contain a growth inhibitor. Went (1955) believed it inhibited germaination, but Knipe and Herbel (1966) found that the inhibitor reduces the development of the shoots and roots of the major grasses (black grama and bush muhly) after germination occurs. This, along with the fact that creosotebush is able to extract water from the soil more efficiently than other species, may explain the lack of other plants within the ecosystem.

The growth inhibitor in creosotebush does not inhibit its own growth. However, once the shrub population is established, the viability of the seeds decreases (Barbour, 1968 and 1969). Due to the general harshness of the creosotebush community--the desert pavement, the growth inhibitors produced by the plant, and the unpalatable nature of the plant--the community is used by few animal species. Around its periphery, where ecotones are formed in its overlap with the grassland, mesquite, or desert shrub, a more significant use of the creosotebush is made by nesting birds, resting animals, or by animals seeking escape cover. This is, perhaps, the most significant relationship between the creosotebush ecosystem and adjacent ecosystems.

(6) Desert Shrub Ecosystem

The desert shrub ecosystem is an area where brush species have replaced grassland. The community is used by birds for nesting. Numerous burrowing rodents use the seeds produced by annual vegetation as a source of food.

(7) Riparian-Farmland Ecosystem

There is no actual community relationship between the many annual crops in this system. The crops are grown individually and harvested without concern for what is growing in the adjacent field. Nutrients, insecticides, herbicides, and water are introduced into this system to enhance crop production; there is little competition between plants.

Although the agricultural areas and their associated crops are the result of unnatural development and require the constant assistance of man to maintain productivity, animals of many species are dependent on them. The grains and forage crops attract numerous birds, (i.e., mourning dove, quail, sandhill crane, geese) as well as mammals, reptiles, amphibians, and invertebrates. Many animals in the area are dependent upon the riparian vegetation for food and cover.

D. Land Use

1. Compatibility

a. Recreation

The assessment area is sparsely inhabited and, based on a four-county planning district, contains only 4 percent of the State's population. Population projections indicate this percentage will still be the same in the year 2000 (SCORP, 1976).

Pleasure walking, horseback riding, picnicking, driving for pleasure, bird watching, fishing, sightseeing, hiking, camping, rockhounding, small and big game hunting, and visiting historical sites account for most of the outdoor recreation in the assessment area. Rock climbing, backpacking, river floating, and archaeological study are also recreational pursuits. Many visitors may participate in several activities during one trip. Residents usually pursue a variety of recreational activities, including big game hunting where resources are available.

Tourists pass through the area on State Highways 15, 26, 27, 61, and 90, and on U.S. Highway 180. Approximately 91,000 people visited City of the Rocks State Park in 1976. This 312 ha (770 ac) park contains unusual rock formations and a desert arboretum, and is a favored picnic spot of the State. Bill Evans Lake, seven miles south of Cliff, also attracts large numbers of visitors.

The supply of resources and services is sufficient at the present time to meet the demands for various recreational pursuits that are occurring within the assessment area. Access and visitor goods and services are readily available for the recreationist. Recreational uses are generally compatible among users and on surrounding lands outside the assessment area. As population increases, various conflicts could increase on the resource base.

b. Grazing

Most of the land within the assessment area is used all year for grazing cattle and horses. Grazing on public lands, which are located mostly in the southeast corner of the area, is administered through both licenses and leases, depending upon land status. Twenty-eight allotments are wholly or partially within the assessment area, and grazing is authorized by annual licenses in accordance with the carrying capacity. The carrying capacity is highly variable, depending on the vegetation present and ranges from only a few acres to several hundred acres per animal unit. Most of the balance of the area is either private or State land with scattered tracts of intermingled public lands. These scattered tracts are leased to adjoining landowners with no restrictions on number of livestock. There are 64 of these leases. Grazing can be compatible with most other uses.

c. Farming

There are small farming areas scattered throughout the assessment area. However, the activity is concentrated along the Gila and Mimbres Rivers and in the Uvas Valley. Farmland along the two rivers is irrigated with water from the streams and is used primarily for growing forage crops, apples, and vegetables. In the

Uvas Valley, farmland is irrigated by pumping ground water from on-site wells. Most of the crops grown here are cash crops: cotton, lettuce, tomatoes, and sorghum, or forage crops, alfalfa and corn, used in nearby feedlots. Farming is compatible with all other uses.

d. Urban and Suburban

Very little land in the proposed leasing area has been used for urban and suburban development. Half of the people living in the assessment area live in towns, but the towns are small and few, so the population concentration remains low. In 1974, urban land use was confined to five towns (Bayard, Central, Grant, Hurley, and Silver City) which had a combined population of less than 16,000 people (BBER 1975).

Although there are no easily definable suburban zones around these towns,the many small villages which dot the countryside might be called suburban developments. These villages are usually strung along some of the better roads, and probably have an average size of well under 500 people per village.

Urban and suburban development can be compatible with most other land use. Such development may not be compatible with the use of surrounding lands for wildlife habitat or for primitive areas.

e. Rights-of-way

The lands in the assessment area are dissected by numerous rights-of-way of vital importance to the people in Silver City, Deming, Lordsburg, and southwestern New Mexico. Major rights-of-way are as follows:

(1) Transportation

U. S. Highway 180, running northwest and southeast from Deming to Silver City and Glenwood, State Highways 90 and 26 from Hillsboro to Silver City and from Hatch to Deming are the major routes of travel in the area. According to New Mexico State Highway Department statistics, at least 900 vehicles travel all the routes daily. Certain segments of U.S. Highway 180 receive up to 3,000 vehicles per day.

Other paved roads include State Highway 15 from Silver City to Pinos Altos, Highway 27 from Nutt to Hillsboro, Highway 71 from City of Rocks State Park to Mimbres, and Highway 78 from U.S. 180 to Mule Creek. Improved and unimproved dirt roads lead to ranch headquaters and various other destinations.

The Atchison, Topeka and Santa Fe Railroad line runs southwest from Hatch to Deming and northwest from Deming to Tyrone and Silver City. Traffic on the route varies, but rarely is less than two trains each way per day. There are no passenger accommodations available on the route.

(2) Electric Power

A number of power lines are found throughout the assessment area. Two 115 kV lines exist within the assessment area. One runs northwest from Deming to Hurley, Bayard, Central and Silver City, and the other runs northeast from Deming to Nutt and beyond. Both are Bureau of Reclamation projects. Community Public Service company has three 69 kV lines running from Silver City to Cliff, Silver City to Lordsburg, and Central to Lordsburg. There is also a 66 kV line running from Hurley to Lordsburg. There are numerous lesser voltage lines serving small communities and ranches which are scattered throughout the area.

(3) Gas Pipeline

There is a natural gas pipeline paralleling the Atchison, Topeka and Santa Fe Railroad running southeast from Silver City and then due south from Whitewater to Gage.

(4) Communications

Telephone lines service communities, ranches, and other installations throughout the assessment area.

(5) Other Considerations

The town of Silver City has two R&PP projects in T. 18S., R. 4W., (sanitary landfill and water storage tanks) and Western New Mexico University has a R&PP lease for a field laboratory in the same area. The town of Central has an R&PP lease with option to purchase in Sec. 1, T. 18S., R. 31W.

All of these rights of way are compatible with other existing land use.

f. Mineral Development

Many different mineral resources are present in the assessment area. Mining of hard rock minerals in the general vicinity of Silver City is the most extensive type of mineral development within the entire assessment area. With the exception of wildlife, recreation, and possibly urban-suburban values, mineral development is generally considered to be compatible with most other land uses in the area.

2. Suitability

Land use suitability has been expressed as "the appropriateness of the relationship between man's use of the land and the natural land base" (BLM, 1974). The land is suitable for a particular activity if: (1) the resources needed for the activity are present; and (2) if the land has some capacity to recover from the activity. The land is not suitable for an activity if the required resources are not present. Further, it is not suitable if permanent damage to the land or loss of other use opportunities will outweigh the advantages of conducting the activity in question. The quality of resources, the flexibility of the environment, and the long-term effects of an activity all vary depending on which land and which activity are concerned. Obviously, there can be many graduations in how suitable a tract of land is for any particular activity.

Some general comments on the suitability of major land use activities to the natural land base are provided below. More specific analyses would be required to determine land use suitability on a site-specific basis.

a. Recreation

Fishing, hunting, sightseeing, enjoyment of primitive values, and general leisure activities do not create long-term loss or damage to any land resources if they are managed properly. They are suitable activities for all lands where these pursuits are possible. Places in the assessment area where these activites are possible are identified under "The Existing Environment - Human Values."

The assessment area lacks the resources required for winter and water sports, so it is clearly unsuitable even without determining the long-term effects of these activities.

ORV use is possible in most places with less than 60% slope and sparse vegetation. The opportunities are more fully described in the "Human Values" section. However, ORV use is not suitable in areas of endangered or threatened wildlife or plant habitat, in areas with fragile soils, in hazardous areas, or in areas of high cultural resource density. The long-term impacts of ORV activity on the natural land base would have to be determined in order to establish the land use suitability in these areas.

b. Grazing

Grazing is one of the primary uses of land in the assessment area today. The suitability of the land for grazing is reflected in the range condition and erosional trends. Clearly,

areas where the range condition has been steadily deteriorating have been subjected to use which is too intensive for the resources. Such areas are less suitable for grazing than areas which have remained in good condition under a similar intensity of use.

Land use suitability of Federal lands for grazing will be established through the BLM Southwest Range Environmental Statement No. 9. Information on State or private lands may be available from the land owners.

c. Farming

The land which is suitable for crop production is limited by terrain and availability of water for irrigation. Additional lands along the Gila and Mimbres Rivers are suitable for irrigated cropland, however, water rights, water supply and other factors preclude any attempt to increase acreage for this use in these area. Additional lands in the Uvas Valley and in the area between Cook's Peak and the Burro Mountains would be suitable for irrigation if water were available.

d. Urban and Suburban

With today's technology, urban and suburban developments are possible wherever the economic requirements of a concentration of people can be met. Because urban or suburban land developments are primarily dependent on the man-made environment, their location is more flexible than that of activities which depend on natural resources.

Land which has localized or relatively rare natural resources is not suitable for urban or suburban developments. Such developments are not suitable on prime agricultural land, on highly concentrated mineral deposits, in the habitat of threatened or endangered species, in the areas with primitve values, or in areas containing a high density of cultural remains.

e. Rights-of-way

Rights-of-way create limited disturbance of most natural resouce values on the lands. Their locational flexibility makes them suitable activities for most places where they are needed. One exception would be in places of high scenic, primitive, or wilderness value.

f. Mineral Development

Mineral development is possible only in locations that contain mineral resources. The land suitable for development is first limited by this consideration.

Although mineral development is necessary to maintain our standard of living, it is a land use which, in some cases, is unsuitable to the natural land base. In particular, open pit and strip mining can leave the land unsuitable for most uses for an indefinite period of time, although appropriate reclamation programs could substantially reduce long-term effects of such operations.

Other mineral activities, such as sand and gravel extraction, drilling of oil and gas wells, and underground mining, are much less disturbing to the surface environment, and may be considered suitable land uses, depending on the nature or quality of the resources present in the local environment.

E. Human Values

1. Visual Resources

a. Landscape Character

The most pronounced characteristic of the area is the variety of natural quality in the landscape (see Figure 14). The basic landscape elements of form, line, color, and texture vary greatly. Dominant colors are red, brown, tan, and dark gray from the soils and rocks, and moderate variations of greens, browns, and tans from vegetative sources. The topography (form) is characterized by valley bottoms, arroyos, rolling hills (30-60% slopes), mesas and bordering cliff escarpments (see Figure 15). Elevation varies from 1288 to 2563 m (4225 to 8408 ft) within the area. Physiographically, the area is Basin and Range and Colorado Plateau. Ecologically, the area is split between Upper Sonoran and Chihuahuan Life Zones. The semi-arid climate results in rather sparse vegetation, chiefly mesquite, creosotebush, beargrass, tarbush, snakeweed, yucca, and Mormon tea. Rolling hills, arroyos and mesas dominate the area. Vegetation of the riparian habitat consists chiefly of cottonwoods, Apache plume, skunkbush, and desert willow, while the more wooded areas in the upper elevations are chiefly pinon-juniper, oak, agave, mountain mahogany, and scattered ponderosa pine (see Figures 16 and 17). Vegetative distribution is closely related to elevation and aspect. Mule Creek is an exception to this rule and is an abundant grama grassland.

The dominant line and texture characteristics are represented by smooth valleys to coarse rolling hills with feathered edges characterized by a strong horizontal influence. Vertical lines are dominant on the northern boundary of the area (Gila National Forest) and vertical lines are also exhibited from within by prominent features such as the Cook Range, Mimbres Mountains, Mule Spring Creek, Blue Mountain, Table Mountain, Taylor Mountain, Bear Mountain and the Mogollon Range.

FIGURE 15 LANDSCAPE CHARACTER

FIGURE 16 TOPOGRAPHY (FORM)

FIGURE 17 RIPARIAN HABITAT

FIGURE 18 UPLAND HABITAT

The flat to rolling valley floors contain lush riparian vegetation and contrast in texture against the sparsely vegetated mesas and arroyos that are higher in elevation. Visual distance factors within the valley corridors and agricultural open spaces also contribute in moderating the rolling hills and mesas which are coarser than actually perceived (see Figures 18 and 19).

The deep and often wide cutting arroyos are the only other factors affecting visual character in the area. These arroyos interrupt form, line, and texture elements and create a disturbance in visual flow.

b. Intrusions

Intrusions are features (land, vegetation, or structures) which are generally considered out of context with the characteristic landscape. Usually, these intrusions are modifications to the natural landscape resulting from man's activities. Intrusions can have negative or positive visual impacts and are a key factor in evaluating scenic quality.

Intrusions in the area with the greatest visual impact are those associated with its 150-year history of copper mining. This historical use of the area results in the present open pit mining, mine waste, and mine related visual intrusions. Pilot mine structures, powerlines, crushers, warehouses, leaching ponds, tailings, and abandoned mines are all evidences of the past, as well as the present, mining history of the area.

The most recent and overpowering visual intrusions are the open pit mines at Santa Rita and Tyrone, and the smelter tailings and smoke at Hurley (see Figures 21, 22, 23, 24, and 25). These energy-related intrusions combined with power transmission lines, are expected to increase as demand for energy sources increases. Ranching and agriculturally related intrusions are also present within the area. Stock ponds, fence lines, windmills, corrals, and associated structures are present.

Existing intrusions have been classified by the degree to which they have modified or intruded upon the natural landscape. This process is known as the magnitude of contrast, and each intrusion was rated on one of three levels of contrast.

FIGURES 18 and 19 AGRICULTURAL OPEN SPACES

TYRONE

TYRONE AERIAL VIEW

FIGURE 21 - Tyrone
FIGURE 22 - Tyrone Aerial View
FIGURE 23 - Santa Rita Aerial View

FIGURE 24 HURLEY SMELTER

FIGURE 25 SANTA RITA INTRUSIONS FROM STATE HIGHWAY 90

Magnitude of Contrast	
Low	Contrast will not attract attention from landscape character.
Medium	Attracts attention and begins to dominate landscape character.
High	Demands attention, will not be overlooked, dominates landscape character.

The mine developments within the area make up many of the existing intrusions. Ancillary buildings, pipelines, powerlines, tailing deposits, waste dumps, leaching areas, air contaminants, and associated noise of mine operations do not fit in with the landscape and have a high contrast rating. Hurley Smelter can be seen from the greatest distance because of the topography and vegetation surrounding the smelter.

Livestock improvements and water developments, such as troughs, stock ponds, catchments, reservoirs, spring developments, and wells, within the area generally fit in with the naturalistic landscape and have low to medium contrast. Windmills and storage tanks are more visually distracting and rate a medium contrast. Corrals, fences, and abandoned buildings rate low in contrast.

Utility lines, highway routes, and the resulting cleared linear rights-of-way generally have a medium rating of contrast.

c. Visual Resource Management Process

The BLM system for visual resources is a process which categorizes the landscape into Visual Resource Management (VRM) units in order to evaluate the amount of modification the visual character of the natural landscape can sustain. Minimum quality standards for management of the visual resources are then established.

The VRM unit boundaries are based on three elements: scenic quality, sensitivity, and distance. The scenic quality is an evaluation of the quality of the scenery based on key factors such as land, form, color, water, vegetation, uniqueness and intrusions. Visual sensitivity is the visual response to an area in relation to the entire area. Criteria elements include use volume, use association, community attitudes, land and agency use and planning interrelationships. Visual distance zones are a direct relationship between observer position (critical viewpoints from major traffic routes) and the landscape feature being observed. The distance from which the feature can be

seen (foreground-middleground 0-8 km (0-5 mi); background 8-24 km (5-15 mi); seldon seen 24 km+ (15 mi+)) determines the visual zone. The Las Cruces District Office has on file maps, overlays, inventory criteria, and documents containing in-depth discussions on the establishment of VRM classes in the Silver City Geothermal Leasing Assessment Area.

d. Visual Resource Management Classes

In determining VRM classes, the scenic quality, sensitivity level, and visual zone maps are combined. Each VRM class describes a different degree of change allowed in the basic elements (form, line, color, texture) of the landscape. The primary character of the landscape should be returned regardless of the degree of modification. The degree of modification for each class is described in Table 15. Figure 24 shows the existing VRM classes in the Silver City Geothermal Leasing Assessment Area.

2. Recreation Resources

a. Sightseeing

The majority of recreational sightseeing is done from automobile along Interstates 10 and 25, U.S. Highway 70, 80, 85, and 180, and State Highways 15, 26, 27, 61, 78, 70, and 211. Scenery is attractive along the Gila, Mangas, and Mimbres River Valleys, parallel routes adjacent to the Gila National Forest, and numerous other tributary ranch roads through the area. Sightseeing of past historical mining districts and current projects at Santa Rita, Central, Hurley, Tyrone, and Silver City attract visitors to the area. The outstanding geological formations at City of Rocks State Park provide a unique opportunity for sightseeing. Cultural opportunities for sightseeing are varied throughout the area and include Faywood ruins, Fort Bayard, San Juan, access to the Gila Cliff Dwellings, Mimbres Valley, and numerous hot springs within the assessment area. Although only visible in certain places, historic trails existing within the area are the Mormon Battalion Trail (Cook's Wagon Road), Kearney's Route, Butterfield Trail (Overland Mail Company Route), El Paso and Fort Yuma Route, Copper Road (Road to Janos). Deer, antelope, fox, bobcat, upland game birds, and raptors add to the scenic values zoologically.

b. Hunting

The area provides hunting opportunities for big game species such as elk, mule deer, whitetail deer, pronghorn antelope, black bear, Merriam's turkey, javelina, and mountain lion. Mule deer hunting provides the most significant big game hunting. There is a scattering of deer over most of the area, but hunting occurs

TABLE 8

VISUAL RESOURCE MANAGEMENT CLASSES

Class I	This class provides primarily for natural ecological changes only. It is applied to primitive areas, some natural areas, and other similar situations where management activities are to be restricted.
Class II	Changes in any of the basic elements (form, line, color, or texture) caused by a management activity should not be evident in the characteristic landscape.
Class III	Changes in the basic elements (form, line, color, texture) caused by a management activity may be evident in the characteristic landscape. However, the changes should remain subordinate to the visual strength of the existing character.
Class IV	Changes may be a dominant feature on the landscape in terms of scale, however, the change must repeat the basic elements (form, line, color, texture) in the characteristic landscape.
Class V	Change is needed. This class applies to areas where the naturalistic character has been disturbed to a point where rehabilitation is needed to bring it back into character with the surrounding countryside. This class would apply to areas identified in the scenery evaluation where quality class has been reduced because of unacceptable intrusions. It should be considered an interim short-term classification until one of the other objectives can be reached through rehabilitation or enhancement. The desired visual quality objective should be identified.

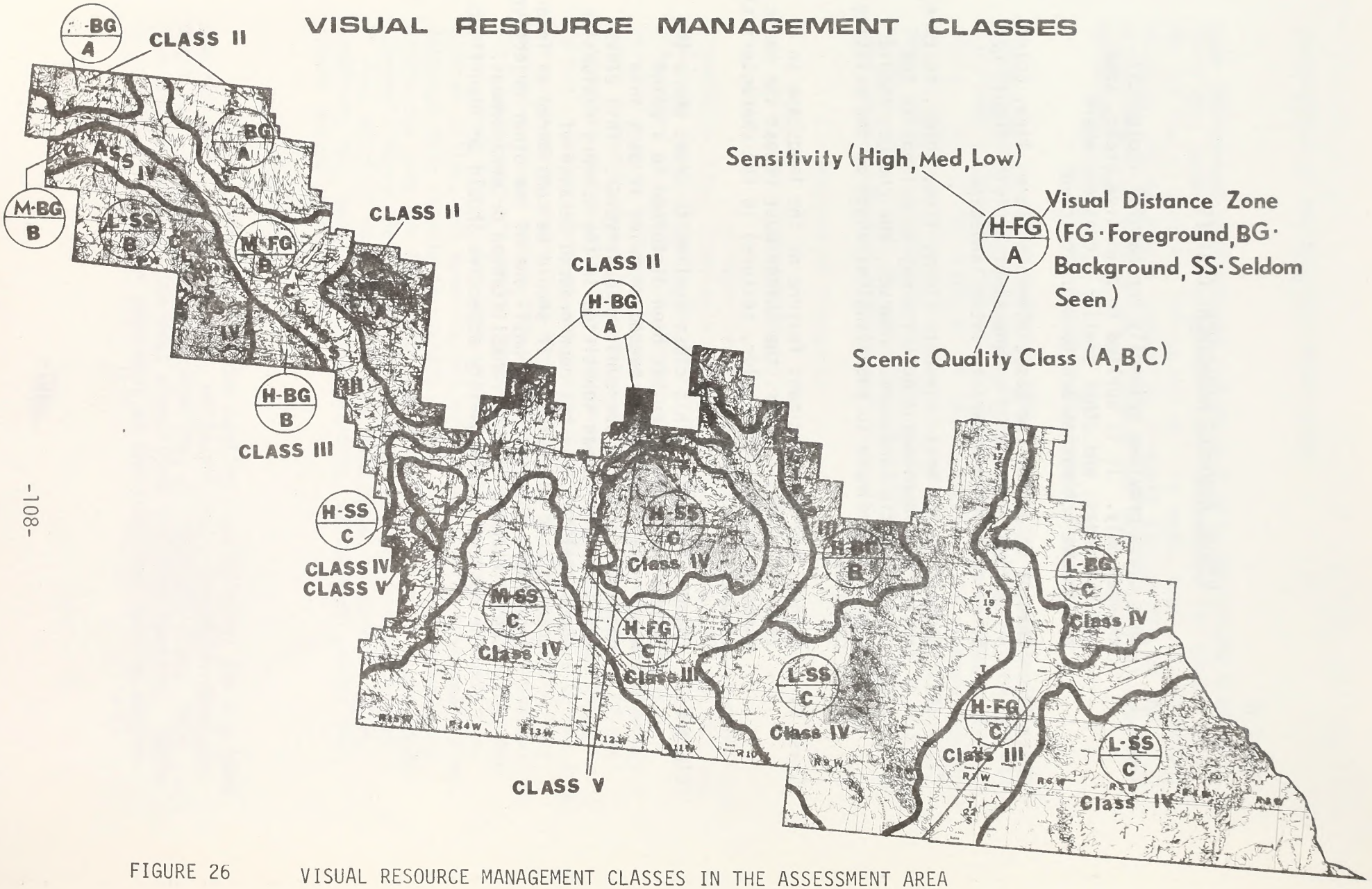


FIGURE 26 VISUAL RESOURCE MANAGEMENT CLASSES IN THE ASSESSMENT AREA

mostly in areas surrounding the Gila National Forest. Antelope and javelina inhabit the lower, foothill country. Bear and mountain lion are elusive and seldom seen. A large variety of small game animals and upland game birds inhabit the area. These include squirrel, cottontail, jackrabbit, pigeon, dove, quail, and waterfowl. Predators include bobcat, gray fox, coyote, raccoon, ringtail cat, badger, skunk, owl, and raptors. Many other small mammals, song-birds, reptiles and amphibians live within the assessment area. No accurate visitor use data is available for the area.

c. Fishing

Fishing opportunities are limited to the Gila National Forest watershed rivers which flow south and westward into the assessment area. Bill Evans Lake, adjacent to the Gila River and seven miles south of Cliff, is the only lake within the area. It is a warm-water, 25 ha (62 ac) lake containing bass, catfish, bluegill, and winter-stocked rainbow trout. Bear Canyon Lake, two miles north of Mimbres, is near the area and draws visitors to the 9 ha (22 ac) lake containing the same species as Bill Evans Lake. The Gila and Mimbres Rivers, Trout and Mogollon Creeks, within the area, provide good fishing opportunities. No reliable visitor use data has been collected for these areas and others within the assessment area.

d. Rockhounding

Old mine dumps near Lake Valley offer rockhounding opportunities for pyrolusite, magnetite, psilomelane and rhodonite crystals, as well as fossils, agate, jasper, and calcite. Near the Cook's Peak area, carnelian agate and red jasper can be collected. South of Mule Creek, in the old Carlisle Mine area, rockhounds can find amethyst crystals and Apache tears (obsidian).

e. Camping, picnicking, hiking, spelunking, and horse-back riding occur on a casual basis throughout the area. Warm water bathing is also enjoyed by visitors to Faywood Hot Springs.

f. Natural and Backcountry Values

Numerous similar wilderness opportunities are available throughout the area. Fringe areas abutting the Gila National Forest offer excellent opportunities for hiking and backcountry camping recreation experiences. These areas rate very highly in scenic and wildlife sightseeing qualities. Combined with relative remoteness, this makes these areas high in near-wilderness opportunities.

g. Off-road Vehicle Use

Depending upon specific activities, certain landscape characteristics are desired by off-road vehicle users. The Motorcycle Association of New Mexico has prepared a set of criteria for terrain selection for specific activities. While these criteria are intended primarily for motorcycle use, four-wheel drive and other terrain vehicles seek similar standards for their respective activities. These criteria are listed in Table 9.

Specific areas where ORV use is occurring is not known, but current trends indicate increase in use is proportional to population growth and concentrated near urban centers.

The New Mexico State Comprehensive Outdoor Recreation Plan, completed in 1976, reports that the current recreation ORV demand for the four counties of Grant, Luna, Catron, and Hidalgo, is 12,000 visitor days per year. This indicates a low popularity at the present time when compared to other activities, but indicates that proper management is needed to concentrate this use on terrain which can withstand intensive use.

h. Visitor Use

This area is within a day's drive of over 3 million people. Over half of these people live in major cities such as Tucson and Phoenix, Arizona, Albuquerque and Las Cruces, New Mexico, and Amarillo, Lubbock, and El Paso, Texas. City dwellers often seek relief from their surroundings by visiting the mountainous regions of the Gila National Forest. Hence, communities within the assessment area are recipients of visitors drawn to the Forest. The most popular family recreation activities within the four-county planning district are picnicking, park visits, pleasure walking, sightseeing, fishing, camping, hunting, horseback riding, and hiking. Visitor use occurs during all months, with the primary season running from May to November. Peak use occurs during the summer months.

3. Wilderness Resources

The only areas containing 2024 ha (5,000 ac) or more of Federal land are in the southeastern portion of the assessment area. The Cook's Mountain Range and the Sierra de las Uvas are essentially public land, however, it is not known how much of these areas will qualify for wilderness study. The roadless area criteria has not been finalized by BLM, so no acreage estimates can be given.

Only 17 percent of the assesement area is under full BLM jurisdication. The prospect for BLM to acquire private and State lands in the future

TABLE 9

Motorcycle Association of New Mexico ORV Terrain Utilization Criteria

Trail Riding: All riders savor scenic values as they ride, some more than others. Many riders enjoy the challenge of difficult terrain such as rocks, rocky ledges, sandy washes, etc. Trails should be well marked, making loops and interconnections for variety and reducing total traffic density. With proper management, vehicular use of trails is no more damaging than any other use.

Open Riding: Similar to trail riding above except not confined to designated trails. Should be limited to designated areas because alteration of terrain may result. This alteration disappears, according to the type of terrain, after use is terminated (perhaps by shifting to another area). Wasteland, arroyos, etc., are suitable. This type of riding is enjoyed by many people and is especially desirable for families who may establish a base and ride short distances in the immediate area.

Enduros: This requires an organized club or other group who will stage and control the event by marking trails, policing other riders, setting up check points, providing for assistance in case of breakdown, clean-up after the event, etc. During the Enduro, the trail should be closed to other uses. Selection of the trails should be done by the organizing club with approval by the land managing agency and cooperation between both is necessary in order to have a successful event. Enduros are often held only once a year in a particular area.

Hare Scrambles: Require selection of little-used trails, jeep roads or arroyos suitable for racing. Otherwise, similar to Enduros.

Motocross: Requires designation of ten to thirty acres and permission for a sponsoring club to use. Club will construct and maintain the course. Should provide reasonable access for spectators in passenger cars and parking.

Trails: A few acres of rough, diverse terrain is all that is required. The users (club or association) will lay out sections for rider tests. This event does not involve speed, is quiet and nonhazardous. Land for a trail event can be as close as one-half mile from habitation without resulting problems. Trails are unobtrusive and quiet, and are often enjoyed by families.

is realistic, but time consuming. State Aid withdrawn lands (3%) being held in limbo pending a court decision could possibly revert to BLM ownership.

Many private and State lands adjacent to the Gila Wilderness possess wilderness characteristics. Although private landowners have the option to destroy these values, the State should recognize and protect them. Thirty-six percent of the lands within the assessment area are in private ownership with the minerals retained in Federal ownership. Although BLM has some control over protecting the water table and subsurface resources, it has no direct control over surface practices. Protection of scenic, wilderness, natural, wildlife, and cultural resources can only be suggested to the private landowner.

4. Sociocultural Interest

a. Social Welfare

The social welfare of people living in an area depends on many factors. The kinds of jobs available, the average family income, and the number of children and older people supported by each working adult are all very important. The number of doctors and hospitals in an area must also be considered.

A brief description of socioeconomic conditions in the area has been put together from the 1975 New Mexico Statistical Abstract (BBER 1975). The information in the Abstract was collected by county, so an impression of conditions in the assessment area was gained by combining information for parts of Dona Ana, Luna, and Grant Counties (See Fig. 2). Since most of the assessment area lies in Grant County, the Grant County information was given the most weight. In most cases, specific figures for populations, etc., can not be quoted because the areas from which the data was collected were not congruent with specific parts of the assessment area.

About half of the people living in the area are concentrated in Silver City, Hurley, Bayard, and Central. The rest live in small, rural villages or on ranches scattered across the countryside. The overall population density is low, averaging less than 1 person per 25 ha (10 people per section).

About a third of the population considers itself part of the labor force. That is, one person in three either has a job or is looking for a job. The other two-thirds of the population include children, retired people, and women who do not work for wages. Since the unemployment rate in the area is not unusually high, and the population is low, it appears that the absolute number of unemployed workers is small.

The age distribution of the population is about average for the State of New Mexico, and so is the ratio of workers to the number of people they support. Since the variation in the ratio of workers to dependents is unknown, it is not clear how seriously a minor change in the employment situation would affect the population. For example, if people working at a particular type of job tend to have 20 dependents each, rather than two, a minor change in employment in this sector could have a significant effect on the region.

A large percentage of the people working in the area are employed in mining, government, or the trades. About three-quarters of the employed work force have jobs related to one of these three fields. The rest of the labor force is employed in manufacturing, construction, agriculture, or one of several other miscellaneous activities. Average per capita income in the area was $3,574 in 1974, which was slightly higher than the State average at that time. During 1974, contract construction workers received the highest average wages, and semiskilled or unskilled nonunionized workers received the lowest wages. Employment trends over the last few years have not been clear, so projection of these is not reasonable.

In 1970, the median educational level of people living in the assessment area was slightly lower than the State median. Less than half of the people over 25 years old had finished high school. This has probably changed in the last seven years, since most of the people just entering the over-25 group will have had more education than their grandparents.

Educational opportunties in the area are reasonably good. The New Mexico Statistical Abstracts (BBER 1975) suggest that there are enough school teachers and presumably enough schools to offer a good public education to all children in the assessment area. In addition, there is one university and a university extension service in the area. Both of these are based in Silver City.

Health facililities in the area include two hospitals, one in Silver City and one at Fort Bayard. There are not many doctors in the area; each doctor handles more people's needs than the State average.

Bayard, Central, Hurley, and Silver City each have regular police and fire protection. Some of the smaller towns have volunteer fire departments. Additional police protection is available from the New Mexico State Police and the Grant County Sheriff's Department.

Culturally, more than half of the population is listed as Spanish speaking or as having a Spanish surname; this is somewhat higher than the State average. Most of the rest are of Anglo-American descent. There is no information available on how many people in the area are functionally bilingual, or on how language abilities may affect a person's opportunities for employment. In the limited

time which was allotted for preparation of this document, no information could be collected on the local availability of public financing for improvements or expansion. In spite of this significant lack, it is suggested, in light of low population, low per capita income, there may not be extensive local resources for support of sudden, significant expansion.

b. Cultural Resources

Prehistoric remains in the area include remains which may date as early as 6000 BC, but most of the known sites are Mogollon village ruins from a considerably later period (750 AD to 1400 AD). At least 200 of these village sites have been identified so far. Many were never properly recorded, and most have suffered extensive damage at the hands of both amateur and professional pothunters, bead hunters, and arrowhead collectors. Because of this, the few villages in the assessment area which remain relatively undamaged must be considered highly significant resources.

Other types of sites may include a variety of special purpose or general purpose camps. Few of these are numbered among the known sites because they frequently lack the high density of colorful pottery which attracts most people. These sites are primarily useful for scientific purposes, but may also have some educational value. Field examinations would probably reveal many of these sites in the vicinity of any residential site.

Many of the prehistoric resources may eventually prove eligible for the State or National Historic Registers. Right now, the Mattocks Ruin and the Woodrow Ruin are actually on the National Historic Register, and three more villages, the Wheaton-Smith, Janss, and Montoya Sites, have been nominated. All of these, plus Kwilleylekia Ruin, are on the State Historic Register. Faywood Hot Springs is reported to have had substantial deposits of prehistoric and Pleistocene debris at depths of 7.6 to 9.1 meters (25 to 30 ft) (Holmes, 1902). This site is eligible for inclusion on both State and National Registers on the basis of the long time span represented by the cultural and palaeontological debris, and the unusual state of its preservation. Insufficient data has been collected on other sites in the assessment area to permit their nomination to either Register at this time.

Although the BLM has no specific site locations for most resources in the area, some possible critical resource areas have been identified through environmental analyses. These areas are shown in Figure 27. All of these areas are currently covered by an active protection effort which includes aerial surveillance. BLM is also conducting an extensive inventory of these areas to allow more successful management and field protection of resources.

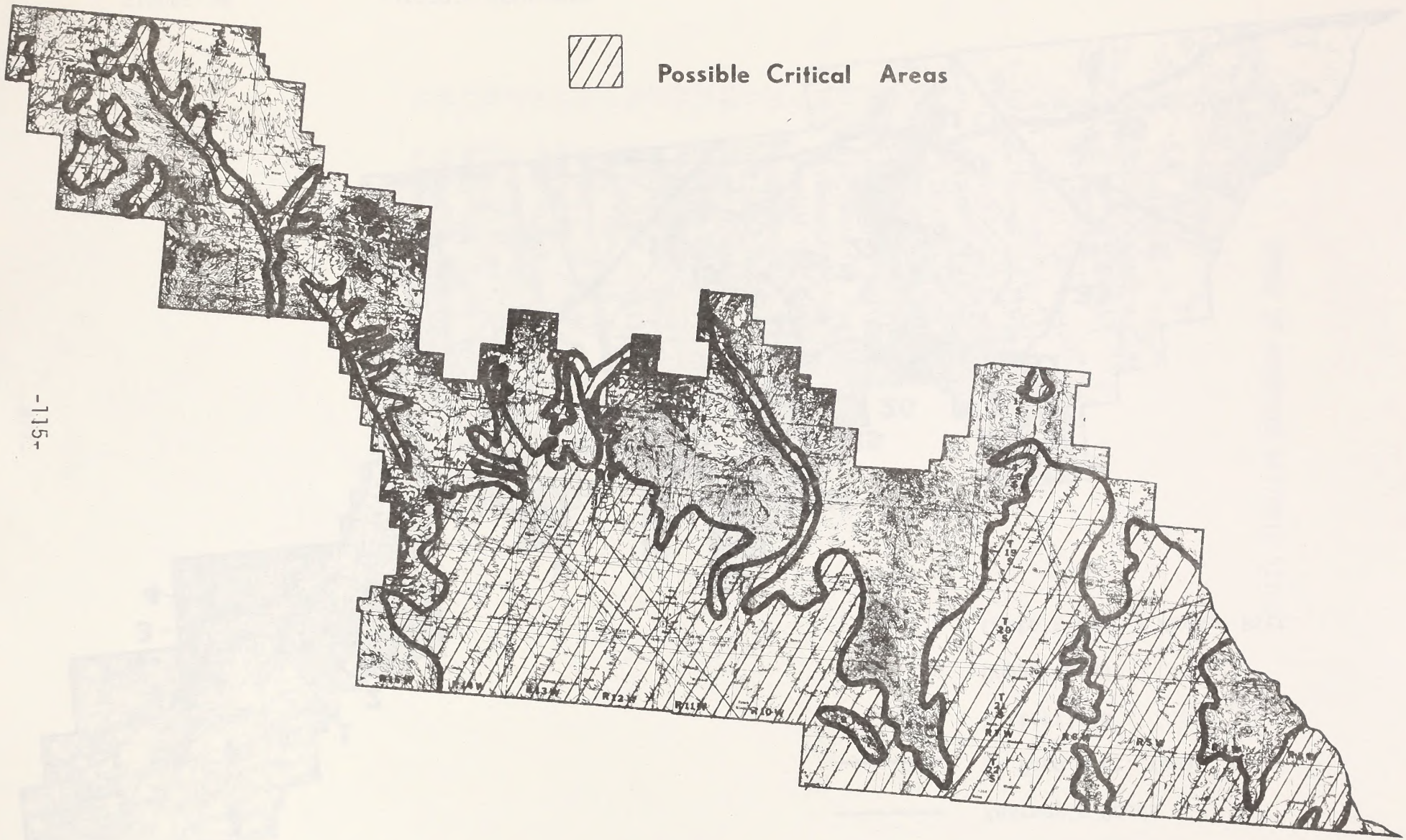


FIGURE 27 POSSIBLE CRITICAL AREAS FOR PREHISTORIC CULTURAL RESOURCES

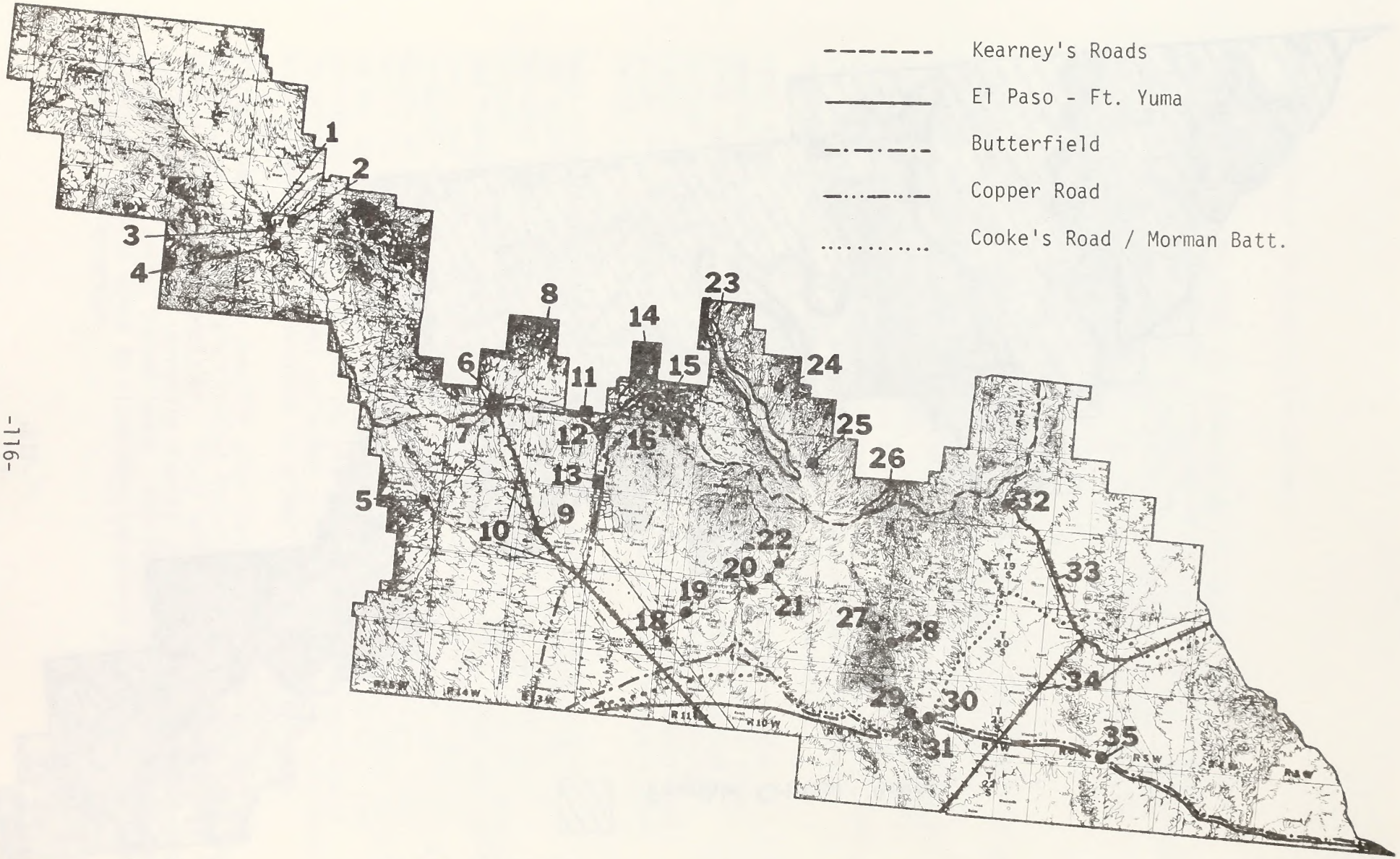


FIGURE 28 HISTORIC RESOURCES

NAMES OF NUMBERED HISTORIC SITES

1. Cliff
2. Gila
3. Ft. West
4. Gila Depot
5. Tyrone
6. Silver City
7. Ft. McLane
8. Birchville/Pinos Altos
9. San Vincente
10. Silver City - Deming Railroad
11. Central
12. Bayard
13, Hurley
14. Area settled in 1859
15. Santa Rita
16. Santa Rita del Cobre
17. Old Spanish Fort
18. Faywood Station
19. Faywood Hot Springs Resort
20. Camp Mimbres
21. San Jose
22. Dwyer (Faywood)
23. Mimbres Valley
24. Fort Webster
25. Mimbres Hot Springs
26. Battle of Gavilan
27. Jose
28. Cooks
29. Massacre
30. Fort Cummings
31. Cook's Spring Station
32. Lake Valley
33. Railroad (1885)
34. Railroad (1881)
35. Goodsight Station

In 1975, Dr. John Wilson prepared a volume on the historic resources in the Las Cruces District. Most of the discussion of historic resources in the assessment area has been taken from his work.

According to Wilson (1975), the whole assessment area was Apache territory by 1620, and European activity in the area was limited to Spanish military campaigns against the Indians until 1800. These campaigns were mounted from garrisons at El Paso, Janos, Fronteras, and Tucson. No presidios were ever built in the assessment area, and since the campaign routes are not known, no field camps have ever been identified.

After 1800, European use of the area began to increase. In 1803, the copper mines at Santa Rita del Cobre were opened for production by a Chihuahuan merchant, and a fort was built to protect the miners. The copper was transported by mule, first to Janos along a trail shown in Figure 28, then on into Mexico. The same trails, known simply as the "road to Janos", were also used by Apache raiding parties for many years.

In the early 1800's, a general influx of miners and trappers began. Although these people probably built base camps or supply camps on occasion, they built no permanent settlements. None of their supply camps have been identified on the ground so far. From 1800 to about 1840, mining and trapping activities increased, and the Apache problem became more severe as the number of Mexicans and Americans using the area increased. The Apache raiding was so bad in the 1830's, that the Santa Rita copper mines were forced to close down for several years.

In 1846, the New Mexico Territory became an American territory and American military activity in the area increased. Brigadier General S. W. Kearney passed through the northern part of the assessment area in 1846, and was followed shortly by the Mormon Battalion crossing on a more southerly route. Both of these routes are shown in Figure 26. These routes were later used by the "49'ers" on their way to California, as well as by other travelers.

By the 1850's, the U.S. military had decided that the Apache problem was out of control, and several campaigns were initiated against their war parties. Fort Webster was built near the Santa Rita mines in 1853, to protect the miners. Bonneville's Gila Depot, built near Cliff in 1857, and his Burro Mountain Camp, built south of Tyrone in 1859, served as supply centers for troops fighting the Apaches. Fort McLane (McLean) was built in 1860 to protect the miners at Pinos Altos, although it was not occupied for very long.

Beginning in 1805, American activity in the area intensified. The Santa Rita copper mines were reopened and the Hanover, Pinos Altos, Silver City, and Georgetown Mining Districts were established. Settlers had moved into the Mimbres Valley by 1860, and many other towns were established by 1885. West Fort, Camp Mimbres, and Fort Bayard were all built during the 1860's, to help protect the growing American population from the Apaches. Regular mail service and transportation through the area was offered by several stage companies, including the well-known Overland Mail Company managed by John Butterfield. Resort hotels, such as the one at Faywood Hot Springs, were built to take advantage of the increasing number of travelers.

By 1900, most of the towns in the assessment area had been established. The Apaches had been removed to reservations in Arizona and central New Mexico, and most of the forts had been abandoned. Portions of the earlier trails, such as the Butterfield, were still being used, and new roads were being constructed. Railroad spurs to many of the mining districts were built in the 1880's, and continued in use until the Depression when the less economical lines were abandoned.

To date, the BLM has made no field examinations of most historic resources in the assessment area. Although most towns in the area classify as historic sites, it is not known whether any of the original structures in these towns remain standing. Original structures which are standing and in reasonable condition will probably be eligible for the National or State Historic Registers. Right now, there are two historic sites from this area on the National Register; the H. B. Ailman House and the Thomas Conway House. Fort Cummings and the Cook's Spring Stage Station have been nominated. Sites on the State Historic Register include: the David Abraham House, the H. B. Ailman House, Bell Block, Gold Avenue Methodist Episcopal Church, the L.C. Ranch Headquarters, Martin Maher House, Meredith & Ailman Bank Block, the Silver City Historical District, Edward Stine House, Thomas Conway House, Warren House, and Fort Cummings.

Places which have had a specific use in the past, and which remain important to people living today because of their traditional use are considered to have heritage value. Shrines may be one of the best examples of places with heritage value.

No information on heritage values was collected for this document. In most cases, field examinations and public interviews would be required to identify these values. Heritage values in the assessment area will be considered for protection along with other cultural resources as they are identified.

c. Scientific and Educational Values

Special opportunities for scientific research are presented by endangered or threatened species living along the river drainages. Information important to range conservation, geological and archaeological studies may also be collected in the area.

In addition to these resources, several finds of vertebrate fossils have been reported. At lease one of these is still in place, and was reported to be a species of elephant. Many invertebrate fossils may also be found in the area. These include crinoids, gastropods, and cephalopods.

Most of the resources discussed in "The Existing Environment" present good educational opportunities. Special field trips could be arranged to take advantage of any of the resources. Right now, City of Rocks State Park is the only place where year round interpretation of resources is available. The Mimbres Foundation, an archaeological research group based at UNM in Albuquerque, has occasionally held educational programs in the last few years. Usually, these special programs are scheduled toward the end of their summer field season.

III. ANALYSIS OF THE PROPOSED ACTION AND ALTERNATIVES

A. Environmental Impacts

1. Anticipated Impacts

The anticipated impacts of geothermal leasing in the Silver City Geothermal Leasing Area were assessed by a team of specialists using the Environmental Analysis Worksheet (Form 1790-3) (Appendix D). The stages of implementation that industry might use in developing geothermal resources were divided into: Pre-lease Exploration (Casual Use), Pre-lease Exploration (Exploration Operation), Post-lease Exploration, Development, Production, and Close-out. The discrete operations are those which take place under the various stages of implementation. These stages and the discrete operations occurring in each stage were described in the background information of the "Description of the Proposed Action and Alternatives."

In an attempt to reduce personal bias, a team approach was used in evaluating the impacts of each type of operation on each environmental element. First, a list of all the environmental elements suggested for consideration by the BLM Environmental Analysis Manual, 1791, was reviewed by the team members. A list of the discrete operations which might occur during geothermal operations was then developed. The team then rated the impact of each discrete action on each environmental element. The team discussed the anticipated impacts and reached agreement on the most reasonable rating for each of these impacts. After this analysis, some of the environmental elements were eliminated because no significant impacts were expected from a discrete operation or stage of implementation.

Casual use methods utilized during the pre-lease stage of exploration have almost no impact on the environment. Field examination is confined to existing roads and trails or crossing country on foot. Small water or rock samples will be collected for analysis. Casual use methods also include a literature search of libraries and public records, and airborne surveys, neither of which impact the environment. The field surveys will bring a small amount of money into the community. Results of the surveys may add to the geologic knowledge of the area, yielding minor positive impacts.

Close-out is the stage which occurs after a geothermal resource has been exhausted. Since five to ten years will elapse between leasing and production, and since a resource must have a minimum life expectancy of 30 years to merit development of the resource for power generation, Close-out would not begin until at least 40 years after leasing. It is difficult to anticipate the impacts of Close-out so far into the future when the type of production and technical advances which will take place are unknown.

The issuance of a geothermal lease, in itself, does not produce impacts upon the environment; but once the lease is issued, impacts may occur. The information gathered during exploration may determine the fate of the geothermal field. If a resource is encountered, plans will be made for the most practical use of the resource. The geothermal resources may be used for the production of electricity, space heating, agricultural production, etc., or a combination of these. If, on the other hand, an economical resource is not discovered at any stage of exploration, industry will probably withdraw from the area and no further impacts will result. Anticipated impacts, however, will be analyzed in the four following sections titled "Pre-lease Exploration (Exploration Operations)," "Post-lease Exploration," "Development," and "Production," even though the development of the field may never take place.

a. Non-living Components

(1) Air

(a) Pre-lease Exploration (Exploration Operations)

Impacts upon air quality due to pre-lease exploration activities should be minimal. Exploration will be confined to existing roads in most instances. Shallow temperature gradient holes and active seismic methods usually require some vehicular movement and off-road travel. This may produce a low impact on air quality by adding to the current levels of particulate matter and carbon monoxide. Negligible amounts of noxious gases will be released during all pre-lease exploratory actions which make use of vehicles.

(b) Post-lease Exploration

Impacts to air quality during the post-lease activities will be similar to those during pre-lease exploration. The increased intensity of activity or the release of noxious/non-condensible gases associated with deep exploratory wells may cause temporary changes in air quality. This would cease when exploration is complete and the wells are plugged.

(c) Development

During this stage of implementation, moderate to high impacts on air quality are expected from particulate matter, and negligible to low impacts are expected from noxious gases. Increased impacts will be due to additional wells being drilled and tested and increased vehicular movement.

(d) Production

The greatest activity in the field should occur during this stage of facility construction and plant operation. Particulate matter and noxious/noncondensible gas levels will increase on a local basis during this time. These levels will decrease with paving, construction completion, erosion control, and revegetation. Power plants will require the most construction activity and supportive surface facilities. A low impact on air quality may be expected, also, from electrical transmission lines emitting nonionizing radiation. Other uses of geothermal resources will require less construction, fewer roads and pipelines, and no transmission lines, so these activities will produce less impact on air quality. Local air movement patterns and air temperature may be affected by the release of large quantities of hot water vapor into the atmosphere. The overall effect of this localized humidification can not be determined at this time, but should be considered carefully during the development of Production plans. Air quality may be affected, also, by radiological contaminants escaping into the atmosphere if tracer isotopes are used. In The Geysers area, such isotopes were used to study underground reservoir characteristics.

(2) Lands

(a) Soils

i. Pre-lease Exploration (Exploration Operations)

Pre-lease Exploration is usually confined to existing roads and trails. Active seismic and shallow drill hole methods require some off-road travel, producing some impact from soil disturbance. This impact will be increased considerably if this work is performed during periods when soil surfaces are wet. Vehicular travel during these periods will produce ruts which provide channels for run-off, causing increased soil erosion and deteriorating watershed conditions.

ii. Post-lease Exploration

Methods used during this stage will be more disturbing to the environment. Sites for exploration wells and geologic information holes vary in location. Some roads will be graded to move equipment to the drill sites. These sites must be cleared and graded. Impacts on the soil and watershed will vary according to location. Certain soils are more susceptible to compaction, surface disturbance, and erosion than others. Soil associations on which the greatest amount of compaction could be expected are:

Cacique-Pinaleno-Hap
Eba
Sonoita-Yturbide-Hap

Soil associations on which the least amount of compaction could be expected are:

Luzena-Arp
San Mateo-Shanta
Cabezon-Thunderbird
Lonti-Poley-Pastura

The other soil associations would have a moderate amount of compaction occurring as a result of vehicular travel. Soil associations and individual soils occurring within other associations which are highly erodible are:

Sonoita-Yturbide-Hap
Bluepoint Soil
Hap Soil
Berino Soil
Glenberg Soil

It could be expected that a considerable amount of erosion would occur on these areas if all the vegetative ground cover were removed.

If drilling mud is used, retention pits may be dug, causing further soil disturbance. Inadvertent oil or fuel spills, as well as accidental release of deep reservoir water containing toxic chemicals, could contribute to soil pollution on a localized basis.

iii. Development

Impacts on soil will be essentially the same as in "Post-lease Exploration," only more severe. Service roads will be constructed to carry increased traffic to existing and additional development wells, and to gain access for construction of pipelines and other surface facilities. The severity of the impact will be dependent upon location and design of roads and facilities. If normal flow patterns of runoff are altered or diverted from established drainage channels, erosion can be expected as a result of the establishment of new drainage channels, thereby causing deteriorating watershed conditions.

iv. Production

Impacts on soils should remain unchanged through this stage, but will diminish when construction is completed, roads are paved, and rehabilitation programs implemented. Structural subsidence might be anticipated as the result of depletion of the underground reservoirs. Rehabilitation of disturbed areas or sites on which the vegetation has been removed will vary in success from poor to good. Some soils are much more difficult to revegetate than

others. Soil associations on which difficulty in revegetation may be encountered are:

Nickel-Upton-Tres Hermanos
Hondale-Mimbres-Bluepoint
Cacique-Pinaleno-Hap
Lehmans-Orogrande-Rockland
Eba
Mimbres-Vehalen
Lonti-Poley-Pastura

In addition, difficulty in revegetation will be encountered on numerous other sites because of lack of sufficient soil on exposed rock or caliche surfaces.

(b) Geology

i. Pre-lease Exploration (Exploration Operation)

No significant impacts are expected.

ii. Post-lease Exploration

No significant impacts are expected

iii. Development

Essentially, no impacts are expected throughout the major portion of this stage of implementation. Impacts might be expected during the final phases, but would most likely be concurrent with production.

iv. Production

During production and the final phase of Development, aggravation of existing geologic-hazardous conditions could result in severe impacts to the environment if adequate precautions are not taken. It is possible that seismic activity may be increased by injection of geothermal fluids along fault zones. Increased earthquake activity could result in landslides and damage to surface structures. There might be a small possiblity of renewed volcanism. Subsidence is an impact that could result from depletion of an underground reservoir. Any subsidence that might occur would be dependent upon the geological structures in the vicinity of the geothermal reservoir, the changes in pressure that occur as fluid is withdrawn, and the compressibility of the rock strata overlying the reservoir.

Impacts to the environment and to facilities (such as cracked foundations, severed pipelines and roads, and other instances of damage too numerous to mention) may result from potentially hazardous geological conditions activated by development of geothermal resources. With each new geothermal development, new data is gathered and new technology may be developed to reduce potential adverse impacts caused by induced seismicity and subsidence.

(3) Water

(a) Pre-lease Exploration (Exploration Operations)

No significant impacts are expected.

(b) Post-lease Exploration

Exploratory drilling for geothermal resources should have little or no impact on water quality; GRO Orders 2 and 3 insure its protection. One possible exception may be near-surface groundwater which could be contaminated accidentally by chemicals, toxic substances, or hot brines from deep geothermal reservoirs.

(c) Development

During Development, the normal hydrologic cycle may be affected by venting steam into the atmosphere, and by the surfacing of groundwaters. The chance of near-surface groundwater contamination may increase due to additional development wells being drilled. Sediment load levels in surface waters may be impacted if proper erosional constraints are not implemented.

(d) Production

Impacts on water quality during this stage are similar to those anticipated during the Development stage. It is possible that the groundwater level could be lowered if water were to be withdrawn in large quantities over a short period of time. Injection of waste water will be dependent on geological and other conditions. Radiological contamination of deep or shallow groundwater could occur if tracer isotopes were to be used in geothermal reservoir studies. Contamination of fresh water aquifers as a result of an injection program is prohibited under existing rules and regulations.

b. Vegetation

(a) Pre-lease Exploration (Exploration Operations)

i. Aquatic Vegetation

The aquatic plant communities associated with the small stockwater reservoirs could be affected by drilling

shallow temperature gradient holes. The holes may be drilled with mud. In the past, some drillers have used the water from small stock water reservoirs to prepare the drilling muds. The removal of some or all of the water decreases or eliminates the habitat necessary for the survival of the aquatic community.

ii. Terrestrial Vegetation

Many of the pre-lease exploration surveys will be confined to existing roads and trails or will be conducted on foot. Active seismic surveys and temperature gradient holes will produce some impacts to the vegetation. Active seismic surveys are conducted in straight lines over a specified area. The number and size of vehicles and the configuration of the geothermal field will determine the amount of destruction to vegetation. A trail along the seismic lines will result from vehicular activity.

The degree of impact caused by this activity will vary according to the vegetation present, the direction of travel in relation to slope, the time of the year the operation is being performed, and the soils. Normally, grassland vegetation would be affected the least by this activity. Under certain conditions, however, the impacts would increase considerably. Vehicular travel during periods when the soil surface is wet or across soils which are easily compacted will cause ruts. If these ruts run parallel to the slopes, they could become channels for runoff and increased erosion would occur, which could destroy vegetation and cause deteriorating watershed conditions. Impacts on the pinon-juniper and oakbrush vegetative types would be similar to impacts on grassland. In some instances, when travel through thick stands of these species is necessary, some clearing may be required.

The impacts of vehicular travel on the brush-type vegetation will vary with the species present. Dune-type mesquite will be affected very little, since travel will be around and between the dunes where very little vegetation is growing. The creosotebush and desert shrub vegetation types, which have very little vegetative growth to provide ground level surface protection, will be impacted similarly. The most noticeable impact will be trampling or flattening of vegetative growth. The most important impact, however, will be that caused to the soil surface, because of the lack of any ground level vegetative cover. Impacts from travel when the soil is wet, or across soils which are susceptible to severe compaction, will be much greater in brush-type vegetation than in vegetation types which provide more ground cover.

Travel through riparian vegetation will cause an impact only if clearing is necessary or if attempted across wet, boggy areas.

The impact upon farmland will depend on the time of year the activity takes place. If it occurs during the time of year when crops are growing or fields are wet, the impact will be severe. If it occurs during the period when crops are not growing and fields are dry, the impacts will disappear at the time the fields are tilled for the next planting season.

The area disturbed by drilling temperature gradient holes may cover an area of about 279 m^2 (3,000 sq ft). The vegetation on these sites will be crushed by the equipment or covered by drill cuttings. These sites are normally less than 46 m (150 ft) from an existing road. The drill cuttings will normally cover an area of about 3.3 m^2 (36 sq ft). Thus, a small amount of disturbance will be produced by the activity associated with the drilling of temperature gradient holes in any vegetative community.

Endangered and threatened plant species, as well as those considered rare, could be destroyed if care is not taken to locate and protect the sites on which they are growing.

(b) Post-lease Exploration

i. Aquatic Vegetation

Geologic information holes and exploration wells will be drilled during this stage of implementation. The holes may be drilled using mud and large volumes of water; about 522-700 l/m (42-62 gal/ft) is required. (W. D. Tipton, pers. comm.). In the past, drillers have used stock water tanks to supply water for the drilling operations, as well as to control dust on access roads and drill pads. This use has reduced the available water in one or more stock water reservoir. If this use is permitted, it may result in the reduction or loss of aquatic vegetation.

ii. Terrestrial Vegetation

Off-road activities during the Post-lease Exploration will intensify. Vehicular travel will crush or break off portions of shrubs and grasses. The degree of impact will depend upon the vegetative community affected. Off-road trails may later become roads to drill sites, etc., which will be cleared, shaped, compacted, and sloped.

Small, mobile drill rigs capable of drilling about 610 m (2,000 ft) are used to drill the geologic information holes. Drill pads 30 x 30 m (10,000 ft sq) will be cleared, leveled, and a pit will be dug. The vegetation will be completely removed from the pad. A temporary access road to the site may be built, then upgraded if the need arises. All of these activites will remove and disturb vegetation.

Large drill rigs used in drilling deep geological and exploration wells require a level drill pad of approximately .81 ha (2 ac). These areas will be completely cleared of vegetation. The intense activity around the drill rig will restrict vegetative regrowth because of soil compaction.

Fluids that inhibit vegetative regrowth may be used in any of the drilling operations, but such fluids are usually confined to mud pits, mud sumps, and drill holes. Oil and grease used at the drill site occasionally are spilled on the ground. When such spills occur, the vegetation which contacts the fluids usually is destroyed.

The degree of impact, again, depends upon the vegetation present, the location of the activity, the number of geologic and exploration holes drilled, the time of the year, and the soils on the site.

The grassland type is one of the most valuable forage-producing vegetative types in the assessment area. When grasslands are cleared, the area is significantly impacted and reduced forage production results. Proper revegation techniques are needed to replace this valuable forage for wildlife and livestock.

The pinon-juniper and oakbrush types also provide valuable forage for livestock and wildlife, as well as highly suitable cover for all forms of wildlife. Clearing of these vegetative species would destroy habitat and forage and would also produce a visual impact.

Mesquite and associated plants produce some forage for livestock and wildlife. Removal of mesquite, if done in the proper manner, could provide a condition which would permit more desirable vegetative ground cover to be come established, and eventually provide more usable forage and better ground level soil surface protection.

The creosotebush and desert shrub types produce very little usable forage and do not provide much ground level protection against soil movement. Removal of these species may allow other species to become established, providing more forage and increased soil stability.

The riparian-farmland is very valuable to man and wildlife. The large trees which grow along the Gila and Mimbres Rivers provide habitat for a large number of wildlife species. Removing any of these trees would decrease this habitat and significantly affect wildlife because of the small amount of riparian habitat in the assessment area.

(c) Development

i. Aquatic Vegetation

No significant impact will occur during this stage of implementation. The operation will be large enough so that water for drilling must come from large storage reservoirs or wells.

ii. Terrestrial Vegetation

Vegetation will be removed from the drill pads and roads, and will be disturbed or destroyed during the construction of pipelines which connect each well. The impacts imposed on vegetation are discussed in the "Post-lease Exploration" section. The Development will continue until the field is fully productive. The total impact on vegetation will increase with each development in the assessment area. Again, the degree of impact depends upon the vegetative type and the area involved.

The hot waters associated with geothermal activities contain soluble compounds. Some of these compounds, such as excessive amounts of sulfur or boron, can inhibit plant growth. If solutions of these compounds escape during drilling and testing, plant growth could be inhibited or destroyed.

Noncondensible gases are released into the atmosphere from steam and hot water during testing. A number of these gases can affect plant growth. Hydrogen sulfide, carbon monoxide, and others are absorbed into plant tissues and may, temporarily or permanently, inhibit some plant growth.

(d) Production

i. Aquatic Vegetation

Very little to no impact should result during the Production stage. Water will probably be taken from deep wells, The development of a geothermal facility should not cause significant changes or impacts on aquatic vegetation. Deep waters brought to the surface and used in the geothermal facility are most likely to be injected into the geothermal reservoir strata, but might be purified and released on the surface, thus possibly increasing the amount of aquatic vegetation.

ii. Terrestrial Vegetation

Vegetation will be impacted as long as any activity associated with geothermal development remains in the area. Pipelines will be needed to carry the energy source to the power plant or other facilities. Power plants, transmission lines, and/or other facilities must be constructed before the geothermal energy can be utilized.

Pipelines connect the producing wells to the power plant. During the construction of these pipelines, vegetation will be either damaged or destroyed. In the past, rights-of-way for pipelines have been cleared of vegetation and maintenance roads have been constructed parallel to each pipeline. Once a pipeline road is constructed, activities will be conducted on the maintenance road and on portions of the pipeline which need attention. Vegetative regrowth will be hindered by continued use of the area. Pipelines could leak or break, and bleed-off from the wells or other accidents could release toxic compounds that hinder plant growth.

If power plants are constructed, vegetation will be removed from 2 to 4 ha (5 to 10 ac) of land. The constant activity around power plants will curtail the regrowth of vegetation. Soil sterilants may be placed on the soils to eliminate vegetation which might become a fire hazard. If soil sterilants are used, most plant growth will be eliminated for a period of two to three years following its application.

Transmission lines will be required to transport electricity from the power plants to population centers. The construction of these lines will disturb the vegetation within the powerline rights-of-way. Large vehicles will be needed to transport and erect the required facilities. A bladed road for the maintenance of powerlines may be needed; this will cause further vegetative destruction.

Each facility within the field will require a road. These roads may be trails used once during the activity, or improved roads to well heads, pipelines, power plants, powerlines, etc. This large transportation network will continually affect the vegetative communities. Again, the degree of impact will depend upon the placement of the developments. If the developments are in creosotebush, mesquite, or desert shrub areas, the impacts will be less than if they are in grassland, pinon-juniper, oakbrush, or riparian-farmland areas.

Once the facility is producing, many of the disturbed areas will be revegetated naturally or mechanically. The sites could benefit from proper rehabilitation, and may produce more usable forage for livestock and wildlife than the original vegetation.

The other uses of geothermal energy should have less impact on the vegetation than the production of electricity since they require less extensive supportive developments.

(2) Animals

(a) Pre-lease Exploration (Exploration Operations)

The Exploration Operations phase of pre-lease exploration may result in temporary, site-specific impacts. The magnitude or extent to which animals and their habitat will be affected cannot be fully evaluated at this time because the locations and number of roads, trails, and drill sites, the number and types of vehicles, and the number of operating personnel involved in the exploration are unknown. No significant impacts are expected except in areas where endangered species are involved. In these areas, high impacts may be expected.

Variations in vegetative composition and density, topography, water availability, etc., directly affect animal species distribution, diversity, and density. The magnitude and severity of impacts will vary from location to location within the assessment area. The relative significance of the impacts will vary among the different animal species (e.g., species of common occurrence vs. species of endangered or threatened classification) and among specific ecosystems (e.g., creosotebush vs. desert shrub).

The degree to which aquatic animals may be impacted will depend on the proximity and duration of activity to existing waters. Aquatic animal life will be influenced by changes in the availability of water and vegetation. Similarly, animals and birds which depend upon aquatic life for food will be affected.

Vehicular travel, drilling operations, and associated activities may cause some temporary displacement or harassment. If such activity were to occur during the nesting season, nests could be abandoned or destroyed and the young lost. Some species, such as the killdeer, are flexible in their habitat needs and could find suitable habitat elsewhere. Other species, such as the bald eagle or Mexican duck, (endangered species), are more specific in their needs and could be seriously affected because of their inability to adapt to other habitat.

Several areas along the Gila River have been identified as inhabited or used by several endangered species, including the Mexican duck, olivaceous cormorant, little blue heron, bald eagle, peregrine falcon, osprey, and lyre snake. Most of these species are easily disturbed. As a result, exploration activities near the edges of

these areas during periods of breeding or nesting could seriously jeopardize the continued propagation of these species. For example, the Mexican duck has been categorized as a relatively secretive species, unable to withstand prolonged disruption (Davis and Bevill, 1970).

Adverse impacts to terrestrial animals should be minor if pre-lease exploration is confined to existing roads. Travel over undisturbed terrain can cause seriously harmful effects to some animal species. Any concentrated or long-term traffic may affect both breeding and nesting activities. Bird nests constructed in low-growing shrubs, young birds, and species which have greatly reduced mobility may be disturbed or destroyed by surface vehicles traveling cross-country.

Off-road vehicular travel and drilling operations could result in the loss of valuable food and/or cover for various animal species. The magnitude and severity of such loss will depend upon the location of such activities and the relative importance of the areas to animal species using them. The relative importance of the impacted species (e.g., game animal, endangered or threatend species, furbearer, etc.) also has a bearing on the significance of the expected impacts.

The use of stockwaters as a source for drilling water could affect antelope and other animal species (aquatic and terrestrial) if the water hole were to be depleted and no other drinking water was available.

Pre-lease exploration in the Santa Rita, Mimbres, and Little Burro Mountains, and along the foothill areas of the Black Range could result in minimal temporary disturbance of associated animal species (e.g., mule deer, Coues' whitetail, wild turkey, Mearns', Gambel's, and scaled quail). The construction of drainage crossings or any drilling in drainage bottoms could result in the destruction of important vegetation, the disturbance of the soil substrate, and disruption of various soil-dwelling organisms.

Within the Gila River and Mimbres River drainages, moderate impacts upon terrestrial habitat and associated species may occur. The agricultural-riparian areas identified would receive the greatest impacts. Such areas are extremely valuable to wildlife, including several endangered and threatened species. During the exploration phase, local sites of riparian habitat could be altered substantially. Agricultural areas, although created and controlled by man, are extremely enticing to many forms of wildlife. The ecotone created results in additional diversity of animal life. Since exploration in these areas will probably be confined to existing roads and trails, crop damage should not result. Nevertheless, some animals may be run over by vehicles or temporarily disturbed or displaced.

Exploration operations in the creosotebush, mesquite, and desert grassland ecosystems could result in the loss of a small amount of vegetation in addition to the temporary displacement, harassment and possible loss of animal life.

Throughout the assessment area, water is a highly limiting component for many animals species. Any change in the availability of this essential substance could be devastating to dependent animal life.

(b) Post-lease Exploration

Post-lease exploration generally includes the same methods as pre-lease exploration; however, all activities will be greatly intensified. Off-road vehicular use, road and trail construction, drilling duration, and site disturbance will all increase. Corresponding increases in the impacts on animal species and their habitat may occur. The amount of acreage involved in Post-Lease Exploration may be smaller than that involved in pre-lease exploration, since more specific, localized sites are involved.

The area of greatest potential impact to animal species during Post-Lease Exploration will be along the Gila and Mimbres Rivers, especially within one mile of the rivers. Thirty-two species of endangered and threatened wildlife have been identified as inhabiting this area, some seasonally, some yearlong. In addition, numerous species of birds, furbearers, and game species inhabit these valleys. Table 10 summarizes probable essential habitat and behavioral components for endangered species and factors to which their decline has been attributed. From this, the activities associated with exploration which will have the greatest impact upon these endangered species can be determined. An evaluation of the table indicates that activities causing further loss or alteration of habitat or prolonged disturbance will result in the greatest impacts.

Habitat alteration has been identified as the primary reason for the decline of species listed as inhabitants of the Gila River Valley to the point where they have become endangered. Human activity (shooting, prolonged disturbance) is the second most harmful factor to which decline has been attributed.

The foothill areas of mountain ranges in the assessment area also support endangered species of fauna as well as game species, furbearers, and wintering birds of prey. Again, habitat alteration and human activity have been identified as primary limiting factors of endangered species in these areas. Any reduction in the availability of grassland areas, including playa beds, through road construction, drill site location, etc., would significantly impact endangered species (Baird's sparrow, McCown's longspur). These areas also provide an essential food source for antelope.

TABLE 10

ENDANGERED AND THREATENED SPECIES HABITAT COMPONENTS OR SPECIFIC BEHAVIORAL CHARACTERISTICS CONSIDERED ESSENTIAL TO SPECIES SURVIVAL AND FACTORS ATTRIBUTABLE TO SPECIES DECLINE

Species	Essential Habitat Components or Species Behavioral Characteristics	Factors Contributing to Species Decline
Birds		
Little blue heron	Breeding and feeding in and along fresh water marshes, streams, creeks, Nest constructed over water	Peripheral habitat Limited breeding and feeding habitat
Mexican duck and Hybrids	Highly secretive. Breeding nesting and brood rearing in dense growth near water	Drainage of marshes diversion of streams and rivers for irrigation etc. Hybridization
Southern bald eagle	Tall trees or cliffs near water; nesting and feeding	Shooting or poisoning; human disturbance; removal of nest trees
Caracara	Brush or woodland areas; nesting	Human disturbance
Peregrine falcon	Cliffs, old trees, river cut-banks overlooking water, night roosts, nesting, hunting	DDT, alteration and loss of habitat; habitat destruction; shooting, collecting, and falconry
Aplomado falcon	Shrub, desert shrub, grass-land, yucca; nesting exclusively in yucca	Alteration of habitat, decline in yucca-grass-land vegetative type.
Olivaceous cormorant	Lowland marshes to mountain streams; requires drowned trees or groves near water for nesting and feeding	Limited availability of nest sites; fluctua-tion of food supply; human disturbance
Buff-breasted flycatcher	Inhabits pinon-juniper woodlands of 5,000 to 9,000 ft in elevation	Species may be extirpated in New Mexico. It is speculated that fire control practices have permitted understory areas to become overgrown, altering habitat suitability

TABLE 10 (continued)

Species	Essential Habitat Components or Species Behavioral Characteristics	Factors Contributing to Species Decline
Zone-tailed hawk	Large cottonwoods of streams and canyons; coniferous forests of high mountains; nesting and hunting in trees along streams.	Shooting; destruction of lowland riparian habitat.
Osprey	Forest, strips of timber along streams or large bodies of clear water; hunting, protection from predators, good visibility and nesting in these areas.	Pesticides; human activity, degradation of streams with subsequent diminished food supplies.
Inland least tern	Sandbars; spits; alkali, level unvegetated ground near water; nesting	Lack of suitable breeding habitat
Red-headed woodpecker	Lowland riparian woodlands; planted trees; utility poles	Habitat destruction (riparian woodland); competition with starlings, *Sturnus vulgaris*, for nest holes
Bell's vireo	Dense shrubland, woodland along stream courses; willows, mesquite, seep willows, characteristic plant species	Loss of riparian habitat, nest parasitism by brown-headed cowbird
Baird's sparrow	Breeding in shortgrass prairies, scattered low bushes, old, matted vegetation.	Drought, agricultural development, excessive grazing affecting shrubby shortgrass prairies where the species winters
McCown's longspur	Feeding and nesting on semi-arid ground; short, sparse grass; winter drylake beds, plowed fields & plains.	Degradation of habitat due to drought; agriculture and over-grazing. Decline in winter seed crops.

TABLE 10 (continued)

Species	Essential Habitat Components or Species Behavioral Characteristics	Factors Contributing to Species Decline
Black Hawk	Well timbered water courses near well shaded pools. Seems to prefer the broad-leaf species of cottonwood	Shooting, human disturbance, clearing of riparian habitat (cottonwood draws)
Gray Hawk	Riparian woodlands, however, they often hunt in more xeric forms of habitat outside of the riparian zone.	Shooting, human disturbance, clearing of riparian habitat
Gila Woodpecker	Well timbered bottom lands and mountain canyons. Also known to utilize groves of giant saguaro cactus.	Destruction of riparian woodlands, illegal shooting, competition with invading starlings for nest cavities.
Reptiles		
Sonoran Mountain kingsnake	Chapparal and pinon-juniper woodland into pine-fir forests; secretive, seeks cover	Limited mobility, commercial collection
Lyre snake	Rocky desert, semi-desert evergreen woodlands, ponderosa pine in canyons rocky areas; seeks cover	Limited mobility, commercial collection
Narrow-headed garter snake	Clear, slow-moving water of permanent or semi-permanent streams associated with pinon-juniper and oak pine belts	Dependence on clear mountain streams and the degradation of habitat due to drought.
Arizona coral snake	Rocky areas of brushland, woodland, grassland and farmland in arid and semi-arid regions.	This species is rare in New Mexico, its low numbersare the principal reason for its classification.

TABLE 10 (continued)

Species	Essential Habitat Components or Species Behavioral Characteristics	Factors Contributing to Species Decline
Arizona black western rattlesnake	Habitat requirements are not well known, but prefers riparian vegetation of pinon-juniper and ponderosa pine zones	Low numbers, restricted range, human disturbance and killing by humans.
Gila monster	Rough rocky terrain of lower foothill regions between 4,000 and 5,000 ft. and sandy outwashes and arroyos of the lower Sonoran Life Zone	Low population numbers, low reproductive rates and heavy collecting pressure
Fish		
Roundtail Chub	Prefers swift waters of the Gila River. Occurs most often at the head of deep pools and under cuts in deep riffles.	Fluctuating water levels and competition from introduced small mouth bass.
Loach minnow	Swift flowing, shallow, unshaded water appears to be preferred habitat.	These fish are subject to both competition and predation from introduced species.
Spikedace	Frequents moderately swift currents flowing over gravel bottoms at the lower end of riffles	Currently does not appear to be in decline in New Mexico. Number have been reduced, however, by competition from the introduced red shinner.
Chihuahua Chub	Prefers pools of the Mimbres River, but often ventures into swift water	Population number are small and very local, and is probably still experiencing competition from the introduced longfin dace.
Gila Trout	Inhabits permanent and semi-permanent streams of the Gila River drainage of New Mexico and Arizona	Danger of hybridization with introduced rainbow trout

TABLE 10 (continued)

Species	Essential Habitat Components or Species Behavioral Characteristics	Factors Contributin to Species Decline
Gila Topminnow	Found in quieter waters of the Gila and San Francisco Rivers.	Extirpated from its former range by competition with the introduced mosquito fish
Mammals		
Mexican Wolf	Occurs mainly within the Upper Sonoran and Transition Zones in the southwestern United States	Man's rivalry with the wolf for game and livestock is considered the primary reason for their decline.
Jaguar	Mainly a neotropical cat in the forests of Central and South America	Illegal sport hunting and fur prices have made this cat very valuable. Also, the jaguar is considered a predator and dangerous to livestock.
River otter	Found in river environment where it can find a suitable abundance of fish.	Trapping for fur and competition with man for water in the southwest.

(c) Development

Impacts associated with Development will be similar to those associated with Exploration, but will be more localized, involve less acreage, and entail more concentrated and intense disturbance. Intensified road construction, drill site preparation, and drilling activity will occur. The sites associated with Development will require clearance of all vegetation. Disturbance and destruction of animal species and habitat will occur.

(d) Production

Construction of power plants or other facilities (greenhouses, etc.) may take place. Permanent vegetative clearance will be required at the sites of some facilities. Additional animal species and their habitat may be lost. The rehabilitation of disturbed sites associated with the Exploration and Development phases should occur during the Production phase. Eventually, partial revegetation should occur. As previously indicated, the impacts ultimately resulting from this phase will depend upon the locations of activities associated with the Development and Production phases.

Increased human population in the area would have wide-ranging effects on wildlife species and their habitat. The population increase related to development of geothermal resources in conjunction with the expansions and increases associated with other mining activities could cause accelerated degradation of the wildlife resource on a regional basis. Animal species and their habitat will be greatly affected as the result of indiscriminate shooting, poaching, increased legal harvests, increased off-road vehicle activity, or other unforeseeable actions.

The impacts associated with increased human populations will not stop at the boundaries of the assessment area. Other areas exhibiting important and unique biota may also be affected. Remote parts of the assessment area may be frequented as the result of increased human pressures.

c. Ecological Interrelationships

(1) Pre-lease Exploration (Exploration Operations)

No drastic changes in succession, food relationships, or community relationships will occur during this phase. Slight changes may take place at isolated locations where exploration activities occur.

(2) Post-lease Exploration

Changes in succession, food relationships, and community relationships may occur as the post-lease activities increase. Water, which is a limiting factor in the desert, may become much less available. If water becomes more limited, plants and animals within the area will suffer. Noise and presence of man within the area will disrupt and displace many animal species. Those most susceptible to this disruption are the endangered species. The destruction of plant species and dependent animal species are related to the amount of surface disturbance. The disturbed surface becomes susceptible to erosion or invasion by other plant species, either enhancing or degrading the area.

Variations in vegetative composition and density, topography, water availability, etc., result in comparable variations in plant and animal species distribution, diversity, and density. The magnitude or severity of impacts will vary from location to location within the assessment area because of these ecological phenomenon. The relative significance of impacts will vary from ecosystem to ecosystem (e.g., ecosystems of common occurrence vs. ecosystems of limited occurrence).

(3) Development

The impacts on succession, food relationships, and community relationships will intensify during the development phase. These impacts will be similar to those discussed in the "Post-lease Exploration" section, but will be greater due to the increased activity.

There may be serious impacts during this stage and during Production that cannot be identified at this time (i.e., changes in air movement and rainfall patterns). This is mentioned to support the need for careful planning and assessment in later stages.

(4) Production

Impacts on succession, food relationships, and community relationships will intensify during the production phase. These impacts will be similar to those discussed in the "Post-lease Exploration" section.

Additional water may become available during the production phase and may be stored in earthen reservoirs. If additional water becomes available, plants and animals attracted to the water will expand their distribution. This expansion may be beneficial in that additional diversified plant and animal communities will become established.

However, the increased water could also attract plant species that include noxious and/or poisonous plants, upsetting the trends of various plant communities. Successional changes through rehabilitation may result in a more desirable and productive ecosystem (i.e., mesquite ecosystem to grassland ecosystem).

d. Land Use

(1) Land Use Compatibility

(a) Recreation

i. Pre-lease Exploration (Exploration Operations)

Pre-lease Exploration is not expected to affect recreational values.

ii. Post-lease Exploration

Recreational values will not be seriously affected because of the temporary nature of Post-lease Exploration.

iii. Development

Recreational uses of the area will be adversely affected by development activities. Areas with limited intrusions will be affected to a greater degree than those with many intrusions. Some access may be affected if a road to a geothermal development is closed in order to facilitate development or to protect the public or the site. Primitive and backcountry values will be most affected.

iv. Production

Recreational use will be impacted in a manner similar to that of the Development phase. Visitor days would probably increase due to the public interest in the uniqueness of geothermal development. Increases in visitation related to the uniqueness of the industry would subside as Development and Production expanded. Long range negative impacts could result because of activities which reduce recreational opportunities and restrict movement. Greatest impacts would be on hunting, open space for casual shooting, and natural open space values.

(b) Grazing

i. Pre-lease Exploration (Exploration Operations)

There will be no significant impact to grazing from Pre-lease Exploration.

ii. Post-lease Exploration

Grazing use will be moderately impacted due to livestock disturbance caused by vehicular traffic both on and off existing roads and trails. Vegetation will be removed from the new roads and trails and from drill pads. Water discovered during drilling may be used for livestock waters. This would be a beneficial impact.

iii. Development

Grazing will be moderately impacted in a local area during the development phase due to the loss of forage production. The development activities could disturb animals and interrupt ranchers' routine grazing operations. Grazing will be temporarily displaced in the immediate area of development. If pipelines are not elevated at least 1.5 m (5 ft) off the ground, they may present a barrier to livestock movement.

iv. Production

Impacts on grazing use will continue during the production phase as more land surface will be taken up by roads, well sites, pipelines, power transmission lines, generating facilities, and other needed facilities. Noise, human and mechanical activities, noxious gases and fluids will disrupt grazing during this phase. Cattle graze near well heads at The Geysers Field, California, indicating that they are not greatly disturbed by the production activities. Nevertheless, the facilities used in the production phase will inhibit livestock movement and reduce the quantity of forage available because of the surface occupancy.

(c) Farming

i. Pre-lease Exploration (Exploration Operations)

Pre-lease exploration will have no significant impact on farming.

ii. Post-lease Exploration

The impacts of post-lease exploration on farming may include limited destruction of agricultural crops if farming lands are occupied by equipment, roads, etc. The quality of agricultural crops might be lowered as a result of increased vehicular activity and emission of noxious gases.

iii. Development

Development could have moderate to severe impacts on farm lands, depending on geothermal project location, the number of people entering the area on a long-term basis, and the existence or nonexistence of town and county zoning regulations. Cropland may be affected by oil or geothermal water spills or leakage.

iv. Production

The impacts of production on farm land use will be similar in nature and degree to those encountered during development.

(d) Urban and Suburban

i. Pre-lease Exploration (Exploration Operations)

Pre-lease exploration should have no impact on urban-suburban land use.

ii. Post-lease Exploration

Post-lease exploration should have no impact on urban-suburban land use.

iii. Development

If development takes place, the use of land for urban or suburban purposes could increase. This might create a conflict between urban-suburban use and other land uses. In particular, urban and suburban development on prime agricultural lands could become a problem.

iv. Production

The impacts of production on urban-suburban land use may be more severe than those encountered during development.

(e) Rights-of-way

i. Pre-lease and Post-lease Exploration

Pre-lease exploration and post-lease exploration should nave no significant impact on rights-of-way.

ii. Development

Rights-of-way now present will not be adversely affected. Future rights-of-way may require some route adjustments if they are in conflict with development activities.

iii. Production

Present rights-of-way will probably be crossed by power transmission lines carrying power from generators to consuming areas. The present rights-of-way have prior rights. There undoubtedly will be additional adverse impacts from the new lines needed to transport geothermally produced power, similar to those encountered in the operation of major powerlines of the 345 KV class. Other types of geothermal use are unlikely to affect rights-of-way.

(f) Mineral Development

i. Pre-lease and Post-lease Exploration

Pre-lease and post-lease explorations should have no impact on mineral development.

ii. Development and Production

During development and production stages, the use of the land surface and subsurface above a geothermal reservoir could prevent the utilization of other mineral resources at that location.

(2) Land Use Suitability

Land use suitability is based on the natural land base and the proposed action. The suitability of the land does not

change just because a particular kind of development is started or stopped. Land use suitability can be impacted only through major changes in the natural land base. Since no such major changes are expected in the assessment area, there will be no impact to suitability from any geothermal operation.

e. Human Values

(1) Visual Resources

(a) Landscape Character

Open space and the naturalistic quality of the assessment area are the primary characteristics of the landscape. Open space is an area which provides minimum obstruction to movement and sight. The proposed geothermal lease area has many man-made intrusions affecting open space. The effect of this is localized because of the vastness of the area. Sight distances range up to 80 km (50 mi).

Generally, natural, as opposed to man-made, features do not intrude open space except on a localized basis. The feeling of spaciousness is affected when the ability to see the horizon is restricted by natural or man-made structures. The Mimbres Mountains and Cook's Range in the central portion of the area, the Sierra de las Uvas mountains on the east, the Burro Mountains on the west, and the Gila Wilderness on the north form horizons that can be seen from great distances.

Views from arroyo bottoms and deep canyons are restricted. Vegetation is generally not restrictive, although some arroyo bottoms contain relatively tall shrubs and trees which localize views and restrict movement. Alluvial valleys and rolling hills make up the topography of the rest of the area.

i. Pre-lease Exploration (Exploration Operations)

All intrusions are considered detrimental to landscape character. These intrusions should occur only on a temporary basis during this stage.

ii. Post-lease Exploration

Post-lease exploration is similar to pre-lease exploration, but will influence landscape character to a greater degree. Exploration is a continuous process until the geothermal field is fully developed. This exploration will become part of the total intrusion, although it is temporary.

iii. Development

Drilling rigs will become a fixture located at the well head for the duration of the drilling process. Usually, the process of drilling a well lasts less than 90 days (Union Oil Co., pers. comm., 1974). One company may employ one, two, or three rigs, depending upon the availability of rigs. The requirement of many wells to support one generating plant implies that the process of drilling wells is an activity continuing over an extended period of time. If this is true, the development process and the equipment required will intrude on the open space.

Field development, which could result in the construction of several plants, would require that drilling continue until the field is fully developed. The period of intrusion to open space by drilling can be considered equivalent to the life of the production phase. It is part of the total impact.

iv. Production

The production phase could include the construction of electric generating plants, pipelines, transmission lines, greenhouses, hothouses, etc. This work may begin as soon as development of the field is sufficient to support such facilities. The production phase will continue for the life of the field, and it will impact open space for that period of time.

(b) Intrusions

Scenic quality is affected by aesthetically undesirable intrusions. One aspect of the scenery is open space. It can be concluded that any intrusions which are visible and obtrusive will be less if they are intermingled with other structures where the natural scene has been previously disturbed. Structures contrasting with existing fixtures in shape, size, and color will have a greater effect, regardless of their location. An electric generating plant or a greenhouse situated among other large structures will not affect the general scene as much as if the building were to be located by itself in an area of open space.

The presence of man-made structures invades the natural scene. Often the feature is acceptable aesthetically, but it alters the landscape character. The construction of facilities within the assessment area will change the scenic quality, but the extent of change will depend

upon the status of the location concerned. For instance, the mountain areas of the assessment area appear from a distance to be undisturbed by man-made intrusions. A power plant complex would change the natural appearance of the mountains, mesa tops, and alluvial valleys. Localized intrusions distributed throughout the remainder of the proposed lease area may be detrimental to scenic quality.

i. Pre-lease Exploration (Exploration Operations)

Pre-lease exploration should not introduce significant undesirable intrusions. Pre-lease exploration will cause minimal impacts on scenic values on a very localized basis, and then only for a short time.

ii. Post-lease Exploration

The natural scenic environment will be intruded most significantly by drilling and associated activity. At this time, the general scenic situation will begin to change. The rapidity and amount of change will depend on the magnitude and location of the exploration.

iii. Development

Development of a geothermal field usually consists of drilling wells until the resources are sufficient to support a generating plant. During this period of time, drill rigs will be moved from drill pad to drill pad. The pads are constructed to support the rig, and are usually .4 to . 8 ha (1 to 2 ac) in size. After the drilling is completed and the well is capped, the rig will be moved to a new location. If the drilling takes place on level ground, the drill pad probably will not be sufficiently noticeable to severely damage scenic values. If the drill pad and well head are located on the side of a hill or on the horizon, they will be more visible, increasing the impact on scenic values. Wells drilled during field development will alter scenic situations, particularly in areas where vegetative cover is sparse or where significant surface damage is required.

iv. Production

Large pipelines to carry steam or hot water, generating plants, and transmission lines will be constructed during the production phase. As these facilities are developed, the existing scene will be intruded. Curiosity-arousing, eye-catching aspects of the normal scenery will be temporarily transferred to the new structures until they are considered part of the normal scene. The production phase will change existing scenic characteristics of the landscape.

(c) Visual Resource Management

The Visual Resource Management (VRM) units and VRM classes discussed in "The Existing Environment" section of this report and BLM's Contrast Rating, Manual 6320, were used to provide a basis for measuring impacts of the proposed action on the visual resources of the lease area.

There are five possible VRM classes in the Silver City assessment area. Generally, these classes provide management objectives which can be used to assess the impact of an action by relating the modification and resulting visual contrast rating to the basic elements of form, line, color, and texture.

i. Pre-lease Exploration (Exploration Operations)

Pre-lease Exploration is not expected to impact the visual resources of the assessment area

ii. Post-lease Exploration

It is possible to discuss the impact of exploration and future actions on visual resources in only general terms. Specific site analysis will be required if post-lease exploration requires manipulation of visible surfaces, particularly in Class II areas. It can be expected, however, that post-lease exploration impacts will be minimal.

iii. Development

The development phase will impose a greater degree of impact on visual resources than any previous activity. An analysis of each proposed action during the development phase will be necessary in order to fully realize total impacts.

iv. Production

Impacts occurring during the production phase will depend upon the location, size, color, architectural design, etc., of the production facilities. This phase will result in more significant impacts than any previous phase.

(2) Recreation Resources

Recreational experiences, for the most part, will be impaired by the presence of heavy equipment, increased traffic, construction activities, and noise. This applies, in particular, to those persons seeking a measure of remoteness, hunting and fishing

opportunities, sightseeing, camping, picnicking, hiking, and other general leisure pursuits. On the other hand, there would be some beneficial effects, such as increased access for hunters, increased off-road vehicle opportunities, and probably increased goods and services available.

(a) Pre-lease Exploration (Exploration Operations)

Pre-lease Exploration will cause minimal, insignificant impacts on recreational resources on a temporary, localized basis.

(b) Post-lease Exploration

Manipulation of the scenic values and the intrusion of structures will moderately infringe upon recreation resources. Natural and backcountry values will be the most affected in a negative sense.

(c) Development

The Development phase will impose a greater impact on recreation resources than any previous activity. Service roads, vehicles, and pipelines will have the greatest overall adverse impact to recreation resources with the exception of off-road vehicles.

(d) Production

Impacts occurring during the Production phase will depend primarily upon location, but will result in more significant impacts than any previous phase.

(3) Wilderness Resources

Only two major areas in the assessment area contain over 2035 ha (5,000 ac) of public land, Cook's Range and the Uvas Mountains. Since it is unknown how much of this area will qualify for wilderness study, due to pending roadless area criteria, general areas have been delineated. In addition, since motor vehicles will not be allowed in winderness areas, there will be no impacts to wilderness during any phase of Exploration, Development or Production, and no further discussion is needed.

(4) Socio-cultural Interests

(a) Social Welfare

i. Pre-lease Exploration (Exploration Operations)

Pre-lease exploration is expected to have a low beneficial impact on the local economy. This impact will be created by a few people visiting the area and spending money in the communities. The effects will be of the same type as those which occur during tourist season. Hotels, restaurants, bars, and other service establishments will benefit, but the scale of the expected activity will be much too low to affect local employment, population, or infrastructure.

ii. Post-lease Exploration

Impacts of Post-lease Exploration should be similar to those of Pre-lease Exploration.

iii. Development

Impacts to the local economy during Development should be greater than the impacts of Pre-lease or Post-lease Exploration. The nature of these impacts may be different than those encountered in previous stages. Capital entering the area will still be added through patronage of hotels, restaurants, and other "service" businesses. A few jobs might become available, and people affiliated with development projects may move into the area. This population increase could have an adverse impact on the local regulatory structure, including law enforcement, schools, public safety organizations, and health agencies. Real estate speculation might become a problem. The impacts of Development are dependent upon the nature and scale of the development project and should be studied carefully before development plans are implemented.

iv. Production

Impacts to the local economy during production would be greater than those of any preceding stage. The nature of these impacts should be similar to those encountered during Development. Currently, available information on geothermal reservoirs is inadequate to determine whether there will be any impacts to surface hot springs and associated dependent businesses (greenhouses, etc.). If production wells enter the same geothermal reservoirs as those feeding the surface hot springs, possible impacts of the Production stage could be: reduction in flow of thermal springs, reduction in temperature of thermal springs, termination of thermal springs' flow, air pollution (if deep reservoirs contain high amounts of hydrogen sulfide (H_2S)), and/or termination of dependent businesses. Other businesses would continue to benefit from increased cash flow in the area.

(b) Cultural Resources

i. Pre-lease Exploration (Exploration Operations)

Pre-lease Exploration requires minimal surface disturbance and is generally restricted to existing roads. Few people are involved in any single pre-lease operation.

Any surface-disturbing activity requires an archaeological survey before operations can be started. The survey reports all archaeological or historic materials in the vicinity of the proposed project. Normally, an effort is made to avoid these materials *in situ*.

It is often possible to relocate proposed pre-lease projects so as to avoid these materials. Direct adverse impacts to archaeological or historic sites are minimal during Pre-lease Exploration. Indirect adverse impacts caused by exploration teams removing cultural materials are also minimal since few people and little area will be involved. Beneficial impacts include the discovery of previously unrecorded archaeological or historic sites.

There are currently no stipulations to provide for the identification of other types of sites with local cultural significance (i.e., historic trails, religious sites). Culturally significant sites which lack cultural debris cannot be identified by field examination. If any such sites are identified in an area involved in pre-lease operations, stipulations for site protection should be appended to the permit.

ii. Post-lease Exploration

The effects of Post-lease Exploration on cultural resources will be similar to those of Pre-lease Exploration. The scale of impacts will be greater, since some off-road vehicle movement will occur. Indirect adverse impacts will increase as new access roads allow greater public use of the area.

iii. Impacts to cultural resources during the development stage will be greater than the impacts of Pre-lease or Post-lease Exploration. Since development projects are harder to relocate than exploration projects, some other form of mitigation, such as intensive surface collection or excavation, is likely to be necessary. These types of mitigating measures lessen, but do not eliminate, impacts to cultural resources. Because of this, some cultural sites may suffer damage during this stage. Increased public use of the area could also result in damage. The increased number of workers involved in development projects will aggravate the problems of work crews collecting artifacts. Beneficial impacts will include retrieval of data from sites as a result of mitigation projects.

iv. Production

Production will involve intensive surface disturbance of localized areas, and locations for production facilities may not always be flexible. It can be expected that the direct impacts of production on cultural resources will be greater than those of any preceding stage.

Indirect impacts of a project in any stage of implementation can also be serious. Damage promoted by easy access to public lands, increased population in the area, and deliberate vandalism cannot be easily controlled. This type of impact should be considered when planning measures to reduce the adverse impacts of a project.

(c) Scientific/Educational

i. Pre-lease Exploration (Exploration Operations)

Pre-lease exploration should have little adverse effect on the scientific and educational values previously mentioned (Existing Environment section). Beneficial impacts may result from the collection of geologic, geothermal, and hydrologic data. These beneficial impacts will be proportional to the amount of pre-lease activity.

ii. Post-lease Exploration

The impacts of post-lease exploration should be similar to those encountered during the pre-lease exploration. The impacts will, again, be proportional to the amount of activity which takes place.

iii. Development

Some of the scientific values (i.e., cultural resources, primitive areas, wildlife habitat) are particularly sensitive to surface disturbing activities. Construction of access roads or other surface occupancy could result in disturbance of these values over a limited area. However, significant geologic and geothermal data should be recovered during development and production stages.

iv. Production

Since it is not known at this time what form geothermal production will take, any discussion of the impacts of this stage on scientific/educational values must remain hypothetical.

Generally, it might be expected that impacts caused by Production will be greater than those caused by any other stage of implementation. These impacts will also be more localized, necessitating careful analysis of each project during this stage. Special attention should be given to impacts on air movement patterns and rainfall patterns which might be created by venting large quantities of steam into the desert environment.

2. Possible Mitigating Measures

The Geothermal Steam Act of 1970, GRO Orders 1, 2, 3, 4, 6, and 7, and the Geothermal Resources Lease state the environmental protection requirements which must be met by anyone conducting geothermal operations on public lands. In some cases, these documents have prescribed specific measures designed to fill the requirements. In others, the Authorized Officer of the managing agency will prescribe the way in which the requirements must be met.

All of the requirements stated in these documents must be met by the permittee/lessee who intends to conduct geothermal operations, including pre-lease exploration, on public lands in the Las Cruces District of BLM. The permittee/lessee will be expected to follow all the mitigating measures which are specified by the Steam Act and the GRO Orders.

A site-specific EAR is written for every proposed surface-disturbing project, regardless of the stage of implementation. This allows determination of site-specific impacts and development of specialized mitigating measures. The Authorized Officer of the managing agency adds these measures in the form of special stipulations to the lease, permit, or other written authorization to begin operations. Special stipulations of this nature augment the standard stipulations and requirements, but do not replace them unless this is specifically stated.

Possible ways of mitigating or enhancing the anticipated impacts of a geothermal program in the Silver City Geothermal Assessment Area include, but are not limited to, those listed in the following pages. Some are a reiteration of measures already required in the Steam Act or GRO Orders, but because of special conditions, are repeated.

a. Non-living Components

(1) Air

(a) Dust may be controlled by sprinkling disturbed areas with water periodically. This may be required on heavily used roads or construction sites if a permit can be obtained from the New Mexico State Engineer's Office to use water for this purpose.

(b) Paving of heavily used roads would reduce airborne particulate matter.

(c) Geothermal wells that produce excessive radioactivity, toxic or noxious fluids or gases could be shut in until the hazard has been eliminated.

(d) Odor filters could be installed on all facilities to minimize the impacts of noxious, odiferous substances.

(e) All measures designed to reduce erosion will help to maintain air quality.

(f) The number of operating combustion engines allowed in an area at one time could be limited to reduce the impacts of exhaust emissions.

(g) All roads with vehicular travel in excess of 150 vehicles per day could be stabilized and paved in a manner most suitable to the traffic load.

(2) Land

Erosion is a major concern in the assessment area. measures designed to reduce erosion are listed below.

(a) Erosion control structures may be required in areas where accelerated erosion could take place.

(b) All facilities related to the geothermal program could be constructed on level lands where possible to reduce impacts anticipated in rough topography.

(c) All facilities related to the geothermal program could be constructed on soils that are suited to such development.

(d) Initial drilling could be restricted to sites where the surface is relatively flat and where vegetative and soil disturbance could be kept to a minimu.

(e) Roads could be located in existing rights-of-way wherever possible.

(f) No roads should be built in areas where terrain will allow vehicles to maneuver without the aid of roads.

(g) Runoff from thunderstorms could be controlled by reshaping and revegetation to prevent erosion.

(h) All measures designed to reduce impacts to terrestrial vegetation will reduce erosion by preserving the vegetative cover.

(i) Impacts caused by movement of vehicles over open terrain may be reduced by:

i. directing the vehicles single file over a route.

ii. driving around large vegetation and critical topography

iii. requiring large tires

iv. requiring light trucks

v. reducing the number of vehicles

iv. permitting only one or two vehicles to follow the same tracks over open terrain

vii. allowing exploration only when weather conditions are favorable.

viii. requiring the construction of road barriers on critical areas to prevent further use.

(j) Shallow exploratory holes could be drilled with air to reduce the chances of soil pollution except where conditions require the use of mud.

(k) Soil sterilants could be restricted from use.

(l) At the conclusion of drilling operations, mud pits could be cleaned, backfilled, and planted with native vegetation.

(m) Portable steel mud pits could be used.

(n) Where excavation will be extensive or where bedrock will be encountered, existing topsoil should be replaced. Stockpiled topsoil (if any) could be evenly distributed over the disturbed area before seeding.

(o) Bentonite lining could be used in earthen pits to prevent fluids from escaping into subsurface strata

(p) Numerous mitigating measures describing ways to prevent and control induced seismicity, subsidence, landslides, etc., are contained in 30 CFR Parts 270.34(b), 270.37, 270.43, 270.48, 270.76, and 43 CFR Part 3204.1(e). GRO Order No. 4 also provides additional measures to mitigate impacts.

(3) Water

(a) Stockwater tanks or reservoirs could be protected by locating operations away from these areas, and by selecting locations where accidental escapes of fluids would not eventually drain into the tanks.

(b) Fresh water zones in the subsurface could be protected by running casing and cementing off these zones to prevent contamination.

(c) Only water wells that have good recharge should be used as a source of water for drilling rigs.

(d) Casing which is set through the fresh water zones and cemented could be left in place. If such casing is removed, the holes could be properly plugged with cement to protect the fresh water zones.

(e) Cooling towers used during Production require large quantities of water. Rather than using fresh water from shallow zones in the subsurface, the waste water from geothermal production could be used, if feasible.

(f) Drilling water should not be obtained from surface water tanks or reservoirs except that water produced from geothermal fluids may be stored on the surface, with approval of the BLM, and used to meet drilling requirements.

(g) If an operational geothermal field produces water in excess of that required for production, the operator could contact BLM and enter into an agreement on the best method of disposing of these fluids. If the water quality is such that it would not be harmful to plants or animals, full consideration could be given to the use of this water to provide additional wildlife habitat or to provide watering holes or tanks for wildlife and/or livestock. The use of water for these purposes will be dependent upon receiving the necessary permits from the New Mexico State Engineer's Office.

(h) The locations of shallow drill holes for the measurement of temperature gradients or heat flow require the special approval of the Authorized Officer if the proposed locations are within a radius of 305 m (1000 ft) from hot springs, fumaroles, or other surface geothermal indicia, or are in areas of known artesian water flow. Locations proposed within such areas will require a detailed drilling program for each hole, approved by the Authorized Officer. The Authorized Officer may require special drilling and completion techniques for such holes (such as cemented surface casing and simple expansion-type blowout preventers) to safely control formations containing geothermal or other resources which may be penetrated.

(i) Drill pads should not be located in or adjacent to major drainage bottoms, lakes, or perennial streams, and should not be closer than 183 m (200 yds) without special approval of BLM.

(j) When drilling is completed, a sample of the reserve pit liquids could be analyzed for toxic substances. A certified analysis should be furnished USGS showing time, location of sample, and accuracy of analysis.

(k) The permittee/lessee could provide effective controls over the discharge of toxic substances.

(l) All measures designed to prevent erosion will also help to maintain water quality.

(m) The use of explosives could be severely restricted and allowed only when conditions are favorable.

b. Living Components

(1) Vegetation

(a) Reclamation of disturbed areas could take place progressively during the course of operations.

(b) Plants disturbed by geothermal operations for which a demand is evident could be salvaged and made available for public use.

(c) All areas could be reclaimed during abandonment.

(d) Slant drilling could be required when environmental conditions require it, and when conditions permit.

(e) When an explored or developed area is no longer needed for geothermal activities, or immediately following termination of the lease, whichever occurs first, the operator should, after removing all surface improvements, contact BLM for concurrence in the plan for rehabilitation of the site, for the time for seeding and the seed mixture to be used. This will be accomplished before release from bond by USGS. The Authorized BLM official will be advised when the planting has been accomplished. If, in the opinion of the Authorized Officer, the first seeding or planting is unsuccessful, he may require the lessee or grantee to make additional seedings or plantings.

(f) The lessee/permittee should take all reasonable precautions to prevent and suppress fires.

(g) All major drainages and other drainages supporting a variety of shrubby vegetation and all waters of permanent nature supporting aquatic and terrestrial vegetation could be provided a protective buffer zone of at least 183 m (200 yds) and .4km (.25 mi) respectively.

(2) Animals

(a) The operator could screen mud pits containing additives known to be toxic to wildlife.

(b) Noise suppressing mufflers could be installed on vents to minimize the adverse effect of operational noise on wildlife.

(c) No drilling or other surface activities should be allowed within .8km (.5 mi) of any pond or reservoir regularly used by waterfowl or shore bords for nesting, resting, or feeding. This includes those locations where use is seasonal.

(d) No prolonged surface activity (drilling, development) should be allowed within 183 m (200 yds) of brushy arroyos and draws, playa beds, or small (less than 16.2 ha or 40 ac) grassland areas within key antelope areas.

(e) The construction of electric distribution lines should conform to appropriate raptor stipulations (BLM Instruction Memorandum No. WO-76-45, dated January 23, 1976).

(f) When pole lines are abandoned, the Authorized Officer may designate the retention of certain poles for raptor perching and nesting.

(g) Prolonged activity should not be allowed within .4 km (.25 mi) of cliffs, ledges, escarpments, rock outcrops, or canyon walls and rims suitable for raptor nesting.

(h) No trees should be removed or damaged in any way. No exploration, development or production activity should be allowed within .4 km (.25 mi) of trees, groves, thickets, etc.

(i) No vegetation should be removed within .8 km (.5 mi) of water (springs, reservoirs, tanks, seeps, etc.).

(j) Pipelines should not be placed across migration routes or regular routes traveled by antelope, deer, or other ungulates. Such action should be coordinated with the BLM to minimize impacts to the extent practical, considering the best and most feasible technology available.

(k) To minimize impacts to vegetation and wildlife, activities related to geothermal exploration, development, production, and abandonment should be confined to access roads, exploration lines, rights-of-way, drill pads, power generating sites, and other areas designated for such activities. Activities outside these areas should be approved in writing by BLM prior to the start of activity.

(l) "Species classified as endangered or threatened shall not have their continued existence jeopardized nor habitat adversely modified which is critical to the survival of the species." (P.L. 93-205, and Wildlife Conservation Act for the State of New Mexico.)

(m) The Gila River drainage is inhabited by 32 species of endangered fauna. Except for a few small areas that are administered by the Bureau of Reclamation, the drainage is essentially privately controlled (including subsurface). The Mimbres River drainage is also inhabited by some of these endangered fauna. This drainage is controlled by State and private interests (including subsurface). To adequately mitigate potential impacts to endangered species and their habitat, exploration, development, and production should be restricted to areas outside a .8 km (.5 mi) buffer zone along either side of each river and around all trees, groves, thickets, etc., that occur beyond this buffer zone. This should be an added stipulation to all "Notices of Intent" and leases on public lands within these drainages in addition to a "Biological Clearance" for endangered or threatened species and/or habitat prior to entry.

c. Ecological Interrelationships

(1) Mitigating measures which provide protection for soils, vegetation, and animals will likewise mitigate impacts upon ecological interrelationships.

(2) Special care should be taken to avoid actions which would change runoff patterns (i.e., berms, roads without culverts, etc) which might adversely affect vegetal communities dependent upon seasonal flooding.

d. Land Use

(1) Land Use Compatibility

(a) Recreation

i. Key management roads identified by BLM should not be reclaimed, but maintained for access and use by the general public for recreation needs.

ii. At any time during production, if it becomes necessary to release steam or other fluid vapors on either an intermittent or regular basis, adequate provisions should be instituted to insure the safety and protection of travelers on nearby roads where vapor clouds may occur and obstruct clear vision. Such provisions should be made relative to adequate posting of all hazards on road networks.

iii. Measures designed to protect the environment and reduce the impacts of the geothermal program will protect recreational values by maintaining pleasing, healthful surroundings.

iv. Measures designed to turn features such as water ponds and access roads to recreational advantage could be added to the provisions of geothermal permits or leases.

v. No off-road vehicular travel in connection with geothermal operations should be allowed within .4 km (.25 mi) parallel to the route of historic trails.

(b) Grazing

i. Efforts should be made to minimize livestock disturbance. Livestock access to customary water sources should not be blocked. Most mitigating measures designed to protect living components of the environment will also reduce impacts to grazing use.

ii. The BLM grazing lessee or permittee should be informed of the approximate starting and completion dates for any geothermal-related activity.

iii. Any excavation, hazardous area, or modification to a fence associated with or as a result of geothermal development should be fenced or otherwise made acceptable to the Authorized Officer.

iv. The location of new gates or cattleguards on public land must be approved by the Authorized Officer and meet standard specifications for such projects.

(c) Farming

All farming takes place on private or State land. Arrangements for mitigating impacts to farmland should be made between the developing company and the private landowners.

(d) Urban-suburban

The companies which are developing the geothermal resources should discuss possible mitigating measures with representatives of the communities which may be affected.

(e) Rights-of-way

i. Existing rights-of-way should be protected from geothermal activities.

ii. Rights-of-way corridors should be required, where possible, for all future utilities.

(f) Mineral Development

Development of a geothermal resource should be limited to locations that would not conflict with the development of other valuable mineral resources which may be needed in the near future.

e. Human Values

(1) Visual Resources

Each proposed project should meet the Visual Resources Management Class requirements for the area in which it will be located. During all geothermal exploration, development, and production phases, the area should be kept free of debris, trash, and/or other unsightly items that would detract from the surrounding environment. This includes picking up windblown debris resulting

from exploration, development, or production operations. Abandoned or unneeded roads should be closed off, reshaped, and seeded as the need is determined by the Authorized Officer. Access to these roads should be blocked to discourage use by off-road vehicles. During Close-out, all development and production facilities will be removed, including foundations, paved areas, footings, or other permanent structures. Residue should be properly disposed of in an approved landfill area.

(2) Recreation Resources

To protect scenic, sightseeing, natural, and backcountry values, site specific VRM contrast ratings will be conducted to minimize losses to the recreation, as well as visual resources during the post-lease exploration, development, and production phases. Various resources should be protected, managed, and interpreted for the general public unless geothermal site location dictates destruction of the surface resource. Interpretation can still be an effective tool to explain lost resources that once were in the area. Although in direct conflict with natural and scenic recreation resource values, ORV's, visitor use, and increased access for the user are positive benefits that must be evaluated according to their demand.

(3) Wilderness Resources

Ways to enhance wilderness resources identified with the area include locating roads, structures, facilities and any intrusions out of the vicinity of the wilderness. Any development or production facility will have to be evaluated on a case by case basis to determine whether local or regional wilderness values will be adversely affected.

(4) Socio-cultural Interests

(a) Social Welfare

i. Appropriate care should be taken to protect all improvements, whether they belong to BLM or to private landowners.

ii. A continuous monitoring of exploration and development operations should be maintained to provide advance notice of any possible changes to surface hot springs. The Area Geothermal Supervisor (USGS) should complete an evaluation of exploration and development data as it is received in order to determine the likelihood and the significance of impacts to the hot springs in the area.

iii. It is suggested that measures to reduce impacts to regulatory structures be arranged between the developing company and the community to be impacted as the need arises.

iv. The permittee/lessee, his contractors, sub-contractors, and employees should be required to comply with all requirements for geothermal operations and activities on BLM lands in conducting geothermal operations and activities on lands with private surface, Federal minerals ownership.

v. The permittee/lessee should submit a copy of his Plan of Exploration or Plan of Operations, as applicable, to the surface owner of the land through the Authorized Officer of the BLM at least 30 days in advance of beginning any activities on the land.

vi. The Authorized Officer and/or the Area Geothermal Supervisor should coordinate all plans and proposed lessee operations with the surface landowner to guarantee that operations do not conflict unduly or interfere with his use of the surface.

vii. The Authorized Officer and/or the Area Geothermal Supervisor should coordinate with the surface landowner all changes in previously approved plans before any field operations or activites re-commence.

(b) Cultural Resources

i. The BLM District Archaeologist should identify all known cultural resources which could be affected by geothermal exploration or development on an individual case action basis. This should include prehistoric, historic, ethnological, and paleontological values. The archaeologist should then specify measures needed to protect these known resources as well as unknown resources which may be in the area.

ii. If a field inspection is needed to allow proper identification and protection of cultural resources, the permittee should be required to engage the services of an archaeologist acceptable to the Authorized Officer to conduct a thorough and complete survey of areas to be disturbed for evidence of archaeological or historical sites or materials. The archaeologist must prepare the certified statement on archaeological values described in Section 18 of the Geothermal Resource Lease, Form 3200-21.

iii. The Authorized Officer and the Area Supervisor retain the right to require relocation of operations to protect cultural resources.

iv. If project relocation is not feasible, the Authorized Officer and the Supervisor may require the lessee to have the cultural resources photographed, recorded, collected, excavated, or their value otherwise saved by professionals with suitable backgrounds before proceeding with operations.

There are no ways to mitigate direct impacts to archaeological sites other than avoiding the site or excavating and salvaging the site. Of these two, avoiding the site will generally be the recommended course of action.

(c) Scientific/Educational

i. Research may be conducted in conjunction with all geothermal operations as long as these actions do not interfere with normal activities or jeopardize the lease holder's development position.

ii. Companies conducting operation in an area of mutual interest should communicate in the planning stages to avoid conflicts.

iii. Development companies should maintain accurate maps of all road networks, locations of developments, and their nature. All such information should be maintained on standard 7½" USGS topographic maps. The maps should be revised semi-annually and made available to BLM and other agencies with official need of such data.

iv. Some areas of scientific and educational value are particularly sensitive to all surface-disturbing activities. These should be recommended for leasing with "no surface occupancy."

3. Alternatives

a. The first alternative proposed in the "Description of the Proposed Action and Alternatives" section is to limit geothermal leasing to lands for which all values can be successfully protected through special environmental protection stipulations; and to delay the leasing of those lands having values which may not be easily protected through these stipulations until further resource information has been gathered.

Special environmental protection stipulations which would successfully protect all but the most sensitive lands could be attached to leases. A stipulation of "no surface occupancy" would eliminate impacts to the most sensitive surface values. With appropriate stipulations attached, most lands in the assessment area could be leased without serious residual impacts to the environment.

Lands for which "no surface occupancy" is stipulated could still be developed through the use of slant drilling techniques. These techniques allow a driller to reach resources up to 1.6 km (1 mi) away from his rig without disturbing the surface directly above the resource. This will allow development of all but a small amount of acreage in the assessment area. Acreage requiring "no surface occupancy" stipulations for adequate environmental protection which cannot be reached with today's technology should be withheld from leasing until technological advances make development feasible or until the reasons for withholding leasing are no longer appropriate.

b. The second alternative is to lease only those areas for which complete resource information has been gathered.

A delay of this type would impede collection of the geological and technological information needed to develop geothermal resources as a cheap and efficient energy source. It could delay development of these resources for years. A delay of this kind would be inconsistent with the national policy to develop new energy sources.

c. The third alternative is to refrain from leasing any of the area.

There would, of course, be no impacts to the physical environment through this alternative. However, to decline to lease would not be in the best interest of the nation and would be contrary to policy promulgated by the Steam Act of 1970.

None of the alternatives provide for Federal protection of values on private lands with privately owned minerals. Protective measures may be required by private citizens or by State or local governments.

4. Recommendations for Mitigation

a. General Recommendations

(1) General stipulations covering such topics as prevention of air and water pollution, noise abatement, aesthetic considerations, etc., are discussed in the Geothermal Regulations and GRO Orders 1-4, 6, and 7.

(2) It is recommended that all of the "Possible Mitigating Measures" be used as stipulations, where appropriate, in all "Notices of Intent" and leases except as modified by mutual agreement of the lessee, the Supervisor, and the Authorized Officer.

(3) It is recommended that areas particularly sensitive to surface disturbance be leased with no surface occupancy. These include environmentally sensitive lands and lands for which the current or previously planned surface use is not compatible with geothermal operations.

(4) It is recommended that sensitive lands which can not be reached within these constraints with today's limited technology be withheld from leasing at this time. These areas could be leased at a later date when technological advances ensure the protection of these lands.

(5) State and local governments and private landowners may wish to develop similar measures or incorporate the mitigating measures recommended in this section into their respective leases for geothermal resource development.

b. Specific Leasing Recommendations

Land which should be leased with no surface occupancy, lands which should not be leased at this time, and lands carrying other special stipulations are listed in the following pages. The general locations of these lands may be found in Figure 29
Lands leased or patented under the Recreation and Public Purposes Act of June 14, 1926 are segregated from all appropriations including locations under the mining laws (43 CFR 2091.3-2a). The reserved minerals are not subject to disposition or to prospecting until rules and regulations are issued by the Secretary of the Interior.

(1) An area covered under a Recreation and Public Purposes lease to the Village of Central, comprised of 7.3 ha (18.4 ac): This land may be leased with no surface occupancy for geothermal activities. The land is described as follows:

T. 18S., R. 13W., NMPM
Sec. 1: Lot 20

(2) The town of Silver City has two areas leased under the Recreation and Public Purposes Act. The first, containing .8 ha (1.99 ac) is for water storage tanks. The second, containing 16 ha (40 ac) is for a sanitary landfill. These lands may be leased with no surface occupancy for geothermal activities and are described as follows:

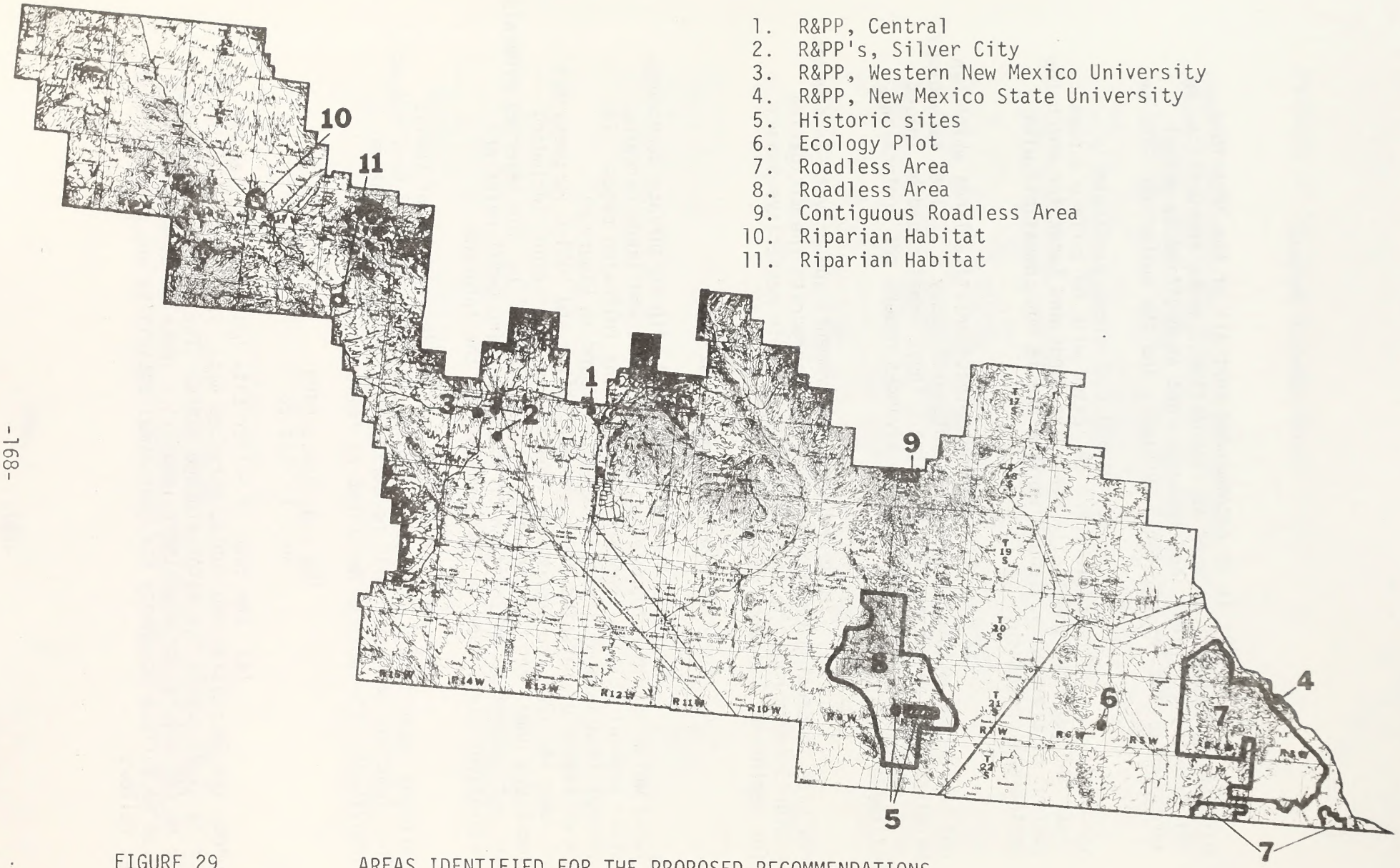


FIGURE 29 AREAS IDENTIFIED FOR THE PROPOSED RECOMMENDATIONS

(a) T. 18S., R. 14W., NMPM
Sec. 4: Tract 38

(b) T. 18S., R. 14W., NMPM
Sec. 22: NW¼NW¼

(3) Western New Mexico University in Silver City has a Recreation and Public Purposes lease of 54.44 ha (134.53 ac) for a field laboratory. This land may be leased with no surface occupancy for geothermal activities and is described as follows:

T. 18S., R. 14W., NMPM
Sec. 4: Lots 12, 15, 24, 27-30

(4) New Mexico State University has a Recreation and Public Purposes patent of 259 ha (640 ac) for an observatory. This land may not be leased for geothermal activities and is described as follows:

T. 21S., R. 3W., NMPM
Sec. 5: SE¼SW¼, SW¼SE¼
Sec. 8: W½NE¼, SE¼NE¼, E½NW¼, SW¼, NE¼NE¼SE¼ W½E½SE¼, W½SE¼, SE¼SE¼SE¼
Sec. 9: SW¼SW¼
Sec. 17: N½NW¼NW¼

(5) Two sites within the assessment area have been classified and segregated as of April 9, 1970, by 35 FR 69 for recreational or historical resource values. These lands can be leased with no surface occupancy for geothermal activities and are described as follows:

(a) Masacre Peak Petroglyphs (97 ha or 240 ac)

T. 21S., R. 8W., NMPM
Sec. 29: SW¼, W½SE¼

(b) Fort Cummings Recreation Area (2,428 ha or 6,000 ac)

T. 21S., R. 8W., NMPM
Sec. 20, 21, and 22: All
Sec. 23: E½, N½NW¼, SE¼NW¼, SW¼
Sec. 24, 25, and 26: All
Sec. 27: NW¼SW¼, E½, NW¼
Sec. 28: All
Sec. 29: N½, E½SE¼

(6) Open Diamond Ecological Plot was withdrawn under Public Land Order 4038, June 6, 1966. It consists of 16 ha (40 ac) of land withdrawn for scientific research purposes. This land can be leased with no surface occupancy for geothermal activities, and is described as follows:

T. 21S., R. 6W., NMPM
Sec. 25: NW¼SW¼

(7) The areas described in Figure 29 as #7, 8, and are roadless areas of 2024 ha (5,000 ac) or more (or are contiguous to USFS Rare II areas) and are subject to review for suitability for wilderness perservation as mandaged by Sec. 603(a) of the Federal Land Policy and Management Act of October 21, 1976 (P.L. 94-579). Although the roadless and wilderness criteria has not been finalized, these areas have been identified so as not to impair their suitability as winderness prior to intensive field inventory under approved review procedures. These lands will not be leased for geothermal activities at this time. The Las Uvas area, containing 20,950 ha (51,767 ac), (Fig. 30) and Sawyer's Peak area, containing 209 ha (516 ac), will be evaluated in accordance with the district range ES schedule and a decision (URA/MFP process) made whether to lease these areas no later than October 1982. The Cook's Range area, containing 12,125 ha (29,961 ac) (Fig. 31), will be evaluated according to the same schedule and a decision (URA/MFP process) reached no later than October, 1986. A legal description of these lands is available upon request from the Las Cruces District Office, BLM.

(8) The following special stipulations are recommended for certain public lands within the Gila drainage (approximately 113 ha (280 ac) (Fig. 29, #10 and #11). These stipulations are necessary for the conservation and protection of endangered and threatened species of flora and fauna as set forth in Federal and State regulations, and as provided for under Section 14 of the Geothermal Resources Lease (Form 3200-21) and Section 6 of GRO Order No. 4.

(a) No surface occupancy on the following land (16 ha or 40 ac):

T. 15S., R. 17W
Sec. 18: SW¼SE¼

(b) No leasing will be allowed on the following lands (146 ha or 360 ac)

T. 15S., R. 18W:
Sec. 13: S½SW¼
Sec. 14: NE¼NW¼, S½NE¼, NE¼SE¼

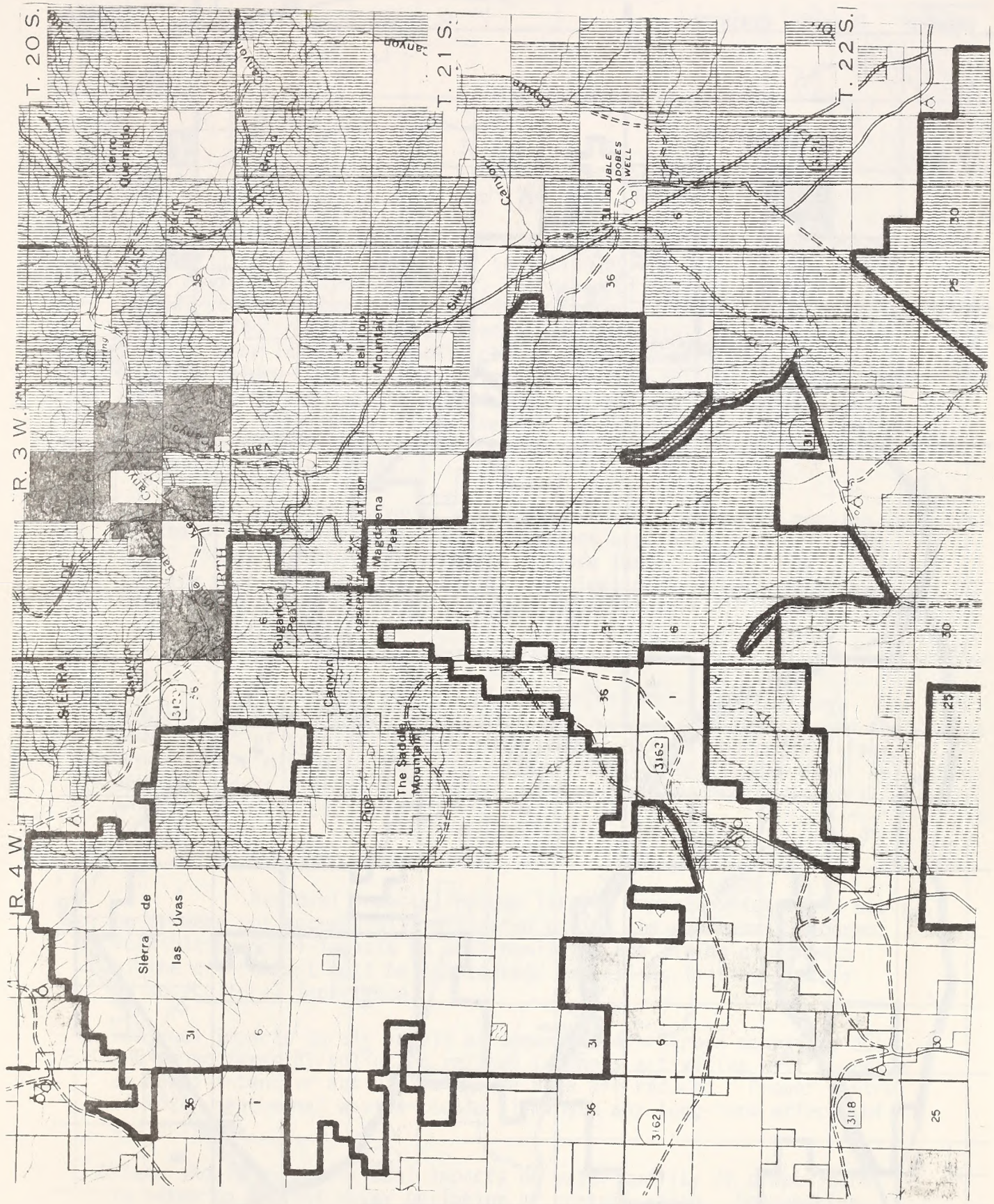


FIGURE 30 SIERRA DE LAS UVAS ROADLESS AREA

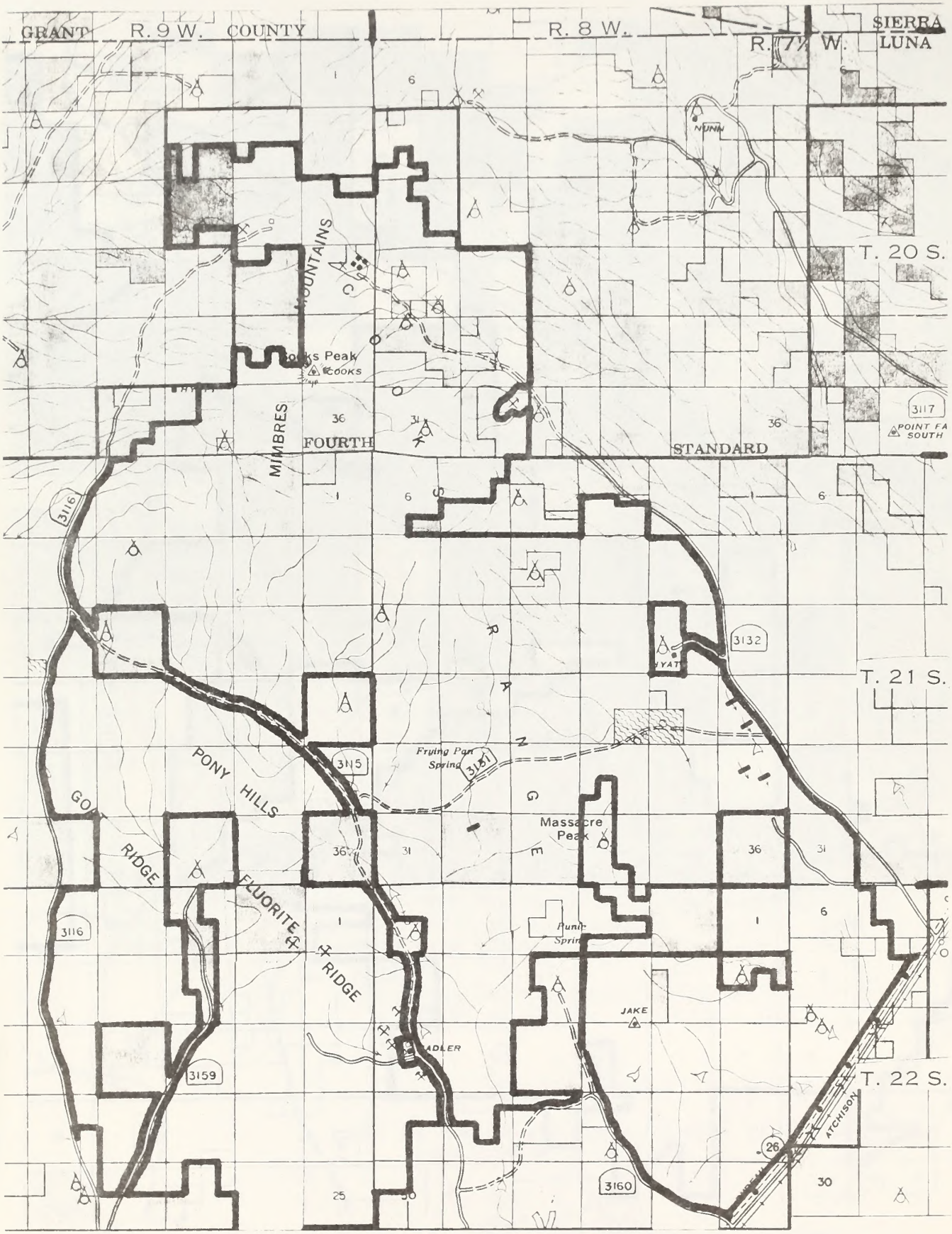


FIGURE 31 COOK'S RANGE ROADLESS AREA

T. 16S., R. 17W
Sec. 34: SE¼NE¼, NE¼SE¼
Sec. 35: NW¼SW¼

(9) Many small areas of public land have been temporarily set aside by BLM for selection by the State of New Mexico. These State Aid Withdrawal Lands, comprised of some 22,513 ha (55,630 ac), have been withdrawn under Executive Orders 6143, 6276, and 6583, closing them to mineral leasing and non-metalliferous mineral entry. These lands will remain closed until either a pending court case is decided or the State relinquishes claim to them. These lands are located throughout the assessment area and are far too numerous to list, but they may be researched on "Master Title Plats" or "Color Quad Maps" available at the BLM Las Cruces District Office and the BLM Santa Fe State Office.

(10) Several small plots of land along the portion of the Gila drainage within the assessment area have been set aside by EO 759 as powersite withdrawals. These lands total 275 ha (680 ac) and are open to entry under the mineral leasing laws providing that concurrence of the withdrawing agency is obtained.

c. Other recommendations

As the EAR for each proposed surface disturbing project is prepared, a determination of site-specific impacts and the development of specialized mitigating measures shall be accomplished. The possible mitigating measures listed in this EAR/TE, the Steam Act, and GRO Orders will form the basis for development of site-specific mitigating measures.

5. Residual Impacts

Residual impacts include lasting impacts which could not be or were not successfully mitigated during the geothermal program. Possible residual impacts to both nonliving and living components of the environment must be considered, as well as lasting impacts of socicultural importance.

Residual impacts to air should be nonexistent. Carbon monoxide, dust, and other forms of pollution related to man's activities will decrease as man's intensive activities in the area are reduced. Proper control of toxic geothermal wastes should eliminate any long-term effects of the program.

There should be no residual impacts on water quality if proper care is taken to prevent water pollution or contamination. Consumptive

yearround water use could affect the water supply. The need for water for geothermally produced electricity in this area has not been determined. If full scale production takes place, and is dependent upon present sources of water, these sources could possibly be seriously impaired.

Residual impacts to surface hot springs could occur. However, currently available information on geothermal reservoirs is inadequate to determine whether there will be any significant impacts to surface hot springs.

There need be no long-term residual impacts on soils in the area. Careful management should eliminate any problems with accelerated erosion or toxic residues. The withdrawal of thermal waters from the geothermal reservoirs might allow localized subsidence of the over-lying strata, creating a lasting impact to the topography. In addition, intensive use of a geothermal resource could deplete the resource to the point where it would take years to recover.

If the non-living environment is properly protected, there should be only low residual impacts to the living environment. Areas which have been cleared of vegetation will revegetate, whether naturally or with man's help. Animals will slowly return to live in these areas as the evidence of prior disturbance decreases. Special care to protect threatened and endangered species of plants and animals during the program should eliminate any serious residual impacts to species which might find recovery difficult. Residual impacts to living components of the environment should be relatively short-term impacts, since plants and animals are a renewable resource. Some features, such as abandoned water ponds, could have a permanent beneficial effect on living components.

Buildings, homes, roads, or other facilities left behind as a result of geothermal activity will degrade primitive and scenic values. They may enhance some forms of recreation such as ORV use opportunities which would be enhanced by various access rights-of-way and pipeline roads. Abandoned facilities could become an attraction to people who are interested in historic ghost towns and abandoned mining camps. There may also be a permanent loss of currently existing archaeological and historical values as a result of increased human activity during the geothermal program.

Communities in the area would feel economic stress from the loss of jobs and tax-base during close-out. Regulatory structure would suffer as well, since both the need for regulatory mechanisms and the method of their support is based on the size of the taxable population. Fortunately human communities can adjust to and recover from impacts

of this nature, just as other living components do. The residual impacts to social welfare could be serious on a local basis, but will create relatively short-term problems.

B. Relationship between Short-term Use and Long-term Productivity

Lands in the proposed leasing area have been used primarily for agriculture and mineral production. In recent years, public recreational interest in the area has increased due to expanding populations and recreational opportunities available on public lands. Significant geothermal development throughout the potential leasing area would immediately affect the livestock and wildlife forage resources, as well as visual and recreational resources on localized areas. Major effects would be reduced forage, habitat, recreational and scenic values, plus soil disturbance, noise, and air pollution.

Geothermal development could promote urban expansion in the area, causing a conversion of prime farmland to housing developments, shopping centers, and gas stations. On the other hand, geothermal waste water might prove usable for expansion of agricultural land uses. These effects would last as long as the geothermal program. Since a geothermal field must have at least 30 years of production potential before it is developed, these "short-term" changes in land use can be expected to last more than 30 years. Both the beneficial and the negative impacts of geothermal development will affect not only the present generation, but at least two future generations.

Under these circumstances, long-term productivity refers to productivity of the land beginning at least 50 years from now and extending indefinitely into the future. Assuming that the historical uses of the land have been suited to the land and have provided materials necessary to man's survival and comfort, it is likely that these uses will continue to be important.

Livestock production, mining operations, and other resources should suffer little or no residual impacts from a full-scale geothermal development program. Proper protection of potable water sources during the program will enable a speedy recovery from any impacts to livestock production. Recreation would recover as development areas are rehabilitated. Mining operations should not be affected even during the program.

Most of the land suitable for farming is privately owned, including subsurface, and many of the Federal environmental protection stipulations cannot be required for actions on these lands. Although impacts cannot be controlled through Federal efforts, State and local authorities may be able to minimize these impacts through zoning ordinances or other regulation.

If farmlands are retained and maintained or expanded with geothermal waste water, no residual impacts need occur. Great care should be taken to control the salinity and mineral content of geothermal irrigation water, since an excessive build-up of mineral salts in the soil could reduce its agricultural productivity.

Primitive values, scenic quality, archaeological and historical resources, and wildlife preservation efforts may all suffer long-term residual impacts. All of these are of cultural and scientific rather than economic interest.

When a civilization is placed under stress to maintain its existence and its economic standard of living, these considerations may become luxuries which it can no longer afford. Full geothermal development may require that cultural and scientific values in the development area be sacrificed in favor of technological maintenance and advancement. Whether this involves destruction or simply a reduction of the quality of these resources, it will constitute a permanent trade-off in resources for short-term benefits. This will affect all future generations adversely, but will allow economic benefits to the next few generations.

Social welfare would improve on a long-term basis if the geothermal resource proves to be long-lasting. If it is not long-lasting the economic welfare of those using its energy would be short-term, lasting only a few generations. Under these circumstances, the impacts of close-out could be substantial, but long-term impacts are unlikely. While exhaustion of a resource certainly affects the productivity of a region, the resource is of no more use in the ground unused than it would be if it were absent.

In conclusion, a fully developed geothermal program will have many short-term benefits and possibly long-term benefits. It need not affect long-term productivity of the land. It will require some sacrifice of the quality of all cultural resources in the area. This will be a permanent trade-off for increased economic benefits and maintenance of the American standard of living. If exploration does not result in a discovery of a significant geothermal resource, the short-term loss of grazing, wildlife habitat, recreational resources, water resources, and other values will be minimal and the long-term productivity of these resources will not be greatly affected.

C. Irreversible and Irretrievable Commitment of Resources

Knowledge of geothermal reservoirs is limited at this time. It may be that the geothermal resource in the assessment area

is of short duration. If it is, full development and commitment of the resource to production of electricity could constitute an irreversible and irretrievable commitment of resources.

Any destruction of cultural resources which occurs as a direct or indirect result of the geothermal program will constitute an irreversible commitment of nonrenewable resources.

If care is not maintained during all phases of geothermal operations to conserve and protect endangered and threatened plant and naimal species, the result could be an irreversible and irretrievable commitment of these resources through neglect.

No other irreversible commitments are likely to result from a geothermal program as long as the developers comply conscientiously with all environmental protection measures.

IV. PUBLIC INTEREST

A. Persons, Groups and Government Agencies Consulted

Copies of the draft EAR/TE were sent for review and comment to State, Federal and local governmental agencies, conservation groups, representatives of industry-related businesses as well as private individuals who expressed a direct interest for this document. Copies were given to those individuals who requested them following the public announcements concerning their availability at the Las Cruces District Office.

Additional copies of the draft EAR/TE were made available for public review at six libraries throughout the assessment area as well as at the Post Office at Gila. Notices advertising the availability of the draft EAR/TE were sent to several newspapers and radio stations throughout the area. In addition, letters of notification were mailed to all those known livestock operators throughout the assessment area.

A copy of the cover letter sent out with the EAR/TE, a list of local, State, and Federal government agencies receiving the EAR/TE, and copies of the press releases can be found in Appendix B. The distribution list of the letter of notification, the complete distribution lists of the draft and final EAR/TE, and similar information is available upon request by contacting the Las Cruces District Office, BLM.

A public meeting was held in Silver city, as advertised and scheduled, on January 18, 1978. The purpose of the meeting was to allow for comment on the draft EAR/TE as well as to answer questions on BLM's geothermal leasing program.

B. Intensity of Public Interest

In contrast to the publicity and number of requests for the draft EAR/TE, few people submitted comments on the material presented at the public meeting on the EAR/TE. Most of those who sent replies were representatives of State and Federal agencies or conservation or industrial groups.

Comments and questions expressed by the public at the Silver City meeting were slanted toward BLM's leasing program rather than input or comment on the draft EAR/TE. Most comments and questions came from private landowners who were concerned about the leasing of Federally owned minerals on their lands.

Intensity of Public Interest

Written comments received during the draft review period were mostly in the form of input to the draft EAR/TE. Comments included notice of typographical and grammatical errors as well as suggestions on material content. Interest was addressed to no particular ideas or sections of the EAR/TE.

An effort has been made to incorporate all of the comments in appropriate sections. The letters received will be permenently kept on file at The BLM's Las Cruces District office and will be available for review upon request

The Las Cruces District Office, BLM, wishes to thank all those who commented on the draft EAR/TE for their help in improving the quality of the final document.

Formal letters of comment were submitted by the following:

- The New Mexico Natural History Institute
- New Mexico Ornithological Society
- Department of Sociology and Anthropology, New Mexico State University
- New Mexico State Engineer's Office
- New Mexico Department of Game and Fish
- Area Geothermal Supervisor, USGS
- Bureau of Land Management, Santa Fe, New Mexico State Office
- Southwest Energy Options
- Geothermal Services, Inc.
- New Mexico State Planning Office
- Regional Director's Office, U, S. Fish and Wildlife Service
- Goodrich-Bartlett & Associates
- Exploration Associates

V. SUMMARY CONCLUSIONS

Low or negligible residual impacts to all components of the environment may be expected if all appropriate mitigating measures are taken. The quantitative and physical limits of impacts incurred by production must be determined at that time. In particular, an interpretation of data collected during exploration will be necessary for evaluation of the effects of production on potable water, surface hot springs, and the geothermal resource of the area.

If no program develops, the exploration will have created minor, short-term impacts (beneficial and adverse) which will not affect the long-term productivity of the land.

If a program does develop, the short-term use of geothermal resources should have great beneficial impacts. The adverse impacts should be minimized by proper use of mitigating measures and careful control procedures. Due care during production should reduce residual impacts to a great degree. The program need have no significant effects on the long-term productivity of the land.

Irreversible and irretrievable commitment of resources may possibly include the loss of historic and archaeological values. Carelessness could result in the loss of endangered flora and fauna. In addition, the geothermal resource could be irretrievably committed if it is found to be nonrechargeable.

BIBLIOGRAPHY

Anderson, J. E. , 1956. The Creosotebush Problem in New Mexico. Ranch Day Pub., NM Agr. Expt. Sta. and Agr. Res. Serv. and Forest Service, USDA. pp. 27-30

Barbour, M. G., 1968. Germination Requirements of the Desert Shrub *Larrea Divaricata*. Ecology 49: 915-923.

Barbour, M. G. 1969. Age and Space Distribution of the Desert Shrub *Larrea Divaricata*. Ecology 50: 679-685.

Buffington, L. C., and Herbel, C., 1965. Vegetational Changes on a Semidesert Grassland Range from 1858 to 1963. Ecol. Monog. 35(2): 139-164.

Bureau of Business and Economic Research, 1975. New Mexico Statistical Abstract. The University of New Mexico, Albuquerque, NM 141 pp.

Bureau of Land Management, 1973. Pronghorn Antelope. BLM Manual, Technical Supplement 6601.1. 30 pp.

Bureau of Land Management, 1973. Wildlife Inventory. BLM Manual, Tehcnical Supplement 6610. 8 pp.

Bureau of Land Management, 1974. Manual 1791: Environmental Analysis

Bureau of Land Management, 1974. Unit Resource Analysis, Las Uvas Planning Unit (03-03); Las Cruces District, Las Cruces, NM (mss.)

Bureau of Land Management, 1975. Visual Resource Management. BLM Manual 6300, 6310, 6320, 37 pp.

Bureau of Land Management, 1975. Unit Resource Analysis, Caballo Planning Unit (03-06); Las Cruces District, Las Cruces, NM (mss.)

Bureau of Land Management, 1976. Management Framework Plan, Las Uvas Planning Unit Information Brochure. Las Cruces District, Las Cruces, NM 43 pp.

Bureau of Land Management, 1976. Management Framework Plan, Caballo Planning Unit Information Brochure. Las Cruces District, Las Cruces, NM. 79 pp.

Campbell, R. S., 1929. Vegetative Succession in the *Prosopis* Sand Dunes of Southern New Mexico. Ecology 10: 392-398.

Campbell, R. S., 1931. Plant Succession and Grazing Capacity on Clay Soils in Southern New Mexico. Jour. Agr. Res. 43: 1027-1051.

Campbell, R. S. and Bomberger, E. H., 1934. The Occurrence of *Gutierreza Sarothrae* on *Bouteloua Eriopoda* Ranges in Southern New Mexico. Ecology 15: 49-61.

Conway, M., 1975. New Mexico's Endangered Fishes, New Mexico Wildlife, Vol. 20, (3) pp 18-23.

Davis, C. A. and Bevill, V. W., 1970. Effects of Restoration and Management of the San Simon Marsh on its Utilization by Mexican Ducks. Final Report. New Mexico State University, Agricultural Experiment Station, Las Cruces, NM 83 pp.

Dick-Peddie, W. A., 1961. Changing Vegetation Patterns in Southern New Mexico. New Mexico Geological Society Guidebook, Sixteenth Field Conference, Southwestern New Mexico II. pp. 234-235.

Durham, John, 1977. Geologic Hazards of the Silver City Area. Conservation Division, Office of the Area Geothermal Supervisor, USGS, Menlo Park, CA 26 pp.

Elston, W. E., Rhodes, R. C., Coney, P. J., Deal, E. G., 1976. Progress Report on the Mogollon Plateau Volcanic Field, Southwestern New Mexico, No. 3- Surface Expression of a Pluton; Cenezoic Volcanism in Southwestern New Mexico, New Mexico Geologic Society Special Publication No. 5., pp 3-28.

Gardner, J. L., 1951. Vegetation of the Creosotebush Area of the Rio Grande Valley in New Mexico. Ecological Monographs 21(4): 279-403.

Holmes, 1902. "Flint Implements and Fossil Remains from a Sulphur Spring at Afton, Indian Territory." American Anthropologist, New Series, Vol. 4: 108-129.

Hubbard, J. P., 1970. Check-list of the Birds of New Mexico. Albuquerque, NM, New Mexico Ornithological Society.

Humphrey, R. R., 1958. The Desert Grassland. University of Arizona Agricultural Experiment Station, Bull. 299. 62 pp.

Jackson, C. V., 1928. Seed Germination in Certain New Mexico Range Grasses. Bot. Gaz. 86: 270-294.

Jardine, J. T. and Forsling, C. L., 1922. Range and Cattle Management During Drought. U.S. Dept. Agr. Bull 1031, 89 pp.

Kelley, V. C., 1955. Regional Tectonics of South-Central New Mexico. Guidebook of South-Central New Mexico. Sixth Field Conference, New Mexico Geological Society, pp. 96-104.

Knipe, D., and Herbel, C., 1966. Germination and Growth of Some Semidesert Grassland Species Treated with Aqueous Extracts from Creosotebush. Ecology 47: 775-781.

Koster, W. J., 1975. Guide to the Fishes of New Mexico. Albuquerque, NM: University of New Mexico Press. 116 pp.

Kruger, P. and Otte, C., 1973. Geothermal Energy, Resources, Production, Stimulation. Stanford University Press. 360 pp.

Ligon, S. J., 1961. New Mexico Birds and Where to Find Them. Albuquerque, NM: University of New Mexico Press. 360 pp.

Maker, H. J., Neher, R. E., Derr, P. H., and Anderson J. U., 1971. Soil Associations and Land Classification for Irrigation, Dona Ana County. Agricultural Experiment Station Research Report 183, New Mexico State University, Las Cruces, NM 41 pp.

Maker, H. J., Neher, R. E., and Anderson, J. U., 1971. Soil Associations and Land Classification for Irrigation, Grant County. Agricultural Experiment Station Research Report 200, New Mexico State University, 43 pp.

Maker, H. J., Bailey, O. F., and Anderson, J. U., 1970. Soil Associations and Land Classification for Irrigation, Luna County. Agricultural Experiment Station Research Report 176, New Mexico State University, 31 pp.

Maker, H. J., Downs, J. M., Anderson, J. U., 1972. Soil Associations and Land Classification for Irrigation, Sierra County. Agricultural Experiment Station Research Report 233, New Mexico State University, Las Cruces, NM 56 pp.

Muller, C. H., 1940. Plant Succession in the *Larrea Flourensia* Climax. Ecology 21: 206-212.

New Mexico Department of Game and Fish, 1972 through 1975. Deer, Antelope, Cougar, Quail, Doves, Ducks, and Geese Hunt Information and Population Trend. NM Game and Fish Dept. Annual Job Progress Report.

New Mexico Planning Office, 1976. NM State Comprehensive Outdoor Recreation Plan (SCORP) 240 pp.

Norris, J. J., 1974. Mesquite Invasion on the Range. In Ranch Day Program, New Mexico Expt. Sta. and Southwestern Forest and Range Expt. Sta.

Odum, E. P., 1959. Fundamentals of Ecology. W. B. Sanders Co., Philadelphia, Pa. 546 pp.

Raschen, R., and Cook, W. S., 1976. Exploration and Development of Geothermal Resources. Conservation Division, Office of the Area Geothermal Supervisor, U.S. Geological Survey, Menlo Park, CA 29 pp and 14 plates.

Simpson, Bessie W., 1947, New Mexico Gem Trails, A Field Guide for Collectors. Gem Trail Publications, Geln Rose, Texas. 88 pp.

Smith, R. L., 1966, Ecology and Field Biology. Harper and Row, New York, NY. 686 pp.

Trauger, F. D., 1972. Water Resources and General Geology of Grant County, New Mexico. New Mexico State Bureau of Mines and Mineral Resources, Hydrologic Report 2. 221 pp.

United States Department of the Interior, 1973. Final Environmental Statement for the Geothermal Leasing Program, Promulgation of Leasing and Operating Regulations for the Geothermal Leasing Program. Report in four volumes.

Went, Fritz W., 1955. The Ecology of Desert Plants. Scientific American, Vol. 192.

Whitfield, C. J., and Beutner, E. L., 1938. Natural Vegetation in the Desert Plains Grassland. Ecology 19: 26-37

Wilson, J. P., 1975. Historical Profile of Southwestern New Mexico. Department of Anthropology and Sociology, New Mexico State University, Las Cruces, NM. Report No. 21. 173 pp.

Wilson, L. O., 1973. Birds, Mammals, Reptiles, and Amphibians of New Mexico. U.S. Department of the Interior, Bureau of Land Management, Santa Fe, NM (unpublished).

APPENDICES

APPENDIX

A

GLOSSARY

GLOSSARY

Bonus Bid	A lump sum paid to the U.S. by the successful bidder for a mineral lease, such payment being in addition to the rents and royalties specified in the lease.
Color	The property of reflecting light of a particular wave length that enables the eye to differentiate otherwise unidentifiable objects.
Contrast	The effect of a striking difference in the form, line, color, or texture of an area being viewed.
Contrast Rating	A method of determining the extent of visual impact for an existing or proposed activity that will modify any landscape feature.
Ecological Succession	The orderly and progressive replacement of one community by another until a relatively stable community occupies the area (Smith, 1966).
Ecotone	A transition between two or more biotic communities.
Endangered Species	Any species which is in danger of extinction throughout all or a significant portion of its range.
En échelon	In steplike arrangement; said of geologic features that are in an overlapping or staggered arrangement.
Facies	General appearance; a particular local aspect or modification of an ecological community.
Geothermometer	A mineral or mineral assemblage whose composition, structure, and inclusions are fixed within known thermal limits under particular conditions of pressure and composition, and whose presence thus denotes a limit or range for the temperature of formation of the enclosing rock or fluid.
Graben	An elongate, down-faulted crustal unit or block that is bound by faults on its long dimensions. In the Basin and Range, grabens are commonly valleys.
Heat Conductivity	A measure of the ability of a material to conduct heat. Rocks with abundant quartz have high thermal conductivities. Poorly consolidated sediments have lower thermal conductivities.

Horst	An elongate, uplifted crustal unit or block that is bound by faults on its long dimensions. In the Basin and Range, horsts are commonly mountain ranges.
Intrusion	Feature (Land, vegetation, or structure) which is generally considered out of context with the characteristic landscape.
Landscape Character	The arrangement of a particular landscape as formed by the variety and intensity of the four basic elements of form, line, color, and texture
Life Zones	A classification of flora and fauna on the bases of elevation and latitude.
Lower Sonoran	The life zone which extends from about 2,817 to 5,000 feet elevation. The major floral type is desert shrub.
Magnitude of Contrast	A classification of intrusions as to the degree which they have modified or intruded upon the natural landscape.
MWCEN	MWCEN of electricity - megawatt-century . . . a megawat of electrical energy produced for a century
Naturalistic Character	A landscape situation where the basic elements are displayed in a composition that appears natural within the surrounding area or character type.
Niche	The space occupied and the function of each species within a community.
Off-Road Vehicle	(ORV) Any motorized vehicle designed for or capable or cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other terrain.
Phreatophyte	A deep-rooted plant that obtains its water from the water table of the layer of soil just above it.
Primary Succession	The first occupation of areas that were previously devoid of organisms.
Scenic Quality	The quality of the scenery as determined through the use of the scenic evaluation process.
Secondary Succession	Species diversity changes occurring on areas as the result of disturbance by man, animals, or natural forces, such as fires, wind storms, and floods.

Sensitivity Level(s)	An index of the relative importance or value of visual response to an area in relation to other areas in the planning unit.
Seral	A biotic community which is a developmental, transitory stage in an ecological succession.
Soil Association	(1) A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways (2) A mapping unit used on general soil maps, in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soil.
Threatened Species	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range
Transition Zone	The life zone which extends from about 7,000 to 9,500 feet elevation. The major floral type is ponderosa pine.
Upper Sonoran	The life zone which extends from about 4,500 to 8,000 feet elevation. The major floral type is pinyon juniper.
Visual Management Unit	An area of land where there is not variation in the visual zone, sensitivity zone, and scenic quality zone.
Visual Resource	The land, water, vegetative, animal, and other features that are visible on all public lands.
Visual Resource Management Class	The degree of alteration that is acceptable within the characteristic landscape. It is based upon the physical and sociological characteristics of any given homogeneous area.
Visual Zones	The area that can be seen as foreground, middle-ground, background, or seldom seen..

APPENDIX

B

EAR/TE DISTRIBUTION LIST

STATE, FEDERAL, LOCAL AGENCIES ONLY

IN REPLY REFER TO

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

District Office
P. O. Box 1420
Las Cruces, New Mexico
88001

February 22, 1978

Gentlemen:

Enclosed is the Environmental Assessment Record and Technical Examination on Proposed Geothermal Leasing in the Silver City Area, New Mexico. If you have any questions about this document, please do not hesitate to contact us at (505) 523-5571 or come to our office at 1705 North Valley Drive, Las Cruces.

Sincerely yours,

Daniel C. B. Rathbun
District Manager

Enclosure

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

EAR/TE DISTRIBUTION LIST

STATE, FEDERAL, LOCAL AGENCIES ONLY

Albuquerque District Office (BLM)
Area Geologist (USGS, Roswell)
Area Geothermal Supervisor (USGS, Menlo Park, CA)
Bureau of Reclamation (USDI, Las Cruces)
Chairman, Grant County Commissioners (Silver City)
Department of Interior Regional Environmental Officer (Albuquerque)
District Geothermal Supervisor (Salt Lake City)
Gila National Forest
New Mexico Bureau of Mines and Mineral Resources (Socorro)
New Mexico Department of Game and Fish (Las Cruces)
New Mexico Department of Game and Fish (Santa Fe)
New Mexico State Central Clearinghouse (Santa Fe)
New Mexico State Engineer (Santa Fe)
New Mexico State Environmental Improvement Agency (Silver City)
New Mexico State Geologist's Office (Santa Fe)
New Mexico State University
Oil Conservation Commission (Santa Fe)
Safford District Office (Arizona) (BLM)
Socorro District Office (BLM)
Soil Conservation Service (Las Cruces)
Southwest New Mexico Resource Conservation and Development Project (Silver City)
State Historical Preservation (State Planning Office, Santa Fe)
State Land Office (Santa Fe)
State Office (BLM, Santa Fe)
Town of Silver City
United States Fish and Wildlife Service (Albuquerque)
United States Forest Service (Albuquerque)
Western New Mexico University

NEW MEXICO
BLM
BUREAU OF LAND MANAGEMENT
UNITED STATES DEPARTMENT OF THE INTERIOR

FOR RELEASE December 27, 1977
CONTACT Charlotte Powey 523-5571
Las Cruces

News Release

BLM ISSUES DRAFT REPORT

Environmental impacts of geothermal leasing are the subject of a draft report released today by the Bureau of Land Management's Las Cruces District Office. The 281 page document assesses this impact for the Silver City area, including portions of Grant, Luna, Sierra, and Dona Ana counties (see enclosed map).

The Las Cruces office is interested in receiving comments on the contents, and indicated January 27 as the deadline to receive them.

Copies can be found at three locations in Silver City--the Western New Mexico library, Southwest Regional library and the Silver City public library. The Deming public library, the Gila Post Office, and the libraries at the University of New Mexico and New Mexico State University also have copies.

--More --More --More

The Las Cruces office has a few copies available on a first come, first serve basis, and will mail them out upon request. Several copies which can be checked out for three days will be reserved.

A public meeting to receive additional comments on the report will be held at the Public Safety Building in Silver City January 18 at 6:30 PM.

Written comments should be addressed to Dan Rathbun, Bureau of Land Management, P.O. Box 1420, Las Cruces, N.M. 88001.

- 30 -

NEW MEXICO
BLM
BUREAU OF LAND MANAGEMENT
UNITED STATES DEPARTMENT OF THE INTERIOR

FOR RELEASE January 10, 1977
CONTACT Charlotte Powey Las Cruces
(505) 523-5571

News Release

BLM TO HOST PUBLIC MEETING

The Las Cruces District of the Bureau of Land Management will hold a public meeting in Silver City on January 18 at 6:30PM in the Public Safety Building. The meeting will be held to receive any comments or questions anyone might have on the draft Environmental Assessment Report on Geothermal Leasing in the Silver City Area, a report recently released by the Bureau.

The meeting will open with a brief slide presentation of the resources found on public lands in this area and will then be opened up for any questions and comments people might have.

All comments the Bureau receives will be considered when writing the final version of the report. The final document will be completed and available by mid-February.

- 30 -

APPENDIX

C

SAMPLE FORMS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Notice Number

NOTICE OF INTENT TO CONDUCT GEOTHERMAL RESOURCE EXPLORATION OPERATIONS

Applicant(s)	Address *(include zip code)*
Operator	Address *(include zip code)*
Contractor(s)	Address *(include zip code)*

hereby apply for authorization to conduct exploration operations pursuant to the provisions of 43 CFR 3209 now or hereafter in force across and upon the following-described lands *(give description of lands by township, attach map or maps showing lands to be entered or affected)*

Type of operations to be conducted *(give brief description)*

Exploration operations will be conducted during the period *(date)* from to

Attached ☐ $ Surety bond ☐ Rider to Nationwide bond ☐ Rider to Statewide bond ☐ Bond to be furnished

Upon completion of exploration operations the undersigned agrees to notify the Authorized Officer that authorized exploration operations have been completed in conformance with the general and special terms and stipulations of the notice.

The undersigned hereby agrees (1) that he will not enter upon the described land until he has been informed in writing whether there are special stipulations applicable to his Notice of Intent, as to either time or method of operation or otherwise, and, if there are such stipulations, what those stipulations are, (2) that he will comply with those special stipulations, if any; and (3) that he will not enter upon the described lands until his entry has been approved by the Authorized Officer.

The undersigned agrees to be bound by the terms and conditions of this notice to conduct exploration operations when approved by the Authorized Officer.

The undersigned agrees that the filing of this *Notice* under the regulations (43 CFR Subpart 3209) does not vest or confer any preference right to a geothermal resources lease.

The undersigned agrees further that all exploration operations shall be conducted pursuant to the following terms and conditions:

1. Exploration operations shall be conducted in compliance with all Federal, State, and local laws, ordinances, or regulations which are applicable to the area of operations including, but not limited to, those pertaining to fire, sanitation, conservation, water pollution, fish, and game. All operations hereunder shall be conducted in a prudent manner.

2. Due care shall be exercised in protecting the described lands from damage. All necessary precautions shall be taken to avoid any damage other than normal wear and tear to improvements on the land including, but not limited to, gates, bridges, roads, culverts, cattle guards, fences, dams, dikes, vegetative cover, improvements, stock watering, and other facilities.

3. All drill holes shall be capped when not in use and appropriate procedures shall be taken to protect against hazards in order to protect the lives, safety, or property of other persons or of wildlife and livestock.

4. All vehicles shall be operated at a reasonable rate of speed and, in the operation of vehicles, due care shall be taken to safeguard livestock and wildlife in the vicinity of operations. Existing roads and trails shall be used wherever possible. If new roads and trails are to be constructed, the Authorized Officer must be consulted prior to construction as to location and specifications. Reclamation and/or reseeding of new roads and trails shall be made as requested by the Authorized Officer.

5. Upon expiration, conclusion, or abandonment of operations conducted pursuant to this *Notice*, all equipment shall be removed from the land, and the land shall be restored as nearly as practicable to its original condition by such measures as the Authorized Officer may specify. All geophysical holes shall be safely plugged. The Authorized Officer shall be furnished a *Notice of Completion of Geothermal Resource Exploration Operations* (Form 3200–3) immediately upon cessation of all such operations and shall be further informed of the completion of reclamation work as soon as possible.

6. Location and depth of water sands encountered shall be disclosed to the Authorized Officer.

(Continued on reverse)

7. Operator shall contact the Authorized Officer prior to actual entry upon the land in order to be appraised of practices which shall be followed or avoided in the conduct of exploration operations pursuant to the terms of this *Notice* and applicable regulations. Operator will conduct no operations on the land unless the attached bond is in good standing.

8. Due care shall be exercised to avoid scarring or removal of ground vegetative cover.

9. All operations shall be conducted in such a manner to avoid (a) blockage of any drainage systems; (b) changing the character, or causing the pollution or siltation of rivers, streams, lakes, ponds, waterholes, seeps, and marshes; and (c) damaging fish and wildlife resources or habitat. Cuts or fills causing any of the above-mentioned problems will be repaired immediately in accordance with specifications of the Authorized Officer.

10. Vegetation shall not be disturbed within 300 feet of waters designated by the Authorized Officer, except at approved stream crossings.

11. Surface damage which induces soil movement and/or water pollution shall be subject to corrective action as required by the Authorized Officer.

12. Trails and campsites shall be kept clean. All garbage and foreign debris shall be eliminated as required by the Authorized Officer.

13. Operator shall protect all survey monuments, witness corners, reference monuments, and bearing trees against destruction, obliteration, or damage. He shall, at his expense reestablish damaged, destroyed, or obliterated monuments and corners, using a licensed surveyor, in accordance with Federal survey procedures. A record of the reestablishment shall be submitted to the Authorized Officer.

14. Operator shall make every reasonable effort to prevent, control, or suppress any fires started by the operator, and to report, as soon as possible, to the Authorized Officer location and size of fires, and assistance needed to suppress such fires. Operator shall inform the Authorized Officer as soon as possible of all fires, regardless of location, noted, or suppressed by Independent action.

15. No work shall be done within one-half mile of a developed recreation site without specific written authority from the Authorized Officer. Any travel within one-half mile of a recreation site shall be over existing roads or trails.

16. Use of explosives within one-half mile of designated waters is prohibited unless approved, in writing, by the Authorized Officer.

17. If operations conducted under the provisions of this *Notice* causes any damage to the surface of the national resource lands, such as, but not limited to, soil erosion, pollution of water, injury or destruction of livestock or wildlife, or littering, operator shall, within 48 hours, file with the Authorized Officer a map showing exact location of such damage and a written report containing operator's plans for correcting or minimizing damage, if possible.

18. Violation of, or failure to comply with any of these terms and conditions shall result in immediate shutdown of field operations until deficiency is corrected. Failure to correct deficiency within the time period allowed by the Authorized Officer shall result in forfeiture of bond.

19. The Bureau of Land Management reserves the right to close any area to operators in periods of fire danger or when irreparable damage to natural resources is imminent.

20. Contractor shall be liable for assuring compliance with all terms and conditions of this *Notice* and all actions of his designated operator, agents, and employees.

21. Where continuation of the operation will result in irreparable damage to the land and other natural resources this *Notice* will be immediately cancelled by the Authorized Officer.

22. Special Stipulations:

(Signature of Applicant)	(Date)	(Signature of Operator)	(Date)

We hereby agree to the special stipulations added and made a part of this *Notice* to conduct exploration operations.

(Signature of Holder of Notice)	(Date)	(Signature of Operator)	(Date)

I hereby approve this *Notice* to conduct exploration operations.

(Signature of Authorized Officer)	(Title)	(Date)

* U.S. Government Printing Office: 1974-780-757/189 Reg.8

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

NOTICE OF COMPLETION OF GEOTHERMAL RESOURCE EXPLORATION OPERATIONS

Name	Address *(include zip code)*

Pursuant to the *Notice Number* heretofore filed to conduct geothermal resource exploration operations, this is to

advise that such operations were completed *(date)* , on the lands described in the above identified notice.

(Geophysical Operator's Signature)

(Address, include zip code)

(Date)

Instructions: Submit original and one (1) copy of completed form to proper Bureau of Land Management Office. Insert Notice Number of *Notice of Intent to Conduct Exploration Operation* (Form 3200–2) which authorized the exploration completed.

GPO 851-318

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

COMPETITIVE GEOTHERMAL RESOURCES LEASE BID

FORM APPROVED
OMB NO. 42–R1687

Known Geothermal Resources Area

State	Date of Sale

The following bid is submitted for competitive geothermal resources lease on the lands identified below

PARCEL NUMBER OR LAND DESCRIPTION	AMOUNT OF BID		
	TOTAL	PER ACRE	DEPOSIT SUBMITTED WITH BID

1. Are you a citizen of the United States? ☐ Yes ☐ No

2. If a corporation or other legal entity, specify kind

3. Are you the sole party in interest in this lease? ☐ Yes ☐ No

I CERTIFY That I am qualified to hold any lease which may issue as a result of this sale under the Geothermal Steam Act of 1970 (84 Stat. 1566) and the regulations thereunder.

(Signature of Bidder)

(Address of Bidder)

(City, State, and zip code)

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

(Instructions on reverse)

Form 3200–4 (December 1973)

INSTRUCTIONS

1. Separate bid for *each* parcel is required. If no parcel number has been assigned to tract, then land description or identification should be furnished.

2. Bid *must* be accompanied by one-half of total amount of bid. The amount should be cash or money order, certified or cashier's check, or bank draft which *must* be made payable to the *Bureau of Land Management.*

3. Identify envelope *Bid for Geothermal Resources Lease* in *(name of KGRA).* Be sure correct parcel number of tract on which bid is submitted and date of bid opening are noted plainly on envelope. No bid may be modified or withdrawn unless such modification or withdrawal is received prior to time fixed for opening of bids.

4. Mail or deliver bid to office and place indicated in *Notice of Sale.*

5. If bid is submitted by an agent or attorney-in-fact, association (including a partnership), corporation, guardian, or a trustee the showing required by 43 CFR 3202.2 should accompany bid, *except* that if the required information has previously been filed, a reference by serial number to the record in which it was filed, together with a statement as to any amendments, will be sufficient.

6. If bidder is *not* the sole party in interest in the lease for which bid is submitted, full disclosure of interests of all other parties *must* be made as required by 43 CFR 3202.2-5, accompanied by a separate showing of qualifications of such parties to hold the lease interest.

GPO 851 - 309

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42–R1688

Serial Number

APPLICATION TO LEASE GEOTHERMAL RESOURCES
(Sec. 4 Noncompetitive Lease)

The undersigned hereby makes application to lease all or any of the lands described herein that are available for lease pursuant and subject to the terms and provisions of the Act of December 24, 1970 (84 Stat. 1566, 30 U.S.C. Sec. 1001), or any amendments hereafter enacted, hereinafter referred to as the Act, and to all applicable regulations now or hereafter in force when not inconsistent with any express and specific provisions herein, which are made a part hereof.

1. Name *(Last, First, Middle initial, print or type)*	Address *(include zip code)*
Social Security or Taxpayer Number	

2. Legal description

State	County
NATIONAL RESOURCE LANDS	ACQUIRED LANDS
Total area Acres	Total area Acres

	YES	NO
3. Service charge enclosed		
4. Rental enclosed		
5. Compliance bond enclosed		
6. Are you the sole party in interest?		
7. Are you a citizen of the United States?		
8. Have you reached the age of majority?		
9. Is application made for a corporation or other legal entity?		
10. Has a statement of qualifications been filed?		

I CERTIFY That my interests, direct or indirect, in geothermal resources leases in the above State do not exceed 20,480 acres. That the statements made herein are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

(Signature of Applicant) (Signature of Applicant)

(Date) (Attorney-in-Fact)

Title 18 U.S.C. Section 1001 makes it a crime for any person knowingly and wilfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

(Instructions on reverse)

Form 3200–8 (December 1973)

GENERAL INSTRUCTIONS

Submit copies of application typewritten or printed plainly, and signed in ink. Application *must* be filed in the proper BLM Office for the State in which the lands are located, in *duplicate* for national resource lands and in *triplicate* where acquired lands are involved. Applications for lands in the following States which have no proper BLM Office should be filed in the office indicated below.

North Dakota, South Dakota
State Office, BLM
Billings, Montana 59101

Kansas, Nebraska
State Office, BLM
Cheyenne, Wyoming 82001

Oklahoma
State Office, BLM
Santa Fe, New Mexico 87501

Eastern States
Eastern States Office, BLM
7981 Eastern Avenue
Silver Spring, Maryland 20910

If additional space is needed in furnishing any of the required information, it should be prepared on additional sheets, initialed, and attached to your application.

Item 1 - Give last name, first name, middle initial, and Social Security or Taxpayer Number. Give street and number (P.O. Box), City, State, and Zip Code.

Item 2 - *Land Description* - Give complete and accurate description of lands for which lease is desired. If lands have been surveyed under the public land rectangular system, each application *must* describe lands by legal subdivision, section, township, and range. When protracted surveys have been approved and effective date thereof published in the Federal Register, all applications to lease lands shown on such protracted surveys, filed on or after such effective date, *must* describe lands only according to section, township, and range shown on approved protracted surveys. If lands have neither been surveyed on the ground nor shown on records as protracted surveys, each application *must* describe lands by metes and bounds, giving courses and distances between successive angle points on the boundary of tract, in cardinal directions except where boundaries of lands are in irregular form, and connected by courses and distances to an official corner of the public land surveys. In Alaska, descriptions of unsurveyed lands *must* be connected by courses and distances to either an official corner of the public land surveys or to a triangulation station established by any agency of the United States *(such as the United States Geological Survey, the Coast and Geodetic Survey, or the International Boundary Commission)*, if the record position thereof is available to the general public. For description of unsurveyed public lands adjacent to tidal waters in Louisiana and Alaska, see 43 CFR 3203.4(d).

Total area of land requested should be shown, in acres, in space provided. That area, except where the rule of approximation applies, must not exceed 2560 acres. All of the land applied for, must be within a six (6) mile square or an area of six (6) surveyed or protracted sections in length or width. In instances where the United States does not own a 100 percent interest in the mineral deposits in any particular tract, the offeror should indicate the percentage of Government ownership.

Item 3 - *Service Charge* - Nonrefundable service charge of fifty dollars ($50) must accompany application.

Item 4 - *Rental* - Advance rental at rate of not less than one dollar ($1) per acre, or fraction thereof, must be submitted at time of filing application.

Item 5 - *Bonding* - A single copy of the bonds on forms approved by the Director *must* be filed in the proper BLM Office. Bonds may be filed with application or *must* be filed within thirty (30) days after receipt of notice from Authorized Officer.

Item 6 - *Party in Interest* - Indicate whether sole party in interest or not. If not, submit, at the time application is filed, a signed statement setting forth names of other interested parties and the nature of the agreement between them. All interested parties *must* furnish evidence of their qualifications to hold an interest in the lease when application is filed.

Item 8 - *Age of Majority* - Indicate whether or not the age of majority. If application is made by a guardian or trustee for a person who has not reached the age of majority, the application *must* be accompanied by evidence required by Section 3202.2-2 of the Regulations.

Item 9 - *Application by Corporation or Association* - If the applicant is a corporation, or an association, it must submit a statement containing the following information: (1) State in which it is incorporated or formed; (2) that it is authorized to hold geothermal leases; (3) that the officer executing this application is authorized to act on behalf of corporation or association in such matters; and, (4) the percentage of voting stock and all stock owned by aliens or for those having addresses outside the United States. If 10 percent or more of the stock of any class is owned or controlled by, or on behalf of, any one stockholder, a separate showing as to his name, citizenship, and holdings *must* be furnished.

Item 10 - *Statement of Qualifications Filed* - If qualification statement has been previously filed indicate and identify by serial number the record in which such statements were filed together with a statement as to any amendments thereof.

Submit application in a sealed envelope. Envelope *must* be plainly identified that it is an application for a lease pursuant to 43 CFR 3210. *(Items not listed are self-explanatory).*

GPO 851-310

Form 3200–21
(May 1974)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Serial Number

USGS – KGRA Determination:

GEOTHERMAL RESOURCES LEASE

☐ Competitive ☐ Noncompetitive

In consideration of the terms and conditions contained herein, and the grant made hereby, this lease is entered into by the UNITED STATES OF AMERICA (hereinafter called the "Lessor"), acting through the Bureau of Land Management (hereinafter called the "Bureau") of the Department of the Interior (hereinafter called the "Department"), and

(hereinafter called the "Lessee").

This lease is made pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; 30 U.S.C. 1001–1025) (hereinafter called "the Act") to be effective on (hereinafter called the "effective date"). It is subject to all the provisions of the Act and to all the terms, conditions, and requirements of (a) all regulations promulgated by the Secretary of the Interior (hereinafter called "the Secretary") in existence upon the effective date, specifically including, but not limited to, 43 CFR Parts 3000 and 3200 and 30 CFR Parts 270 and 271, (b) all geothermal resources operational orders (hereinafter called "GRO orders") issued pursuant thereto, all of which are incorporated herein and by reference made a part hereof, and (c) any regulations hereafter issued by the Secretary (except those inconsistent with any specific provisions of this lease other than regulations incorporated herein by reference) all of which shall be, upon their effective date, incorporated herein and, by reference, made a part hereof.

Sec. 1. GRANT – The Lessor hereby grants and leases to the Lessee the exclusive right and privilege to drill for, extract, produce, remove, utilize, sell, and dispose of geothermal steam and associated geothermal resources, (hereinafter called "geothermal resources"), in or under the following described lands situated within the County of , State of :

National Resource Lands	Acquired Lands
T. ; R. ; Meridian	T. ; R. ; Meridian
Total Area	Total Area

Containing acres (hereinafter called the "leased area" or "leased lands"), together with:

(a) The nonexclusive right to conduct within the leased area geological and geophysical exploration in accordance with applicable regulations; and

(b) The right to construct or erect and to use, operate, and maintain within the leased area, together with ingress and egress thereupon all wells, pumps, pipes, pipelines, buildings, plants, sumps, brine pits, reservoirs, tanks, waterworks, pumping stations, roads, electric power generating plants, transmission lines, industrial facilities, electric, telegraph or telephone lines, and such other works and structures and to use so much of the surface of the land as may be necessary or reasonably convenient for the production, utilization, and processing of geothermal resources or to the full enjoyment of the rights granted by this lease, subject to compliance with applicable laws and regulations; *Provided that*, although the use of the leased area for an electric power generating plant or transmission facilities or a commercial or industrial facility is authorized hereunder, the location of such facilities and the terms of occupancy therefor shall be under separate instruments issued under any applicable laws and regulations; and

(c) The nonexclusive right to drill potable water wells in accordance with state water laws within the leased area and to use the water produced therefrom for operations on the leased lands free of cost, provided that such drilling and development are conducted in accordance with procedures approved by the Supervisor of the Geological Survey (hereinafter called "Supervisor"); and

(d) The right to convert this lease to a mineral lease under the Mineral Leasing Act of February 25, 1920, as amended, and supplemented (30 U.S.C. 181–287) or under the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351–359), whichever is appropriate, if the leasehold is primarily valuable for the production of one or more valuable by-products which are leasable under those statutes, and the lease is incapable of commercial production or utilization of geothermal steam: *Provided that*, an application is made therefor prior to the expiration of the lease extension by reason of by-product production as hereinafter provided, and subject to all the terms and conditions of said appropriate Acts. The Lessee is also granted the right to locate mineral deposits under the mining laws (30 U.S.C. 21–54), which would constitute by-products if commercial production or utilization of geothermal steam continued, but such a location to be valid must be completed within ninety (90) days after the termination of this lease. Any conversion of this lease to a mineral lease or a mining claim is contingent on the availability of such lands for this purpose at the time of the conversion. If the lands are withdrawn or acquired in aid of a function of any Federal Department or agency, the mineral lease or mining claim shall be subject to such additional terms and conditions as may be prescribed by such Department or agency for the purpose of making operations thereon consistent with the purposes for which these lands are administered; and

(e) The right, without the payment of royalties hereunder, to reinject into the leased lands geothermal resources and condensates to the extent that such resources and condensates are not utilized, but their reinjection is necessary for operations under this lease in the recovering or processing of geothermal resources. If the Lessee, pursuant to any approved plan, disposes of the unusable brine and produced waste products into underlying formations, he may do so without the payment of royalties.

Sec. 2. TERM

(a) This lease shall be for a primary term of ten (10) years from the effective date and so long thereafter as geothermal steam is produced or utilized in commercial quantities but shall in no event continue for more than forty (40) years after the end of the primary term. However, if at the end of that forty-year period geothermal steam is being produced or utilized in commercial quantities, and the leased lands are not needed for other purposes, the Lessee shall have a preferential right to a renewal of this lease for a second forty-year term in accordance with such terms and conditions as the Lessor deems appropriate.

(b) If actual drilling operations are commenced on the leased lands or under an approved plan or agreement on behalf of the leased lands prior to the end of the primary term, and are being diligently prosecuted at the end of the primary term, this lease shall be extended for five (5) years and so long thereafter, but not more than thirty-five (35) years, as geothermal steam is produced or utilized in commercial quantities. If at the end of such extended term geothermal steam is being produced or utilized in commercial quantities, the Lessee shall have a preferential right to a renewal for a second term as in (a) above.

(c) If the Lessor determines at any time after the primary term that this lease is incapable of commercial production and utilization of geothermal steam, but one or more valuable by-products are or can be produced in commercial quantities, this lease shall be extended for so long as such by-products are produced in commercial quantities but not for more than five (5) years from the date of such determination.

Sec. 3. RENTALS AND ROYALTIES

(a) *Annual Rental* – For each lease year prior to the commencement of production of geothermal resources in commercial quantities on the leased lands, the Lessee shall pay the Lessor on or before the anniversary date of the lease a rental of $ for each acre or fraction thereof.

(b) *Escalating Rental* – Beginning with the sixth lease year and for each year thereafter until the lease year beginning on or after the commencement of production of geothermal resources in commercial quantities, the Lessee shall pay on or before the anniversary date of the lease an escalated rental in an amount per acre or fraction thereof equal to the rental per acre for the preceding year and an additional sum of one (1) dollar per acre or fraction thereof. If the lease is extended beyond ten (10) years for reasons other than the commencement of production of geothermal resources in commercial quantities, the rental for the eleventh year and for each lease year thereafter until the lease year beginning on or after the commencement of such production will be the amount of rental for the tenth lease year. If any expenditures are made in any lease year for diligent exploration on the leased lands in excess of the minimum required expenditures for that year, the excess may be credited against any rentals in excess of $ per acre or fraction thereof due the Lessor for that or any future year.

(c) *Royalty* – On or before the last day of the calendar month after the month of commencement of production in commercial quantities of geothermal resources and thereafter on a monthly basis, the Lessee shall pay to the Lessor:

(1) A royalty of percent on the amount or value of steam, or any other form of heat or other associated energy produced, processed, removed, sold, or utilized from this lease or reasonably susceptible to sale or utilization by the Lessee.

(2) A royalty of percent of the value of any by-product derived from production under this lease, produced, processed, removed, sold, or utilized from this lease or reasonably susceptible of sale or utilization by the Lessee, except that as to any by-product which is a mineral named in Sec. 1 of the Mineral Leasing Act of February 25, 1920, as amended, (30 U.S.C. 181), the rate of royalty for such mineral shall be the same as that provided in that statute and the maximum rate of royalty for such mineral shall not exceed the maximum royalty applicable under that statute.

(3) A royalty of percent of the value of commercially demineralized water which has been produced from the leased lands, and has been sold or utilized by the Lessee or is reasonably susceptible of sale or utilization by the Lessee. In no event shall the Lessee pay to the Lessor, for the lease year beginning on or after the commencement of production in commercial quantities on the leased lands or any subsequent lease year, a royalty of less than two (2) dollars per acre or fraction thereof. If royalty paid on production during the lease year has not satisfied this requirement, the Lessee shall pay the difference on or before the expiration date of the lease year for which it is paid.

(d) *Waiver and Suspension of Rental and Royalties* – Rentals or royalties may be waived, suspended, or reduced pursuant to the applicable regulations on the entire leasehold or any portion thereof in the interest of conservation or for the purpose of encouraging the greatest ultimate recovery of geothermal resources if the Lessor determines that it is necessary to do so to promote such development, or because the lease cannot be successfully operated under the terms fixed herein.

(e) *Undivided Fractional Interests* – Where the interest of the Lessor in the geothermal resources underlying any tract or tracts described in Sec. 1 is an undivided fractional interest, the rentals and royalties payable on account of each such tract shall be in the same proportion to the rentals and royalties provided in this lease as the individual fractional interest of the Lessor in the geothermal resources underlying such tract is to the full fee interest.

(f) *Readjustments* – Rentals and royalties hereunder may be readjusted in accordance with the Act and regulations to rates not in excess of the rates provided therein, and at not less than twenty (20) year intervals beginning thirty-five (35) years after the date geothermal steam is produced from the lease as determined by the Supervisor.

Sec. 4. PAYMENTS – It is expressly understood that the Secretary may establish the values and minimum values of geothermal resources to compute royalties in accordance with the applicable regulations. Unless otherwise directed by the Secretary, all payments to the Lessor will be made as required by the regulations. If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date shall cause the lease to terminate by operation of law except as provided by Sec. 3244.2 of the regulations. If the time for payment falls on a day on which the proper office to receive payment is closed, payment shall be deemed to be made on time if made on the next official working day.

Sec. 5. BONDS – The Lessee shall file with the Authorized Officer of the Bureau (hereinafter called the "Authorized Officer") shall maintain at all times the bonds required under the regulations to be furnished as a condition to the issuance of this lease or prior to entry on the leased lands in the amounts established by the Lessor and to furnish such additional bonds or security as may be required by the Lessor upon entry on the lands or after operations or production have begun.

Sec. 6. WELLS

(a) The Lessee shall drill and produce all wells necessary to protect the leased land from drainage by operations on lands not the property of the Lessor, or other lands of the Lessor leased at a lower royalty rate, or on lands as to which royalties and rentals are paid into different funds from those into which royalties under this lease are paid. However, in lieu of any part of such drilling and production, with the consent of the Supervisor, the Lessee may compensate the Lessor in full each month for the estimated loss of royalty through drainage in the amount determined by said Supervisor.

(b) At the Leasee's election, and with the approval of the Supervisor, the Lessee shall drill and produce other wells in conformity with any system of well spacing or production allotments affecting the field or area in which the leased lands are situated, which is authorized by applicable law.

(c) After due notice in writing, the Lessee shall diligently drill and produce such wells as the Supervisor shall require so that the leased lands may be properly and timely developed and for the production of geothermal steam and its by-products, including commercially demineralized water for beneficial uses in accordance with applicable state laws. However, the Supervisor may waive or modify the requirements of this subparagraph (c) in the interest of conservation of natural resources or for economic feasibility or other reasons satisfactory to him. If the products or by-products of geothermal production from wells drilled on this lease are susceptible of producing commercially demineralized water for beneficial uses, and a program therefor is not initiated with due diligence, the Lessor may at its option elect to take such products or by-products and the Lessee shall deliver all or any portion thereof to the Lessor at any point in the Lessee's geothermal gathering or disposal system without cost to the Lessee, if the Lessee's activities, under the lease, would not be impaired and such delivery would otherwise be consistent with field and operational requirements. The retention of this option by the Lessor shall in no way relieve the Lessee from the duty of producing commercially demineralized water where required to do so by the Lessor, except when the option is being exercised and then only with respect to wells where it is being exercised, or limit the Lessor's right to take any action under Sec. 25 to enforce that requirement.

Sec. 7. INSPECTION – The Lessee shall keep open at all reasonable times for the inspection of any duly authorized representative of the Lessor the leased lands and all wells, improvements, machinery, and fixtures thereon and all production reports, maps, records, books, and accounts relative to operations under the lease, and well logs, surveys, or investigations of the leased lands.

Sec. 8. CONDUCT OF OPERATIONS – The Lessee shall conduct all operations under this lease in a workmanlike manner and in accordance with all applicable statutes, regulations, and GRO orders, and all other appropriate directives of the Lessor to prevent bodily injury, danger to life or health, or property damage, and to avoid the waste of resources, and shall comply with all requirements which are set forth in 43 CFR Group 3200, including, but not limited to, Subpart 3204, or which may be prescribed by the Lessor pursuant to the regulations, and with the special stipulations which are attached to the lease, all of which are specifically incorporated into this lease. A breach of any term of this lease, including the stipulations attached hereto, will be subject to all the provisions of this lease with respect to remedies in case of default. Where any stipulation is inconsistent with a regular provision of this lease, the stipulation shall govern.

Sec. 9. INDEMNIFICATION

(a) The Lessee shall be liable to the Lessor for any damage suffered by the Lessor in any way arising from or connected with the Lessee's activities and operations conducted pursuant to this lease, except where damage is caused by employees of the Lessor acting within the scope of their authority.

(b) The Lessee shall indemnify and hold harmless the Lessor from all claims arising from or connected with the Lessee's activities and operations under this lease.

(c) In any case where liability without fault is imposed on the Lessee pursuant to this section, and the damages involved were caused by the action of a third party, the rules of subrogation shall apply in accordance with the law of the jurisdiction where the damage occurred.

Sec. 10. CONTRACTS FOR SALE OR DISPOSAL OF PRODUCTS – The Lessee shall file with the Supervisor not later than thirty (30) days after the effective date thereof any contract, or evidence of other arrangement for the sale or disposal of geothermal resources.

Sec. 11. ASSIGNMENT OF LEASE OR INTEREST THEREIN – Within ninety (90) days from the date of execution thereof, the Lessee shall file for approval by the Authorized Officer any instruments of transfer made of this lease or of any interest therein, including assignments of record title and working or other interests.

Sec. 12. REPORTS AND OTHER INFORMATION – At such times and in such form as the Lessor may prescribe, the Lessee shall comply with all reporting requirements of the geothermal resources leasing, operating, and unit regulations and shall submit quarterly reports containing the data which it has collected through the monitoring of air, land, and water quality and all other data pertaining to the effect on the environment by operations under the lease. The Lessee shall also comply with such other reporting requirements as may be imposed by the Authorized Officer or the Supervisor. The Lessor may release to the general public any reports, maps, or other information submitted by the Lessee except geologic and geophysical interpretations, maps, or data subject to 30 CFR 270.79 or unless the Lessee shall designate that information as proprietary and the Supervisor or the Authorized Officer shall approve that designation.

Sec. 13. DILIGENT EXPLORATION – In the manner required by the regulations, the Lessee shall diligently explore the leased lands for geothermal resources until there is production in commercial quantities applicable to this lease. After the fifth year of the primary term the Lessee shall make at least

the minimum expenditures required to qualify the operations on the leased lands as diligent exploration under the regulations.

Sec. 14. PROTECTION OF THE ENVIRONMENT (LAND, AIR AND WATER) AND IMPROVEMENTS – The Lessee shall take all mitigating actions required by the Lessor to prevent: (a) soil erosion or damage to crops or other vegetative cover on Federal or non-Federal lands in the vicinity; (b) the pollution of land, air, or water; (c) land subsidence, seismic activity, or noise emissions; (d) damage to aesthetic and recreational values; (e) damage to fish or wildlife or their habitats; (f) damage to or removal of improvements owned by the United States or other parties; or (g) damage to or destruction or loss of fossils, historic or prehistoric ruins, or artifacts. Prior to the termination of bond liability or at any other time when required and to the extent deemed necessary by the Lessor, the Lessee shall reclaim all surface disturbances as required, remove or cover all debris or solid waste, and, so far as possible, repair the offsite and onsite damage caused by his activity or activities incidental thereto, and return access roads or trails and the leased lands to an acceptable condition including the removal of structures, if required. The Supervisor or the Authorized Officer shall prescribe the steps to be taken by Lessee to protect the surface and the environment and for the restoration of the leased lands and other lands affected by operations on the leased lands and improvements thereon, whether or not the improvements are owned by the United States. Timber or mineral materials may be obtained only on terms and conditions imposed by the Authorized Officer.

Sec. 15. WASTE – The Lessee shall use all reasonable precautions to prevent waste of natural resources and energy, including geothermal resources, or of any minerals, and to prevent the communication of water or brine zones with any oil, gas, fresh water, or other gas or water bearing formations or zones which would threaten destruction or damage to such deposits. The Lessee shall monitor noise, air, and water quality conditions in accordance with any orders of the Supervisor.

Sec. 16. MEASUREMENTS – The Lessee shall gauge or otherwise measure all production, sales, or utilization of geothermal resources and shall record the same accurately in records as required by the Supervisor. Reports on production, sales, or utilization of geothermal resources shall be submitted in accordance with the terms of this lease and the regulations.

Sec. 17. RESERVATIONS TO LESSOR – All rights in the leased area not granted to the Lessee by this lease are hereby reserved to the Lessor. Without limiting the generality of the foregoing such reserved rights include:

(a) *Disposal* – The right to sell or otherwise dispose of the surface of the leased lands or any resource in the leased lands under existing laws, or laws hereafter enacted, subject to the rights of the Lessee under this lease;

(b) *Rights-of-way* – The right to authorize geological and geophysical explorations on the leased lands which do not interfere with or endanger actual operations under this lease, and the right to grant such easements or rights-of-way for joint or several use upon, through or in the leased area for steam lines and other public or private purposes which do not interfere with or endanger actual operations or facilities constructed under this lease;

(c) *Mineral Rights* – The ownership of and the right to extract oil, hydrocarbon gas, and helium from all geothermal steam and associated geothermal resources produced from the leased lands;

(d) *Casing* – The right to acquire the well and casing at the fair market value of the casing where the Lessee finds only potable water, and such water is not required in lease operations; and

(e) *Measurements* – The right to measure geothermal resources and to sample any production thereof.

Sec. 18. ANTIQUITIES AND OBJECTS OF HISTORIC VALUE – The Lessee shall immediately bring to the attention of the Authorized Officer any antiquities or other objects of historic or scientific interest, including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease, and shall leave such discoveries intact. Failure to comply with any of the terms and conditions imposed by the Authorized Officer with regard to the preservation of antiquities may constitute a violation of the Antiquities Act (16 U.S.C. 431-433). Prior to operations, the Lessee shall furnish to the Authorized Officer a certified statement that either no archaeological values exist or that they may exist on the leased lands to the best of the of the Lessee's knowledge and belief and that they might be impaired by geothermal operations. If the Lessee furnishes a statement that archaeological values may exist where the land is to be disturbed or occupied, the Lessee will engage a qualified archaeologist, acceptable to the Authorized Officer, to survey and salvage, in advance of any operations, such archaeological values on the lands involved. The responsibility for the cost for the certificate, survey, and salvage will be borne by the Lessee, and such salvaged property shall remain the property of the Lessor or the surface owner.

Sec. 19. DIRECTIONAL DRILLING – A directional well drilled under the leased area from a surface location on nearby land not covered by the lease shall be deemed to have the same effect for all purposes of this lease as a well drilled from a surface location on the leased area. In such circumstances, drilling shall be considered to have been commenced on the nearby land for the purposes of this lease, and production of geothermal resources from the leased area through any directional well located on nearby land, or drilling or reworking of any such directional well shall be considered production or drilling or reworking operations (as the case may be) on the leased area for all purposes of this lease. Nothing contained in this section shall be construed as granting to the Lessee any right in any land outside the leased area.

Sec. 20. OVERRIDING ROYALTIES – The Lessee shall not create overriding royalties of less than one-quarter (1/4) of one percent of the value of output nor in excess of 50 percent of the rate of royalty due to the Lessor specified in Sec. 3 of this lease except as otherwise authorized by the regulations. The Lessee expressly agrees that the creation of any overriding royalty which does not provide for a prorated reduction of all overriding royalties so that the aggregate rate of royalties does not exceed the maximum rate permissible under this section, or the failure to suspend an overriding royalty during any period when the royalties due to the Lessor have been suspended pursuant to the terms of this lease, shall constitute a violation of the lease terms.

Sec. 21. READJUSTMENT OF TERMS AND CONDITIONS – The terms and conditions of this lease other than those related to rentals and royalties may be readjusted in accordance with the Act at not less than ten-year intervals beginning ten (10) years after the date geothermal steam is produced from the leased premises as determined by the Supervisor.

Sec. 22. COOPERATIVE OR UNIT PLAN – The Lessee agrees that it will on its own, or at the request of the Lessor where it is determined to be necessary for the conservation of the resource or to prevent the waste of the resource, subscribe to and operate under any reasonable cooperative or unit plan for the development and operation of the area, field, or pool, or part thereof embracing the lands subject to this lease as the Secretary may determine to be practicable and necessary or advisable in the interest of conservation. In the event the leased lands are included within a unit, the terms of this lease shall be deemed to be modified to conform to such unit agreement. Where any provision of a cooperative or unit plan of development which has been approved by the Secretary, and which by its terms affects the leased area or any part thereof, is inconsistent with a provision of this lease, the provisions of such cooperative or unit plan shall govern.

Sec. 23. RELINQUISHMENT OF LEASE – The Lessee may relinquish this entire lease or any officially designated subdivision of the leased area in accordance with the regulations by filing in the proper BLM office a written relinquishment, in triplicate, which shall be effective as of the date of filing. No relinquishment of this lease or any portion of the leased area shall relieve the Lessee or its surety from any liability for breach of any obligation of this lease, including the obligation to make payment of all accrued rentals and royalties and to place all wells in the leased lands to be relinquished in condition for suspension or abandonment, and to protect or restore substantially the surface or subsurface resources in a manner satisfactory to the Lessor.

Sec. 24. REMOVAL OF PROPERTY ON TERMINATION OR EXPIRATION OF LEASE

(a) Upon the termination or expiration of this lease in whole or in part, or the relinquishment of the lease in whole or in part, as herein provided, the Lessee shall within a period of ninety (90) days (or such longer period as the Supervisor may authorize because of adverse climatic conditions) thereafter remove from the leased lands, no longer subject to the lease all structures, machinery, equipment, tools, and materials in accordance with applicable regulations and orders of the Supervisor. However, the Lessee shall, for a period of not more than six (6) months, continue to maintain any such property needed in the relinquished area, as determined by the Supervisor, for producing wells or for drilling or producing geothermal resources on other leases.

(b) Any structures, machinery, equipment, tools, appliances, and materials, subject to removal by the Lessee, as provided above, which are allowed to remain on the leased lands shall become the property of the Lessor on expiration of the 90-day period or any extension of that period which may be granted by the Supervisor. If the Supervisor directs the Lessee to remove such property, the Lessee shall do so at its own expense, or if it fails to do so within a reasonable period, the Lessor may do so at the Lessee's expense.

Sec. 25. REMEDIES IN CASE OF DEFAULT

(a) Whenever the Lessee fails to comply with any of the provisions of the Act, or the terms and stipulations of this lease, or of the regulations issued under the Act, or of any order issued pursuant to those regulations, and that default shall continue for a period of thirty (30) days after service of notice by the Lessor, the Lessor may (1) suspend operations until the requested action is taken to correct the noncompliance, or (2) cancel the lease in accordance with Sec. 12 of the Act (30 U.S.C. 1011). However, the 30-day notice provision applicable to this lease under Sec. 12 of the Act shall also apply as a prerequisite to the institution of any legal proceedings by the Lessor to cancel this lease while it is in a producing status. Nothing in this subsection shall be construed to apply to, or require any notice with respect to any legal action instituted by the Lessor other than an action to cancel the lease pursuant to Sec. 12 of the Act.

(b) Whenever the Lessee fails to comply with any of the provisions of the Act, or of this lease, or the regulations, or of any GRO Orders, or other orders, and immediate action is required, the Lessor without waiting for action by the Lessee may enter on the leased lands and take such measures as it may deem necessary to correct the failure, including a suspension of operations or production, all at the expense of the Lessee.

(c) A waiver of any particular violation of the provisions of the Act, or of this lease, or of any regulations promulgated by the Secretary under the Act, shall not prevent the cancellation of this lease or the exercise of any other remedy or remedies under paragraphs (a) and (b) of this section by reason of any other such violation, or for the same violation occuring at any other time.

(d) Nothing herein shall limit or affect the Lessee's right to a hearing and appeal as provided in Sec. 12 of the

Act and in the regulations promulgated thereunder.

(e) Upon cancellation, the Lessee shall remove all property in accordance with Sec. 24 hereof, and shall restore the leased lands in a manner acceptable to the Lessor or as may be otherwise required by the Lessor.

Sec. 26. HEIRS AND SUCCESSORS IN INTEREST – Each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns, of the respective parties hereto.

Sec. 27. UNLAWFUL INTEREST – No Member of, or Delegate to Congress, or Resident Commissioner, after his election or appointment, either before or after he has qualified, and during his continuance in office, and no officer, agent, or employee of the Department shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Sec. 3741 of the Revised Statutes (41 U.S.C. Sec. 22), as amended, and Sections 431, 432, and 433 of Title 18 of the United States Code, relating to contracts made or entered into, or accepted by or on behalf of the United States, form a part of this lease so far as the same may be applicable.

Sec. 28. MONOPOLY AND FAIR PRICES – The Lessor reserves full power and authority to protect the public interest by promulgating and enforcing all orders necessary to insure the sale of the production from the leased lands at reasonable prices, to prevent monopoly, and to safeguard the public interest.

Sec. 29. EQUAL OPPORTUNITY CLAUSE – The Lessee agrees that, during the performance of this contract:

(1) The Lessee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Lessor setting forth the provisions of this Equal Opportunity clause.

(2) The Lessee will, in all solicitations or advertisements for employees placed by or on behalf of the Lessee, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(3) The Lessee will send to each labor union or representative of workers with which Lessee has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Lessor, advising the labor union or workers' representative of the Lessee's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The Lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The Lessee will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to its books, records, and accounts by the Secretary of the Interior and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the Lessee's noncompliance with the Equal Opportunity clause of this lease or with any of said rules, regulations, or orders, this lease may be canceled, terminated or suspended in whole or in part and the Lessee may be declared ineligible for further Federal Government contracts or leases in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, as amended, and such other sanctions as may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, as amended, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(7) The Lessee will include the provisions of Paragraphs (1) through (7) of this Section (29) in every contract, subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, as amended, so that such provisions will be binding upon each contractor, subcontractor, or subcontract, or purchase order as the Secretary may direct as a means of enforcing such provisions including sanctions for noncompliance; *provided, however,* that in the event the Lessee becomes involved in, or is threatened with, litigation with a contractor, subcontractor, or vendor as a result of such direction by the Secretary, the Lessee may request the Lessor to enter into such litigation to protect the interests of the Lessor.

Sec. 30. CERTIFICATION OF NONSEGREGATED FACILITIES – By entering into this lease, the Lessee certifies that it does not and will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not and will not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. The Lessee agrees that a breach of this certification is a violation of the Equal Opportunity clause of this lease. As used in this certification, the term "segregated facilities" means, but is not limited to, any waiting rooms, work areas, rest rooms and wash rooms, or restaurants or other eating areas, time clocks, or locker rooms, and other storage or dressing rooms, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive, or are in fact segregated on the basis of race, color, religion, or national origin because of habit, local custom, or otherwise. Lessee further agrees that (except where it has obtained identical certifications from proposed contractors and subcontractors for specific time periods) it will obtain identical certifications from proposed contractors and subcontractors prior to the award of contracts or subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that it will retain such certifications in its files; and that it will forward the following certification to such proposed contractors and subcontractors (except where the proposed contractor or subcontractor has submitted identical certifications for specific time periods); it will notify prospective contractors and subcontractors of requirement for certification of nonsegregated facilities. A Certification of Nonsegregated Facilities, as required by the May 9, 1967 Order (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities, by the Secretary of Labor, must be submitted prior to the award of a contract or subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each contract and subcontract or for all contracts and subcontracts during a period (i.e., quarterly, semiannually, or annually).

Sec. 31. SPECIAL STIPULATIONS – *(stipulations, if any, are attached hereto and made a part hereof)*

In witness whereof the parties have executed this lease.

Lessee:

(Signature of Lessee)

(Signature of Lessee)

SEAL (Date)

THE UNITED STATES OF AMERICA, Lessor:

By (Authorized Officer)

(Title)

(Date)

GPO 853 - 471

APPENDIX

D

ENVIRONMENTAL ANALYSIS WORKSHEETS

(1790-3)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation

Pre-lease exploration (Casual use)

3. DISCRETE OPERATIONS		Research (Lit.)	Geol. Reconnaissance	Geochemical Survey	Airborne Surveys		
	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS					6. REMARKS
I. NONLIVING COMPONENTS	A. AIR						
	Air movement patterns	0	0	0	0		
	Temperature & Humidity	0	0	0	0		
	Particulate matter	0	0	0	0		
	Noxious Gases	0	0	0	0		
	Radiological contaminants	0	0	0	0		
	Non-ionizing radiation	0	0	0	0		
	B. LAND						
	Soil depth	0	0	0	0		
	Soil structure	0	0	0	0		
	Soil nutrient properties	0	0	0	0		
	Soil erosion	0	0	0	0		
	Geologic hazards	0	0	0	0		
	C. WATER						
	Hydrologic cycle	0	0	0	0		
	Sediment load	0	0	0	0		
	Dissolved Solids	0	0	0	0		
	Solid debris	0	0	0	0		
	Temperature	0	0	0	0		
	Chemicals, toxic substances	0	0	0	0		
	Nutrients	0	0	0	0		
	Coliform contamination	0	0	0	0		
	Acid balance (ph)	0	0	0	0		
	Dissolved oxygen	0	0	0	0		
	Radiological contaminants	0	0	0	0		
II. LIVING COMPONENTS	PLANTS (*Aquatic*)						
	Small stockwater reservoirs	0	0	0	0		
	Rivers	0	0	0	0		

(Continued on reverse)

	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
	DISCRETE OPERATIONS	Research	Geol. Reconnaissance	Geochemical Survey	Airborne Survey		
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Creosote	0	0	0	0		
	Oak Brush Grassland	0	0	0	0		
	Mesquite/Mesquite Grassland	0	0	0	0		
	Grassland	0	0	0	0		
	Desert Shrub	0	0	0	0		
	Pinyon-juniper/grassland	0	0	0	0		
	Cropland-riparian	0	0	0	0		
	C. ANIMALS *(aquatic)*						
	Mammals	0	0	0	0		
	Birds	0	0	0	0		
	Reptiles	0	0	0	0		
	Amphibians	0	0	0	0		
	Fish	0	0	0	0		
	Invertebrates	0	0	0	0		
	D. ANIMALS *(Terrestrial)*						
	Mammals	0	0	0	0		
	Birds	0	0	0	0		
	Reptiles	0	0	0	0		
	Amphibians	0	0	0	0		
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	0	0	0	0		
	Food Relationships	0	0	0	0		
	Community relationships	0	0	0	0		
IV. HUMAN VALUES	A. Visual Resources						
	Landscape Character	0	0	0	0		
	Intrusions	0	0	0	0		
	B. RECREATION RESOURCES	0	0	0	0		
	C. WILDERNESS RESOURCE	0	0	0	0		
	D. SOCIOCULTURAL INTERESTS						
	Socioeconomic conditions	0	+L	+L	0		
	Local regulatory structure	0	0	0	0		
	Cultural values	0	0	0	0		
	Attitudes & expectations	X	X	X	X		
	Scientific & educ. consid	+L	+L	+L	+L		
V. LAND USE	A. LAND USE COMPATIBILITY						
	Recreation	0	0	0	0		
	Grazing	0	0	0	0		
	Agriculture	0	0	0	0		
	Urban & Suburban	0	0	0	0		
	Rights- of-way	0	0	0	0		
	Mineral Development	X	X	X	X		
	B. LAND USE SUITABILITY	0	0	0	0		

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation

Pre-lease exploration (exploration operations)

3. DISCRETE OPERATIONS									
4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED		5. ANTICIPATED IMPACTS								6. REMARKS
		Gravity Surveys	Magnetic Surveys	Electrical Resistivity	Telluric Surveys	Radiometric Surveys	Passive Seismic	Active Seismic	Shallow Drill Holes	
I. NONLIVING COMPONENTS	A. AIR									
	Air movement patterns	0	0	0	0	0	0	0	0	
	Temperature & Humidity	0	0	0	0	0	0	0	0	
	Particulate matter	0	0	0	0	0	0	x	0	
	Noxious gases	X	X	X	X	X	X	X	X	
	Radiological contaminants	0	0	0	0	0	0	0	0	
	Non-ionizing radiation	0	0	0	0	0	0	0	0	
	B. LAND									
	Soil depth	0	0	0	0	0	0	-L	X	
	Soil structure	0	0	0	0	0	0	0	0	
	Soil nutrient properties	0	0	0	0	0	0	0	0	
	Soil erosion	0	0	0	0	0	0	-L	X	
	Geologic hazards	0	0	0	0	0	0	0	0	
	C. WATER									
	Hydrologic cycle	0	0	0	0	0	0	0	0	
	Sediment load	0	0	0	0	0	0	0	0	
	Dissolved solids	0	0	0	0	0	0	0	0	
	Solid debris	0	0	0	0	0	0	0	0	
	Temperature	0	0	0	0	0	0	0	0	
	Chemicals, toxic substances	0	0	0	0	0	0	0	0	
	Nutrients	0	0	0	0	0	0	0	0	
	Coliform contamination	0	0	0	0	0	0	0	0	
	Acid balance (ph)	0	0	0	0	0	0	0	0	
	Dissolved oxygen	0	0	0	0	0	0	0	0	
	Radiological contaminants	0	0	0	0	0	0	0	0	
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*									
	Small stockwater reservoir	0	0	0	0	0	0	0	-L	
	Rivers	0	0	0	0	0	0	0	0	

(Continued on reverse)

	DISCRETE OPERATIONS	Gravity Surveys	Magnetic Surveys	Electrical Resistivity	Telluric Surveys	Radiometric Surveys	Passive Seismic	Active Seismic	Shallow Drill Holes	
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS								REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS (Terrestrial) Creosote	0	0	0	0	0	0	-L	-L	
	Oakbrush/grassland	0	0	0	0	0	0	-L	-L	
	Mesquite/mesquite grassland	0	0	0	0	0	0	-L	-L	
	Grassland	0	0	0	0	0	0	-L	-L	
	Desert shrub	0	0	0	0	0	0	-L	-L	
	Pinyon-juniper/grassland	0	0	0	0	0	0	-L	-L	
	Cropland-Riparian	0	0	0	0	0	0	-L	-L	
	C. ANIMALS (Aquatic)									
	Mammals	0	0	0	0	0	0	0	0	
	Birds	0	0	0	0	0	0	0	0	
	Reptiles	0	0	0	0	0	0	0	0	
	Amphibians	0	0	0	0	0	0	0	0	
	Fish	0	0	0	0	0	0	0	0	
	Invertebrates	0	0	0	0	0	0	0	0	
	D. ANIMALS (Terrestrial)									
	Mammals	0	0	0	0	0	0	-L	-L	
	Birds	0	0	0	0	0	0	-L	-L	
	Reptiles	0	0	0	0	0	0	-L	-L	
	Amphibians	0	0	0	0	0	0	-L	-L	
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES									
	Succession	0	0	0	0	0	0	0	0	
	Food relationships	0	0	0	0	0	0	0	0	
	Community relationships	0	0	0	0	0	0	0	0	
IV. HUMAN VALUES	A. VISUAL RESOURCES									
	Landscape character	-L	-L	-L	-L	-L	-L	-L	-L	Temporary Physical
	Intrusions	-L	-L	-L	-L	-L	-L	-L	-L	
	B. RECREATION RESOURCES	-L	-L	-L	-L	-L	-L	-L	-L	
	C. WILDERNESS RESOURCES	0	0	0	0	0	0	0	0	All activities prohibited
	D. SOCIOCULTURAL INTERESTS									
	Socio-economic conditions	+L	+L	+L	+L	+L	+L	+L	+L	
	Local regulatory structure	0	0	0	0	0	0	0	0	
	Cultural values	-L	-L	-L	-L	-L	-L	-L	-L	
	Attitudes & expectations	X	X	X	X	X	X	X	X	
	Scientific & Educ. Cons.	+L	+L	+L	+L	+L	+L	+L	+L	
V. LAND USE	A. LAND USE COMPATIBILITY									
	Recreation	0	0	0	0	0	0	0	0	
	Grazing	0	0	0	0	0	0	X	X	
	Agriculture	0	0	0	0	0	0	-L	-L	
	Urban & Suburban	0	0	0	0	0	0	0	0	
	Rights-of-way	0	0	0	0	0	0	0	0	
	Mineral Development	X	X	X	X	X	X	X	X	
	B. LAND USE SUITABILITY	X	X	X	X	X	X	X	X	

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation

Post-lease exploration

3. DISCRETE OPERATIONS

	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS: Geologic Information	Holes	Exploration Wells			6. REMARKS
I. NONLIVING COMPONENTS	A. AIR						
	Air Movement Patterns	0	0				
	Temperature & Humidity	0	0				
	Particulate Matter	-L	-L				
	Noxious Gases	-L	-L				
	Radiological Contaminants	0	0				
	Non-ionizing radiation	0	0				
	B. LAND						
	Soil depth	-L	-L				
	Soil structure	X	X				
	Soil nutrient properties	X	X				
	Soil erosion	-L	-L				
	Geologic hazards	0	0				
	C. WATER						
	Hydrologic cycle	0	0				
	Sediment load	0	0				
	Dissolved solids	0	0				
	Solid debris	0	0				
	Temperature	0	0				
	Chemicals, toxic substances	-L	-L				
	Nutrients	0	0				
	Coliform contamination	0	0				
	Acid balance (ph)	0	0				
	Dissolved oxygen	0	0				
II. LIVING COMPONENTS	Radiological contaminants	0	0				
	A. PLANTS *(Aquatic)*						
	Small stockwater reservoir	0	0				
	Rivers	0	0				

(Continued on reverse)

	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	DISCRETE OPERATIONS: Geologic Information Holes	Exploration Well					REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*							
	Creosote	-L	-L					
	Oak brush grassland	-H	-H					
	Mesquite/Mesquite grassland	-M	-M					
	Grassland	-H	-H					
	Desert Shrub	-M	-M					
	Pinyon-juniper/grassland	-H	-H					
	Cropland-riparian	-H	-H					
	C. ANIMALS *(Aquatic)*							
	Mammals	0	0					
	Birds	X	X					
	Reptiles	0	0					
	Amphibians	0	0					
	Fish	0	0					
	Invertebrates	0	0					
	D. ANIMALS *(Terrestrial)*							
	Mammals	-M	-M					
	Birds	-M	-M					
	Reptiles	-M	-M					
	Amphibians	-M	-M					
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES							
	Succession	M	M					
	Food relationships	M	M					
	Community relationships	M	M					
IV. HUMAN VALUES	A. Visual Resources							
	Landscape Character	0	0					
	Scenic Quality Intrusions	-M	-M					
	B. RECREATION	-M	-M					
	C. WILDERNESS	0	0					
	D. SOCIOCULTURAL INTERESTS							
	Socioeconomic conditions	+L	+L					
	Local regulatory structure	0	0					
	Cultural values	-L	-L					
	Attitudes and expectations	X	X					
	Scientific & educ. consid.s	+L	+L					
V. LAND USE	A. LAND USE COMPATIBILITY							
	Recreation	-L	-L					
	Grazing	-L	-L					
	Agriculture	-H	-H					
	Urban & Suburban	0	0					
	Rights-of-way	+L	+L					
	Mineral Development	L	L					
	B. LAND USE SUITABILITY	+L	+L					

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation

Development

3. DISCRETE OPERATIONS		4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS					6. REMARKS
			Development Wells	Service Roads	Pipelines	Surface facilities at well location	vehicles	
I. NONLIVING COMPONENTS		A. AIR						
		Air movement patterns	0	0	0	0	0	
		Temperature & Humidity	0	0	0	0	0	
		Particulate matter	-M	-H	-M	-M	-M	
		Noxious gases	-L	-L	0	-L	-M	
		Radiological contaminants	0	0	0	0	0	
		Non-ionizing radiation	0	0	0	0	0	
		B. LAND						
		Soil depth	-M	-M	-M	-M	0	
		Soil structure	-M	-M	-L	-L	0	
		Soil nutrient properties	-M	-M	-L	-L	0	
		Soil erosion	-M	-M	-M	-M	0	
		Geologic hazards	X	0	0	0	0	
		C. WATER						
		Hydrologic cycle	L	L	L	L	0	
		Sediment load	-L	-L	-L	-L	0	
		Dissolved solids	X	X	X	X	0	
		Solid debris	0	0	0	0	0	
		Temperature	0	0	0	0	0	
		Chemicals, toxic substances	-M	-L	-M	0	0	
		Nutrients	0	0	0	0	0	
		Coliform contamination	0	0	0	0	0	
		Acid balance (ph)	0	0	0	0	0	
		Dissolved oxygen	0	0	0	0	0	
		Radiological contaminants	0	0	0	0	0	
II. LIVING COMPONENTS		A. PLANTS *(Aquatic)*						
		Small stockwater reservoir	0	0	0	0	0	
		Rivers	0	0	0	0	0	

(Continued on reverse)

	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	Development Wells	Service Roads	Pipelines	Surface facilities	Vehicles	REMARKS
	DISCRETE OPERATIONS						
II. LIVING COMPONENTS (Con.)	B. PLANTS (*Terrestrial*) Creosote	-L	-L	-L	-L	-L	
	Oakbrush/grassland	-H	-H	-H	-L	-L	
	Mesquite/mesquite grassland	-M	-M	-M	-L	-L	
	Grassland	-H	-H	-H	-L	-L	
	Desert shrub	-M	-M	-M	-L	-L	
	Pinyon-juniper/grassland	-H	-H	-H	-L	-L	
	Cropland-Riparian	-H	-H	-H	-L	-L	
	C. ANIMALS (*Aquatic*)						
	Mammals	-L	-L	-L	L	L	
	Birds	M	-M	-M	-M	-M	
	Reptiles	0	0	0	0	0	
	Amphibians	0	0	0	0	0	
	Fish	0	0	0	0	0	
	Invertebrates	0	0	0	0	0	
	D. ANIMALS (*Terrestrial*)						
	Mammals	-M	-H	-H	-M	-M	
	Birds	M	-M	-L	-M	-M	
	Reptiles	-L	-M	-L	-L	-M	
	Amphibians	0	-L	0	0	-L	
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	M	M	M	M	-L	
	Food relationships	M	M	M	M	-L	
	Community relationships	M	M	M	M	-L	
IV. HUMAN VALUES	A. VISUAL RESOURCES						
	Landscape character	-M	-H	-H	-M	-M	
	Intrusions	-M	-H	-H	-M	-M	
	B. RECREATION RESOURCES	-M	H	-H	-M	H	
	C. WILDERNESS RESOURCES	0	0	0	0	0	
	D. SOCIOCULTURAL INTERESTS						
	Socio-economic conditions	+M	+M	+M	+M	+M	
	Local regulatory structure	-M	-L	-L	-L	0	Development Wells-Zoning Considerations
	Cultural values	-M	H	-M	-M	0	
	Attitudes & expectations	X	X	X	X	X	
	Scientific & Educ. Cons.	+M	0	0	0	0	
V. LAND USE	A. LAND USE COMPATIBILITY						
	Recreation	-M	M	H	-H	M	
	Grazing	-L	-L	-L	-L	-L	
	Agriculture	-H	-H	-H	-H	-L	
	Urban & Suburban	L	L	L	L	L	Expansion of urban-suburban land use w/population
	Rights-of-Way	0	0	0	0	0	
	Mineral Development	L	L	0	0	0	
	B. LAND USE SUITABILITY	M	M	M	M	M	

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation

Production

	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS: 3. DISCRETE OPERATIONS — Pipelines & Roads	Construction of Surface Facilities	Transmission Lines	Facility Operations	Other Uses	6. REMARKS
I. NONLIVING COMPONENTS	A. AIR						
	Air movement patterns	0	0	0	L	L	
	Temperature & Humidity	0	0	0	L	L	
	Particulate matter	-L	-L	-L	0	-L	
	Noxious gases	-L	-M	X	X	X	
	Radiological contaminants	0	0	0	0	0	
	Non-ionizing radiation	0	0	-L	0	0	
	B. LAND						
	Soil depth	-M	-M	-L	0	X	
	Soil structure	-M	-M	-L	0	X	
	Soil nutrient properties	-M	-M	-L	0	X	
	Soil erosion	-M	-M	-L	-L	-L	
	Geologic hazards	0	0	0	X	X	
	C. WATER						
	Hydrologic cycle	L	L	0	M	L	
	Sediment load	-L	-L	-L	0	X	
	Dissolved solids	X	X	X	X	X	
	Solid debris	0	0	0	0	0	
	Temperature	0	0	0	L	X	
	Chemicals, toxic substances	0	0	0	X	X	
	Nutrients	0	0	0	0	0	
	Coliform contamination	0	0	0	0	0	
	Acid balance (ph)	0	0	0	0	0	
	Dissolved oxygen	0	0	0	0	0	
	Radiological contaminants	0	0	0	X	0	
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						
	Small stockwater reservoir	0	0	0	X	X	
	Rivers	0	0	0	X	X	

(Continued on reverse)

DISCRETE OPERATIONS		Pipelines & Roads	Construction of Surface facilities	Transmission Lines	Facility Operations	Other Uses	
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS (Terrestrial) Creosote	-L	-L	-L	M	L	
	Oakbrush/grassland	-H	-H	-L	M	L	
	Mesquite/mesquite grassland	-M	-M	-L	M	L	
	Grassland	-H	-H	-L	M	-M	
	Desert shrub	-H	-H	-L	M	-M	
	Pinyon-juniper/grassland	-H	-H	-L	M	L	
	Cropland-Riparian	-H	-H	-H	M	M	
	C. ANIMALS (Aquatic)						
	Mammals	-L	-L	-L	-L	-L	Assuming these operations occur
	Birds	-M	-M	-L	M	M	near aquatic habitat
	Reptiles	-L	-L	-L	0	0	
	Amphibians	0	0	0	0	0	
	Fish	0	0	0	0	0	
	Invertebrates	0	0	0	0	0	
	D. ANIMALS (Terrestrial)						
	Mammals	-H	-H	-L	M	M	
	Birds	-L	-L	M	L	L	
	Reptiles	-M	-M	-L	L	L	
	Amphibians	-L	-L	0	0	0	
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	L	L	L	L	L	
	Food relationships	L	L	L	L	L	
	Community relationships	L	L	L	L	L	
IV. HUMAN VALUES	A. VISUAL RESOURCES						
	Landscape character	-M	-M	-M	-M	-M	
	Intrusions	-M	-M	-M	-M	-M	
	B. RECREATION RESOURCES	H	H	H	H	M	
	C. WILDERNESS RESOURCES	0	0	0	0	0	
	D. SOCIOCULTURAL INTERESTS						
	Socio-economic conditions	+M	+H	+M	+H	+H	
	Local regulatory structure	-M	-H	-M	X	X	
	Cultural values	-H	-H	-M	X	X	
	Attitudes & expectations	X	X	X	X	X	
	Scientific & Educ. Cons.	0	0	0	+L	+L	
V. LAND USE	A. LAND USE COMPATIBILITY						
	Recreation	M	M	M	M	M	
	Grazing	-M	-M	-L	-L	X	
	Agriculture	-H	-H	-H	M	M	Dependent on facility location
	Urban & Suburban	H	H	H	H	H	Expansion of Urban-Suburban
	Rights-of-way	0	0	0	0	0	land use w/ population
	Mineral Development	X	X	L	X	L	
	B. LAND USE SUITABILITY	M	M	M	M	M	

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action
Proposed Geothermal Leasing in the Silver City Area

2. Stages of implementation
Close-out

3. DISCRETE OPERATIONS

4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED		5. ANTICIPATED IMPACTS					6. REMARKS
		Abandonment of subsurface facilities	Removal of surface installations	Reclamation			
I. NONLIVING COMPONENTS	A. AIR						
	Air movement patterns						
	Temperature & Humidity						
	Particulate matter						
	Carbon monoxide						
	Hydrocarbons						
	Nitrogen oxides						
	Sulfer oxides						
	Radiological contaminants						
	Non-ionizing radiation						
	B. LAND						
	Soil depth						
	Soil structure						
	Soil nutrient properties						
	Soil erosion						
	Geology						
	Geologic hazards						
	C. WATER						
	Hydrologic cycle						
	Sediment load						
	Dissolved solids						
	Solid debris						
	Temperature						
	Chemicals, toxic substances						
	Nutrients						
	Coliform contamination						
	Acid balance (ph)						
	Dissolved oxygen						
	Radiological contaminants						
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						
	Small stockwater reservoir						
	Rivers						

(Continued on reverse)

	DISCRETE OPERATIONS	Abandonment of subsurface facilities	Removal of surface installations	Reclamation			
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Creosote						
	Oakbrush grassland						
	Mesquite/mesquite grassland						
	Grassland						
	Desert Shrub						
	Pinyon-juniper/grassland						
	Cropland-riparian						
	C. ANIMALS *(aquatic)*						
	Mammals						
	Birds						
	Reptiles						
	Amphibians						
	Fish						
	Invertebrates						
	D. ANIMALS *(Terrestrial)*						
	Mammals						
	Birds						
	Reptiles						
	Amphibians						
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession						
	Food relationships						
	Community relationships						
IV. HUMAN VALUES	A. VISUAL RESOURCES						
	Landscape character						
	Intrusions						
	B. RECREATION						
	C. WILDERNESS						
	D. SOCIOCULTURAL INTERESTS						
	Socioeconomic conditions						
	Local regulatory structure						
	Cultural values						
	Attitudes and expectations						
	Scientific & educ. consid.s						
V. LAND USE	A. LAND USE COMPATIBILITY						
	Recreation						
	Grazing						
	Agriculture						
	Urban & Suburban						
	Rights-of-way						
	Other Considerations						
	B. LAND USE SUITABILITY						

INSTRUCTIONS

1. *Action* – Enter action being taken, analytic step for which worksheet is being used, environmental viewpoint of impact, and any assumptions relating to impact.
   a. Worksheet is normally used to analyze *"Anticipated Impacts"* of action; *however*, it may be used to analyze *"Residual Impacts."* Worksheets may also be used to compare impacts before and after mitigating measures are applied.
   b. State viewpoint that best describes environmental impact. For example, a fence viewed down the fence line has greater impact than the same fence viewed over an entire allotment. Generally, narrow viewpoints better illustrate specific impacts than will broad viewpoints.
   c. Assumptions may be made to establish a base for analysis *(e.g. estimated time periods, season of year, etc.)*.
2. *Stages of Implementation* – Identify different phases of proposed project *(e.g. a road project consists of survey, construction, use, and maintenance stages)*.
3. *Discrete Operations* – Identify separate actions comprising a particular stage of implementation *(e.g. the construction stage of the road project has the discrete operations of clearing, grading, and surfacing)*.
4. *Elements Impacted* – Enter under appropriate heading all environmental elements susceptible to impact from action and alternatives. Relevant elements not contained in the digest should also be entered. See BLM Manual 1791, Appendix 2, Environmental Digest.
5. *Anticipated Impact* – Evaluate anticipated impact on each element and place an entry in the appropriate square indicating degree of impact as low (L), medium (M), high (H), no impact (O), or unknown or negligable (X). Preceed each entry by a plus (+) or minus (–) sign indicating a beneficial or adverse type of impact. If type of impact reflects a matter of opinion or is not known, *do not* preceed with a sign. For example, construction of a wind mill on open range has a definite visual impact; *however*, to some people the effect is detrimental while to others it is an improvement. By not entering a plus (+) or minus (–) sign the worksheet is kept factual and unbiased. If both degree and type of impact are unknown, place an (x) in the appropriate square.
   a. The measures of impact *(e.g. low, medium, and high)* are relative and their meaning may vary slightly from action to action. The term *"low"* should not be applied to impacts of a negligible nature. For example, we know that a pickup truck driving down a proposed fence line laying wire has some impact on air quality. However, the significance of this impact is not normally great enough to warrant even a *"low"* rating. In cases like this, the impact will usually be marked *"O"* or the element left off the worksheet.
   b. It is recognized that some environmental elements may defy accurate measurement or in-depth analysis within current Bureau capabilities or expertise. The nature of the action as well as type and degree of impact should guide in the decision to seek outside expertise or assistance.
6. *Remarks* – Enter clarifying information.

☆U.S. GOVERNMENT PRINTING OFFICE 1974 — 781-866