PHOENIX SOUTH and SONORAN DESERT NATIONAL MONUMENT

RESOURCE MANAGEMENT PLANS AND

ENVIRONMENTAL IMPACT STATEMENT

ENERGY AND MINERAL RESOURCE POTENTIAL REPORT

U.S. Department of the Interior
Bureau of Land Management
Phoenix Field Office

Prepared by:

URS Corporation

APRIL 2004

Table of Contents

Executive Summary ES-1

Section 1.0 Introduction 1
1.1 Definition of Energy and Mineral Resources 2
1.2 Guidance Documents 2

Section 2.0 Description of Geology 4
2.1 Physiography 4
2.1.1 Colorado Plateau Province 4
2.1.2 Basin and Range Province 4
2.1.3 Transition Zone 4
2.2 Rock Units 5
2.2.1 Precambrian (Proterozoic) (pЄ) 5
2.2.1.1 Central Volcanic Belt 5
2.2.1.2 Southeast Schist Belt 6
2.2.2 Paleozoic Rocks, undifferentiated [PZ] 7
2.2.3 Cambrian to Mississippian [MЄ] 7
2.2.3.1 Cambrian [Є] 7
2.2.3.2 Ordovician 8
2.2.3.3 Silurian 8
2.2.3.4 Devonian [Dev] 8
2.2.3.5 Mississippian [M] 8
2.2.4 Pennsylvanian [ℙ] 9
2.2.5 Permian [P] 9
2.2.6 Triassic [Tr] 10
2.2.7 Jurassic [J] 10
2.2.8 Cretaceous [K] 11
2.2.9 Tertiary [T] 12
2.2.10 Quaternary [QT and Q] 13
2.3 Structural Geology and Tectonics 13
2.4 Historical Geology 14
2.4.1 Precambrian 14
2.4.2 Paleozoic 15
2.4.3 Mesozoic 15
2.4.4 Tertiary 15
2.4.5 Quaternary 16

Section 3.0 Description of Energy and Mineral Resources 17
3.1 Leasable Minerals 17
3.1.1 Oil and Gas 18
3.1.1.1 Known Occurrences and Prospects 18
3.1.1.2 Leasing Activity 20
3.1.1.3 Mineralized Areas and Types 20
3.1.1.4 Mineral Economics 21
3.1.2 Carbon Dioxide and Helium 21
3.1.2.1 Known Occurrences and Prospects 21

3.1.2.2 Leasing Activity 21
3.1.2.3 Mineralized Areas and Types 22
3.1.2.4 Mineral Economics 22
3.1.3 Coal 22
3.1.4 Geothermal 23
3.1.4.1 Known Occurrences and Prospects 23
3.1.4.2 Leasing Activity 23
3.1.4.3 Resource Areas and Types 24
3.1.4.4 Mineral Economics 25
3.1.5 Sodium 25
3.1.5.1 Known Occurrences and Prospects 25
3.1.5.2 Leasing Activity 26
3.1.5.3 Resource Areas and Types 26
3.1.5.4 Mineral Economics 26
3.1.6 Solar Energy 27
3.1.6.1 Known Occurrences and Prospects 27
3.1.6.2 Right-of-Way Permitting Activity 27
3.1.6.3 Prospective Areas and Types 28
3.1.6.4 Resource Economics 28
3.1.7 Wind Energy 29
3.1.7.1 Known Occurrences and Prospects 29
3.1.7.2 Right-of-Way Permitting Activity 30
3.1.7.3 Prospective Areas and Types 30
3.1.7.4 Resource Economics 30
3.2 Locatable Minerals 31
3.2.1 Metallic Locatable Minerals 31
3.2.1.1 Known Occurrences and Prospects 31
3.2.1.2 Mineral Claims Activity 33
3.2.1.3 Mineralized Areas and Types 33
3.2.2 Nonmetallic Locatable Minerals 34
3.2.2.1 Known Occurrences and Prospects 35
3.2.2.2 Mineral Claims Activity 36
3.2.2.3 Mineralized Areas and Types 36
3.2.3 Mineral Economics 37
3.3 Salable Minerals 37
3.3.1 Known Occurrences and Prospects 38
3.3.2 Salable Mineral Activity 39
3.3.3 Mineral Areas and Types 40
3.3.4 Mineral Economics 40

Section 4.0 Potential for Occurrences of Mineral Resources 41
4.1 Definition of Mineral Resource Potential 41
4.2 Leasable Mineral Potential 42
4.2.1 Oil and Gas Potential 42
4.2.2 Carbon Dioxide and Helium Potential 43
4.2.3 Geothermal Potential 43
4.2.4 Sodium 44
4.2.5 Solar Energy 44
4.2.6 Wind Energy 44
4.3 Locatable Mineral Potential 45

4.3.1 Metallic Minerals 45
4.3.2 Nonmetallic Minerals 45
4.4 Salable Mineral Potential 45

Section 5.0 Reasonable Foreseeable Development 47
5.1 Leasable Minerals 49
5.1.1 Oil and Gas 49
5.1.1.1 Background Information and Assumptions 49
5.1.1.2 Reasonable Foreseeable Development 49
5.1.1.3 Disturbance to the Decision Area 50
5.1.2 Carbon Dioxide and Helium 50
5.1.2.1 Background Information and Assumptions 50
5.1.2.2 Reasonable Foreseeable Development 51
5.1.2.3 Disturbance to the Decision Area 51
5.1.3 Coal Potential 51
5.1.4 Geothermal 51
5.1.4.1 Background Information and Assumptions 51
5.1.4.2 Reasonable Foreseeable Development 52
5.1.4.3 Disturbance to the Decision Area 52
5.1.5 Sodium 52
5.1.5.1 Reasonable Foreseeable Development 52
5.1.5.2 Disturbance to the Decision Area 52
5.1.6 Solar Energy 52
5.1.6.1 Background Information and Assumptions 52
5.1.6.2 Reasonable Foreseeable Development 53
5.1.6.3 Disturbance to the Decision Area 53
5.1.7 Wind Energy 53
5.1.7.1 Background Information and Assumptions 53
5.1.7.2 Reasonable Foreseeable Development 54
5.1.7.3 Disturbance to the Decision Area 54
5.2 Locatable Minerals 54
5.2.1 Background Information and Assumptions 54
5.2.2 Reasonable Foreseeable Development 55
5.2.3 Disturbance to the Decision Area 55
5.3 Salable Minerals 55
5.3.1 Background Information and Assumptions 55
5.3.2 Reasonable Foreseeable Development 56
5.3.3 Disturbance to the Decision Area 56

Section 6.0 References 57

LIST OF TABLES

1 Oil and Gas Exploration Wells
2 Geothermal Energy Resource Types and Locations
3 Metallic Mineral District Production History
4 Locatable Mineral Resources and Locations
5 Salable Mineral Resources and Locations

LIST OF FIGURES

1 Stratigraphic Nomenclature Chart

LIST OF MAPS

1 Physiographic Provinces, Topographic and Tectonic Features
2 Geologic Map
3 Oil and Gas Potential
4 Geothermal Resources Potential
5 Sodium Potential
6 Average Daily Solar Radiation per Month – Annual for Flat Plate Collector
7 Average Daily Solar Radiation per Month – Annual for Solar Concentrator
8 Arizona – 50m Wind Power
9 Mineral Districts
10 Mineral Districts and Locatable Minerals Potential
10a Mineral Districts and Locatable Minerals Potential for Pinal Mountains Area
10b Mineral Districts and Locatable Minerals Potential for Baboquivari Mountains Area
11 Salable Mineral Resources Potential
12 Federal Mineral Estate

LIST OF ACRONYMS

ADMMR	Arizona Department of Mines and Mineral Resources
ASMI	Arizona State Mine Inspector
BLM	Bureau of Land Management
Btu	British thermal units
°C	degrees Centigrade
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CO_2/He	carbon dioxide/helium
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EOI	Expression of Interest
°F	degrees Fahrenheit
FEMP	Federal Emergency Management Program
FLPMA	Federal Land Policy and Management Act
GSD	gross surface disturbance
HDR	hot dry rock
He	helium
KGRA	Known Geothermal Resource Area
kV	kilovolt
m^2	square meter
Ma	million years ago
mcf	thousand cubic feet
MFP	Management Framework Plan
MRDS	Minerals Record Data System
MSHA	Mine Safety and Health Administration
NEPA	National Environmental Policy Act
NGDC	National Geophysical Data Center
NREL	National Renewable Energy Laboratory
NSD	net surface disturbance
PI	Petroleum Information
R	Range
RFD	Reasonable Foreseeable Development
RMFLF	Rocky Mountain Federal Leadership Forum
RMP	Resource Management Plan

SWTDI	Southwest Technology Development Institute
T	Township
TD	total depth
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
W	watts
W/m^2	watts per square meter
Wh	watt-hour
$Wh/m^2/day$	watt-hours per square meter per day
3-D	three-dimension

EXECUTIVE SUMMARY

The Bureau of Land Management (BLM), Phoenix Field Office, is preparing Resource Management Plans (RMPs) and an associated Environmental Impact Statement (EIS) for both the Phoenix South Planning Area (Planning Area) and Sonoran Desert National Monument (SDNM), the boundaries of which are within the Planning Area. The Planning Area is located in the south-central portion of Arizona and includes much of Maricopa County as well as portions of Gila, Pima, Pinal, and Yuma Counties.

One of the goals of the RMPs/EIS is to assess current and future energy and mineral resource potential and prepare RMPs that address changing requirements and demands of those resources. Since the monument is within the Planning Area and to gain a comprehensive understanding of the energy and mineral resources in the area, this report assesses energy and mineral potential in the entire Planning Area regardless of surface or mineral ownership. However, the Presidential Proclamation (No. 7397, January 17, 2001) that establishes the SDNM withdraws the lands within the boundaries of the monument from all forms of entry, location, selection, sale, or leasing, or other disposition under the public land laws, mining laws, and laws relating to mineral and geothermal leasing (subject to valid existing rights).

This resource assessment consisted of collecting relevant information, researching published documents, and interviewing Federal, State, and industry experts on resources in the Planning Area to characterize the area geology, type and occurrence of each resource, resource potential, and reasonable foreseeable development of those energy and mineral resources. This report presents the results of the energy and mineral resource potential assessment.

Two distinct physiographic provinces have influenced the geologic history and rock types in the Planning Area. The Basin and Range Province occupies approximately the southwestern 40 percent of Arizona and is the dominant physiographic terrain in the Planning Area. The Basin and Range Province is characterized by northwest-trending block-faulted mountain ranges separated by deep, alluvium-filled basins. Mountain ranges in the Planning Area generally are composed of Precambrian (Proterozoic) to Tertiary igneous or metamorphic rocks bounded by block-faulted and folded Mesozoic to Cenozoic sedimentary rocks or Tertiary volcanic rocks. The deep intermontane basins generally contain slightly altered Paleozoic and Mesozoic sedimentary rocks overlain by Tertiary sedimentary and volcanic sequences. The Transition Zone Province bisects Arizona from northwest to southeast and is present in the northeastern corner of the Planning Area. The Transition Zone is a geologically complex area where the monocline and uplift tectonic characteristics of the Colorado Plateau are developed on Precambrian basement rocks and Mesozoic granitic rocks, and complicated by extensive block faulting encompassing and/or overlain by Tertiary volcanic and sedimentary rocks.

Geologic conditions are suitable for the potential occurrence of leasable fluid minerals, which include energy minerals oil and gas, and nonenergy mineral carbon dioxide (CO_2). Mature petroleum source rocks are present in Paleozoic and Mesozoic marine shales in structural basins in the eastern portion of the Planning Area, and in Tertiary evaporites in the western and southern portions of the Planning Area. Sandstones and limestones contain reservoir-quality porosity for fluid minerals to accumulate beneath structural and within stratigraphic traps. Although there has not been economic production, moderate oil and gas potential is mapped in the Arizona-New Mexico Trough, Chihuahua Trough/Bisbee Basin, and Tertiary basins, where hydrocarbon shows have been encountered in exploratory wells.

Sodium and coal are leasable solid mineral resources. Sodium may be present in deep evaporite deposits in Tertiary basins throughout the Planning Area. There are no reported coal resources in the Planning Area.

Geothermal energy resource potential exists throughout the Planning Area. A high potential for occurrence exists for using low-temperature geothermal energy in 16 geothermal resource areas in the Planning Area. Most of these resource areas are defined by multiple water well fields, but have not been developed. Moderate potential for occurrence of geothermal energy resources also is present throughout southern Arizona where several isolated geothermal wells are located.

Solar and wind energy are renewable resources with high potential for occurrence in the Planning Area. With a climate and elevation ideal for exploiting solar energy resources, the Planning Area has high solar energy potential. Flat-plate collectors or solar concentrators could generate an average of at least 6,000 watt-hours per square meter of collector surface per day. Wind energy resource potential is concentrated in the upper elevations of mountain ranges. For commercial wind turbine application, the upper elevations of the Quijotoa, Sierra Blanca, Sierra Estrella, Superstition, western Baboquivari, southern Mazatzal, and western Pinal Mountains have high potential for converting wind energy into electricity. However, for small-scale and noncommercial applications, any area within the Planning Area is suitable for wind energy usage.

There are 65 mineral districts mapped in the Planning Area. The types of mineral deposits in those districts include porphyry copper, volcanic-epithermal, placer, vein, vein/replacement, and alteration of sedimentary rocks. Past mining for metallic minerals has primarily produced gold, silver, copper, lead, zinc, tin, and uranium. With the exception of four large copper mines and one silver mine, none of those mines is active. However, there is high potential for occurrence of those and other metallic mineral resources. Current mining for nonmetallic minerals includes gemstones, clay, limestone, mica, feldspar, silica (quartz), and perlite. There is high potential for occurrence of those nonmetallic mineral resources in the Planning Area.

Salable mineral materials are found at Precambrian to Tertiary rock outcrops and in extensive Quaternary deposits of alluvial sand and gravel, piedmont alluvium, colluvium, and eolian sand throughout the Planning Area. Pits, quarries, and prospects for salable minerals are mapped to show the potential for occurrence of salable mineral resources. These salable minerals have high potential for occurrence in the Planning Area.

This report prepared Reasonable Foreseeable Development (RFD) scenarios to estimate future mineral resource activity and potential disturbance to the Decision Area for the next 15 years. Oil and gas RFD activity in the Decision Area may result in discovery of one new small oil and/or gas field, with 12 new wells drilled and an estimated 500 acres impacted by the activity. No RFD activity is projected for sodium, CO_2 and helium nonenergy resources; or coal and geothermal energy resources. The RFD for development of solar energy estimates that rights-of-way for two solar array facilities and accompanying transmission lines could be permitted and an estimated 80 acres of land could be disturbed. The RFD for development of wind energy estimates that rights-of-way for one wind farm facility and accompanying transmission lines could be permitted and an estimated 540 acres of land could be disturbed. Two new small underground mines for locatable minerals could be established in the Decision Area and a total of 260 surface acres could be disturbed (80 surface acres for each mine plus 100 acres for road construction). An estimated 10 new salable mineral pits could be permitted for the disposal of approximately 15 million tons of mineral materials, with associated disturbance of approximately 200 acres.

1.0 INTRODUCTION

The Bureau of Land Management (BLM), Phoenix Field Office, is preparing Resource Management Plans (RMPs) and an associated Environmental Impact Statement (EIS) for both the Phoenix South Planning Area (Planning Area) and Sonoran Desert National Monument (SDNM), the boundaries of which are within the Planning Area. The Planning Area is located in the south-central portion of Arizona and includes much of Maricopa County as well as portions of Gila, Pima, Pinal, and Yuma Counties.

One of the goals of the RMPs/EIS is to assess current and future energy and mineral resource potential and prepare RMPs that address changing requirements and demands of those resources. Since the monument is within the Planning Area and to gain a comprehensive understanding of the energy and mineral resources in the area, this report assesses energy and mineral potential in the entire Planning Area regardless of surface or mineral ownership. However, the Presidential Proclamation (No. 7397, January 17, 2001) that established the SDNM withdraws the lands within the boundaries of the monument from all forms of entry, location, selection, sale, or leasing, or other disposition under the public land laws, mining laws, and laws relating to mineral and geothermal leasing.

Also, it is useful to note that there are two terms used in this report to describe the areas addressed—Planning Area and Decision Area. The Planning Area encompasses the entirety of the area within the BLM's Phoenix South Planning Area boundary regardless of jurisdiction or ownership. The Decision Area for the majority of resources or resource uses refers to the public land within the Planning Area for which BLM has authority and makes decisions. However, in addressing Federal minerals and decisions regarding these minerals, BLM's Decision Area extends to split estate (i.e. areas where BLM administers Federal subsurface minerals, but the surface is owned by a non-Federal entity (e.g., State Trust Land, private land).

Federal energy and mineral resources in the Planning Area are managed by the BLM Phoenix Field Office with direction from three land use plans: the Lower Gila South Resource Management Plan (RMP) (1988), parts of the Lower Gila North Management Framework Plan (MFP) (1983), and Phoenix Resource Area RMP (1989). Since these plans were developed, numerous changes have occurred in the area that requires reconsideration of certain management decisions, including the designation of the SDNM. In order to address future management of public land in the Planning Area, BLM will prepare two new RMPs: one to provide management direction for public land in the Phoenix South Planning Area, and one for the SDNM. This energy and mineral resource assessment was completed for use in the RMPs as required by the Federal Land Policy and Management Act (FLPMA) of 1976 and preparation of the EIS as required by the National Environmental Policy Act (NEPA).

This resource assessment consisted of reviewing published data, interviewing resource specialists and scientists having a working knowledge of the Planning Area, and selecting relevant data for use in the assessment. The assessment did not include field studies or original investigations of resource conditions. The assessment consisted of evaluating the area and historical development of energy and mineral resources and preparing maps showing the location of existing resources and the potential for occurrence of those resources. Finally, the RFD of each energy and mineral resource was assessed. The RFD is the professional opinion of the mineral report preparer based on the historic, current, and projected (15 years) demands and markets for those resources. The report will provide the BLM decision maker a better understanding of energy and mineral resources in the area such that the importance of those energy and mineral resources can be evaluated during future land use decisions.

1.1 DEFINITION OF ENERGY AND MINERAL RESOURCES

The BLM has established the following categories for energy and mineral resources on public lands:

- Leasable minerals – include fluid minerals such as oil, gas, coalbed methane, carbon dioxide (CO_2), and geothermal resources; and solid minerals such as coal, sodium, and potash. Although not a leasable mineral, helium is included in this category because it is typically associated with CO_2 exploration and development.
- Locatable minerals – include metallic minerals such as gold, silver, tin and uranium; and nonmetallic minerals such as gemstones, mica, silica, and perlite.
- Salable minerals – include construction materials such as sand, gravel, limestone, cinders, decorative rock, and building stone.

Renewable energy sources such as wind and solar energy are included in this discussion because right-of-way permits may be obtained to construct collection facilities on public land.

1.2 GUIDANCE DOCUMENTS

This assessment was conducted at a level of detail in accordance with guidance provided in BLM Manual 3031 – Energy and Mineral Resource Assessment (BLM 1985) and BLM Handbook H-1624-1 – Planning for Fluid Mineral Resources (BLM 1990). The potential for energy or mineral resources was predicted by collecting and evaluating available information for each resource in the area of interest. The potential is an assessment of the likelihood that a resource will occur in the area of interest based on the information available. The potential occurrence of the resource depends on whether the geologic or environmental conditions are present to increase the likelihood of the occurrence of the resource. The potential for the resource to occur does not take into account the likelihood that the resource will be developed or is economically exploitable.

The format for this report conforms to requirements for Mineral Assessment Reports outlined in Illustration 4 of BLM Manual 3060 – Mineral Reports-Preparation and Review (BLM undated). The report includes the following sections:

- Executive Summary for Managers.
- Section 1: Introduction – This section lists the types of energy and mineral resources assessed in the report, and guidance documents that describe the methodology to be used for the resource assessment.
- Section 2: Description of Geology – This section includes discussions on physiography, lithology and stratigraphy, structural geology and tectonics, and historical geology.
- Section 3: Description of Energy and Mineral Resources – This section includes known leasable, locatable, and salable mineral deposits; known prospects, mineral occurrences, and mineralized areas; mining claims, leases, and material sites; types of mineral deposits in the area of interest; and mineral economics including strategic and critical minerals. This section includes separate subsections for coal, oil and gas, geothermal, CO_2 and helium, coalbed methane, metallic minerals, nonmetallic minerals/industrial minerals, and other resources such as wind and solar energy.

- Section 4: Potential for Occurrence of Mineral Resources – This section includes separate subsections for coal, oil and gas, geothermal, CO_2 and helium, sodium, metallic minerals (including uranium), nonmetallic minerals/industrial minerals, salable minerals, and other resources such as wind and solar energy.
- Section 5: Reasonable Foreseeable Development – this section describes the RFD in the Decision Area for the next 15 years including separate subsections for oil and gas, geothermal, CO_2 and helium, sodium and potash, metallic minerals (including uranium), nonmetallic minerals/industrial minerals, salable minerals, and other resources such as wind and solar energy.
- Section 6: References and Selected Bibliography.
- Tables, Figures, and Maps.

2.0 DESCRIPTION OF GEOLOGY

2.1 PHYSIOGRAPHY

Arizona is characterized by three physiographic provinces: Colorado Plateau, Basin and Range, and a so-called Transition Zone having characteristics intermediate between those two physiographic provinces. As shown on Map 1, the Planning Area has characteristics of the Basin and Range physiographic province and the Transition Zone (Peirce 1986; Rauzi 2002). These physiographic provinces have influenced the geomorphic features and geologic history of the Planning Area.

2.1.1 COLORADO PLATEAU PROVINCE

The Colorado Plateau physiographic province occupies approximately the northeastern 40 percent of Arizona and is not developed in the Planning Area. Distinctive characteristics of the Colorado Plateau include thick sequences of Paleozoic and Mesozoic sedimentary rocks, and a relatively stable cratonic platform having monoclines and uplifts as significant tectonic features. In the Planning Area, Colorado Plateau sedimentary rocks are not present, but the uplifts and monoclines characteristic of that province have impacted upper Precambrian formations (Krantz 1989).

2.1.2 BASIN AND RANGE PROVINCE

The Basin and Range physiographic province occupies approximately the southwestern 40 percent of Arizona and is the dominant physiographic terrain in the Planning Area. The Basin and Range province is characterized by northwest-trending block-faulted mountain ranges separated by deep, alluvium-filled basins. The mountain ranges in the Planning Area generally are composed of a Precambrian (Proterozoic) to Mesozoic igneous or metamorphic core complex bounded by block-faulted and folded Mesozoic to Cenozoic sedimentary rocks or Tertiary volcanic rocks. Mountain ranges in the southern and western part of the Planning Area generally are dominated by Tertiary volcanics. The deep intermontane basins generally contain Paleozoic and Mesozoic sedimentary rocks, formerly part of the Colorado Plateau, which were faulted and folded during the Tertiary, then overlain by Tertiary sedimentary and volcanic sequences that become more prevalent and thicker to the west.

2.1.3 TRANSITION ZONE

The Transition Zone bisects Arizona from northwest to southeast, occupies approximately 20 percent of the State, and is present in the northeastern corner of the Planning Area. The Transition Zone is a geologically complex area where the monocline and uplift tectonic characteristics of the Colorado Plateau are developed on Precambrian basement rocks and Mesozoic granitic rocks. The geology of the Transition Zone is complicated by extensive block faulting encompassing and/or overlain by Tertiary volcanic and sedimentary rocks. The Mogollon Rim is a sharp escarpment at the southern limit of the Colorado Plateau where exposures of Paleozoic and Mesozoic sedimentary rocks overlook the deep canyons, mesas, and valleys of the Transition Zone.

2.2 ROCK UNITS

The lithology, areal extent, and thickness of the major rock types present in Arizona are described in *Geologic Evolution of Arizona*, a volume of papers collected and edited by Jenney and Reynolds (1989) for the Arizona Geological Society. A general stratigraphic chart for southern and central Arizona is presented on Figure 1 (Butler 1996a, 1996b). A geologic map of the Planning Area, extracted from the State of Arizona geologic map prepared by the Arizona Geological Survey (Richard et al. 2000), is provided on Map 2. The geologic formation symbols are shown with the descriptions of the corresponding rock units in the following sections. It is useful to mention that the formation names for Figure 1 may not match those for Map 2 because the geologic map includes formation names for age-correlative formations in other areas of Arizona, and Figure 1 includes age-correlative formations found in western New Mexico. This report describes the rock types, areal extent, stratigraphic thicknesses, and general thickness trends for the Planning Area beginning with the oldest known rocks.

2.2.1 PRECAMBRIAN (PROTEROZOIC) [PЄ]

Precambrian rocks exposed in the Planning Area include Early Proterozoic (1,650 to 1,750 million years ago [Ma]) granites, metamorphics, gabbros, gneisses, metasedimentary, and metavolcanics; Middle Proterozoic (1,400 Ma) granitics; and Middle Proterozoic (1,400 to 1,100 Ma) sedimentary rocks. Significant exposures of Precambrian rocks are found in the Pinal Mountains in Gila County; Mohawk Mountains in Yuma County; Cimarron, Waterman, and Agua Dulce Mountains in Pima County; Palo Verde, Santan, Sacaton, and Table Top Mountains in Pinal County; Gila Bend, Maricopa, Sand Tank, McDowell, and South Mountains in Maricopa County; Goldfield, Superstition, Mazatzal, and Sierra Estrella Mountains in Maricopa and Pinal Counties; and Slate Mountains in Pima and Pinal Counties (Richard et al. 2000). Minor exposures are found in the Sierra Blanca Mountains in Pima County and the Vekol Mountains in Pinal County. Precambrian rocks typically host metallic and other locatable minerals and have been mined for gold, silver, gems, and other minerals at several locations in the Planning Area.

Anderson (1986) documented three Proterozoic tectonic belts in Arizona and described their distinctive assemblages of rock units. Two of those tectonic belts are present in the Planning Area: Central Volcanic Belt and Southeast Schist Belt. The Central Volcanic Belt occupies approximately the northwestern half of the Planning Area while the Southeast Schist Belt occupies the southeastern half. The approximate boundary between these two belts extends from the Roosevelt Dam southwest to Mobile, continues through Black Gap and into Childs Valley, then curves southeast and follows Growler Valley to the Arizona-Mexico border (refer to Map 1).

2.2.1.1 Central Volcanic Belt

The complex geological history of Arizona and the large separation distances between Precambrian mountain outcrops makes spatial correlation of equivalent units difficult without radiometric dating. Two igneous and four stratified rock units are characteristic of the southeastern part of the Central Volcanic Belt, which is depositionally distal to the volcanic-dominated core of the belt, and thus received mostly reworked volcaniclastic debris eroded off the core. The sedimentary rock units for the Planning Area east and north of Phoenix (Anderson 1989) are described below and, for purposes of this report, extrapolated to outcrops of similar Precambrian rocks south and west of Phoenix.

- **Estrella Gneiss [Xm]** – a dark, quartz feldspathic gneiss that grades to an amphibolite gneiss or biotite gneiss. This unit ranges from 1,600 to 1,800 Ma, is recognized in the Sierra Estrella,

Buckeye Hills, and South Mountains, and is postulated to extend farther south and west (Reynolds 1985).

- **Pinal Schist [Xms]** – a low-grade, silicic, micaceous metamorphosed sedimentary rock derived from clay- and feldspar-rich quartz sandstones of volcanic origin. Outcrops are found in the Maricopa, Pinal, Santan, Sand Tank, Sierra Estrella, and Vekol Mountains, and are postulated to extend through Pinal County into northeast Pima and Cochise Counties (Anderson 1989). Ages range from 1,650 to 1,620 Ma.

- **Union Hills Group [Xmv]** – a thick sequence of undifferentiated, typically weakly altered andesitic flows, breccias and tuffs that grade laterally to a volcanic greywacke that overlies the Precambrian basement in the Planning Area. Ages range from 1,730 to 1,720 Ma.
- **Alder Group** – a sedimentary rock sequence containing siliceous volcanic conglomerates and quartzites, rhyodacite tuffs, and siltstones with an age range of 1,720 to 1,710 Ma. Locally distinct from the Alder Group, yet age-correlative, is the McDowell Mountains Formation in the north Phoenix area.
- **Felsic Complexes** – unnamed quartz-, feldspar- and muscovite-rich volcanic conglomerates and rhyolitic tuff ignimbrites. The ignimbrite deposits are not stratigraphically correlative because they had localized, areally restricted sources within a complex intrusive area.
- **Mazatzal Group [Xq]** – sequence of pale pink to pale maroon quartzites, conglomerates, and siltstones; locally named, such as Four Peaks Quartzite.
- **Granite and Granodiorite Intrusives [Xg] –** locally named, such as Four Peaks Granite and Maricopa Granite. Komatke Granite in the South Mountains is a pinkish gray, coarse-grained porphyritic granite with potassium feldspar phenocrysts.

2.2.1.2 Southeast Schist Belt

The large distances separating outcrops of Precambrian metamorphic and plutonic basement rocks makes spatial correlation of equivalent units difficult without radiometric dating. However, this belt is less complex than the Central Volcanic Belt. The following rock units are characteristic of the Southeast Schist Belt in the Planning Area.

- **Pinal Schist [Xms]** – a low-grade, silicic, micaceous metamorphosed sedimentary rock derived from clay- and feldspar-rich quartz sandstones of volcanic origin. This unit may have been converted to high-grade gneisses by later tectonic overprinting.
- **Madera Diorite [Xg]** – plutonic rocks consisting of quartz diorite, granodiorite, and tonalite granitic rocks often containing xenoliths of Pinal Schist; most abundant in the Pinal Mountains area and extended into nearby mountain ranges (Conway and Silver 1989), possibly with different nomenclature, such as Oracle Granite in the Table Top Mountains (Peterson et al. 1988), and the Ruin Granite in the Pinal Mountains (Peterson 1963).

Outcrops of Middle Proterozoic sedimentary rocks are prevalent in the hills and mountains surrounding Superior, Miami, and Globe (Peterson 1963), and outcrop in the Vekol and Slate Mountains in southwestern Pinal County (Wrucke 1989). These sedimentary rocks, mapped as **Ys**, include the following formations that comprise the **Apache Group** and the overlying Troy Quartzite:

- **Pioneer Shale** – consists of the basal Scanlan Conglomerate member with subrounded pebble and cobbles overlain by a finely laminated, grayish-red tuffaceous silty mudstone or siltstone. This formation can be up to 500 feet thick.
- **Dripping Spring Quartzite** – this formation has three members and can range from 300 to 750 feet thick. The basal Barnes Conglomerate member is gray to purplish-gray and consists of bedded pebbles and cobbles in a sand matrix. The middle sandstone member is a grayish-red, hard, dense cross-bedded sandstone. The upper member is a gray to black, thin-bedded carbonaceous sandstone to siltstone that is known to have anomalous uranium in some subunits and has been found to contain hydrocarbons (Desborough et al. 1984; Wrucke et al. 1986). This unit is considered a potential source rock.
- **Mescal Limestone** – this formation has three members and can range from 240 to 420 feet thick. The lower member is a brown to yellowish-brown cherty dolomite with layers of dolomitic collapse breccia and black chert. An overlying algal member is a yellowish-brown, hard, thick-bedded dolomite containing laterally extensive and thick algal stromatolites. The upper member is a yellowish-brown to black argillite and shale containing chert and chert breccia. The argillite is often separated from the underlying algal member by a basalt flow that locally qualifies as a member unit, although the same basalt also overlies the Mescal Limestone. This unit is considered a potential source rock.
- **Basalt** – this dark red, hematite-rich unit overlies the Mescal Limestone and ranges from 30 to 380 feet thick depending on erosion of the overlying Troy Formation.
- **Troy Quartzite** – this formation overlies the Apache Group and consists of three members. The basal arkose member is a pale red, fine- to medium-grained sandstone and interbedded mudstone. The Chediski Sandstone member is a pale pinkish-gray quartz sandstone. The upper quartzite member is a gray, clean cross-bedded sandstone.
- **Diabase [Yd]** – although not a sedimentary rock, many thick diabase sills have been intruded discordantly into the sedimentary rocks of the Apache Group and along the unconformity between the Mescal and Troy. Diabase is dark gray to greenish-black basalt having ophitic texture, in which well-formed crystals of white plagioclase feldspar (1 to 8 millimeters long) are embedded in a dark clinopyroxene matrix. Small olivine crystals are present in the matrix. The diabase sills may be up to 1,000 feet thick and contain multiple intrusions. Isotopic dating of the diabase yielded an age range of 1,050 to 1,140 Ma.

2.2.2 PALEOZOIC ROCKS, UNDIFFERENTIATED [PZ]

The scarcity of, and distances between, outcrops in southern Arizona combined with the characteristic Pennsylvanian cyclical depositional history makes correlation of Paleozoic strata difficult. The complex geological history of the region resulted in a confusion of multiple names and descriptions for some Paleozoic sediments.

2.2.3 CAMBRIAN TO MISSISSIPPIAN [MЄ]

2.2.3.1 Cambrian [Є]

Exposures of Cambrian sedimentary rocks are reported in the Table Top, Vekol, and Slate Mountains in Pinal County; Waterman and Coyote Mountains in Pima County; and Organ Pipe Cactus National Monument, and Pinal Mountains in Gila County (Gardulski 1980; Haxel et al. 1980; Hogue 1940; McClymonds 1957; Middleton 1989). Formations include the following:

- **Middle Cambrian Bolsa Quartzite** – a white-to-brown to reddish-brown, tightly cemented fine- to medium-grained quartz sandstone and conglomerate. The thickness of this unit may reach 800 feet and varies depending on the paleotopographic relief of the underlying Precambrian basement. Probably equivalent to the Southern Belle Quartzite of Hogue (1940) in the northern Slate Mountains.
- **Abrigo Formation** – a carbonate sequence consisting of three members. The lower member is an interbedded and bioturbated silty shale and limestone ranging from 230 to 650 feet thick that grades northward to fine-grained quartz sandstone and siltstone. The middle member is a thin-bedded limestone and dolomitic limestone ranging from 130 to 300 feet thick that grades northward to a fine-grained quartz sandstone. The upper sandy member is 100 to 180 feet thick and ranges from a sandy dolostone in the south to a dolomitic sandstone in the north.

2.2.3.2 Ordovician

No outcrops of Ordovician rocks are reported in the Planning Area.

2.2.3.3 Silurian

No outcrops of Silurian rocks are reported in the Planning Area.

2.2.3.4 Devonian [Dev]

Sedimentary rocks of Devonian age outcrop in the Vekol, Slate, and Table Top Mountains in Pinal County; Coyote and Waterman Mountains in Pima County; and Pinal Mountains in Gila County (Beus 1989; Gardulski 1980; McClymonds 1957). These sediments are absent in western Pima and Maricopa Counties. Formations include the following:

- **Middle to Late Devonian Martin Formation** – consists of two members: the basal Beckers Butte Member is a light-gray, thin-bedded quartz sandstone to conglomerate up to 130 feet thick and is present in most of Gila County and part of Pinal County; the Jerome Member is a gray dolomitic mudstone to brownish-gray dolomite that can attain a thickness of 530 feet. This unit is considered a potential petroleum source rock.
- **Late Devonian Percha Formation** – a sequence of slope-forming gray shale, siltstone, or sandstone overlain by a hard ledge-forming limestone and less than 65 feet thick.

2.2.3.5 Mississippian [M]

Rocks of Mississippian age are exposed in the Vekol, Slate, and Table Top Mountains in Pinal County; Waterman Mountains in Pima County; and Pinal Mountains in Gila County (Beus 1988; McClymonds 1957). Formations include the following:

- **Escabrosa Limestone** – this formation ranges from a light- to dark-gray massive crinoidal limestone grading upward to a light-gray, thin-bedded, cherty limestone, then grades to a gray, massive crinoidal grainstone. The dark gray limestone may be a source rock (Butler 1996).

2.2.4 PENNSYLVANIAN [ℙ]

In areas where sufficient geologic information was reported, Blakey and Knepp (1989) used a time-series stratigraphic method to correlate Pennsylvanian and Permian formations and identify facies changes. Sedimentary rocks of Pennsylvanian age are exposed in outcrop only in the eastern and northern parts of the Planning Area. Erosion apparently removed Pennsylvanian rocks from southwestern Arizona. Pennsylvanian rocks range from 500 to 1,000 feet thick, generally thin to the northeast, and are absent in the western half of the Planning Area (Blakey and Knepp 1989). Pennsylvanian and Permian units are mapped as **PℙP** where undifferentiated. Formations include the following:

- **Lower Pennsylvanian Black Prince Limestone** – contains three members: a basal maroon mudstone and shale consisting of reworked Escabrosa debris; a middle thin-bedded, shelly calcarenite limestone, and an upper dense, massive micritic limestone with local solution features. The Black Prince Limestone is exposed in the mountains of southeastern Arizona and thins to the north and west to limited exposures in the Vekol, Brownell, and Waterman Mountains. The formation ranges from 100 to 200 feet thick (Blakey and Knepp 1989). The shale may be a source rock (Butler 1996).

The **Naco Group** contains six formations ranging from Middle Pennsylvanian to Permian age. Naco Group Pennsylvanian strata outcrop from the Mogollon Rim to the Vekol Mountains, but Permian strata are not reported north of the Pima-Pinal County line or west of Silver Bell (Blakey and Knepp 1989).

- **Middle and Upper Pennsylvanian Horquilla Limestone** – consists of fossiliferous fine- to coarse-grained limestones with chert, cyclically interbedded with mudstones and siltstones of terrigenous origin, with possible reservoir-quality porosity. Outcrops are mapped in the Vekol and Silver Bell Mountains. This dark limestone also may be a source rock (Butler 1996).
- **Upper Pennsylvanian to Lower Permian Earp Formation** – a complex sequence of silty and clayey limestones interbedded with calcareous siltstones and sandstones that are part of an overall transition from carbonate to clastic deposition. The thickness of the Earp Formation is uncertain because it is difficult to recognize formation boundaries within similar sequences and in faulted outcrops. Naco-age equivalent undifferentiated Pennsylvanian-Permian outcrops are mapped in the Vekol, Silver Bell, and Pinal Mountains; Waterman Mountains; and the mountains around Superior. This unit is a possible source rock.

2.2.5 PERMIAN [P]

The Earp Formation sequence of interbedded carbonate and clastic rocks continued into Lower Permian time with deposition of upper Earp Formation fine-grained sandstones and siltstones in the northern part of the Planning Area, while calcareous mudstones and silty limestones were deposited to the south. Isopach maps show that Permian rocks are less than 1,500 feet thick in the Planning Area (Blakey and Knepp 1989). Permian formations include the following:

- **Lower to Middle Permian Colina Limestone and Epitaph Dolomite** – the Colina Limestone is a dark gray, thick-bedded limestone having a gradational intertonguing contact with the Earp Formation. More interesting is the irregular lateral and vertical transitional chemical contact from limestone to dolomite observed in outcrop, in which Colina Limestone beds dolomitize to Epitaph Dolomite. The upper beds of the Epitaph Dolomite grade to limestone and fine-grained red bed clastics. The Colina Limestone is approximately 200 feet thick in the eastern part of the Planning

Area and thickens to the east. The Epitaph Dolomite has not been reported in the Planning Area but can be more than 1,000 feet thick in southeastern Arizona (Blakey and Knepp 1989). Portions of the Colina and Epitaph may provide source rock material.

- **Upper Permian Scherrer Formation** – the fine-grained red beds of the basal Scherrer Formation overlie the thin interbedded red siltstones and gray limestones of the Epitaph Dolomite. The Scherrer Formation thins to the west and south, and grades to a limestone as it thickens to the east, where it measured 150 feet thick (Blakey and Knepp 1989).
- **Upper Permian Concha Limestone** – a massive, medium- to dark-gray cherty fossiliferous limestone that may be dolomitized at the base. This unit is about 130 feet thick in eastern Arizona and thins to the west. (Blakey and Knepp1989). Dolomitization may have formed reservoir-quality porosity.
- **Upper Permian Rainvalley Formation** – a light gray to brownish gray fine-grained sandstone that grades upward to a sandy dolomitic limestone and limestone. The Rainvalley Formation is gradational with the underlying Concha Limestone. It typically is 300 feet thick in eastern Arizona but has not been reported in the Planning Area (Blakey and Knepp 1989).
- **Middle Permian San Andres Limestone** – a marine limestone that has reservoir-quality porosity and is greater than 300 feet thick in the northern part of the Planning Area.

2.2.6 TRIASSIC [TR]

Paleotectonic and paleogeographic maps prepared by Blakey (1989) show that southern Arizona was dominated by highlands during the Lower and Upper Triassic. The Planning Area was generally an area of uplift and erosion of granitic rocks of Triassic age. Recognition of Triassic rocks has been tenuous and generally limited to undesignated supracrustal rocks underlying abundant Jurassic deposits.

2.2.7 JURASSIC [J]

Thick sequences of interstratified volcanic and sedimentary rocks comprise the Jurassic in southern Arizona and the Planning Area. The rocks characterize a period of intense volcanism with volcanic flows and ash flows and subvolcanic intrusions.

- **Lower Jurassic Fresnal Canyon Sequence** – the most abundant volcanic rock types include brown to reddish rhyolitic to dacitic flows, ash-flow tuffs and tuffs, with lesser amounts of andesitic flows and tuffs. Quartz and quartz-feldspar porphyry intrusive rocks are present locally and commonly grade into granite porphyry. Sedimentary rocks interbedded with volcanic sequence include reddish-brown volcanic porphyry conglomerates and breccias, quartzites, and brown fine-grained, large-scale cross-bedded quartz sandstones. Some of the volcanic and sedimentary sequences exhibit light gray and gray colors indicative of moderate-to-strong metamorphism. This sequence is reported in the Artesa, Baboquivari, Bates, Comobabi, Puerto Blanco, Quinlan, Quitobaquito, and Sheridan Mountains. The maximum thickness of the Fresnal Canyon Sequence is unknown and is estimated by Tosdal et al. (1989) at 4 to 5 miles.
- **Middle(?) and Upper Jurassic Artesa Sequence** – this sequence consists of volcanic rocks such as andesite and trachyandesite with lesser amounts of rhyolite interbedded with immature sedimentary rocks (Tosdal et al. 1989). Volcanic deposits include flows, flow breccia, and conglomerates of volcanic debris. Pyroclastic deposits are less common and volcanics generally exhibit lower grade metamorphism in the Artesa Sequence than in the underlying Fresnal Canyon Sequence. Subvolcanic pluton intrusives also are reported (Nowlan et al. 1989). Sedimentary

rocks are commonly interstratified with and occasionally exceed the thickness of volcanic rocks. Sedimentary rocks include brown to purplish-gray clayey siltstones, volcaniclastic sandstones, and pebble conglomerates. The Artesa sequence outcrops in the Artesa, Comobabi, Quijotoa, and Roskruge Mountains. No range in thickness was reported for this sequence.

- **Upper Jurassic to Lower Cretaceous Glance Conglomerate** – this basal formation of the Bisbee Group is a coarse-grained conglomerate and poorly bedded sedimentary breccia containing angular clasts of subjacent Precambrian, Paleozoic, and Jurassic rocks. Similar formations that reportedly outcrop in the Brownell, Comobabi, Growler, Sheridan, Santa Rosa, Vekol, Silver Bell, Tat Momoli, and Roskruge Mountains may be correlative because they overly or contain clasts of late Jurassic granite. The Glance Conglomerate unconformably overlies the Artesa Sequence and can be up to 6,000 feet thick in the Planning Area (Tosdal et al. 1989).
- **Plutonic Rocks [Jv]** – Tosdal et al. (1989) divided Jurassic plutonic rocks in southern Arizona into three regionally extensive super-units: Ko Vaya, Kitt Peak-Trigo Peaks, and Cargo Muchacho. Only the first two of those super-units are mapped in the Planning Area.
    - **Middle Jurassic Ko Vaya** – super-unit outcrops in the Agua Dulce, Artesa, northern Baboquivari, Brownell, Comobabi, Puerto Blanco, Quitojoa, and Santa Rosa Mountains, and in the Ko Vaya and Quitobaquito Hills. This super-unit is composed of fine- to coarse-grained alkali-feldspar granitic rocks ranging from quartz-rich monzogranite and syenogranite to quartz syenite and monzonite. Isotopic ages for this super-unit range from 160 to 145 Ma.
    - **Middle(?) and Late Jurassic Kitt Peak-Trigo Peaks** – super-unit outcrops in the La Lesna Mountains, Kupk Hills, Horse Peak, and northern Baboquivari Mountains. This super-unit contains four calc-alkaline intrusive units that range from plagioclase-rich to quartz-rich, including: hornblende diorite, quartz monzonite, porphyritic granodiorite, and granite. Isotopic ages for the Kitt Peak-Trigo Peaks super-unit range from 165 to 160 Ma.

2.2.8 CRETACEOUS [K]

Sedimentary rocks of Cretaceous age are exposed in the southeastern part of the Planning Area and attain subsurface thicknesses of up to 3,000 feet (Dickinson et al. 1989). Cretaceous sediments generally thicken to the southeast. Cretaceous volcanic and plutonic rocks also outcrop throughout the Planning Area. Formations include the following:

- **Lower Cretaceous Glance Conglomerate** – as described previously, this basal unit of the Bisbee Group is Upper Jurassic to Lower Cretaceous age.
- **Middle Cretaceous Sand Wells Formation** – this formation is a terrestrial sandstone interpreted by Haxel et al. (1980) to be laterally correlative south-eastward to Bisbee Group marine strata and westward to the nonmarine McCoy Mountains Formation. The Sand Wells Formation is a fine-grained sandstone and conglomerate interbedded with andesitic volcanic rocks. Locally this unit has reservoir-quality rock.
- **Upper Cretaceous Phonodoree Formation** – a thick clastic sequence consisting of a basal orange-brown, coarse-grained pebble conglomerate overlain by a reddish feldspar-rich sandstone, white quartzite and red to brown mudstone (Heindl 1965a). It unconformably overlies Paleozoic sediments and ranges from 150 to 300 feet thick.

- **Upper Cretaceous Vekol Formation** – consists of a sequence of immature volcanic-rich sedimentary rocks including arkosic sandstone, pebble conglomerate, greywacke, and mudstone. The Vekol Formation ranges from 1,000 to 2,000 feet thick and is generally conformable with the underlying Phonodoree Formation.
- **Upper Cretaceous to Tertiary Volcanic Rocks [Kv]** – large volumes of late Cretaceous to Tertiary andesitic-dacitic to rhyolitic volcanic rocks were deposited in southern Arizona during the Laramide orogeny (Titley and Anthony 1989). These rocks outcrop in the Roskruge, Little Ajo, Vekol, and Silver Bell Mountains (Heindl 1965b). The older volcanics range in age from 67 to 74 Ma.
- **Upper Cretaceous to Tertiary Intrusive Rocks [TKg]** – Late Cretaceous initiation of the Laramide orogeny resulted in the intrusion of granitic plutons throughout the Planning Area. These rocks are primarily responsible for placement of the base- and precious-metal orebodies present in the Planning Area, particularly porphyry copper deposits. Ages range from 75 to 50 Ma. The cores of volcanic systems contain porphyritic granitic rocks that host large copper orebodies. Age-correlative plutons found in the Planning Area include garnet-rich two-mica granite in the Artesa, South Comobabi, Sierra Blanca, and Baboquivari Mountains (Pan Tak Granite), and in the Kupk Hills; and hornblende-biotite granite in the Bates, Little Ajo, Cimarron, Quitobaquito, Slate, Vekol, and Santa Rosa Mountains, and in the Kupk and Gunsight Hills.

2.2.9 TERTIARY [T]

Outcrops of Tertiary-age volcanic rocks are extensive throughout the Planning Area as a result of active tectonism that formed the Basin and Range province. Emplacement of plutonic rocks also occurred during the middle Tertiary. In contrast, Tertiary sedimentary rocks typically were deposited in local basins, some of which formed between detachment-fault blocks associated with extensional tectonism. Scarborough (1989) described four “stratotectonic assemblages” of Tertiary deposits that suggest four episodes of tectonism and subsequent deposition. These sedimentary deposits generally have younger isotopic ages to the northwest (Scarborough 1989).

Formations include the following:

- **Early Tertiary Whitetail Conglomerate [Tso]** – a light-colored conglomerate to pebbly sandstone that ranges from 200 to more than 3,000 feet thick. Isotopic ages of volcanic rocks that bound the Whitetail range from 40 to 28 Ma and pre-date Tertiary volcanic rocks. Outcrops have been reported in the Globe area (Melchiorre and Clement 1993; Peterson et al. 1983).
- **Early to Middle Tertiary Volcanics [Tv]** – calc-alkalic, silicic, caldera-style volcanism consisting of flows, pyroclastic deposits, and ash-flow tuffs. Volcanic deposits are time transgressive from east to west with ages ranging from 28 to 15 Ma (Spencer and Reynolds 1989). Age-correlative volcanic rocks in the Planning Area may include the Apache Leap Tuff in the Superstition Mountains (Peterson et al. 1983) and the Miocene Childs Latite in the Growler Mountains, Batamote Mountains, and the Ajo Range (Jones 1974). Mid-Tertiary volcanics and associated dikes are host to many epithermal-vein mineral districts in the Planning Area that are classified by production into gold-rich, silver-rich, or base-metal rich (Spencer and Welty 1989).
- **Middle Tertiary Volcanic Sediments [Tvs]** – generally reddish fanglomerates and conglomerates containing volcanic clasts, intercalated with andesite flows and tuffs. These volcaniclastic deposits can range from 28 to 23 Ma and generally are younger to the northwest

(Scarborough 1989). Equivalent formations may include the Sil Murk Formation on the Gila Bend Indian Reservation (Heindl and Armstrong 1963).

- **Middle Tertiary Plutonic Rocks [Tg]** – regional east-northeast extensional tectonism resulted in the emplacement of granites and granodiorites, such as the Telegraph Pass Granite and South Mountains Granodiorite in the South Mountains (Reynolds 1985). Emplacement of these plutons coincided with faulting and mylonitization in deep shear zones that formed metamorphic core complexes in several mountain ranges in southern Arizona.
- **Middle to Late Tertiary San Manuel Assemblage [Tsy]** – a sequence of light-colored volcaniclastic conglomerates, tuffaceous sediments, and interbedded tuffs and ash flows. Equivalent rocks may include the Mesquite Flat conglomerate in the Superstition Mountains (Scarborough 1989). The structural characteristics include internal faulting and moderate deformation. These sediments range from 21 to 17 Ma.
- **Late Tertiary Gila Group Sediments [Tsy]** – thick sequences of conglomerate, gravelly sandstone, fine laminated siltstone and shale described as alluvial fan "basin-fill" sediments because the deposits are generally contiguous with present-day drainage systems. Massive evaporite bodies, including anhydrite, gypsum, and halite (salt) are present in the older part of the sequence. Closed-basin continental evaporite deposits are recognized as source rock for hydrocarbons in many basins of the world (Butler 1996; Kirkland and Evans 1981). Gila Group sediments range from 13 to 4 Ma and can exceed 5,000 feet in thickness.

2.2.10 QUATERNARY [QT AND Q]

Rocks of Quaternary age in the Planning Area are diverse, widespread, and have a range of thicknesses from a few hundred to greater than 1,000 feet. Quaternary deposits [QTs] include alluvial and colluvial sands, silts, and gravels; piedmont slope and valley border fanglomerates grading from proximal bouldery alluvium to distal sand-silt-clay mixtures; basin floor playa and lacustrine mudstones and siltstones; fine-grained eolian sand sheets and dunes; terrace, valley fill, floodplain, and channel sand, silt and clay deposits along major streams; and angular cobble- and boulder-size talus deposits. The surface accumulation and local abundance of these sediments make them preferred sources for construction aggregate and other industrial materials. Plio-Pleistocene basalt flows also are present in the Planning Area [QTv].

2.3 STRUCTURAL GEOLOGY AND TECTONICS

The Planning Area in southern Arizona and within the Basin and Range physiographic province has a complex structural regime resulting from a long tectonic history (Dickinson 1989). Tectonic features in the Planning Area are shown on Map 1.

As previously mentioned, Anderson (1989) identified two Proterozoic tectonic belts in the Planning Area: the Central Volcanic Belt and the Southeast Schist Belt. The contact between those belts is roughly correlative with the Salt River Lineament of Peirce (1986), which separates a block of Precambrian and Cenozoic rocks with few ore deposits in the northwestern part of the Planning Area from a block of Precambrian, Paleozoic, Upper Cretaceous, and Cenozoic rocks with abundant ore deposits in the southwest part of the Planning Area.

The northeastern part of the Planning Area is characterized by a shallow intracratonic basin south of the Transcontinental Arch referred to as the Arizona-New Mexico Trough (Nations et al. 1989). That basin

formed during the early Paleozoic and contains clastic sediments eroded and/or reworked from the cratonic platform as well as marine limestones.

Southeastern Arizona was subjected to subsidence during the late Paleozoic Ouachita orogeny as thrust sheets extended westward into northern Mexico. The Pedregosa Basin formed as a result of this downwarping (Dickinson 1989). The basin was filled with thick sequences of Pennsylvanian to Permian limestones and clastics that thin to the west into the Planning Area.

Southern Arizona was an area of subaerial erosion during early Mesozoic time as the Mogollon Highlands were uplifted and eroded into basins in northern Arizona. A Jurassic magmatic arc system developed in southwestern Arizona east of a circum-Pacific subduction zone and deposited large volumes of volcanic and volcaniclastic sediments. During the Early Cretaceous, the opening of the Gulf of Mexico resulted in rifting and subsidence of the crust in southeastern Arizona that formed the Chihuahua Trough. Thick sequences of Cretaceous marine clastics were deposited in that basin.

The Late Cretaceous-Early Tertiary Laramide orogeny caused regional uplift. Structural warping and crustal extension formed closed basins in which volcanic and clastic sedimentary rocks accumulated. Much of the northeastern portion of the Planning Area may have been impacted by the Laramide Overthrust Trend (Nations et al. 1989).

The majority of the Planning Area is in the structurally complex Basin and Range Province. The crust in this province has been thinned and lengthened by detachment faults and block-faulted grabens associated with Miocene extensional tectonism. Crustal thinning enabled upward migration and emplacement of middle Tertiary plutons. Extensive Miocene volcanism deposited thick sequences of extrusive rocks in the Planning Area. Faulting and mylonitization resulted in metamorphism of rocks in the shallow crustal shear zone that were later uplifted and exposed in mountain ranges as metamorphic core complexes. Numerous small structural basins bounded by block-faulted, uplifted mountains were filled with terrigenous clastic and volcanic rocks (Dickinson 1989; Nations et al. 1989).

2.4 HISTORICAL GEOLOGY

The region within southern Arizona has a complex geological history dominated by three tectonic events: Mesozoic Cordilleran orogeny, Late Cretaceous-Early Tertiary Laramide orogeny, and crustal extension during Tertiary Basin and Range tectonism. The historical geology is presented in detail by Dickinson (1989).

2.4.1 PRECAMBRIAN

The earliest recognizable geologic event in the Planning Area was consolidation of volcanogenic rocks in the Proterozoic crust approximately 1,700 to 1,600 Ma. It is uncertain whether the crust formed by an arc-trench system or was transported and accreted to the craton. The crustal rocks subsequently were intruded by younger granitic plutons and covered in part with minor amounts of volcanic-derived sediments. Intense deformation of these rocks into schists and gneisses formed the so-called basement rocks of southern Arizona. A period of tectonism in Middle Precambrian unrelated to any known orogenic activity emplaced large granitic batholiths about 1,450 Ma. The batholiths may have resulted from crustal subduction or continental collision to the southeast.

2.4.2 PALEOZOIC

From Middle Precambrian and into the early Paleozoic, Arizona was the location of a relatively stable craton as suggested by a slight angular unconformity between Precambrian and Paleozoic strata. Middle Paleozoic sediments were deposited in stable shallow marine and coastal plain environments. However, interbedded basalts and diabase dikes may indicate that an area of crustal extension existed.

Early Paleozoic carbonate shelf sediments were deposited in shallow seas adjacent to the platform. Slow subsidence of the Paleozoic platform resulted in deposition of laterally extensive Cambrian quartzites and thick Mississippian carbonates. The Planning Area was not affected by late Paleozoic to early Mesozoic orogenic events. The Ouachita orogeny of Pennsylvanian-Permian age was caused by plate collisions to the southeast that formed Pangaea. By the Middle Permian, deformation of the crustal interior resulted in downwarping of the area ahead of the Ouachita thrust sheets and flooding of the continent. Thick sequences of Pennsylvanian and Permian limestone, sandstone and shale were deposited in the Planning Area.

2.4.3 MESOZOIC

During the Triassic, most of the area was an exposed erosional surface being weathered from highlands to interior lowlands and coastal plains (Dickinson 1989). The Cordilleran orogeny developed in the Middle Mesozoic with a subduction zone system in California and a Jurassic magmatic arc oriented northwest to southeast across southwestern Arizona, with the subaerially exposed Mogollon Highlands to the north. Extensive volcanics and thick volcaniclastic sediments were deposited in the Planning Area and now outcrop in several mountain ranges. The magmatic arc also generated Jurassic plutonic rocks.

During the Late Cretaceous beginning of the Laramide orogeny, the subduction angle decreased and the magmatic arc migrated into central and southeastern Arizona, thickening the crust and forming basement-cored uplifts throughout the Southwest. Late Cretaceous rifting began to open the Gulf of Mexico. Rifting, backarc crustal extension and subsidence opened the Chihuahua Trough and its westward extension, the Bisbee Basin in southeastern Arizona, to deposition of marine and nonmarine rocks.

2.4.4 TERTIARY

Continuation of the Laramide orogeny into the early Tertiary initiated a new episode of magmatism as the angle of the subduction slab increased (Spencer and Reynolds 1989). Early to Middle Tertiary plutonic rocks were intruded through much of the area. Basin and Range extensional tectonism began in the Miocene with development of the San Andreas transform fault system. Thin crustal deformation and mylonitization of Tertiary plutonic rocks and overlying volcanic rocks formed metamorphic core complexes. Miocene to Pliocene volcanism reportedly was caused by upwelling of the mantle beneath the crustal extension as thinning of the crust occurred. The basaltic composition of the volcanic deposits confirms the mantle source (Menges and Pearthree 1989).

Detachment-faulted crustal extension formed graben-like basins elongated northwest to southeast. Those basins subsequently were filled with continental deposits: alluvial fan gravels and sands; continental evaporates; fluvial sands, silts and clay; and Late Tertiary volcanics. Most Tertiary rocks were deposited in local basins within the Basin and Range province.

2.4.5 QUATERNARY

Erosion of the highlands and deposition in the intermontane basins continued into the Quaternary. Continent-derived sediments include alluvial and colluvial sand and gravel deposits, fluvial sediments, basin-floor and piedmont-slope sediments, and localized fine-grained eolian sands or lacustrine silts and muds. The predominantly alluvial sediments may intertongue with an occasional basalt flow or cinder deposit.

3.0 DESCRIPTION OF ENERGY AND MINERAL RESOURCES

There are three basic types of Federal minerals: leasable, locatable, and salable. These minerals have been defined by Federal laws, regulations, and legal decisions (BLM 1997).

Leasable minerals discussed in this section include the following:

- Nonrenewable energy fluid minerals – oil, natural gas (gas), and geothermal
- Nonrenewable solid energy minerals – coal
- Nonrenewable solid minerals – sodium (salt) and potash
- Nonrenewable nonenergy fluid minerals – CO_2 and helium

Although not leasable, renewable solar and wind energy resources are discussed here because right-of-way permits may be required to construct renewable energy collection facilities on public land. Helium typically is associated with CO_2 gas and, for the purposes of this report, the two gases are considered one resource. However, helium is developed under extraction and sales contracts between the developer and the BLM instead of sales royalties under standard oil and gas leases.

Locatable mineral resources discussed in this section include the following:

- Metallic minerals – e.g., gold, silver, uranium
- Nonmetallic minerals – e.g., asbestos, gemstones, fluorspar, perlite

Salable mineral resources discussed in this section include sand, gravel, limestone, cinders, and building stone.

The resource discussions include known prospects, mineral occurrences, and mineralized areas; mining claims, leases, and material sites; types of mineral deposits in the area of interest; and mineral economics, which include strategic and critical minerals.

3.1 LEASABLE MINERALS

Federal leasable minerals are fluid or solid minerals that can be developed after obtaining a lease from BLM. Leasable fluid minerals include oil, gas, geothermal, and CO_2. Leasable solid minerals include coal, potash, sulfur, and sodium. Leasing for mineral development may be accomplished by competitive bid, as typically is the case for oil and gas. A lease sale may be initiated by an Expression of Interest (EOI) nomination, wherein an interested party nominates a parcel for exploration and development. If there is no interest in the competitive lease of a parcel, the interested party may obtain a noncompetitive lease. Leasing of coal in Arizona is by the Lease by Application procedure.

A successful lessee for oil and gas leases is required to pay rent on the leased parcel. Rental costs range from $1.50 per acre per year for the first five years to $2.00 per acre per year for the last five years. Competitive bonus bids are determined by oral auction on a per-acre basis, and range from approximately $1.00 per acre for a parcel having little or no competitive interest up to $10.00 per acre for a parcel having high competitive interest. The lessee also is required to pay royalties on the sale of mineral resources

produced from the leased parcel. For example, oil and gas royalties are 12.5 percent of sales. Royalty payments are paid to the U.S. General Revenue Fund.

Coal lease sales are by sealed competitive bid, with the winning bid being the highest one that meets or exceeds the "fair market value" established prior to the bid and kept confidential by the BLM. For coal leases, rental costs are $3.00 per acre per year. Coal royalties are 12.5 percent for surface-mined coal and 8 percent for coal extracted from the subsurface. Royalty payments are paid to the U.S. General Revenue Fund.

3.1.1 OIL AND GAS

Oil and gas are nonrenewable energy fluid mineral resources that typically are discovered and exploited by drilling exploratory and development wells into oil- and/or gas-bearing sedimentary rocks. Such sedimentary rocks have reservoir-quality porosity, are proximal to petroleum source rocks such as organic-rich shale or coal, and have formed a structural or stratigraphic trap that may accumulate oil and/or gas in the pore spaces. From 1913 to 1981 there have been 33 exploratory wells drilled in the Planning Area (Petroleum Information [PI]/Dwights 2003; Rauzi 2003) as shown on Map 3 and listed in Table 1. Also shown on Map 3 and in Table 1 is the Hatchett #1 McFarland (Reference #11-11), adjacent to the Planning Area, which provides additional information on oil and gas potential. Although there have been shows of oil and/or gas reported in seven of those wells, there has been no economic production to date.

3.1.1.1 Known Occurrences and Prospects

Several basin plays (prospects) for oil and gas exploration within the Planning Area are shown on Map 3 (Rauzi 2001). Exploration activity in each of those plays since the first well was drilled in 1913 is discussed below. One well was drilled in 1913 and one in 1928. Two exploration wells were drilled in the Planning Area in the 1930s, six wells in the 1940s, five wells in the 1950s, eleven wells in the 1960s, six wells in the 1970s, and one well in the 1980s (PI/Dwights 2002; Rauzi 2003).

Bisbee Basin – This basin is the westward extension of the Early Cretaceous Chihuahua Trough that protrudes into southern Pinal County and eastern Pima County (refer to Map 3). It contains thick sequences of Early Paleozoic marine shelf deposits and Cretaceous terrigenous and marine sediments (Nations et al. 1989; Rauzi 2001). The western part of the basin was first tested for oil and gas in 1930, and has seen mild drilling activity since the 1940s. In the Planning Area, the northwestern extremity of the Bisbee Basin has been tested by the following wells (Rauzi 2003). In 1945, Casa Grande Valley #1 Laveen (Reference #11-09) drilled 4,742 feet to total depth (TD) in Tertiary sediments. In 1953, Western Oil Fields #1 Federal (Reference #15) drilled to 5,142 feet TD in Tertiary sediments. In 1964, Crouch Drillers #1 Holland (Reference #11-10) drilled to a TD of 3,243 feet in Tertiary sediments. Those three dry holes did not penetrate and test the Paleozoic section. Oil and/or gas shows were reported in the Casa Grande Valley #1 Laveen, and in the Hatchett #1 McFarland, which is located east the Planning Area. Encouraging shows also were encountered in wells that tested Bisbee Basin sediments southeast of the Planning Area (Rauzi 2001).

Arizona-New Mexico Trough – The westward extension of the Paleozoic Arizona-New Mexico Trough (Pedregosa Basin) has been tested by seven wells, none of which reported oil or gas shows (Nations et al. 1989).

Laramide Overthrust Trend – Successful oil and gas exploration in the Laramide Overthrust Trend in Utah and Wyoming led to exploration in the early 1980s for a similar Laramide Overthrust Trend play in

Arizona (refer to Map 3). In this play, the test anticipated drilling through a thick sheet of thrusted Cretaceous and younger rocks and encountering a sequence of untested older Cretaceous through Paleozoic sedimentary rocks. None of the eight wells drilled by Phillips Petroleum to test the overthrust play in 1981 and 1982 were within the Planning Area, and none of them had oil or gas shows.

Tertiary Basins – These basins are located beneath intermontane valleys and based in graben structures that may contain sequences of Paleozoic and Cretaceous marine rocks. The older sediments are overlain by thick Cenozoic volcanic and sedimentary rocks deposited during mid-Tertiary and Miocene Basin and Range extensional tectonism (Nations et al. 1989; Rauzi 2001). Similar basins produce hydrocarbons in eastern Nevada and western Utah. Tertiary basins are present throughout the Planning Area and are posted on Map 3 with letter identifications shown below. Tertiary basins that have been tested by drilling include:

- Luke Basin (A) in west and northwest Phoenix Valley, bounded by the Sierra Estrella and South Mountains to the south, Phoenix Mountains to the east, Heiroglyphic Mountains to the north, and White Tank Mountains to the west. Of the 16 wells drilled in or near the basin, of which four were within the Planning Area, one well had an oil and gas show (refer to Map 3).
- Paradise Basin (B) northeast of Phoenix, bounded by the McDowell Mountains to the east, New River Mountains to the north, and Phoenix Mountains to the west. No shows were reported in the five wells that tested this basin, none of which were inside the Planning Area.
- Higley Basin (C) southeast of Phoenix, bounded by the Santan Mountains, Superstition Mountains, Goldfield Mountains, and South Mountains to the south, east, north, and west, respectively. The four wells drilled in the Higley Basin did not encounter oil or gas shows.
- Tonopah Basin (D) west of Phoenix, bounded by the White Tank Mountains to the east, Belmont Mountains to the north, and Palo Verde Hills to the south. Four wells tested this basin and one reported a gas show.
- Maricopa-Stanfield Basin (E), bounded by the Santan and Sacaton Mountains to the east and the Sierra Estrella and Palo Verde Mountains to the west. Four wells tested in or near this basin and did not report oil or gas shows.
- Picacho Basin (F) near Eloy, bounded by the Picacho Mountains to the east, Sawtooth Mountains to the west, Silver Bell Mountains to the south, and Santan Mountains to the north. This basin is adjacent to the northwestern limits of the Bisbee Basin. The shows reported for the Bisbee Basin also apply to this Tertiary basin.
- San Cristobal Basin (G), bounded by the Aguila and Granite Mountains to the east and the Mohawk Mountains to the west. One well tested this basin and reported no show of oil or gas.

Tertiary basins that have not been tested by drilling include:

- Arlington Basin (H) southwest of Buckeye, bounded by the Palo Verde Hills to the west, Buckeye Hills and Gila Bend Mountains to the south, and White Tank Mountains to the east.
- Harquahala Basin (I) in western Maricopa County, bounded by the Gila Bend Mountains, Saddle Mountain, Big Horn Mountains, and Eagletail Mountains to the south, east, north, and west, respectively.
- Santa Rosa Basin (J), bounded by the Santa Rosa and Comobabi Mountains to the east and the Vekol, Sheridan, Brownell, and Quijotoa Mountains to the west.

- Quijotoa Basin (K), bounded by the Vekol, Sheridan, Brownell, and Quijotoa Mountains to the east and the Ajo Range and Sikort Chuapo Mountains to the west.
- Vekol Basin (L), bounded by the Vekol and Table Top Mountains to the east and the Sand Tank Mountains to the west.
- Gila Bend Basin (M), bounded by the Sand Tank, Sauceda, and Maricopa Mountains to the east, the Gila Bend Mountains to the north, and the Painted Rock and Aguila Mountains to the west.
- Rainbow Basin (N), bounded by the Sierra Estrella Mountains to the east and the Maricopa Mountains to the west.
- Growler Basin (O), bounded by the Growler Mountains to the east and the Granite Mountains to the west.
- Ajo Basin (P), bounded by the Bates and Little Ajo Mountains to the west and the Pozo Redondo, Batamote and Gunsight Hills to the east.
- Baboquivari Basin (Q), bounded by the Baboquivari Mountains to the east and the Comobabi and Artesa Mountains to the west.

The only reported surface occurrence of oil in the Planning Area is a late Oligocene to early Miocene age thin-bedded petroliferous limestone outcrop in the Gila Bend Mountains (Rauzi 2001). This location was tested by three wells drilled between 1962 and 1973 (Reference Nos. 171, 208, and 573). Two of those wells reported oil shows.

3.1.1.2 Leasing Activity

Regulations applicable to Federal oil and gas leasing in the Planning Area include the Mineral Leasing Act of 1920, the Mineral Leasing Act of 1947, Mining and Minerals Policy Act of 1970, Federal Onshore Oil and Gas Leasing Reform Act of 1987, and 43 Code of Federal Regulations (CFR) 3100 – Oil and Gas Leasing. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning, BLM Manual Section 1624-2 – Supplemental Program Guidance for Fluid Minerals, and BLM Manual Series 3100 – Onshore Oil and Gas Leasing.

Leasing of Federal minerals for exploration and development of oil and gas is stimulated by the submittal to the Arizona State Office of the BLM of an EOI. The EOI is an informal nomination by an interested entity, such as an energy company, to request that certain lands be included in a competitive lease sale. BLM administers competitive lease sales, which are held on a quarterly schedule following public notification of the sale. Permitting for oil and gas exploration and drilling within the State is administered by the Arizona Oil and Gas Conservation Commission.

3.1.1.3 Mineralized Areas and Types

For the purposes of this report, oil and gas mineralized areas are characterized as plays or geologic basins having reported oil and/or gas shows in exploration wells; or evidence for, or reports of encountering and testing thermally mature or moderately mature petroleum source rock. The oil and gas potential for mineralized areas in the Planning Area is shown on Map 3.

Oil and/or gas shows reported in exploration wells characterize the Luke, Tonopah, Bisbee, and Picacho Basins, and the Gila Bend Mountains area plays as mineralized for oil and/or gas.

3.1.1.4 Mineral Economics

Exploration for oil and gas is a high-risk venture requiring large, up-front capital expenditures for leasing prospects, drilling and testing, production, and transportation pipelines. The level of risk is weighed against the current market value of oil (in dollars per barrel) and gas (in dollars per million British thermal units [Btu]). When market prices are high, the level of risk may be lowered enough that oil companies will drill new or more risky exploration plays. The lack of success and the limited understanding of oil maturation, migration, and accumulation in the existing plays in the Planning Area present a high level of risk under current market conditions. If market demands for oil and/or gas change substantially, more exploratory drilling activity could be expected in the Planning Area.

Oil and gas exploration and development provide economic benefits to Federal, State, and local governments as well as to the public. Annual lease rent and royalties on sales of mineral resources generate considerable revenue to the general fund of the surface/mineral owner. The local economy also benefits through additional jobs and purchase of goods and services such as food, lodging, and supplies by oil field contracting companies and personnel. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the State and local economy.

3.1.2 CARBON DIOXIDE AND HELIUM

CO_2 and helium (CO_2/He) are nonrenewable nonenergy fluid mineral resources typically discovered by exploratory oil and gas wells that encounter natural gas or nonflammable gas. Helium typically is associated with CO_2 gas and, for the purposes of this report, the two gases are considered one resource. If CO_2/He can be economically separated, collected, and delivered to a market, then a CO_2/He gas field is developed.

From 1928 to the present there have been 33 exploratory oil and gas wells drilled in the Planning Area. Three of those wells have reported gas shows, and gas was reported in one well drilled adjacent to the Planning Area (Hatchett #1 McFarland). There is no information that the gas tested in those wells was analyzed for CO_2 and helium. The gas shows may contain CO_2/He and, for the purposes of this report, are considered as having CO_2/He potential.

3.1.2.1 Known Occurrences and Prospects

There are no known occurrences or prospects for CO_2/He in the Planning Area. However, there are known occurrences of CO_2/He in volcanic terrain comparable to the Planning Area where volcanic outgassing is the proposed source for CO_2/He (Staudacher 1987). Although CO_2/He may not be primary targets for future exploration, gas analyses may confirm the presence of CO_2/He in test wells.

3.1.2.2 Leasing Activity

Regulations applicable to CO_2 leasing in the Planning Area include the Mineral Leasing Act of 1920, Mineral Leasing Act of 1947, Mining and Minerals Policy Act of 1970,and Federal Onshore Oil and Gas Leasing Reform Act of 1987. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning, BLM Manual Section 1624-2 – Supplemental Program Guidance for Fluid Minerals, and BLM Manual Series 3100 – Onshore Oil and Gas Leasing.

Exploration and development for CO_2 is conducted under standard oil and gas leasing procedures. Leasing is stimulated by the submittal to the Arizona State Office of the BLM of an EOI. The EOI is an

informal nomination by an interested entity, such as an energy company, to request that certain lands be included in a competitive lease sale. BLM may administer competitive or noncompetitive lease sales following public notification of the sale. Permitting for CO_2 exploration and drilling within the State is administered by the Arizona Oil and Gas Conservation Commission.

Although helium is an important component of CO_2 gas it is not a leasable mineral. Helium is developed under extraction and sales contracts between the developer and the BLM instead of sales royalties under standard oil and gas leases.

3.1.2.3 Mineralized Areas and Types

For the purposes of this report, CO_2/He mineralized areas are characterized as plays or geologic basins having reported CO_2/He or undifferentiated gas shows in exploration wells (refer to Map 3). There are no known CO_2/He mineralized areas in the Planning Area. However, potential CO_2/He mineralized areas may include basins near volcanic activity where reservoir-quality rock has been charged by volcanic gases sourced in the upper mantle. As such, the Luke, Tonopah, Picacho and San Cristobal Tertiary Basins are potential mineralized areas for CO_2/He (Map 3).

3.1.2.4 Mineral Economics

The current market demand for CO_2/He favors the development of those resources in the Planning Area. Helium currently sells for $52.50 per thousand cubic feet (mcf) and CO_2 sells for $0.75 per mcf (Ridgeway 2003).

The Helium Privatization Act of 1996 directed that the Federal government no longer pay for the extraction and storage of helium for national security. With this artificial demand for helium closed, and declines in production from the largest helium gas fields in Kansas and Texas, the helium supply will decrease (Gage and Driskill 2001). Helium demand will continue to increase for a multitude of industrial applications, and this impetus to develop new reserves could result in drilling activity in the Planning Area.

CO_2/He exploration and development provides economic benefits to Federal, State, and local governments as well as to the public. Annual lease rent and royalties on sales of mineral resources generate considerable revenue to the surface/mineral owner. The local economy also benefits through additional jobs and purchase of goods and services such as food, lodging, and supplies by contracting companies and personnel. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the State and local economy.

3.1.3 COAL

Coal is a nonrenewable, leasable, solid energy mineral resource. Coal resources typically are exposed in outcrops of coal-bearing sedimentary formations, such as the Upper Cretaceous Mesaverde Group in northeastern Arizona. Locations where coal resources occur and can be mined are designated as coalfields. Coalfields in Arizona include the Black Mesa field in northeastern Arizona, the Pinedale field along the Mogollon Rim in east-central Arizona, and the Deer Creek field in southeastern Arizona east of Winkelman (Duncan and Mancini 1991). There are no outcrops of coal-bearing sedimentary formations or coalfields reported in the Planning Area.

3.1.4 GEOTHERMAL

Geothermal resources are nonrenewable leasable energy fluid resources. Sources of geothermal energy include artesian hot springs and wells that tap into groundwater or dry rock at elevated temperatures resulting from high heat flow gradients in the subsurface. New sources of geothermal energy have been discovered by drilling exploratory wells in areas of known or suspected high temperature gradients, or by coincidence during drilling for water resources. There are 15 low-temperature geothermal resource regions in the Planning Area: 8 in Maricopa County, 3 in Pima County, 3 in Pinal County, and 1 in Gila County (Witcher et al. 1982; National Geophysical Data Center [NGDC] 2003). These regions are shown as high potential areas and warm springs on Map 4.

There are no significant current uses of geothermal energy resources reported for the Planning Area. Potential uses include residential and commercial space heating, greenhousing, aquaculture, crop and food processing, and heated swimming pools and spas. Geothermal resources in the Planning Area are not applicable for power generation because the temperatures are not high enough to produce steam (Duncan and Mancini 1991).

3.1.4.1 Known Occurrences and Prospects

Information on the known occurrences of geothermal energy resources in the Planning Area is reported by the Arizona Geological Survey (formerly the State of Arizona Bureau of Geology and Mineral Technology) (Duncan and Mancini 1991; Witcher et al. 1982); National Geophysical Data Center (2003); and Farhar and Heimiller (2003). Witcher et al. (1982) provided a database of sites or regions with measured temperatures equal to or greater than 20 degrees Centigrade (ºC)/68 degrees Fahrenheit (ºF). The geothermal energy resources are presented in Table 2, and the reference numbers listed on those tables correspond to the locations posted on Map 4.

Geothermal energy resources in the Planning Area range in temperature from 35 to 120 ºC (95 to 248 ºF). Thirteen of the fifteen known geothermal regions reported are thermal wells or loose clusters of thermal wells that have low-temperature geothermal resources. The other two regions are hot springs at isolated locations: one downstream from Roosevelt Dam, and one in Organ Pipe Cactus National Monument near the Arizona-Mexico border (refer to Map 4). There are no reported Known Geothermal Resource Areas (KGRAs) in the Planning Area. None of the geothermal energy resources in the Planning Area have been developed, with the exception of El Dorado Hot Spring in Tonopah, a resort and spa that uses hot well water but claims to have a hot mineral water spring.

3.1.4.2 Leasing Activity

Regulations applicable to geothermal leasing of Federal minerals in the Planning Area include the Mineral Leasing Act of 1920, Mineral Leasing Act of 1947, Mining and Minerals Policy Act of 1970, Geothermal Steam Act of 1970, and 43 CFR 3200. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning, BLM Manual Section 1624-2 – Supplemental Program Guidance for Fluid Minerals, and BLM Manual Series 3200 – Geothermal Resource Leasing.

Federal leasing for geothermal exploration and development is noncompetitive unless the land is within a KGRA. A noncompetitive lease pays $1.00 per acre and is generally limited to a 640- to 2,560-acre lease. Competitive or KGRA lease sales are by sealed bid following a sale notice. The BLM will establish “fair market value” as a minimum bid for the lease acreage. Leases are held for a 10-year term, or longer if proven commercially productive. Royalties range from 10 to 15 percent of commercial energy production, and 5 percent of byproduct sales, such as produced minerals and demineralized water.

Permitting for geothermal exploration and drilling within the State is administered by the Arizona Oil and Gas Conservation Commission.

There is no reported leasing or development activity for geothermal energy resources in the Planning Area. Witcher et al. (1982) identified 15 regions in the Planning Area as potential sites for geothermal resource utilization: hot springs at Roosevelt Dam and Quitobaquito; the southern Harquahala Valley, Avondale-Tolleson, Tonopah, Rainbow Valley, Gila Bend, Mesa-Chandler-Gilbert, and Cotton Center areas in Maricopa County; the Coolidge-Casa Grande, Maricopa, and Superior areas in Pinal County; and the Sells, Papago Farms, and Ajo areas in Pima County. These regions are shown as high potential areas on Map 4.

3.1.4.3 Resource Areas and Types

For the purposes of this report, a geothermal energy resource area refers to an area characterized by known occurrences of geothermal energy resources, or where geologic conditions are conducive for generating geothermal gradients that could develop into a geothermal energy resource. Geothermal energy resource areas include the known occurrences described above.

Geothermal energy resource types can be classified by the temperature range, geologic setting, and fluid phase.

Temperature – Resource types based on temperature range are as follows (Southwest Technology Development Institute [SWTDI] 1999):

- Low-temperature resources – less than 90 ºC (194 ºF)
- Moderate-temperature resources – range from 90 to 150 ºC (194 to 302 ºF)
- High-temperature resources – greater than 150 ºC (302 ºF)

Geologic Setting – The temperature of the resource is dependent on the geologic setting, or tectonic diversity, in the resource area. The tectonic diversity includes the geologic structure, geologic history, hydrology, topography, climate, and rocks characteristic of the physiographic province. Resource types based on geologic setting include the following:

- Magma or magmatic resources – have magma as the direct heat source
- Convective resources – have deep-circulating groundwater that flows to the surface and produce thermal gradients greater than the normal 3 to 5 ºC per 100 meters (2 to 3 ºF per 100 feet)
- Conductive resources – confined hot water aquifers or hot rock at a depth associated with a normal thermal gradient
- Geopressured resources – have highly pressured hot brines with dissolved methane

Fluid Phase – The fluid phase produced by the geothermal energy resource also helps define the resource type, including the following:

- Liquid-dominated resources – have water or a combination of steam and water
- Vapor-dominated resources – have only steam
- Hot dry rock (HDR) resources – have only hot, deep-seated rock

The preceding categories were used to identify the resource type for each geothermal energy resource listed in Table 2. The resource type, if known, is included in that table. It is important to note that all but three geothermal energy resources mapped in the Planning Area are low-temperature and liquid-dominated. Three moderate-temperature, liquid-dominated geothermal energy resources are reported in the Planning Area: two south of Williams-Gateway Airport in Mesa and one north of Eloy. These are deep water wells in areas having normal geothermal temperature gradients; i.e., 30 to 50 ºC/kilometer for southern Arizona valleys (Witcher et al. 1982).

3.1.4.4 Mineral Economics

With a geologic terrain known to produce low-temperature geothermal energy resources throughout the Planning Area, conditions are favorable for exploitation of the known occurrences and exploration for new resources (Duncan and Mancini 1991). Low-temperature resources are best suited for heating needs, but insufficient for generating electricity. Exploitation likely will be focused on local heating needs where geothermal resources are available. Exploration and development of more significant commercial resources may be limited by the expense of drilling and completing wells to tap into the conductive geothermal resources deep beneath the Planning Area.

Geothermal exploration and development provide economic benefits to Federal, State, and local governments as well as to the public. Annual lease rent and royalties on sales of geothermal resources may generate limited revenue to the general fund of the surface/mineral owner. The local economy also may benefit through additional jobs and purchase of goods and services such as food, lodging, and supplies by geothermal contracting companies and personnel. Development of low-temperature geothermal resources for space heating, aquaculture, or spas will generate revenue through sales of those products. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the state and local economy.

3.1.5 SODIUM

Sodium is a nonrenewable leasable solid mineral resource. Sodium typically occurs as salt [halite] in marine evaporite sediment sequences of anhydrite ($CaSO_4$), gypsum ($CaSO_4 \cdot 2H_2O$) and halite (NaCl) or continental closed basin evaporite sediment sequences of anhydrite and halite. Late Tertiary evaporites of the Gila Group include bedded continental anhydrite and salt deposits that have been penetrated in oil and gas exploration wells and/or water wells drilled in the Luke, Higley, and Picacho Basins in the Planning Area (Eberly and Stanley 1978; Rauzi 2002) (refer to Map 5).

There is no active development or mining of sodium in the Planning Area. Sodium is being extracted by solution-mining in the northern part of the Luke Basin north of the Planning Area. The salt-saturated brine is discharged to evaporation ponds where it evaporates, and the salt is harvested for various commercial uses.

3.1.5.1 Known Occurrences and Prospects

Rauzi (2002) reports that salt has been penetrated in wells drilled in three Tertiary basins in the Planning Area: the Luke Basin, located in Maricopa County beneath Luke Air Force Base northwest of Phoenix; the Higley Basin, located in southeast Maricopa County beneath Mesa-Chandler-Gilbert; and the Picacho Basin, located in Pinal County between Coolidge and Casa Grande. Several other Tertiary Basins in the Planning Area have not been tested at depth. The Gila Bend, Growler, Harquahala, Maricopa-Stanfield, Rainbow, San Cristobal, Santa Rosa, and Tonopah Basins have geologic histories comparable to the salt-

bearing basins and it is anticipated that salt is present at depth in one or more of those basins (Nations et al. 1989; Rauzi 2002) (Map 5).

3.1.5.2 Leasing Activity

Regulations applicable to leasing of Federal minerals in the Planning Area include the Mineral Leasing Act of 1920, Mineral Leasing Act of 1947, Mining and Minerals Policy Act of 1970, and 43 CFR 3500. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning and BLM Manual Series 3500 – Federal Mineral Leasing.

Leasing of public land for sodium exploration and development is noncompetitive unless interest is expressed in the land following a public sale notice. A noncompetitive lease pays $1.00 per acre and is generally limited to a 640-acre lease. Competitive lease sales are by sealed bid following a sale notice. The BLM will establish "fair market value" as a minimum bid for the lease acreage. Leases are held for a 10-year term, or longer if proven commercially productive. Royalties may range from 10 to 15 percent of commercial sales.

Permitting for subsurface sodium exploration and drilling within the State is administered by the Arizona Oil and Gas Conservation Commission. A mining permit for reclamation is administered by the Arizona State Mine Inspector (ASMI).

There is no reported leasing or development activity for sodium resources in the Planning Area. Potential sites for sodium exploration and development are the Tertiary basins (Luke, Higley, and Picacho Basins) where proven sodium resources exist. The Gila Bend, Growler, Harquahala, Maricopa-Stanfield, Rainbow, San Cristobal, Santa Rosa, and Tonopah Basins also are potential areas for development even though the presence of salt deposits in those basins has not been established.

3.1.5.3 Resource Areas and Types

For the purposes of this report, a sodium resource area refers to an area characterized by known subsurface occurrences of salt deposits, or where geologic conditions are comparable to known areas of salt deposits. The type of sodium resource is limited to subsurface sedimentary salt deposits of late Tertiary age.

3.1.5.4 Mineral Economics

Conditions in the Tertiary basins are favorable for exploitation of the known sodium occurrences and exploration for new resources (Rauzi 2002). Exploitation likely will be focused on the three existing known salt deposits unless new drilling discovers sodium in one or more of the untested basins. Exploration and development may be limited by the expense of drilling and completing wells to tap into the salt deposits beneath the Planning Area.

Sodium exploration and development provide economic benefits to Federal, State, and local governments as well as to the public. Annual lease rent and royalties on sales of sodium resources may generate limited revenue to the general fund of the surface/mineral owner. The local economy also may benefit through additional jobs and purchase of goods and services such as food, lodging, and supplies by contracting companies and personnel. Development of sodium resources will generate revenue through sales of produced materials. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the state and local economy.

3.1.6 SOLAR ENERGY

A recent report prepared by the U.S. Department of Energy (DOE 2003a) in cooperation with the BLM identified the Planning Area as having a large total land area for high-potential concentrating solar power and/or photovoltaic sites. Solar energy is a renewable energy resource that has excellent potential for generating electricity in Gila, Maricopa, Pima, Pinal, and Yuma Counties. Installation of solar energy facilities on public lands requires a right-of-way permit instead of a lease. Rental costs may range from $1,000 per year or more depending on the permitted acreage.

Electricity is generated when sunlight contacts a photovoltaic cell that transforms solar energy to electricity. Solar energy resources are classified based on the amount of solar radiation that contacts the ground surface in a specified area. Solar radiation is measured in units of watt-hours per square meter per day ($Wh/m^2/day$). The amount of solar energy resource available at a specific location varies with the latitude of that location, the season, and the time of day.

3.1.6.1 Known Occurrences and Prospects

Solar energy resource maps (Maps 6 and 7) were prepared by the DOE National Renewable Energy Laboratory (NREL) (DOE 2001a, 2003a). In addition to varying by latitude, season, and time of day, the amount of solar radiation available at known occurrences of solar energy resources is dependent on the type of collector used. The two basic designs of solar collectors are flat-plate collectors and solar concentrators. The annual average solar radiation throughout Arizona is relatively uniform at 8,000 to 10,000 $Wh/m^2/day$ for a flat-plate collector and 6,000 to 7,000 $Wh/m^2/day$ for solar concentrators.

The flat-plate collector is a fixed panel containing photovoltaic cells or solar water heaters. The flat-plate panels collect sunlight and convert it to electricity or heat. The flat panel is installed where no obstructions will block sunlight from reaching the panel. A flat-plate collector generally receives the most sun when it is tilted towards the south at an angle equal to the latitude of the location. The solar energy resource available to a north-south axis tracking flat-plate collector tilted at latitude is shown on Map 6.

The solar concentrator is a flat panel of photovoltaic cells or a concave arrangement of mirrors that concentrate sunlight onto a collector. The concentrator is attached to a motor-driven tracking mechanism. It is installed where no obstructions will block sunlight from reaching the concentrator, and uses the tracking mechanism to follow the sun as it crosses the sky each day. The tracking mechanism adjusts for seasonal variations in the Sun's azimuth and allows the solar concentrator to collect the maximum amount of direct sunlight. The flat-plate collector is more effective at collecting solar radiation than the solar concentrator. The solar energy resource available to a north-south axis tracking solar concentrator tilted at latitude is shown on Map 7.

Commercial solar generating stations have been constructed and operated in Arizona and other states, particularly in desert locations. Existing solar array technology can place approximately 125 to 150 kilowatts of photovoltaic cells per acre. Such an array will generate 250 to 300 megawatt-hours of electricity per year (Arizona Public Service 2002; GlobalSolar 2002).

3.1.6.2 Right-of-Way Permitting Activity

Regulations applicable to solar arrays on public lands in the Planning Area include the Federal Land Policy and Management Act of 1976 (FLPMA) and 43 CFR 2800 – Public Lands: Interior: Rights of Way, Principles and Procedures. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning and BLM Manual 2801 – Rights-of-Way.

There is no established guidance for procedures to install solar energy arrays on BLM-administered land. However, it is anticipated that use of BLM-administered land must be authorized by application for a right-of-way permit at the appropriate BLM Field Office in accordance with BLM Instruction Memorandum No. 2002-011. If sufficient interest is recognized for a specific area, then competitive bidding may be required for a right-of-way permit.

There is no reported right-of-way permitting activity on public lands for the testing or exploitation of commercial-scale solar resources in the Planning Area.

3.1.6.3 Prospective Areas and Types

For the purposes of this report, a solar energy prospective area refers to a solar energy resource area characterized by the amount of solar radiation collectable by either of the two types of collectors described above. The solar energy resources in the Planning Area are considered adequate for generating electricity using photovoltaic cells (DOE 2001a, 2003a).

Based on the use of flat-plate collectors to generate electricity, the entire Planning Area is considered a solar energy resource area. The solar energy resource for a flat-plate collector ranges from 8,000 to 10,000 $Wh/m^2/day$.

Based on the use of solar concentrators to generate electricity, the entire Planning Area is considered a solar energy resource area. The solar energy resource for a solar concentrator ranges from 6,000 to 7,000 $Wh/m^2/day$.

3.1.6.4 Resource Economics

As shown above, solar energy is a viable resource throughout the Planning Area. However, current costs to generate electricity using solar energy are more expensive, generally 25 to 50 cents per kilowatt-hour, and not competitive with conventional generation methods (Federal Energy Management Program [FEMP] 2003). Development of solar energy resources requires capital expenditures for research to develop efficient solar collectors and energy storage facilities, leasing of suitable land for siting commercial size collection systems, and construction of power transmission lines to the customer or to an existing power network (Wentz 2002).

Research and development to design efficient solar collection systems continues to progress with funding by the energy industry and DOE. In fact, Congress is planning to increase levels of funding for research on renewable energy resources to help reduce dependence on foreign oil imports. As more efficient solar collectors are developed, and with possible government subsidies or tax breaks for clean energy sources, the incentive for using solar energy resources should increase.

Development of renewable solar energy resources provides economic benefits to Federal, State, and local governments as well as to the public. Annual rent for right-of-way permits and annual rent for commercial production of solar energy will generate revenue to the surface/mineral owner. The local economy also may benefit through additional jobs and purchase of goods and services such as food, lodging, and supplies by commercial solar energy companies and personnel. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the State and local economy.

3.1.7 WIND ENERGY

Wind energy is a renewable energy resource that has excellent potential for generating electricity. Wind resources are classified based on the typical wind speed measured at a location or area. The wind power classification developed by the NREL establishes seven wind classes based on the wind power density at a height of 50 meters, measured in watts per square meter (W/m^2). Wind power classes range from lowest (Class 1) to highest (Class 7). Wind power is considered economic for large turbines (commercial utilities-scale) at Class 3 and higher, although a small noncommercial turbine can be used at Class 1. Wind resources for Arizona are shown on Map 8. Installation of wind energy facilities on public lands requires a right-of-way permit instead of a lease. Rental costs may range from $50 per tower installation up to $1,000 per year or more depending on the permitted acreage.

3.1.7.1 Known Occurrences and Prospects

Map 8 was prepared by the DOE NREL (DOE 2003b). The map shows that there are five wind power classes available in the Planning Area: Class 5, Class 4, Class 3, Class 2, and Class 1. Values are estimates of wind power at ridge crest locations where the local relief is greater than 1,000 feet. The areas having the highest wind power class correspond to areas of higher elevation and higher relief as well as higher wind velocity. The general locations for each wind power class in the Planning Area are as follows:

- **Class 5** – includes the uppermost peaks of the Superstition, Goldfield, Sierra Estrella, Baboquivari, Quijotoa, Sierra Blanca, Mazatzal, and western Pinal Mountains. Wind energy resources range from 500 to 600 W/m^2 at a turbine elevation of 50 meters.
- **Class 4 –** includes the upper elevations of the Superstition, Goldfield, Sierra Estrella, Baboquivari, Quijotoa, Sierra Blanca, Mazatzal, and western Pinal Mountains; and the uppermost peaks of the Growler, Ajo, Agua Dulce, Comobabi, Santa Rosa, Santan, Maricopa, and Gila Bend Mountains. Wind energy resources range from 400 to 500 W/m^2 at a turbine elevation of 50 meters.
- **Class 3** – includes the middle to upper elevations of the above-mentioned mountains and the remaining moderately elevated locations in the Planning Area. Wind energy resources range from 300 to 400 W/m^2 at a turbine elevation of 50 meters.
- **Class 2 –** includes the lower to middle elevations of the above-mentioned mountains and the remaining elevated locations in the Planning Area. Wind energy resources range from 200 to 300 W/m^2 at a turbine elevation of 50 meters.
- **Class 1** – includes the low-lying areas on the desert floor and between mountain ranges. Wind energy resources are less than 200 W/m^2 at a turbine elevation of 50 meters.

Commercial wind generating facilities are operating in other states. The San Gorgonio Pass wind resource area near Palm Springs, California has more than 1,500 wind turbine towers that can generate in excess of 588 megawatts. That resource area has an electricity output of more than 805 kilowatt-hours (American Wind Energy Association 2002). One wind turbine tower occupies approximately one acre of land and can generate 100 to more than several hundred kilowatts depending on the size of the turbine. In addition, most of the ground surface around the towers may be available for other uses, such as farming or grazing.

3.1.7.2 Right-of-Way Permitting Activity

Regulations applicable to wind farms on public lands in the Planning Area include FLPMA and 43 CFR 2800 – Public Lands: Interior: Rights of Way, Principles and Procedures. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning, BLM Manual 2801 – Rights-of-Way, and BLM Instruction Memorandum No. 2002-020 – Interim Wind Energy Development Policy.

Wind energy site testing, monitoring, and development on BLM-administered public land is authorized by application for a right-of-way permit at the appropriate BLM Field Office. If sufficient interest is recognized for a specific area, then competitive bidding may be required for a right-of-way permit.

At this time, there are no monitoring sites, commercial operations, or permitting activity reported in the Planning Area. Wind energy still is in the research stage in Arizona.

3.1.7.3 Prospective Areas and Types

For the purposes of this report, a wind energy prospective area refers to a wind energy resource area as characterized by the wind power class ratings described above. Areas of Class 3 or greater are considered usable for generating wind power with large turbines (DOE 2001b). Based on the nonindustrial use of small turbines to generate electricity, the entire Planning Area is considered a wind resource area. Based on the industrial use of large turbines to generate electricity, there are several wind energy resource areas in the Planning Area:

- The Class 4 and 5 wind energy resource areas incorporated in the upper elevations of the Baboquivari, Goldfield, Mazatzal, western Pinal, Quijotoa, Sierra Estrella, Sierra Blanca and Superstition Mountains.
- The Class 3 wind energy resource area incorporated in the moderate elevations of the desert mountains of Maricopa, Pima and Pinal Counties in southern Arizona.

3.1.7.4 Resource Economics

As shown above, the Planning Area has several areas where wind energy resources can be exploited. Current costs to generate electricity using wind energy range from 4 to 30 cents per kilowatt-hour depending on the size of the wind turbines and the grid setup of the wind farm (FEMP 2003). Development of wind energy resources requires capital expenditures for research to develop efficient wind turbines, turbine and grid design and construction, purchasing or leasing of suitable land for siting wind turbines, siting studies, and construction of power transmission lines to the customer or to an existing power network (Wentz 2002). Research and development to design efficient turbines continues to progress with funding by the energy industry and DOE. As more efficient and low-cost turbines come on the market, and with possible government subsidies or tax breaks for clean energy sources, the incentive to construct and operate wind energy generating facilities will become competitive with conventional power generating facilities.

Development of renewable wind energy resources provides economic benefits to Federal, State and local governments as well as to the public. Annual rent for right-of-way permits and annual rent for commercial production of wind energy will generate revenue to the surface/mineral owner. The local economy also may benefit through additional jobs and purchase of goods and services such as food, lodging and supplies by commercial wind energy companies and personnel. The State realizes additional

revenue from taxes on those sales. The above benefits have a net positive impact on the State and local economy.

3.2 LOCATABLE MINERALS

Locatable minerals are defined as those minerals that make the land more valuable because of their existence, are recognized as a mineral by the standard experts, and are not subject to disposal under some other law. Most solid minerals are locatable, but due to complexities in the law there are exceptions (such as leasable coal, potash, sulfur, and sodium). Locatable minerals include both metallic minerals (e.g., gold, silver, lead, uranium) and nonmetallic minerals (e.g., gemstones, kaolin, fluorspar, perlite). Locatable minerals can be obtained by filing a mining claim and can be extracted by mining or quarrying methods.

3.2.1 METALLIC LOCATABLE MINERALS

The Planning Area has many locales historically designated as mineral districts, as shown on Map 9. Metallic mineral districts are listed in Table 3 (Keith et al. 1983; Niemuth 2003; Welty et al. 1985). Within the Planning Area there are five metallic mineral districts in Gila County, one district in Yuma County, 11 districts in Maricopa County, 23 districts in Pinal County, and 25 districts in Pima County. Three areas not listed by Keith et al. (1983) and Welty et al. (1985), but recognized as metallic mineral districts by the Arizona Department of Mines and Mineral Resources [ADMMR] (Niemuth 2003), also are shown on Table 3.

Detailed historical reviews of mineral exploration and development in the Planning Area by the Arizona Bureau of Geology and Mineral Technology [now the Arizona Geological Survey] and ADMMR have documented metallic mineral commodity types and production data for 55 of the 65 mineral districts (Keith et al. 1983; Niemuth 2003; Welty et al. 1985). Most of the mineral districts have been mined historically and are no longer active; eight are known prospects that have not been mined (Keith et al. 1983). Commodities historically produced by each mineral district are posted on Map 9 as a mineral assemblage classification and presented in Table 3. Production data through 1982 are from Keith et al. (1983). Production data from 1982 through 2002, where available, were provided by Niemuth (2003).

Area-specific mineral resource assessments have been completed for portions of the Planning Area: Miller (1979) evaluated mineral resources for the Luke Air Force Range, which included the southwestern portion of the Planning Area. Krason et al. (1982) conducted a mineral resource assessment for the Maricopa and Table Top Mountains, which are part of the SDNM. A mineral potential report was completed for the Barry M. Goldwater Range land withdrawal by Geraghty and Miller, Inc. (1998).

3.2.1.1 Known Occurrences and Prospects

Map 9 shows the locations of 65 mineral districts in the Planning Area, of which 55 have production data (Keith et al. 1983; Niemuth 2003; Welty et al. 1985). Eight of these districts are known prospects and have not been mined, or there is no current information on their production. Table 3 lists each district name and known aliases, the commodities (metallic minerals) that have been mined from the district, the dates the mineral district was active, commodities that are present but have not been mined (prospects), production tonnage (or ounces of precious metals), and the classification of the deposit that characterizes each district.

The locations of known occurrences and prospects for locatable minerals are too numerous to discuss on an individual basis. Instead a map and table of known occurrences and prospects for the Planning Area has been prepared (Map 10 and Table 4). The U.S. Geological Survey [USGS] Mineral Resource Data System [MRDS] lists 399 mine sites in the Planning Area (USGS 1999). Those mine sites are listed on Table 4 and include site name; county; mineral district; mine location by latitude, longitude and mountain range; commodity; age; and formation name, where known. The mine sites are posted on Map 10.

Rocks exposed in the mineral districts range from Middle Proterozoic (Precambrian) to Quaternary. Geologic formations or rock types reported to be present in the mineral districts are listed in Table 4 and presented below.

Precambrian rocks in the mineral districts include metamorphic and plutonic rocks younger than 1,750 million years old. Regional metamorphic rocks such as the Pinal Schist and Estrella Gneiss may host mineral deposits where contacted by local intrusive plutons such as the Madera Diorite, Four Peaks Granite, Komatke Granite, and Maricopa Granite, and associated dikes. Volcanic flows, tuffs, diabase, and volcaniclastic sedimentary rocks of the Precambrian Union Hills Group and Apache Group are present in some mineral districts. Conglomerates and quartzites that dominate the sedimentary sequences of the Alder Group, Apache Group, and Mazatzal Group also host mineral deposits. The Pioneer Shale and Mescal Limestone often host mineral deposits where intruded by plutonic rocks and dikes.

Paleozoic rocks in the mining districts are of Cambrian, Devonian, Mississippian, Pennsylvanian, and Permian age. Cambrian sedimentary rocks include the Bolsa Quartzite and carbonates of the Abrigo Formation. Mineral deposits are found in Late Devonian Martin Formation sandstones and dolomites. Mississippian rocks include the Escabrosa Limestone. Pennsylvanian rock groups include limestones and sandstones of the Naco Group, and Pennsylvanian undivided rocks. Permian rock groups that host mineral deposits include limestones and red bed clastics of the Scherrer Formation, Concha Formation, and San Andreas Limestone.

Mesozoic rocks in the mineral districts are of Jurassic and Cretaceous age. Jurassic rocks include extensive plutonic intrusions, and volcanic flows, tuffs and volcaniclastics of the Fresnal Canyon and Artesa Sequences. Late Cretaceous to Early Tertiary volcanic and intrusive rocks host porphyry copper deposits. Mineral resources may be found in mineralized veins and dikes associated with Laramide intrusive rocks.

Tertiary rocks are of Paleocene, Oligocene, Miocene, and middle Quaternary age. Tertiary rocks include early to middle Tertiary volcanic flows, ash-flow tuffs and pyroclastics; Paleocene sedimentary rocks; Paleocene to Oligocene coarse-grained volcaniclastic sedimentary rocks; Miocene tuffs, ash flows, and volcaniclastic conglomeratic rocks; Pliocene basin-fill sedimentary rocks including evaporite deposits in Tertiary basins.

Quaternary rock groups include piedmont alluvial deposits, basin-fill sedimentary deposits, landslide deposits, colluvium, and alluvium.

Several rock types listed above are intruded locally by silicic to felsic plugs and dikes, some of which are associated with epithermal vein formation.

Active metallic mineral mines reported in the Planning Area include four copper mines and one silver mine (Phillips et al. 2002; ASMI 2002). The silver mine is the Silver King Mining, LLC - Silver King Mine (Reference #353), in Pinal County. The four copper mines are:

- BHP Copper – Pinto Valley/Miami Unit (Reference #364), in Gila County.
- Carlota Copper Company – Carlota Mine (Reference #215), in Gila County.
- Phelps Dodge Corporation – Ajo Mine (Reference #10), in Pima County.
- Phelps Dodge Corporation – Miami Mine (Reference #214), in Gila County.

3.2.1.2 Mineral Claims Activity

Regulations applicable to metallic mineral claims on public lands in the Planning Area include the General Mining Law of 1872, FLPMA, 43 CFR 3700 – Multiple Use; Mining, and 43 CFR 3800 – Mining Claims under the General Mining Laws. Policy/guidance specific to the BLM include BLM Manual 1601 – Land Use Planning and Instructions, BLM Handbook H-3042-1 – Solid Minerals Reclamation Handbook, and BLM Manual Sections 3700 and 3800.

Notification is not required to casually prospect on public lands that are open to mineral entry. Notification to the BLM is required 15 days prior to notice-level work, wherein exploration will cause unreclaimed surface disturbance to less than five acres of public land. A plan of operations and approval is required for other than casual use or notice-level operations. A claim is staked for a locatable mineral and recorded at the appropriate county office and BLM State Office.

3.2.1.3 Mineralized Areas and Types

Metallic and nonmetallic mineralized areas in the Planning Area are designated as mineral districts (refer to Map 9; Table 3). There are 65 mineral districts encompassing areas where prospects for mineral resources are located and/or mining has been conducted. Different geologic conditions and mechanisms of mineralization can account for the metallic mineral assemblages found in the Planning Area. Each mineral district is classified by the primary mineral assemblage and type of mineralization present in the district. These classifications or mineralized types include porphyry-copper deposits associated with granitic intrusions, volcanic-epithermal deposits, vein and pegmatite deposits, vein/replacements, and sedimentary deposits (Keith et al. 1983).

Metallic mineral resources in 21 mining districts in the Planning Area formed as porphyry-copper deposits (Type 1a) associated with granitic intrusion activity during the Late Cretaceous-Early Tertiary Laramide orogeny (Keith et al. 1983). Porphyry-copper deposits formed when hot groundwater and metal-rich fluids released from cooling magma interacted with rocks adjacent to the intrusion. The host rock was chemically altered and enriched in copper and other metals, such as gold, lead, silver, molybdenum, manganese, and zinc. Mineral districts that have a disseminated copper-dominated mineralized type (1a) include the Miami-Inspiration, Globe Hills, Ajo, Vekol, and Mineral Creek/Ray. The southern Maricopa Mountains have several occurrences of copper (Krason et al. 1982).

The Ajo Cornelia District contains primarily stratabound copper deposits (Type 1b) formed during Late Cretaceous-Early Tertiary time.

Keith et al. (1983) differentiated metallic mineral resources in vein deposits by the primary mineral content. Four mineral districts, such as the Estrella District (Wilson 1969), are primarily copper-rich vein deposits with or without gold or lead (Type 2). The age of formation for most of these districts is uncertain, and one is mid-Tertiary.

Thirteen districts are primarily gold-bearing vein deposits with or without copper or lead (Type 3), including Gila Bend Mountains, Goldfield, Salt River Mountains (South Mountain), and Superstition Mountains. Many of these districts were mineralized during middle Tertiary, while others were mineralized during the Laramide orogeny. The Quijotoa District (Type 3*) contains primarily gold-bearing vein deposit with silver and was deposited during early Tertiary.

There are 16 mining districts characterized by vein/replacement mineralization. Vein/replacement occurred when andesites, basalts, silicic, and felsic flows intruded the host rock through dikes, plugs, and fractures. As the volcanic rock intruded the parent rock, a combination of contact remineralization and the formation of epithermal veins occurred. Where the intrusive dike or plug intersected groundwater, fluids in the intrusive and the parent rock locally were boiled, cooled, and mixed. In the boiling and mixing reaction, remineralization occurred, for example, quartz after calcite in limestone. In-place mineral replacement, and fluid transport and formation of late-stage mineralization occurred, at which point the base and precious metals were formed.

Vein/replacement mineralized types include Type 4 for lead-zinc-silver, Type 4* for lead-zinc-silver with copper, Type 5 for primarily silver, and Type 5* for primarily silver with copper. Examples include the Painted Rock (4), Cababi (4*), Mineral Hill (5) and Mildred Peak (5*) Districts. The majority of these districts were mineralized during the Laramide orogeny and into the middle Tertiary.

Four mineral districts are characterized by primarily manganese deposits in veins (Type 6a). The Sawtooth and Cimarron Mountains Districts have produced manganese from several mines. The mineralization is early to middle Tertiary. Three districts have tungsten as the primary mineral in veins or pegmatites, or as skarn deposits in limestone (Type 8). The Four Peaks and Quinlan Districts contain rich deposits of tungsten. Tungsten deposits are generally determined to be Cretaceous-Tertiary age.

The Buckeye Hills District is recognized for uranium prospects (Type 10c) where the uranium mineralization is in veins or fissures. Uranium also is listed as primary metallic mineral in mines at three other Districts (refer to Table 4). At the Lobos Group mine in the Aguirre Peak District, uranium probably was found in shear zones in Late Cretaceous rhyolitic rocks. At the M & M Group mine in the Silver Reef District, uranium was likely found in Late Creteaceous vein systems associated with porphyry copper deposits. At the Boyle Group #1 and 2 mine in the Miami-Inspiration District, uranium is found in thin veins cut by diabase dikes into siltstones of the Precambrian Dripping Spring Quartzite. Wenrich et al. (1989) report that production from uranium mines in the Basin and Range Province are typically insignificant compared to those in the Colorado Plateau Province.

Several districts have deposits of iron (Type 11) or other minerals and remain unclassified (Type 12), such as the Midway District near Tonopah.

3.2.2 NONMETALLIC LOCATABLE MINERALS

Many of the mineral districts in the Planning Area historically have mined nonmetallic locatable minerals, including asbestos, barite, feldspar, gemstones, mica, perlite, silica, and industrial-grade limestone and clay. Prospects and locations that have mined nonmetallic minerals are included in Table 4 and shown on Map 10 (Keith et al. 1983; USGS 1999). Those nonmetallic locatable mineral locations and associated geologic deposits are summarized below.

3.2.2.1 Known Occurrences and Prospects

Asbestos mines are concentrated in the Globe Hills, Pinto Creek, Pioneer, San Carlos, and Wood Camp Canyon Districts in western Gila and eastern Pinal Counties. The host rock for asbestos is slightly altered Precambrian Mescal Limestone.

Barite is mined in the Cababi District in Pima County, the Goldfield and Webb Districts in Maricopa County, and the Summit District in Gila County. The host rock for barite ranges from Precambrian Pinal Schist to Tertiary volcanic and sedimentary rocks.

Feldspar, mica and quartz are mined from a wide variety of locations, including the Buckeye Hills District in Maricopa County, Salt River Mountains Districts in Pinal County, and Pinal Mountains District in Gila County. Host rock types include porphyry granites and coarse-grained pegmatites having ages ranging from Precambrian to early Tertiary.

Gemstones include amethyst from Four Peaks District Precambrian Mazatzal Group quartzites and conglomerates, and turquoise from the Pinal Mountains District porphyry copper deposits of Late Cretaceous-Early Tertiary age. The ADMMR lists the Arnett Rhyolite in the Superior District as a source for unnamed gemstones (refer to Table 4).

Gypsum is mined in the Sauceda Mountains in Maricopa County from outcrops of Tertiary lacustrine and evaporite sediments.

Perlite mines or prospects are located in the Buckeye Hills District in Maricopa County, and the Mineral Hill, Pioneer, Silver Reef, Superior, and Wood Camp Canyon Districts in Pinal County. These mines extract perlite from the Tertiary Arnett Rhyolite or equivalent volcanic rocks.

Silica is mined in the Ajo, Baboquivari, Casa Grande, Growler, Mineral Hill, Quijotoa, Slate, and Waterman Districts throughout the Planning Area. Silica is mined from quartz-rich sedimentary rocks, such as the Precambrian Dripping Spring and Troy Quartzites, and the Cambrian Bolsa Quartzite, as well as Late Cretaceous to Early Tertiary intrusive dikes.

Industrial-grade **limestone** and **clay** deposits are located in the Goldfield and McDowell Districts in Maricopa County, Miami-Inspiration and Pinal Mountains Districts in Gila County, and at several mine sites outside the established mineral districts.

Active nonmetallic mineral mines in the Planning Area are documented by the ASMI (2002) and Phillips et al. (2002), and include:

- Clinton-Campbell Contracting Inc. – Tolleson Mine (clay) (Reference #373), in Maricopa County [no district].
- Four Peaks Mining – Four Peaks Mine (amethyst) (Reference #384), in Maricopa County [Four Peaks District].
- Harborlite Corporation – Superior Perlite Mine (perlite) (Reference #425), in Pinal County [Superior District].
- Kessen and Kessen – Copper Hill Mine (silica) (Reference #400), in Gila County [Globe Hills District].

- Kessen and Kessen – Cyprus Lime Quarry (lime) (Reference #469), in Gila County [Globe Hills District].
- McKusick Mosaic – Weary Lode Mine (clay) (Reference #383), in Pinal County [Pinal Mountains District].
- OMYA (Arizona) Inc. – Queen Creek Marble Quarry (calcium carbonate) (Reference #354), in Pinal County [Pioneer District].
- Sleeping Beauty Turquoise – Sleeping Beauty Mine (turquoise) (Reference #364), in Gila County [Miami-Inspiration District].

3.2.2.2 Mineral Claims Activity

Regulations applicable to nonmetallic mineral claims on public lands in the Planning Area include the General Mining Law of 1872, FLPMA, 43 CFR 3700 – Multiple Use; Mining, and 43 CFR 3800 – Mining Claims under the General Mining Laws. Policy/guidance specific to the BLM include BLM Manual 1601 – Land Use Planning and Instructions, BLM Handbook H-3042-1 – Solid Minerals Reclamation Handbook, and BLM Manual Sections 3700 and 3800.

Notification is not required to casually prospect on public lands that are open to mineral entry. Notification to the BLM is required 15 days prior to notice-level work, wherein exploration will cause unreclaimed surface disturbance to less than five acres of public land. A plan of operations and approval is required for other than casual use or notice-level operations. A claim is staked for a locatable mineral and recorded at the appropriate county office and BLM State Office.

3.2.2.3 Mineralized Areas and Types

Metallic and nonmetallic mineralized areas in the Planning Area are designated as mineral districts (refer to Map 10). Mining districts are areas where prospects for mineral resources are located and/or mining has been conducted. Different geologic conditions and mechanisms of mineralization can account for the types of nonmetallic minerals found in the Planning Area. These mineralized types include Precambrian to Paleozoic limestones, Precambrian to early Tertiary granites and pegmatites, Precambrian to Paleozoic quartzites, and sedimentary limestone and quartzite deposits.

Asbestos is commonly found in the Precambrian Mescal Limestone. It formed where the Mescal Limestone was silicified prior to metamorphism by intrusion of diabase dikes and subsequently reacted with chert to form calcium-magnesium silicate minerals. Asbestos-bearing serpentine zones were formed as a replacement product of the silicate minerals (Wrucke et al. 1986). Asbestos deposits are found in several mineral districts within the Pinal and Superstition Mountains region including the Pinto Creek, Globe Hills, Miami-Inspiration, Pioneer, and San Carlos Districts (refer to Map 10 and Table 4).

Feldspar, mica, and quartz minerals are commonly found in Precambrian to Tertiary granites and pegmatite intrusive rocks. These minerals are used for a wide variety of industrial applications. Deposits of these mineral resources are located in several districts in the Planning Area that are close to industrial areas, including the Salt River Mountains, Buckeye Hills, Pinal Mountains, Casa Grande, and McDowell Districts (refer to Map 10 and Table 4).

Silica is used as a flux for processing ores and other industrial processes. Quartz-rich deposits are found in sedimentary quartzites and granitic pegmatite dikes. Silica is mined in many districts where the sedimentary Precambrian Dripping Spring and Troy Quartzites, and Cambrian Bolsa Quartzite outcrop.

Industrial-grade calcium carbonate and lime are used in many industrial processes. The Planning Area contains several limestone deposits that are mined for these resources, including the Devonian Martin, Mississippian Escabrosa, and Pennsylvanian Naco Limestones. Deposits of these minerals have been mined in the Casa Grande, Globe Hills, Superstition, and Quinlan Districts.

Several sedimentary and volcanic-derived clay deposits have been developed for industrial and commercial applications, including drilling fluid additives, sealants, cosmetic additives, tiles, and structural products such as adobe bricks. Kaolin is a group of clay minerals including kaolinite, typically derived from the weathering of alkali feldspars and micas in granite. In the Planning Area, it is found as hydrothermal alteration of Tertiary volcanic tuffs and rhyolite porphyry, or in sedimentary deposits. Clay deposits are reported in the Goldfield, Miami-Inspiration, and McDowell Mountains Districts, and are actively mined in the Pinal Mountains District.

Perlite is a volcanic glass with a high water content that is derived from high-silica rhyolite lava. Perlite is mined from the Tertiary Arnett Rhyolite in several mineral districts near Superior, including the Pioneer, Mineral Hill and Wood Camp Canyon Districts, and from the Silver Reef and Buckeye Hills Districts. When heated, perlite expands to many times the original volume, creating glass foam. Perlite is used in horticulture, lightweight construction material, and as a shipping material (refer to Map 10 and Table 4).

3.2.3 MINERAL ECONOMICS

Most of the metallic and nonmetallic locatable mineral resources present in the Planning Area (refer to Table 4) are not being actively mined. Economic factors contributing to the lack of mining activity for those resources probably include one or more of the following: the assayed or mineralized value of the deposits; current market demand for those resources; and/or expenses for mining, processing, and transport of the mineral products. Mining of any of these mineral resources could commence if one or more of these factors change the economic value of the resource.

Development of locatable mineral resources provides economic benefits to Federal, State, and local governments as well as to the public. Annual rentals for mining claims generate limited revenue. There are no royalties or fees paid to the Federal minerals owner for the sale of locatable minerals extracted from a mineral claim. However, reclamation costs to reclaim public lands at the completion of mining activities are necessary. At this time, there is a moratorium on mineral patent applications. The local economy may benefit through jobs and purchase of goods and services such as food, lodging, and supplies by mining companies and personnel. The State realizes additional revenue from taxes on those sales. The benefits described above have a net positive impact on the State and local economy.

3.3 SALABLE MINERALS

Since 1955, BLM defines common varieties of sand, gravel, stone, pumice, pumicite, cinders, and ordinary clay as salable, not locatable (BLM 1997). Salable minerals include materials used for building and construction, both commercially and privately. Sand, gravel, aggregate, lime (limestone), cinders, and building stone are the more common salable minerals. Use of salable minerals from public land requires either a sales contract or a free-use permit. Sales are at the appraised fair-market value. Under a free-use permit, salable minerals may be provided at no cost to government agencies for use in public projects.

3.3.1 KNOWN OCCURRENCES AND PROSPECTS

The locations of known occurrences and prospects for salable minerals are too numerous to discuss on an individual basis. Instead a map and table of known occurrences and prospects for the Planning Area has been prepared (Map 11 and Table 5). The significant salable mineral occurrences in the Planning Area include:

- Sand and gravel pits located adjacent to or near the major river channels of the Agua Fria River, Queen Creek, Salt River, and Gila River, including the reaches of the Salt and Gila Rivers on tribal land (Resource Science, Inc. [RSI] 2000). Sand and gravel are commonly used for construction, although some sand deposits of superior quality may be used for silica/slag flux.

- Decorative rock and dimension stone quarries and pits located throughout the Planning Area, but primarily sited within a reasonable distance from markets to reduce transportation costs (Headquarters West 1998). Decorative rock varies in market demand depending on the weathering, color and grain size, and is used primarily for landscaping. Dimension stone includes granite, marble and flagstone blocks and slabs, and varies in market demand depending on color, size and durability.

- One cinder/pumice pit near Florence. Cinders are used for construction of cinder blocks and as an application for icy roads.

A search of Case Recordation files on the BLM Land and Mineral Records LR 2000 database identified 16 BLM salable mineral pits in the Planning Area. Those pits are listed in Table 5 and shown on Map 11. Table 5 lists the BLM pits by the corresponding Arizona six-digit BLM ID number (i.e., AZA----012345); the pit sales designation; commodity; type of deposit; and location by county, latitude, and longitude. Although not provided in Table 5, the LR 2000 also reports the name and address of the permittee, the volume and sales price of the commodity produced, and sales activity for the pit. Sand and gravel pits are distinguished from decorative rock pits on Map 11 using different color symbols.

The USGS MRDS lists 94 salable mineral mine sites in the Planning Area (USGS 1999). Those mine sites are listed on Table 5 and, where known, include site name; county; mine location by latitude and longitude; commodity; age; formation name; and type of deposit. The mine sites are posted on Map 11. It is unclear whether some of the clay and limestone deposits listed in the MRDS are locatable or salable minerals. Those deposits are posted on both Map 10/Table 4 and Map 11/Table 5, as locatable and salable mineral resources, respectively.

Also included in Table 5 and shown on Map 11 are active commercial pits, quarries, and mines listed by Phillips et al. (2002). Where provided, those locations are cross-referenced with MRDS locations. Many salable mineral resource locations are listed in the annual report prepared by ASMI (2002), but no locations are provided to cross reference with data provided by the MRDS.

The Arizona Department of Transportation (ADOT) has historical maps and data tables for each county describing the location and type of construction material sources (pits or prospects) adjacent to or near public roads for road construction. URS Corporation (URS) contacted the ADOT Materials Group to examine those documents applicable to the Planning Area. ADOT has records for more than 8,000 material pits in the State, but many of the pits are no longer used. Most of ADOT's active pits are located on Federal or fee land in rural areas where there are no commercial operations (RSI 2000). The following documents were reviewed:

- ADOT Construction Material Sources for Gila County, dated 1961, 30 pages
- ADOT Construction Material Sources for Maricopa County, dated 1977, 88 pages
- ADOT Construction Material Sources for Pima County, dated 1963, 32 pages
- ADOT Construction Material Sources for Pinal County, dated 1964, 65 pages
- ADOT Construction Material Sources for Yuma County, dated 1962, 29 pages.

Data for ADOT construction material sources in Maricopa County are available in digital format from the USGS (2001). Data for the other four counties enclosing the Planning Area are not digitized. After reviewing the above documents, URS estimated that more than 3,000 construction material source locations are shown on the ADOT maps and tables. However, because the documents are more than 25 years old it is uncertain which ADOT pits remain active. RSI (2000) reports that many ADOT pits formerly were located on State Trust Lands and are no longer used. Because of this uncertainty and due to space limitations, the ADOT construction material pit locations are not posted on Map 11.

Several of the pits, quarries, and prospects listed by the BLM LR 2000 and Phillips et al. (2002) are Quaternary alluvial deposits consisting of unconsolidated sand and gravel in river channels and/or adjacent to major public roads. Other potential prospects for sand, gravel, and aggregate may include Quaternary sand and gravel deposits not listed in those references. Quaternary geologic formations described on the geologic map (refer to Map 2) as alluvial sand and gravel, colluvium, and eolian sand are identified on Map 11 by a cross-hachured pattern and designated as having high potential for development as salable mineral materials.

Because most granitic and volcanic rocks have high potential for development as salable mineral materials, outcrops of those rock types are identified on Map 11 by a cross-hachured pattern. The age of those rocks was not considered a limiting factor to development, so volcanic and granitic rocks ranging from Precambrian to Tertiary are included as potential salable minerals.

Sedimentary rocks, such as limestone and Quaternary-Tertiary shale, sandstone and conglomerate, have moderate potential for development as salable mineral materials. Localized occurrences of specialty stone, such as granite, cinders and flagstone, typically are associated with outcrops of consolidated rock. These outcrops also have moderate potential for development as salable mineral materials. Locations for salable minerals of moderate potential are identified by a hachured pattern on Map 11.

3.3.2 SALABLE MINERAL ACTIVITY

Regulations applicable to salable minerals on public lands in the Planning Area include the General Mining Law of 1872, Mineral Leasing Act of 1947, Mineral Materials Act of 1947, Mineral Materials Act of 1955, and FLPMA, and 43 CFR Part 3600. Policy/guidance specific to BLM include BLM Manual 1601 – Land Use Planning, BLM Handbook H-3042-1 – Solid Minerals Reclamation Handbook, and BLM Manual and Handbook 3600.

Use of salable minerals from BLM-administered lands requires either a sales contract or a free use permit from the appropriate BLM Field Office. The contract or permit may have stipulations on multiple land use. Disposals of salable minerals from BLM-administered lands are regulated by 43 CFR Part 3600.

3.3.3 MINERAL AREAS AND TYPES

Salable mineral resources obtained from Quaternary alluvial sediments typically are found in active and former stream channels, floodplains, washes, and alluvial fans where they were deposited by streams and floods. Mineral types associated with Quaternary alluvial sediments include the following:

- very fine- to very coarse-grained sand
- well-graded sand and gravel aggregate
- rounded river rock
- cobbles and boulders

Eolian sand dunes are a mineralized area having a mineral type that consists of clean, fine-grained sand of uniform size. Some salable mineral resources may be obtained from talus slopes or rock falls. Mineral types associated with these mineral areas include small to large, angular cobbles and boulders of volcanic or intrusive rock that can be crushed to obtain construction materials of a specific size range, or that have a specific mineral composition needed for construction.

3.3.4 MINERAL ECONOMICS

The demand for salable mineral resources is a function of market preferences and construction activity, and depends on where the construction activity is taking place. Transportation costs for sand and gravel aggregate can be minimized by using a salable mineral source close to a construction site. It is likely that construction projects will prefer using mineralized areas close to public roads. Development of salable mineral resources provides economic benefits to Federal, State and local governments as well as to the public. Use of salable minerals under a sales contract at fair market value will generate revenue to the surface/mineral owner. Reclamation costs to reclaim public lands at the completion of salable mining activities also are necessary. The local economy may benefit through jobs and purchase of goods and services such as food, lodging and supplies by mining companies and personnel. The State realizes additional revenue from taxes on those sales. The above benefits have a net positive impact on the State and local economy.

4.0 POTENTIAL FOR OCCURRENCE OF MINERAL RESOURCES

This section presents a narrative of the potential for occurrence of energy and mineral resources in the Planning Area. The narrative references resource potential maps for each of the energy and mineral resources discussed above. The potential for occurrence of mineral resources is determined using guidance provided in BLM Manual 3031 – Energy and Mineral Resource Assessment. The manual sets standards for assessing, classifying, and reporting the potential for occurrence of mineral resources on lands managed by the BLM.

4.1 DEFINITION OF MINERAL RESOURCE POTENTIAL

The potential occurrence of a mineral resource is a prediction of the likelihood that the mineral resource will occur in a given area. The potential occurrence of a mineral resource includes both exploitable and potentially exploitable occurrences, and does not evaluate whether the mineral resource can be developed economically. The four categories of mineral potential, as defined in BLM Manual 3031, are as follows:

- O (no potential) – The geologic environment, inferred geologic processes, and lack of mineral occurrences do not indicate potential for accumulation of mineral resources.
- L (low potential) – The geologic environment and inferred geologic processes indicate low potential for accumulation of mineral resources.
- M (moderate potential) – The geologic environment, inferred geologic processes, and reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.
- H (high potential) – The geologic environment, inferred geologic processes, and reported mineral occurrences or valid geochemical/geophysical anomaly, and known mines or deposits [within the same type of geologic environment] indicate high potential for accumulation of mineral resources.

In addition to those four categories, within each mineral potential category the potential must be supported according to a level of certainty regarding the available data. The level of certainty is a measure of the report preparer's confidence in the data that were assessed. The four mineral potential categories are displayed on the mineral resource potential maps. The levels of certainty are annotated in the narrative of mineral resource potential using the letter designations described below, and are not displayed on the mineral resource potential maps:

- *A*: The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.
- *B*: The available data provide indirect evidence to support or refute the possible existence of mineral resources.
- *C*: The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.
- *D*: The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

4.2 LEASABLE MINERAL POTENTIAL

As discussed in Section 3.0, a map showing the known occurrences, prospects, and resource potential in the Planning Area was prepared for each leasable energy and mineral resource. Using those maps as a guide, the potential for each leasable energy and mineral resource is discussed below.

4.2.1 OIL AND GAS POTENTIAL

Oil and gas potential is allocated to areas that have the following characteristics:

- Source for hydrocarbons – for example, an organic-rich shale or coalbed that has attained a level of thermal maturity through burial or other heating mechanism such that oil and/or gas could be generated. These data generally are obtained by testing core or drill cuttings samples in a laboratory.
- Reservoir-quality rock – sandstone, limestone, or fractured rock having interconnected porosity and permeability into which oil and/or gas may migrate from the source rock and be trapped.
- Trapping mechanism that prevents oil and/or gas from migrating out of the reservoir-quality rock. Structural traps, stratigraphic traps, and faults are some common trapping mechanisms.
- Known deposits of oil and/or gas.

Areas having oil and gas potential are shown on Map 3. Using the criteria discussed above, no plays or basins in the Planning Area have high potential because there is no proven production from those areas.

The following basins or plays have moderate potential: the Cambrian-Mississippian Arizona-New Mexico Trough, the Early Cretaceous Chihuahua Trough/Bisbee Basin, and the Luke and Picacho Tertiary Basins (refer to Map 3). The level of certainty for those plays is *C* because there is direct evidence through oil and gas shows, source rock, and geologic structures of the possible existence of oil and gas mineral resources. It is important to note that plays or basins having moderate potential in the Planning Area may not necessarily have direct evidence of oil and gas shows within their corresponding areal boundaries. Oil and gas shows reported in correlative structures or continuations of those structures outside the Planning Area may contain oil and gas shows that provide sufficient evidence for the presence of oil and gas. For example, oil and gas shows in the Arizona-New Mexico Trough and Bisbee Basin outside the Planning Area provide sufficient evidence for the presence of oil and gas inside the Planning Area.

The remaining Tertiary Basins in the Planning Area also have moderate potential, but the level of certainty for those plays is *B*. The untested Tertiary Basins are given a moderate potential because it is anticipated that they have geologic structures, reservoir-quality sedimentary rocks, and source rock (evaporites) similar to that found in the Luke and Picacho Tertiary Basins, where oil and gas shows are reported (Nations et al. 1989). However, the level of certainty is reduced because there is no direct or indirect evidence that source rocks are present in those closed basins.

The remaining portions of the Planning Area have low potential because there is no proven production, reservoir-quality rock, oil or gas shows, and/or no evidence for source rock (refer to Map 3). The level of certainty for the western Gila Bend Mountains area is *B* because of reported oil and gas shows in two wells. However, there is insufficient reservoir-quality rock and geologic structure documented for that area to warrant a higher potential or level of certainty. The level of certainty for the remaining areas of low potential is *A* because there are insufficient data to evaluate those plays.

Areas with no potential occur where reservoir-quality rocks have been uplifted and exposed, or removed by erosion adjacent to the Precambrian basement outcrops (refer to Map 2). These areas are not annotated on Map 3 because the areal extent is generally too small to be distinguished at the scale of the oil and gas potential map. The level of certainty is *C* because oil and gas potentially could escape through the exposed surface of reservoir-quality rock or through extensive fractures in uplifted fault blocks or overthrusts. The presence of thermally mature petroleum source rock is uncertain in those areas for two reasons. First, the source rock may not have been buried deep enough to "cook" prior to uplift. Second, source rocks may have been altered thermally by high-temperature intrusive rocks during uplift.

4.2.2 CARBON DIOXIDE AND HELIUM POTENTIAL

CO_2/He potential is allocated to areas that have the following characteristics:

- A source for CO_2/He such as thick volcanic sequences that may have locally charged reservoir-quality sediments with CO_2. Volcanic rocks are prominent throughout the Planning Area but may not have the thickness and areal extent necessary to provide abundant CO_2 to reservoir-quality rocks.
- Reservoir-quality rock – sandstone, limestone, or fractured rock having interconnected porosity and permeability into which CO_2/He may migrate from the source area and be trapped.
- Trapping mechanism that prevents CO_2/He from migrating out of the reservoir-quality rock. Structural traps, stratigraphic traps, and faults are some common trapping mechanisms.
- Known production of CO_2/He.

Areas having CO_2/He potential are generally correlative with areas having oil and gas potential because those areas are known to have the necessary reservoir-quality rock and geologic structures (refer to Map 3). However, since there is no known production and no known shows of CO_2/He in the Planning Area, and the extent of a volcanic source for CO_2/He is uncertain, those areas have low potential. The level of certainty is *B* for those areas because no CO_2/He has been reported.

The remaining portion of the Planning Area has low potential for CO_2/He. The level of certainty is *A* because there is insufficient evidence for the presence of CO_2/He or evidence that sufficient source rock is available to have generated abundant CO_2.

Areas with no potential occur where reservoir-quality rocks have been uplifted and exposed, or removed by erosion adjacent to the Precambrian basement outcrops (refer to Map 2). These areas are not annotated on Map 3 because the areal extent is generally too small to be distinguished at the scale of the map. The level of certainty is *C* because CO_2/He potentially could escape through the exposed surface of reservoir-quality rock or through extensive fractures in uplifted fault blocks or overthrusts.

4.2.3 GEOTHERMAL POTENTIAL

The potential for geothermal energy resources ranges from high to low (refer to Map 5). High potential is located in regions having demonstrated geothermal resources in thermal wells. Those regions are convective resource areas characterized by low-temperature geothermal energy resources suitable for heating buildings, swimming pools or spas, or for agriculture or aquaculture. Those locations have a level of certainty of *D*.

Much of the Planning Area has moderate potential because of crustal thinning that occurred during Basin and Range extension. Isolated known occurrences of low-temperature geothermal resources are located in the intermontane basins, which have moderate potential (refer to Map 5). The level of certainty for moderate geothermal resources is *B* because for most of the area there are only isolated occurrences of geothermal resources.

The mountainous areas in the Planning Area have low geothermal resource potential because there are no known occurrences. The level of certainty for low geothermal resources potential is *A* because the absence of occurrences provides insufficient evidence for the existence of geothermal resources.

4.2.4 SODIUM

Areas having sodium potential are correlative to the Tertiary basins shown on Map 3. High potential is allocated to the Luke, Higley, and Picacho Basins, which have known occurrences of sodium-bearing salt deposits. The level of certainty for those basins is *D* because there is direct evidence of the presence of sodium mineral resources. However, it should be noted that the thickest salt beds were deposited toward the center of those basins. Attempts to explore and develop sodium resources along the distal edges of those basins may be less successful than in the center of the basins.

The remaining Tertiary basins shown on Map 3 have moderate potential because geologic conditions are favorable for the presence of sodium. The level of certainty for those basins is *B* because information from comparable geologic deposits provides indirect evidence that sodium resources exist in those basins.

The remaining portions of the Planning Area have no potential for sodium resources because there is no geologic evidence that sodium resources occur outside the Tertiary basins. The level of certainty for the areas of no potential is *A* because there are insufficient data to evaluate those areas.

4.2.5 SOLAR ENERGY

The maps of solar energy resources show that the Planning Area has uniform, high potential (refer to Maps 6 and 7). The generally clear skies and arid climate are conducive to clear, sunny days with high solar radiation. The level of certainty is *D* because surveys have documented the known solar energy resources shown on Maps 6 and 7.

4.2.6 WIND ENERGY

Wind energy potential ranges from high to low and is dependent on the differences in Planning Area elevation. Hence, the higher mountain elevations have greater wind energy potential (refer to Map 8). High potential is found at the highest elevations, which include the Superstition, Goldfield, Sierra Estrella, Baboquivari, Quijotoa, Sierra Blanca, Mazatzal, and western Pinal Mountains. Moderate potential is found at the upper elevations of the Superstition, Goldfield, Sierra Estrella, Baboquivari, Quijotoa, Sierra Blanca, Mazatzal, and western Pinal Mountains; and the uppermost peaks of the Growler, Ajo, Agua Dulce, Comobabi, Santa Rosa, Santan, Maricopa, and Gila Bend Mountains. Low potential is found in areas having lesser elevation differences and low elevations, such as the flat desert floors and intermountain valleys. There are no areas of no wind-energy potential because even areas having light winds can generate power using small-scale wind turbines. The level of certainty is *D* for all wind energy resources because surveys have documented the known wind energy resources shown in Map 8.

4.3 LOCATABLE MINERAL POTENTIAL

As discussed in Section 3.2, a map showing the known occurrences, prospects, and resource potential in the Planning Area was prepared for locatable mineral resources. Using the map as a guide, the potential for locatable mineral resources is discussed below.

4.3.1 METALLIC MINERALS

High potential for metallic mineral resources is shown on Map 10 in mineral districts with known occurrences of the primary metallic minerals listed in Tables 3 and 4. The level of certainty is *D* because available data provide abundant direct evidence that the metallic minerals occur in those districts.

There is moderate potential for metallic minerals in hachured areas immediately outside the mineral districts. Mineral occurrences are inferred in those areas because the geological environment for mineral occurrence in the mountains surrounding the mineral district is comparable to the known mineralized areas in the district. Moderate potential also is attributed to mountainous areas having rock types and geologic histories comparable to the established mineral districts. The level of certainty is *B* because available data provide indirect evidence that the metallic minerals occur in those districts.

There is generally insufficient information on the geologic environment and geologic processes present outside the existing mineral districts to support other than a low potential for metallic mineral occurrences. The level of certainty is *B* because the areas designated as having low potential are areas that generally have isolated mineral occurrences or indirect evidence that metallic mineral resources exist (i.e., no mineral exploration has been conducted and/or no mineral district has been established).

4.3.2 NONMETALLIC MINERALS

High potential for nonmetallic mineral resources is shown on Map 10 in mineral districts with known occurrences of the nonmetallic minerals listed in Table 4. The level of certainty is *D* because available data provide abundant direct evidence that the nonmetallic minerals occur in those districts.

There is moderate potential for nonmetallic minerals in hachured areas immediately outside the mineral districts. Mineral occurrences are inferred in those areas because the geological environment for mineral occurrence in the mountains surrounding the mineral district is comparable to the known mineralized areas in the district. Moderate potential also is attributed to mountainous areas having rock types and geologic histories comparable to the recognized mineral districts. The level of certainty is *B* because available data provide indirect evidence that the nonmetallic minerals occur in those districts.

There is generally insufficient information on the geologic environment and geologic processes present outside the existing mineral districts to support other than a low potential for nonmetallic mineral occurrences. The level of certainty is *B* because the areas designated as having low potential are areas that generally have isolated mineral occurrences or indirect evidence that nonmetallic mineral resources exist (i.e., no mineral exploration has been conducted and/or no mineral district has been established).

4.4 SALABLE MINERAL POTENTIAL

The known occurrences, prospects, and potential of salable mineral resources in the Planning Area are shown on Map 11 and listed in Table 5. Many of the active pits, quarries, and prospects shown on Map 11 are Quaternary alluvial deposits consisting of unconsolidated sand and gravel in river channels and near

public roads. Thus, high potential salable mineral resources are deposits comparable to the active pits and quarries, but are not necessarily accessible by public roads. Quaternary to Pliocene geologic formations described as alluvium (such as sand and gravel, colluvium, and eolian sand) are shown as cross-hachured areas on Map 11 and are high potential prospects for salable minerals. The level of certainty is *D* for those resources because they are surface deposits shown on the geologic map of the Planning Area.

Decorative rock (such as crushed granite, volcanic rock, and limestone) and dimension stone (such as granite and flagstone) are classified as salable mineral resources. The quality of the rock at each resource location is subjective and based on the current market demand. This report gives outcrops of such resources a high potential, as shown by hachured areas on Map 11. The level of certainty is *C* because there is direct mapped evidence for the occurrence of those resources, but the preferred quality of the salable mineral resource may not occur at all locations

Older, more consolidated Tertiary sedimentary formations contain salable sand and gravel materials classified as moderate potential. The older Tertiary deposits typically have more variable composition and are more indurated than Quaternary deposits. As such, certain outcrops of those deposits may be less suitable as salable mineral resources. For that reason, Tertiary deposits having moderate potential are shown as hachured areas on Map 11. The level of certainty is *C* because there is direct mapped evidence for the occurrence of those resources, but the preferred salable mineral resource may not occur at all locations.

The remaining portions of the Planning Area are given a low potential because the presence of salable minerals is uncertain. The level of certainty is *A* because there is generally insufficient information whether the mineral materials in those areas have marketable qualities and quantities.

5.0 REASONABLE FORESEEABLE DEVELOPMENT

There are three factors of analysis to be considered when making mineral determinations in RMPs: (1) the potential for occurrence and development of mineral resources, (2) immediate and cumulative impacts due to reasonable foreseeable development (RFD) of mineral resources, and (3) the need to apply constraints or restrictions, known as stipulations, to the determination (BLM 1986). The first factor, mineral resource potential, is discussed in Section 4.0. The second factor, RFD, is discussed in this section. The third factor, stipulations, will be analyzed and considered in the RMP.

The primary basis for the RFD of mineral resources is the geology, along with past and present mineral resources activity and the potential for development of the mineral resources. The RFD is a reasonable projection of the most likely anticipated activity for development of mineral resources in the Decision Area for the next 15 years, and is supported by clearly stated assumptions. The minerals specialist focuses attention on projecting the area that may be disturbed by mineral leasing, exploration, development, production and abandonment activities likely to occur on BLM-administered land (BLM 1990). When implementing the RMP, the RFD provides vital information to assist the resource specialist and interdisciplinary team with making informed leasing decisions for proposed resource development projects. The interdisciplinary team uses the RFD projection to analyze the potential direct, indirect and cumulative impacts of exploration, development, production and abandonment activities on the alternatives presented in the Environmental Impact Statement (EIS). The impact of the RFD scenario is typically expressed in acres of land disturbance to the Decision Area.

The RFD scenario is a professional opinion presented by the mineral resource preparer and is based primarily on the geologic potential for resource occurrence along with past and present energy and mineral resource activity and projected (15 years) demands and markets. Development of the RFD scenario also considers other factors that may significantly affect development of the resources such as technological changes, economics, access restrictions, existing or anticipated infrastructure, and transportation. The RFD also describes surface uses that may be necessary to implement the anticipated development of the mineral resources, and the resulting impacts or disturbances to other resources (e.g., soil, water, air, wildlife, visual, cultural) and human communities. The baseline RFD is not constrained by management-imposed conditions on where, when, or how resource development might occur because it is based primarily on geology and historical exploration and development activity.

The RFD is projected on that portion of the Federal mineral estate that remains open to leasing and subsequent development (Map 12). The RFD is not projected on those areas of the Federal mineral estate that have been closed to leasing and subsequent development by law, regulation, Executive Order and Secretarial decision, defined here as nondiscretionary closure; and those areas that the BLM or U.S. Forest Service (USFS) have closed because the area warrants special protection or attention, defined here as discretionary closure. Those areas within the Decision Area nondiscretionarily closed to leasing and development are shown on Map 12 and include:

- Barry M. Goldwater Range, withdrawn as part of the Military Land Withdrawal Act of 1986 by Public Law (P.L.) 99-606 on November 11, 1986 and renewed by the Military Land Withdrawal Act of 1999 by P.L. 106-65 on October 5, 1999.

- Cabeza Prieta National Wildlife Refuge, established by Executive Order 8038 on January 25, 1939.

- Organ Pipe Cactus National Monument, established by Presidential Proclamation 2232 on April 13, 1937 and further withdrawn as wilderness area on November 10, 1978.
- Sonoran Desert National Monument, established by Presidential Proclamation 7397 on January 17, 2001.
- Casa Grande Ruins National Monument, preserved by Executive Order 28-A on June 20, 1892, and designated as a national monument by Presidential Proclamation 1470 on August 3, 1918.
- Four Peaks Wilderness (USFS), closed to new leasing and development after 1984 by the Wilderness Act of 1964.
- Superstition Wilderness (USFS), withdrawn on August 28, 1984 (P.L. 98-406) and closed to new leasing and development by the Wilderness Act of 1964.
- Sierra Estrella Wilderness (BLM), withdrawn on November 28, 1990 (P.L. 101-628) and closed to new leasing and development by the Wilderness Act of 1964.
- Signal Mountain Wilderness (BLM), withdrawn on November 28, 1990 (P.L. 101-628) and closed to new leasing and development by the Wilderness Act of 1964.
- Woolsey Peak Wilderness (BLM), withdrawn on November 28, 1990 (P.L. 101-628) and closed to new leasing and development by the Wilderness Act of 1964.
- Estrella Mountain, McDowell Mountain, and Santan Mountains Regional Parks (Maricopa County). Estrella Mountain withdrawn by purchase from BLM on December 9, 1971. McDowell Mountain withdrawn by purchase from BLM on April 6, 1971. Santan Mountains withdrawal by purchase from BLM is pending as of July 7, 1999. Mineral leasing and development generally are closed by plans of development for these areas.
- Buckeye Hills Recreation Area (Maricopa County), withdrawn by purchase from BLM on January 10, 1972.
- South Mountain Park (City of Phoenix), withdrawn by purchase from BLM on April 22, 1924.
- Miscellaneous smaller parcels preserved by military, state or municipal agencies, including:
    - Florence Military Reservation (Camp Florence; Arizona Army National Guard).
    - Rittenhouse Auxiliary Airfield (U.S. Air Force).
    - Casa Grande Mountain Park (City of Casa Grande).
    - Equestrian Park (Town of Apache Junction).
    - Undesignated open space (Town of Buckeye).

Areas closed at the discretion of the BLM or USFS also are shown on Map 12, but a separate listing is not provided in this report.

5.1 LEASABLE MINERALS

5.1.1 OIL AND GAS

5.1.1.1 Background Information and Assumptions

Oil and gas exploration was active in the Planning Area from 1913 to the 1980s, with a total of 33 wells drilled (refer to Table 1). No oil and gas development has occurred in the Decision Area and there are no documented proven reserves. There is currently no leasing interest in the Decision Area. However, areas of moderate oil and gas potential exist in the Decision Area (refer to Map 3).

The price of crude oil was a significant driving force for increased oil and gas exploration activity in the 1970s when four wells were drilled in the Planning Area. The 1980s saw active exploration in the Basin and Range Physiographic Province of Arizona to test the Laramide Overthrust Trend, but only one exploration well was drilled in the Planning Area, and none in the Decision Area. There has been no drilling activity since 1981. A trend toward increasing exploration is occurring throughout the United States as the active rig count increases in conjunction with rising crude oil prices. Thus, there is potential for domestic crude demand to stimulate oil and gas exploration in the Decision Area.

The following assumptions were considered when evaluating the RFD for oil and gas in the Decision Area:

- Oil and gas drilling activity would increase in the next 15 years in response to increasing crude oil and gas prices, increasing domestic demand, and decreasing domestic production.
- Advances in three-dimensional (3-D) seismic acquisition and processing technology would improve the resolution of subsurface structural and/or stratigraphic traps and delineate potential reservoir targets.
- A discovered oil and gas field would be small (less than 500 acres). This assumes that the size of an oil and gas field is limited by the structural complexity present throughout much of the Planning Area, particularly within the Basin and Range Physiographic Province. It is assumed that there have been no discoveries in the Planning Area despite 80 years of exploration because no areally extensive (i.e., large) oil and gas deposits exist.

5.1.1.2 Reasonable Foreseeable Development

The RFD for oil and gas development in the Planning Area estimates that five exploratory wells would be drilled. Compared to the previous 23 years where one well was drilled, an estimated one well per 3 years would be drilled in the next 15 years. For purposes of this report, it is estimated that two of those five wells will be drilled on BLM-administered land in the Decision Area.

An estimated one exploratory well (20 percent of the total drilled) would lead to the discovery and production of one small economic oil and gas field in the next 15 years. The discovered field would be small (less than 500 acres). For purposes of this report, it is estimated that one of the two wells drilled on BLM-administered land in the Decision Area will be an oil and/or gas discovery well.

An estimated maximum of 12 development or production wells would be drilled to delineate and exploit the oil and gas discovery field, approximately one per 40 acres.

5.1.1.3 Disturbance to the Decision Area

The extent of disturbance or impact on the land from development of a small oil and gas field is estimated using the mean generalized impact values presented by the Rocky Mountain Federal Leadership Forum [RMFLF] (2002). Those assumptions are:

- The small field discovery would require approximately 12 delineation and/or development wellsites on a total development field area of 500 acres with roads and associated infrastructure.
- The small field would impact or disturb an estimated 100 acres by installation of drill pads, roads and infrastructure such as pipelines, compressor stations, storage tanks, and processing facilities.
- The exploration well site would occupy 10 acres and each development or production wellsite would occupy 5 acres, including roads.
- Pad reclamation would reclaim approximately 50 percent of the exploration and production well drill pads for the long term.
- The average life of a small field would be 20 years.

Approximately 100 acres would be developed within the small oil and gas field and generally would not be accessible for other resource uses. Another 400 to 500 acres within the oil field leased area probably would not be developed. The gross surface disturbance (GSD) assumes impact to the field within the first five years and is calculated using the following guidance (BLM 2002; RMFLF 2002):

GSD = current disturbance + future disturbance

= (exploration wells)(acres/pad + road) + production wells (acres/pad + road).

The GSD for one small oil and gas field = (1 x 10) + (12 x 5) = 70 acres.

The net surface disturbance (NSD) is an estimate of the long-term surface disturbance and includes reclamation of 50 percent of the exploration and production drill pads during the remaining 15 years life of the field (BLM 2002):

NSD = current disturbance + future disturbance – reclamation

= (exploration wells)(acres/pad + road) + production wells (acres/pad + road) –

exploration wells (acres reclaimed) - production wells (acres reclaimed).

The NSD for one small oil and gas field = (1 x 10) + (12 x 5) – (1 x 5) - (12 x 2.5) = 35 acres.

The potential impact on other resources must be evaluated prior to making a leasing decision.

5.1.2 CARBON DIOXIDE AND HELIUM

5.1.2.1 Background Information and Assumptions

There has been no CO_2/He exploration in the Planning Area. Areas having moderate CO_2/He potential are assumed to be correlative with areas of moderate oil and gas potential (refer to Map 3). There is currently no leasing interest in the Decision Area.

The following assumptions were considered when evaluating the RFD for CO_2/He in the Decision Area:

- Oil and gas drilling activity would increase in the next 15 years in response to increasing crude oil and gas prices, increasing domestic demand, and decreasing domestic production.
- Production tests in two oil and gas exploratory wells drilled in the Decision Area would not recover economic concentrations of CO_2 or helium gas.
- No exclusively CO_2/He exploratory wells would be drilled in the Decision Area.

5.1.2.2 Reasonable Foreseeable Development

The RFD for CO_2/He development in the Decision Area estimates that no oil and gas exploratory wells drilled in the Decision Area would discover CO_2/He reserves, and no exclusively CO_2/He exploratory wells would be drilled in the Decision Area.

5.1.2.3 Disturbance to the Decision Area

There will be no disturbance or impact on the land from development of a CO_2/He field.

5.1.3 COAL POTENTIAL

There are no coal deposits reported in the Decision Area.

5.1.4 GEOTHERMAL

5.1.4.1 Background Information and Assumptions

A total of 15 low-temperature geothermal resource regions are recognized in the Planning Area. These regions are shown as high potential areas and warm springs on Map 5. However, there has been no significant development of those geothermal energy resources. These low-temperature geothermal resources may be used for small-scale space heating and for resort spas.

There are no geothermal energy leases in the Decision Area and no indications for future leasing activity. The absence of geothermal leasing activity in the Decision Area probably is due to the limited uses for those low-temperature resources and the considerable expense to explore and develop them.

The following assumptions were considered when evaluating the RFD for geothermal energy resources in the Decision Area:

- There would be no leasing interest in the next 15 years.
- Drilling costs to explore and develop subsurface geothermal resources are comparable to costs for oil and gas exploration, and are probably too expensive for the limited revenue that would be generated by a low-temperature geothermal resource.

5.1.4.2 Reasonable Foreseeable Development

The RFD for geothermal resource development in the Decision Area expects that no leasing, exploration, or development would occur in the next 15 years. Costs to develop low-temperature geothermal resources are prohibitive compared to the potential revenue generation and limited uses of those resources.

5.1.4.3 Disturbance to the Decision Area

There is no foreseeable disturbance to public lands from geothermal resource development in the Decision Area in the next 15 years.

5.1.5 SODIUM

Three areas of known sodium resources exist in the subsurface of the Planning Area. However, there has been no significant development of those resources and no indications for future leasing and development activity. The absence of leasing activity for sodium resources in the Decision Area is probably due to the limited demand for sodium resources and the considerable expense to explore and develop them.

There has been modest activity using caverns formed by salt extraction in the Luke Basin to store natural gas. Caverns that are located near existing natural gas pipelines are being used by gas suppliers to store excess natural gas during periods of low usage.

5.1.5.1 Reasonable Foreseeable Development

The RFD for sodium resource development expects that no leasing, exploration, or development will occur in the Decision Area in the next 15 years. Costs to explore and extract by drilling are considerable compared to the local demand and limited uses of those resources in Arizona.

5.1.5.2 Disturbance to the Decision Area

There is no foreseeable disturbance to public lands from sodium resource development in the Decision Area in the next 15 years.

5.1.6 SOLAR ENERGY

5.1.6.1 Background Information and Assumptions

There has been limited, small-scale commercial development of solar energy resources in the Planning Area (Arizona Public Service 2002; GlobalSolar 2002). The maps of solar energy resources show that the Decision Area has uniform, high potential (refer to Maps 6 and 7). There are no indications for permitting activity in the near future. However, it is anticipated that interest in permitting public lands to develop solar energy resources will increase in the next 15 years as new technology and lower equipment costs make solar arrays economically competitive as a renewable energy source. It is also anticipated that Federal and State governments will actively promote new programs, such as tax incentives and low-interest loans to businesses, designed to encourage development of renewable energy resources.

The following assumptions were considered when evaluating the RFD for solar energy resources in the Decision Area:

- There would be two right-of-way permits issued for solar testing and commercial development in the Decision Area in the next 15 years.
- Each right-of-way permit would allow development of one solar array facility on 10 acres of land. The solar array facility will include a series of solar collector arrays, access roads, battery storage facilities, and power transfer stations.
- Each solar array facility right-of-way would include acreage for transmission lines. It is anticipated that to remain cost-effective the solar array facility must be constructed within 10 miles of the electricity end-user such as a city or commercial development, or within 10 miles of existing regional transmission lines rated at greater than 115 kilovolts (kV).

5.1.6.2 Reasonable Foreseeable Development

The RFD for solar energy resources in the Decision Area is that two right-of-way permits would be issued in the next 15 years. Incentives to develop solar energy resources will include Federal and State programs designed to encourage use of renewable energy resources, such as tax incentives and low-interest business loans.

5.1.6.3 Disturbance to the Decision Area

The RFD anticipates permitting two rights-of-way totaling 20 acres for construction of solar array facilities. The solar array facilities would occupy most of the permitted acreage with solar concentrators, access roads, battery storage facilities, and power transfer stations.

The right-of-way permits also would include an estimated 20 miles of transmission lines to connect with the end user or regional transmission grid. The transmission lines could range in capacity from 69 kV to 230 kV depending upon the size of the solar array facilities. The right-of-way required for construction, operation, and maintenance of this line is approximately 75 to 150 feet wide.

5.1.7 WIND ENERGY

5.1.7.1 Background Information and Assumptions

There has been no commercial development of wind energy resources in the Planning Area. Wind energy potential ranges from high to low and varies depending on differences in ground elevation. Hence, the higher mountain elevations have greater wind energy potential (refer to Map 8). There are no indications for permitting activity in the near future. However, it is anticipated that interest in permitting public lands to develop wind energy resources will increase in the next 15 years as new technology and lower equipment costs make wind turbines economically competitive as a renewable energy source. It also is anticipated that Federal and State governments will actively promote new programs, such as tax incentives and low-interest loans to businesses, designed to encourage development of renewable energy resources.

The following assumptions were considered when evaluating the RFD for wind energy resources in the Decision Area:

- There would be one right-of-way permit issued for wind energy testing and commercial development in the Decision Area in the next 15 years.

- The right-of-way permit would allow development of 40 acres of land, including wind turbine towers, access roads, battery storage facilities, and power transfer stations.
- Each wind farm facility right-of-way would include acreage for transmission lines. It is anticipated that to remain cost-effective the wind farm facility must be constructed within 50 miles of the electricity end-user such as a city or commercial development, or within 50 miles of existing regional transmission lines rated at greater than 115 kV.

5.1.7.2 Reasonable Foreseeable Development

The RFD for wind energy resources in the Decision Area is that one right-of-way permit would be issued in the next 15 years. Incentives to develop wind energy resources will include Federal and State programs designed to encourage use of renewable energy resources, such as tax incentives and low-interest business loans.

5.1.7.3 Disturbance to the Decision Area

The RFD anticipates permitting one right-of-way totaling 40 acres for construction of a wind farm facility. The facility will occupy most of the permitted acreage with 40 wind turbines (approximately one per acre), access roads, battery storage facilities, and power transfer stations. The wind farm right-of-way permit would include acreage for an estimated 50 total miles of transmission lines to the end-user or regional transmission lines. It is assumed that construction of the transmission lines will cause a moderate level of disturbance to the Decision Area. A moderate level of disturbance is based on the establishment of a new 150-foot-wide right-of-way on easily accessible flat terrain, and installation of a 69 kV to 230 kV transmission line on that right-of-way. The moderate level of impact of the transmission lines is estimated at 10 acres per mile, for a total disturbance of 500 acres.

5.2 LOCATABLE MINERALS

5.2.1 BACKGROUND INFORMATION AND ASSUMPTIONS

Mineral districts in the Planning Area are regions of known occurrences of locatable metallic and nonmetallic mineral resources (refer to Map 9). The name, county, years of production, commodities mined, type of geologic deposit, geologic age, and cumulative tons or ounces of mineral production for each district are listed in Table 3. Specific mine locations are shown on Map 10 and listed in Table 4. The mineral districts have high potential for metallic and nonmetallic mineral resources because the minerals are known to occur. However, most of the mines have been inactive for many years because the cost to mine the commodity exceeds the market value of the commodity. There are five locatable metallic mineral mines currently operating in the Planning Area, four of which are in or adjacent to the Decision Area (Phillips et al. 2002). There are eight nonmetallic mineral mines currently operating in the Planning Area, five of which are in or adjacent to the Decision Area (Phillips et al. 2002).

The following assumptions were considered when evaluating the RFD for locatable mineral resources in the Decision Area:

- There would be two new small locatable mineral discoveries or mineral districts discovered in the next 15 years.
- Each new locatable mineral discovery would occupy approximately 80 surface acres, and include tailings piles.

- The majority of the mining activity would be on the surface, based on recent trends in new mine permit applications to the BLM.
- Where applicable, milling of the commodity ore would be conducted off site.
- Transportation of the commodity ore would be by surface road.
- The land surface would not be reclaimed during the life of the mine.

5.2.2 REASONABLE FORESEEABLE DEVELOPMENT

The RFD for locatable mineral resources in the Decision Area expects that some exploration would occur in the next 15 years and two surface locatable mineral deposits would be developed.

5.2.3 DISTURBANCE TO THE DECISION AREA

There is some foreseeable disturbance by mining activities on public lands in the Decision Area in the next 15 years. Activities associated with two new surface mines would impact up to 160 acres, including placement of tailings piles. Disturbance of the land surface would require reclamation at the end of the life of the mine.

The plan of operations for the mine would include a new road to transport commodity ore off site. For a 40-foot-wide road, approximately five acres would be disturbed per mile of road. Based on an estimate of 10 miles of road for each new mine, a total of 100 acres of land would be disturbed by new road construction.

5.3 SALABLE MINERALS

5.3.1 BACKGROUND INFORMATION AND ASSUMPTIONS

There are many locations for salable mineral resources in the Planning Area. Known occurrences (quarries and pits), prospects, and potential locations for salable mineral resources are shown on Map 11. The name, location, identification number, commodity type, age, formation, and deposit type at each pit is presented in Table 5. Those locations have high potential for salable mineral resources because the minerals are known to occur. Most of the locations are actively used for dimension stone, decorative rock, or local construction operations. BLM community pits on public lands are used by the local community.

The following assumptions were considered when evaluating the RFD for salable mineral resources in the Decision Area:

- The demand for salable minerals would increase during the next 15 years as population increases stimulate new construction of roads, buildings and infrastructure.
- An estimated 10 new salable mineral pits or community pits would be permitted in the next 15 years.
- New quarry or pit access will require new road construction because those locations are usually sited some distance from existing paved roads.

5.3.2 REASONABLE FORESEEABLE DEVELOPMENT

An estimated 10 new salable mineral pits or quarries would be permitted or reactivated in the next 15 years. The type and volume of salable minerals disposed is uncertain and depends on the increase in community development and construction activities. A review of the BLM LR2000 database revealed that there are 13 salable mineral pits in the Decision Area that have recorded active disposal since January 1, 2001. The average disposal tonnage for four types of salable mineral pits are:

- Weathered granite stone – an average of 180,000 tons per year per pit for five active pits that average 92 acres per contract/permit.
- Pumice/cinders – 121,900 tons per year per pit from two active pits that average 130 acres per contract/permit.
- Specialty stone – 33,600 tons per year per pit from three active pits that average 255 acres per contract/permit.
- Sand and gravel – 30,600 tons per year per pit from three active pits that average 48 acres per contract/permit.

The average annual current sales volume from those 13 active BLM salable mineral pits in the Decision Area is approximately 100,000 tons per year per pit. Based on the estimated average disposal of 100,000 tons per year per pit from each of 10 new pits during the next 15 years, the disposal of 15,000,000 tons of salable mineral materials is projected.

5.3.3 DISTURBANCE TO THE DECISION AREA

Each salable mineral pit or community pit would occupy approximately 20 acres, which is the average area for the 13 salable mineral pits that have active sales records (BLM LR2000). Approximately 200 total acres would be impacted by 10 new pits. Disturbance of the land surface would require reclamation at the end of the life of the pits.

The potential impact on other resources and human communities must be evaluated prior to making a decision to dispose of mineral materials.

6.0 REFERENCES

American Wind Energy Association. 2002. Website: www.awea.org/projects/California.htmlNo.San%20Gorgonio%20Pass.

Anderson, Phillip 1989. Stratigraphic framework, volcanic-plutonic evolution, and vertical deformation of the Proterozoic volcanic belts of central Arizona. Arizona Geological Society Digest 17. Pages 57-147.

_____. 1986. Summary of the Proterozoic plate tectonic evolution of Arizona from 1900 to 1600 Ma. Arizona Geological Society Digest 16. Pages 5-11.

Arizona Geological Survey. 2003. Well files.

Arizona Public Service. 2002. Website: www.aps.com/my_community/Solar/Solar_22.html.

Arizona State Mine Inspector (ASMI). 2002. Ninety-first annual report for the calendar year 2002. 37 pages.

Beus, Stanley S. 1989. Devonian and Mississippian geology of Arizona. Arizona Geological Society Digest 17. Pages 287-311.

Blakey, Ronald C. 1989. Triassic and Jurassic geology of the southern Colorado Plateau. Arizona Geological Society Digest 17. Pages 369-396.

Blakey, Ronald C. and Rex Knepp. 1989. Pennsylvanian and Permian geology of Arizona. Arizona Geological Society Digest 17. Pages 313-347.

Butler, William C. 1996a. Southern Arizona-southwestern New Mexico Province. U.S. Geological Survey, National Oil and Gas Assessment (NOGA), Region 3-Colorado Plateau and Basin and Range. 24 pages.

_____. 1996b. Northern Arizona Province. U.S. Geological Survey, National Oil and Gas Assessment (NOGA), Region 3-Colorado Plateau and Basin and Range. 28 pages.

Conway, Clay M. and Leon T. Silver. 1989. Early Proterozoic rocks (1710-1615 Ma) in central to southeastern Arizona. Arizona Geological Society Digest 17. Pages 165-186.

Desborough, G.A., F.G. Poole, T.A. Daws, and Robert Scarborough. 1984. Hydrocarbon source rock evaluation of the Middle Proterozoic Apache Group, Gila County, Arizona. *in* Woodward, Jane, F.F. Meissner, and J.L. Clayton, eds. Hydrocarbon source rocks of the greater Rocky Mountain region. Rocky Mountain Association of Geologists. Pages 51-55.

Dickinson, William R. 1989. Tectonic setting of Arizona through geologic time. Arizona Geological Society Digest 17. Pages 1-16.

_____, Anthony Fiorillo, Dwight L. Hall, Rogelio Monreal, Andre R. Potochnik, and Peter N. Swift. 1989. Cretaceous strata of southern Arizona. Arizona Geological Society Digest 17. Pages 447-462.

Duncan, John T. and Frank P. Mancini. 1991. Energy resources of Arizona. Arizona Geological Survey Down-to-Earth Series 1. 15 pages.

Eberly, L.D. and T.B. Stanley. 1978. Cenozoic stratigraphy and geologic history of southwestern Arizona. Geological Society of America Bulletin 89:921-940.

Farhar, Barbara C. and Donna M. Heimiller. 2003. Opportunities for near-term geothermal development on public lands in the western United States. U.S. Department of Energy Energy Efficiency and Renewable Energy and U.S. Department of the Interior Bureau of Land Management. CD format.

Federal Energy Management Program. 2003. Website: www.eere.energy.gov/femp/techassist/photovoltaics.html.

Gage, B.D. and D.L. Driskill. 2001. Helium resources of the United States-2001. U.S. Department of the Interior, Bureau of Land Management Technical Note 408. 30 pages.

Gardulski, Anne F. 1980. A structural and petrologic analysis of a quartzite-pegmatite tectonite, Coyote Mountains, southern Arizona. University of Arizona Thesis. 69 pages.

Geraghty and Miller, Inc. 1998. Mineral potential report, Barry M. Goldwater Range, Arizona land withdrawal. 110 pages, 12 plates.

GlobalSolar. 2002. 1.4MW Springerville Generating Station. GlobalSolar website: www.globalsolar.com/ourprojects/SGS.htm.

Haxel, Gordon B., J.E. Wright, Daniel J. May, and Richard M. Tosdal. 1980. Reconnaissance geology of the Mesozoic and lower Cenozoic rocks of the southern Papago Indian Reservation, Arizona. Arizona Geological Society Digest 12. Pages 17-29.

Headquarters West, 1998. Arizona Statewide Mineral Commodity Study and Analysis. 67 pages.

Heindl, Leopold. 1965a. Mesozoic formations in the Vekol Mountains, Papago Indian Reservation, Arizona. U.S. Geological Survey Bulletin 1194-G. 9 pages.

_____. 1965b. Mesozoic formations in the Comobabi and Roskruge Mountains, Papago Indian Reservation, Arizona. U.S. Geological Survey Bulletin 1194-H. 14 pages.

Heindl, Leopold and Charles A. Armstrong. 1963. Geology and groundwater conditions in the Gila Bend Indian Reservation, Maricopa County, Arizona. U.S. Geological Survey Water Supply Paper 1647-A. 48 pages.

Hogue, William G. 1940. Geology of the northern part of the Slate Mountains, Pinal County, Arizona. University of Arizona Thesis. 86 pages.

Jenney, J.P. and Stephen J. Reynolds. 1989. Geologic Evolution of Arizona. Arizona Geological Society Digest 17. 866 pages.

Jones, William P. 1974. General geology of the northern portion of the Ajo Range, Pima County, Arizona. University of Arizona Thesis. 77 pages.

Keith, Stanley B., Don E. Gest, Ed Dewitt, Netta Woode Toll, and Beverly A. Everson. 1983. Metallic mineral districts and production in Arizona. Arizona Bureau of Geology and Mineral Technology Bulletin 194. 58 pages.

Kirkland, D.W. and R. Evans. 1981. Source rock potential of evaporite environments. American Association of Petroleum Geologists Bulletin 65:181-190.

Krantz, Robert W. 1989. Laramide structures of Arizona. Arizona Geological Society Digest 17. Pages 463-484.

Krason, Jan, Antoni Wodzicki, and Susan K. Cruver. 1982. Geology, energy and mineral resources assessment of the Maricopa area, Arizona. Geoexplorers International. Inc. 94 pages.

McClymonds, Neal A. 1957. The stratigraphy and structure of the Waterman Mountains, Pima County, Arizona. University of Arizona Thesis. 157 pages.

Melchiorre, Erik B. and Drew M. Clement. 1993. Geology of the south-central Goldfield Mountains, Arizona. Arizona Geological Survey Contributed Map CM-93-A. 1 map.

Menges, Christopher M. and Philip A. Pearthree. 1989. Late Cenozoic tectonism in Arizona and its impact on regional landscape evolution. Arizona Geological Society Digest 17. Pages 649-680.

Middleton, Larry T. 1989. Cambrian and Ordovician depositional systems in Arizona. Arizona Geological Society Digest 17. Pages 273-286.

Miller, Glenn A. 1979. Status of mineral resource information for the Luke Air Force Range, Arizona. Arizona Department of Mineral Resources. 221 pages.

Mine Safety and Health Administration [MSHA]. 2003. Data Retrieval System. Website: www.msha.gov/drs/ASP/BasicMineInfo.asp

National Geophysical Data Center. 2003. Hot springs in Arizona. Western Data Center-A for Solid Earth Geophysics, Boulder, Colorado. Website: www.ngdc.noaa.gov/cgi-bin/seg/globsys/springret?springs.men+MAIN_-MENU+Arizona.

Nations, J. Dale, Daniel J. Brennan, and Rudy A. Ybarra. 1989 Oil and gas in Arizona. Arizona Geological Society Digest 17. Pages 795-816.

Niemuth, Nyal J. 2003. Copper production. Letter from Nyal Niemuth (Arizona Department of Mines and Mineral Resources) to Dennis Carlson (URS), dated August 25, 2003. 6 pages.

Nowlan, Gary A., Gordon B. Haxel, William F. Hanna, James A. Pitkin, Denny V. Diveley-White, John R. McDonnell, Jr., and William Lundby. 1989. Mineral resources of the Baboquivari Peak and Coyote Mountains Wilderness Study Area, Pima County, Arizona. U.S. Geological Survey Bulletin 1702-E. 30 pages.

Peirce, H. Wesley. 1986. Paleogeographic linkage between Arizona's physiographic provinces. Arizona Geological Society Digest 16. Pages 74-82.

Peterson, Donald W., Jimmie E. Jinks, W.R. Miller, J.M. Motooka, and Jeffrey C. Wynn. 1983. Mineral resource potential of the Superstition Wilderness and contiguous roadless areas, Maricopa, Pima, and Gila Counties, Arizona. U.S. Geological Survey Open-file Report 83-885. 34 pages.

Peterson, Jocelyn A., D.P. Cox, and Floyd Gray. 1987. Mineral resource assessment of the Ajo and Lukeville 1x2 degree quadrangles, Arizona. U.S. Geological Survey Open-file Report 85-527. 77 pages.

Peterson, Jocelyn A., Gary A. Nowlan, William F. Hanna, James A. Pitkin, and John R. McDonnell, Jr. 1988. Mineral resources of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona. U.S. Geological Survey Bulletin 1702-A. 18 pages.

Peterson, Nels P. 1963. Geology of Pinal Ranch quadrangle, Arizona. U.S. Geological Survey Bulletin 1141-H. 18 pages.

Petroleum Information [PI]/Dwights. 2003. Well information from scout tickets.

Phillips, K.A., Nyal J. Niemuth, and D.R. Bain. 2002. Active mines in Arizona – 2001-2002. Arizona Department of Mines and Mineral Resources Directory 49. 34 pages.

Rauzi, Steven L. 2003. Arizona well location map and report. Arizona Oil and Gas Conservation Commission. Arizona Geological Survey Oil and Gas Publication OG-12. 21 pages. 4 maps.

_____. 2002. Arizona has salt. Arizona Geological Survey Circular 30. 36 pages.

_____. 2001. Arizona has oil and gas potential. Arizona Geological Survey Circular 29. 40 pages.

Resource Science, Inc. 2000. Market study of alluvial aggregate. *in* An assessment of alluvial aggregate and porphyry copper deposits in selected portions of Maricopa, Pima, and Pinal Counties, Arizona. Chapter VII. Arizona State Land Department. Pages 102-133.

Reynolds, Stephen J. 1985. Geology of the South Mountains, central Arizona. Arizona Bureau of Geology and Mineral Technology Bulletin 195. 61 pages.

Richard, S.M., Stephen J. Reynolds, Jon E. Spencer, and Philip A. Pearthree. 2000. Geologic map of Arizona. Arizona Geological Survey Map 35. 1 map.

Ridgeway Arizona Oil Corporation. 2003. CO_2 project brewing in western New Mexico. Ridgeway Petroleum website: www.ridgewaypetroleum.com/news/nmbj0212.html.

Rocky Mountain Federal Leadership Forum (RMFLF). 2002. Interagency Reference Guide: Reasonable Foreseeable Development Scenarios and Cumulative Effects Analysis for Oil and Gas Activities on Federal Lands in the Greater Rocky Mountain Region. August 30. 71 p.

Scarborough, Richard. 1989. Cenozoic erosion and sedimentation in Arizona. Arizona Geological Society Digest 17. Pages 515-538.

Southwest Technology Development Institute. 1999. Geothermal energy. New Mexico State University website: www.nmsu.edu/~tdi/geothermal.htm.

Spencer, Jon E. and Stephen J. Reynolds. 1989. Middle Tertiary tectonics of Arizona and adjacent areas. Arizona Geological Society Digest 17. Pages 539-574.

Spencer, Jon E. and John W. Welty. 1989. Mid-Tertiary ore deposits in Arizona. Arizona Geological Society Digest 17. Pages 585-608.

Staudacher, Thomas. 1987. Upper mantle origin for Harding County well gases. Nature 325:605-607.

Titley, Spencer R. and E.Y. Anthony. 1989. Laramide mineral deposits in Arizona. Arizona Geological Society Digest 17. Pages 485-514.

Tosdal, Richard M., Gordon B. Haxel, and James E. Wright. 1989. Jurassic geology of the Sonoran Desert region, southern Arizona, southeastern California, and northernmost Sonora: Construction of a continental-margin magmatic arc. Arizona Geological Society Digest 17. Pages 397-434.

U.S. Department of Energy (DOE). 2003a. Assessing the potential for renewable energy on public lands. U.S. Department of Energy, Energy Efficiency and Renewable Energy, and U.S. Department of the Interior, Bureau of Land Management. February. 27 pages.

_____. 2003b. Arizona – 50 m wind power. U.S. Department of Energy, National Renewable Energy Laboratory.1 map.

_____. 2001a. National Solar Radiation Database. Renewable Resource Data Center (RReDC), National Renewable Energy Laboratory website: rredc.nrel.gov/solar.

_____. 2001b. Wind Energy Resource Atlas of the United States. Renewable Resource Data Center (RReDC), National Renewable Energy Laboratory website: rredc.nrel.gov/wind.

U.S. Department of the Interior, Bureau of Land Management (BLM). 2004. Policy for Reasonably Foreseeable Development (RFD) Scenario for Oil and Gas. Instruction Memorandum No. 2004-089. January 16. 9 p.

_____. 2003. Land and Mineral Records. LR 2000 System.

_____. 1997. Mining claims and sites on Federal lands. BLM Solid Minerals Group brochure.

_____. 1990. Planning for Fluid Mineral Resources. BLM Handbook H-1624-1. 67 pages.

_____. 1986. Supplemental Program Guidance for Energy and Mineral Resources. BLM Manual 1624.2.

_____. 1985. Energy and Mineral Resource Assessment. BLM Manual 3031. 39 pages.

_____. Undated. Mineral Reports-Preparation and Review, BLM Manual 3060. 38 pages.

U.S. Geological Survey (USGS). 2001. Digital data for construction material sources reported by the Arizona Department of Transportation in 1977 for Maricopa County, Arizona. U.S. Geological Survey Open-file Report 01-122. CD format.

_____. 1999. Mineral Resource Data System.

Welty, John W., Stephen J. Reynolds, Stanley B. Keith, Don E. Gest, and Richard A Trapp. 1985. Mine index for metallic mineral districts of Arizona. Arizona Bureau of Geology and Mineral Technology Bulletin 196. 92 pages.

Wenrich, Karen J., William L. Chenoweth, Warren I. Finch, and Robert B. Scarborough. 1989. Uranium in Arizona. Arizona Geological Society Digest 17. Pages 759-794.

Wentz, Chris J. 2002. Renewable energy in New Mexico: current status and future outlook. *in* Brister, Brian F. and L. Greer Price, eds., New Mexico's Energy, Present and Future: Policy, Production, Economics, and the Environment. New Mexico Bureau of Geology and Mineral Resources. Pages 97-101.

Wilson, Eldred D. 1969. Mineral deposits of the Gila River Indian Reservation, Arizona. Arizona Bureau of Mines Bulletin 179. 34 pages.

Witcher, James C., Claudia Stone, and W. Richard Hahman, Sr. 1982. Geothermal resources of Arizona. Arizona Bureau of Geology and Mineral Technology. 1 map.

Wrucke, Chester T. 1989. The Middle Proterozoic Apache Group, Troy Quartzite, and associated diabase of Arizona. Arizona Geological Society Digest 17. Pages 239-258.

Wrucke, Chester T., James K. Otton, and George A. Desborough. 1986. Summary and origin of the mineral commodities in the middle Proterozoic Apache Group in Central Arizona. Arizona Geological Society Digest 16. Pages 12-17.

TABLES

Table 1
Oil and Gas Exploration Wells
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Reference Number [1]	Lease Name	Well No.	Operator Name	Location							County Name	Current Statis	Driller TD (ft)	Formation Name At TD	Comp Date	Potential/ Shows
				Quad	Twp	Rge	Sec	160	40	10						
7-01	Gardiner	1	Peoples Gas & Oil	1	1	3	2	4	4		Maricopa	D	3,500	Tertiary Alluvium	1945/06	Oil and gas show
7-02	CAP	A1-3	USBR	1	1	3	13	2	4		Maricopa	S	757	Tertiary Alluvium	1964/10	None reported
7-03	N/A		American Union Pet	1	1	4	5	2	3		Maricopa	D	600	Tertiary Alluvium	1931/	None reported
7-11	Liberty	1	USBR	2	1	2	19	1	4		Maricopa	S	1,208	N/A	1967/10	None reported
725	Heisler	1	Gemini OG & Mining	2	2	7	27	3	3		Maricopa	D	2,040	N/A	1981/10	None reported
7-12	King	1	Reaves Oil	2	1	4	33	4	3		Maricopa	D	1,780	Cenozoic	1940/	None reported
7-13	Fuqua	1	Reaves Oil	2	1	4	34	1	2		Maricopa	D	4,117	Tertiary	1939/08	Oil and gas show
7-14	State	1	Dixie Oil	2	1	5	34				Maricopa	D	3,505	Tertiary volcanics	1947/03	None reported
171	Federal	1A	Montezuma Oil & Gas	3	2	9	30	2	3		Maricopa	D	248	N/A	1962/07	None reported
208	Federal	1X	Montezuma Oil & Gas	3	2	9	30	2	3		Maricopa	D	441	N/A	1964/04	Oil show
573	Federal	1	P&H Development	3	2	9	30	2	3		Maricopa	D	1,700	N/A	1973/04	Oil show
14-11	Loftus	1	Baird, Frank	3	8	13	4	1	2		Yuma	D	2,630	Tertiary?	1928/	Gas show
7-21	CAP	C5-4	U.S. Bur Reclam	3	5	4	33	4	4		Maricopa	S	1,782	N/A	1965/05	None reported
7-22	Gila Bend Ind.	N/A	Bur. Indian Affair	3	5	5	23	3	4		Maricopa	S	1,475	N/A	1957/	None reported
10-22	N/A	01	New Cornelia Copper	3	11	6	24	3	1		Pima	S	1,348	N/A	1913?	None reported
7-25	Fee	8	Nichols, Hugh E.	4	1	6	1	1	1		Maricopa	S	1,446	Valley fill	1972/03	None reported
7-24	CAP	D1-6	USBR	4	1	6	27	4	4		Maricopa	S	1,940	N/A	1964/09	None reported
05	State	1	Nichols, Hugh E.	4	1	8	17	4	4		Pinal	D	2,836	Precambian	1952/05	None reported
11-01	CAP	D1-8	USBR	4	1	8	30	1	4		Pinal	S	1,929	Tertiary clastics	1965/09	None reported
11-21	Bonanza	1	Superior Oil	4	1	12	33	3	1		Pinal	S	4,707	Precambian	1971/	None reported
11-22	Bonanza	2	Superior Oil	4	1	12	34	2			Pinal	S	5,931	Precambian	1972/	None reported
11-23	DCA	2	American Smelting	4	1	13	11	2	4		Pinal	S	1,772	N/A	1971/	None reported
11-24	OF	1A	American Smelting	4	1	13	21	2	1		Pinal	S	2,150	N/A	1971/	None reported
11-02	State	1	East Lantron	4	2	10	32	3			Pinal	D	1,020	Cenozoic	1949/	None reported
11-03	CAP	D4-3	USBR	4	4	3	9	4	3		Pinal	S	1,777	N/A	1964/06	None reported
11-04	Harbor	1	Robinson & Mason	4	4	3	36	1	2		Pinal	D	3,642	Cenozoic	1951/01	None reported
11-05	Moorehouse	1	Schoenheit, John H.	4	4	9	25	4	3		Pinal	D	415	Cenozoic	1945/	None reported
15	Federal	1	Western Oil Fields	4	5	10	31	3	3		Pinal	D	5,142	Tertiary	1953/05	None reported
11-07	CAP	D6-3	USBR	4	6	3	21	2	2		Pinal	S	1,335	N/A	1964/01	None reported
11-08	CAP	D6-5	USBR	4	6	5	19	4	4		Pinal	S	1,780	N/A	1965/06	None reported
11-09	Laveen	1	Casa Grande Valley	4	6	7	25	4	4		Pinal	D	4,742	Tertiary	1945/09	Oil show
11-10	Holland	1	Crouch Drillers	4	6	8	18	4	3		Pinal	D	3,243	Tertiary	1964/	None reported
11-11 [2]	McFarland	1	Hatchett, J.L.	4	7	8	22	1	2		Pinal	D	1,260	Tertiary	1943/	Oil and gas show
11-17	CT	10	Bur. Indian Affair	4	9	4	15	4	3		Pinal	S	700	N/A	1956/	None reported

SOURCES: Rauzi 2003; PI/Dwights 2003; Arizona Geological Survey Files 2003

NOTE: For purposes of this report all "gas" shows are considered potential CO_2/Helium shows even though many tests did not analyze for and/or report CO_2/Helium composition in gas.

1. Reference number refers to locations posted on Map 3 - Oil and Gas Potential
2. Well located outside Planning Area, and included for potential evaluation only

TWP = Township
RGE = Range
SEC = Section
D = drilled and abandoned
S = Stratigraphic test
TD = Total depth of well in feet
N/A = Not available
USBR = U.S. Bureau of Reclamation

QUAD = Quadrant relative to the intersection of the baseline and meridian (see diagram).
160 = The 160-acre quadrant within the designated Section.
40 = The 40-acre quadrant within the designated 160-acre portion of the Section.
10 = The 10-acre quadrant within the designated 40-acre portion of the Section.
1 = Northeast quadrant
2 = Northwest quadrant
3 = Southwest quadrant
4 = Southeast quadrant

2	1
3	4

Table 2
Geothermal Energy Resource Types and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Reference Number [1]	Well/ Spring	County	Depth m	Temp °C	Location							Geothermal Energy Resource Type [2]		
					Quad	Twn	Rng	Sec	160	40	10	Temp	Geology	Fluid
GI-5	W	GILA	580	35.0	1	1	15	30				L	Gv	W
MA-14	W	MARICOPA	NA	36.0	1	4	8	15	1	2	3	L	Gv	W
MA-16	W	MARICOPA	458	35.0	2	2	9	9	4	2	2	L	Gv	W
MA-17	W	MARICOPA	470	35.0	2	2	9	9	1	2	2	L	Gv	W
MA-18	W	MARICOPA	396	35.0	2	2	9	10	2	2	2	L	Gv	W
MA-19	W	MARICOPA	458	35.0	2	2	9	10	1	2	2	L	Gv	W
MA-20	W	MARICOPA	457	35.0	2	2	9	11	2	2	2	L	Gv	W
MA-21	W	MARICOPA	459	35.0	2	2	9	11	3	2	2	L	Gv	W
MA-22	W	MARICOPA	329	35.0	2	2	8	19	3	2	2	L	Gv	W
MA-23	W	MARICOPA	363	35.0	2	2	8	18	4	1	1	L	Gv	W
MA-24	W	MARICOPA	360	35.0	2	2	8	30	1	1	1	L	Gv	W
MA-25	W	MARICOPA	506	36.0	2	2	8	29	2	4	4	L	Gv	W
MA-26	W	MARICOPA	366	37.0	2	2	8	31	2	1	1	L	Gv	W
MA-27	W	MARICOPA	525	35.0	2	2	8	32	2	2	1	L	Gv	W
MA-28	W	MARICOPA	NA	38.0	2	2	9	26	1	4	3	L	Gv	W
MA-29	W	MARICOPA	579	40.0	2	2	9	34	4	2	2	L	Gv	W
MA-30	W	MARICOPA	433.0	35.0	2	1	9	6	3	3	3	L	Gv	W
MA-32	W	MARICOPA	519.0	35.0	2	1	9	7	3	3	3	L	Gv	W
MA-33	W	MARICOPA	279.0	36.0	2	1	9	7	4	3	3	L	Gv	W
MA-34	W	MARICOPA	374.0	39.0	2	1	9	2	1	2	2	L	Gv	W
MA-35	W	MARICOPA	488.0	35.0	2	1	9	2	3	1	1	L	Gv	W
MA-36	W	MARICOPA	NA	35.0	2	1	8	6	1	4	4	L	Gv	W
MA-37	W	MARICOPA	NA	35.0	2	1	8	7	1	1	1	L	Gv	W
MA-38	W	MARICOPA	NA	37.0	2	1	9	1	4	4	3	L	Gv	W
MA-39	W	MARICOPA	244.0	40.0	2	1	8	7	3	2	2	L	Gv	W
MA-40	W	MARICOPA	522.0	36.0	2	1	9	15	1	2	3	L	Gv	W
MA-41	W	MARICOPA	456.0	36.0	2	1	9	17	3	2	2	L	Gv	W
MA-42	W	MARICOPA	457.0	35.0	2	1	9	18	2	3	3	L	Gv	W
MA-43	W	MARICOPA	NA	35.0	2	1	9	20	3	3	3	L	Gv	W
MA-44	W	MARICOPA	344.0	36.0	2	1	9	28	3	3	3	L	Gv	W
MA-45	W	MARICOPA	195.0	45.0	3	1	9	6	4	3	3	L	Gv	W
MA-46	W	MARICOPA	NA	37.0	3	1	8	4	2	4	1	L	Gv	W
MA-50	W	MARICOPA	105.0	42.0	2	2	7	25	2	3	1	L	Gv	W
MA-51	W	MARICOPA	302.0	38.0	2	2	7	36	1	2	2	L	Gv	W
MA-54	W	MARICOPA	63.0	49.0	2	2	7	26	1	1	1	L	Gv	W
MA-55	W	MARICOPA	122.0	44.0	2	2	7	26	1	2	2	L	Gv	W
MA-56	W	MARICOPA	152.0	37.0	2	2	7	26	1	3	2	L	Gv	W
MA-57	W	MARICOPA	137.0	36.0	2	2	7	26	2	1	2	L	Gv	W
MA-58	W	MARICOPA	NA	37.0	2	2	7	36	2	2	1	L	Gv	W
MA-59	W	MARICOPA	NA	35.0	2	2	7	36	3	2	2	L	Gv	W
MA-60	W	MARICOPA	552.0	35.0	2	1	5	35	1	4	2	L	Gv	W
MA-61	W	MARICOPA	482.0	41.0	3	1	4	6	2	2		L	Gv	W
MA-62	W	MARICOPA	NA	40.0	2	1	4	30	1	3	2	L	Gv	W

Table 2
Geothermal Energy Resource Types and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Reference Number [1]	Well/ Spring	County	Depth m	Temp °C	Location							Geothermal Energy Resource Type [2]		
					Quad	Twn	Rng	Sec	160	40	10	Temp	Geology	Fluid
MA-63	W	MARICOPA	235.0	36.0	2	1	4	32	2	2	2	L	Gv	W
MA-64	W	MARICOPA	451.0	42.0	3	1	4	4	3	4	4	L	Gv	W
MA-65	W	MARICOPA	552.0	35.0	2	1	4	35	1	1	4	L	Gv	W
MA-66	W	MARICOPA	607.0	40.0	2	1	4	35	1	3	4	L	Gv	W
MA-67	W	MARICOPA	306.0	43.0	3	1	3	6	2	3	2	L	Gv	W
MA-103	W	MARICOPA	457.0	50.0	2	1	2	16	4	2	4	L	Gv	W
MA-104	W	MARICOPA	458.0	43.0	2	1	2	18	3	1	2	L	Gv	W
MA-105	W	MARICOPA	506.0	41.0	2	1	2	18	2	1	1	L	Gv	W
MA-106	W	MARICOPA	464.0	46.0	2	1	2	2	2	2	2	L	Gv	W
MA-107	W	MARICOPA	464.0	48.0	2	1	2	2	2	2	2	L	Gv	W
MA-108	W	MARICOPA	NA	48.0	2	1	2	2	3	3	2	L	Gv	W
MA-109	W	MARICOPA	549.0	49.0	2	1	2	2	3	3	3	L	Gv	W
MA-110	W	MARICOPA	347.0	43.0	2	1	2	3	4	2	2	L	Gv	W
MA-111	W	MARICOPA	NA	46.0	2	1	2	3	4	3	4	L	Gv	W
MA-112	W	MARICOPA	548.0	49.0	2	1	2	3	4	3	3	L	Gv	W
MA-113	W	MARICOPA	362.0	42.0	2	1	2	8	4	3	3	L	Gv	W
MA-114	W	MARICOPA	516.0	44.0	2	1	2	8	4	4	1	L	Gv	W
MA-115	W	MARICOPA	97.0	43.0	2	1	2	8	4	1	4	L	Gv	W
MA-116	W	MARICOPA	515.0	41.0	2	1	2	8	4	4	1	L	Gv	W
MA-117	W	MARICOPA	402.0	37.0	2	1	2	9	2	2	2	L	Gv	W
MA-118	W	MARICOPA	307.0	43.0	2	1	2	16	2	2	2	L	Gv	W
MA-119	W	MARICOPA	266.0	46.0	2	1	2	15	2	2	2	L	Gv	W
MA-120	W	MARICOPA	NA	36.0	2	1	2	21	4	2	2	L	Gv	W
MA-121	W	MARICOPA	274.0	36.0	2	1	2	21	4	3	1	L	Gv	W
MA-125	W	MARICOPA	407.0	35.0	3	1	6	18	2	2	2	L	Gv	W
MA-147	W	MARICOPA	592.0	35.0	1	1	2	9	4	3	3	L	Gv	W
MA-148	W	MARICOPA	1590.0	39.0	1	1	2	24	4	4	3	L	Gv	W
MA-157	W	MARICOPA	243.0	40.0	1	1	6	14	1	1	1	L	Gv	W
MA-158	W	MARICOPA	92.0	42.0	1	1	6	23	1	4		L	Gv	W
MA-159	W	MARICOPA	99.0	42.0	1	1	6	23	3	4		L	Gv	W
MA-160	W	MARICOPA	92.0	41.0	1	1	6	23	4	2		L	Gv	W
MA-161	W	MARICOPA	298.0	38.0	1	1	6	22	4	1	1	L	Gv	W
MA-162	W	MARICOPA	305.0	40.0	1	1	6	28	4	3	4	L	Gv	W
MA-163	W	MARICOPA	107.0	37.0	1	1	6	26	1	3	3	L	Gv	W
MA-164	W	MARICOPA	305.0	54.0	1	1	6	24	1	3		L	Gv	W
MA-165	W	MARICOPA	397.0	47.0	1	1	7	36	4	1		L	Gv	W
MA-166	W	MARICOPA	336.0	41.0	4	1	7	4	2	3		L	Gv	W
MA-167	W	MARICOPA	659.0	36.0	4	1	7	7	2	3		L	Gv	W
MA-168	W	MARICOPA	594.0	47.0	4	1	6	27	4	4	1	L	Gv	W
MA-169	W	MARICOPA	2783.0	120.0	4	2	6	1	1	4		M	Gv	W
MA-170	W	MARICOPA	2768.0	118.0	4	2	6	1	4	1		M	Gv	W
MA-171	W	MARICOPA	393.0	35.0	4	2	6	14	4	4	1	L	Gv	W
MA-172	W	MARICOPA	610.0	44.0	4	2	5	27	4	4	1	L	Gv	W
MA-173	W	MARICOPA	440.0	35.0	4	2	6	33	1	1	2	L	Gv	W

Table 2
Geothermal Energy Resource Types and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Reference Number [1]	Well/ Spring	County	Depth m	Temp °C	Location							Geothermal Energy Resource Type [2]		
					Quad	Twn	Rng	Sec	160	40	10	Temp	Geology	Fluid
MA-174	W	MARICOPA	438.0	37.0	4	2	6	33	1	2	1	L	Gv	W
MA-175	W	MARICOPA	279.0	36.0	4	2	6	34	2	4	4	L	Gv	W
MA-176	W	MARICOPA	NA	37.0	4	2	6	25	4	1	1	L	Gv	W
MA-177	W	MARICOPA	208.0	38.0	4	2	6	25	4	4	4	L	Gv	W
MA-178	W	MARICOPA	152.0	35.0	4	2	7	33	1	4	4	L	Gv	W
MA-179	W	MARICOPA	323.0	37.0	4	2	7	34	1	4	4	L	Gv	W
MA-180	W	MARICOPA	140.0	36.0	3	2	4	32	3	1	1	L	Gv	W
MA-181	W	MARICOPA	261.0	36.0	3	2	4	25	3	3	3	L	Gv	W
MA-182	W	MARICOPA	287.0	36.0	3	2	2	27	3	3	3	L	Gv	W
MA-183	W	MARICOPA	322.0	35.0	3	2	2	27	3	2		L	Gv	W
MA-184	W	MARICOPA	330.0	36.0	3	2	2	27	3	4	4	L	Gv	W
MA-185	W	MARICOPA	NA	38.0	3	2	1	19	1	1	4	L	Gv	W
MA-186	W	MARICOPA	292.0	36.0	3	2	1	18	4	1	1	L	Gv	W
MA-187	W	MARICOPA	472.0	36.0	3	2	1	20	2	1	1	L	Gv	W
MA-188	W	MARICOPA	219.0	36.0	3	2	1	20	4	2	1	L	Gv	W
MA-189	W	MARICOPA	247.0	35.0	3	2	1	29	2	1	2	L	Gv	W
MA-190	W	MARICOPA	247.0	36.0	3	2	1	29	3	1	1	L	Gv	W
MA-191	W	MARICOPA	NA	37.0	3	2	1	31	1	3	1	L	Gv	W
MA-192	W	MARICOPA	314.0	35.0	3	2	2	26	2	2	2	L	Gv	W
MA-193	W	MARICOPA	286.0	36.0	3	2	1	29	4	1	1	L	Gv	W
MA-194	W	MARICOPA	NA	36.0	3	2	1	29	4	4	1	L	Gv	W
MA-195	W	MARICOPA	NA	38.0	3	2	1	28	2	1	2	L	Gv	W
MA-196	W	MARICOPA	NA	37.0	3	2	1	24	1	3	2	L	Gv	W
MA-197	W	MARICOPA	245.0	37.0	3	2	1	28	4	1	4	L	Gv	W
MA-198	W	MARICOPA	314.0	37.0	3	2	1	33	1	1	1	L	Gv	W
MA-199	W	MARICOPA	NA	38.0	3	2	1	33	2	1	1	L	Gv	W
MA-200	W	MARICOPA	268.0	35.0	3	2	1	32	1	4	1	L	Gv	W
MA-212	W	MARICOPA	152.0	35.0	3	4	8	26	4	4	4	L	Gv	W
MA-213	W	MARICOPA	534.0	49.0	3	5	4	31	3	2	4	L	Gv	W
MA-214	W	MARICOPA	532.0	35.0	3	5	4	31	1	4	4	L	Gv	W
MA-215	W	MARICOPA	532.0	42.0	3	5	4	31	3	1	3	L	Gv	W
MA-216	W	MARICOPA	NA	41.0	3	6	5	1	2	1	1	L	Gv	W
MA-217	W	MARICOPA	305.0	35.0	3	6	5	2	1	4	2	L	Gv	W
MA-218	W	MARICOPA	300.0	38.0	3	6	5	2	2	4	3	L	Gv	W
Roosevelt Dam Spring	S	MARICOPA	NA	48.0	1	4	12	19	4	4	3	L	Gv	W
Quitobaquito Spring	S	PIMA	NA	32.0	3	17	7	17	3	3		L	Gv	W
PM-1	W	PIMA	440.0	36.0	3	12	6	32				L	Gv	W
PM-2	W	PIMA	690.0	44.0	3	12	6	33				L	Gv	W
PM-3	W	PIMA	540.0	41.0	3	13	6	10				L	Gv	W
PM-11	W	PIMA	31.0	36.0	4	13	8	11	2	4	3	L	Gv	W
PM-21	W	PIMA	213.0	36.0	4	17	4	30	3	2	3	L	Gv	W
PM-22	W	PIMA	36.0	42.0	4	17	4	25	1	4	3	L	Gv	W
PM-27	W	PIMA	128.0	47.0	4	19	1	5	3	1	2	L	Gv	W
PM-28	W	PIMA	290.0	38.0	3	19	1	12	4	1	1	L	Gv	W

Table 2
Geothermal Energy Resource Types and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Reference Number [1]	Well/ Spring	County	Depth m	Temp °C	Location							Geothermal Energy Resource Type [2]		
					Quad	Twn	Rng	Sec	160	40	10	Temp	Geology	Fluid
PM-29	W	PIMA	127.0	46.0	4	19	1	7	4	2	2	L	Gv	W
PM-30	W	PIMA	194.0	51.0	4	19	1	8	3	2	2	L	Gv	W
PM-31	W	PIMA	284.0	39.0	4	19	1	8	4	2	2	L	Gv	W
PM-32	W	PIMA	223.0	36.0	4	20	5	15	3	2	2	L	Gv	W
PN-1	W	PINAL	1408.0	53.0	4	1	12	33	1	3		L	Gv	W
PN-2	W	PINAL	1808.0	72.0	4	1	12	34	2			L	Gv	W
PN-3	W	PINAL	342.0	38.0	4	3	6	5	2	1	1	L	Gv	W
PN-4	W	PINAL	168.0	39.0	4	4	2	14	2	2	2	L	Gv	W
PN-5	W	PINAL	154.0	36.0	4	4	3	2	3	2	2	L	Gv	W
PN-6	W	PINAL	111.0	37.0	4	4	3	13	4	4	4	L	Gv	W
PN-7	W	PINAL	140.0	37.0	4	4	7	27	2	2	2	L	Gv	W
PN-9	W	PINAL	NA	37.0	4	5	8	2	1	4	1	L	Gv	W
PN-10	W	PINAL	106.0	36.0	4	5	3	12	1	1	4	L	Gv	W
PN-11	W	PINAL	183.0	36.0	4	5	2	25	3	3	3	L	Gv	W
PN-12	W	PINAL	306.0	35.0	4	5	7	12	4	4	4	L	Gv	W
PN-13	W	PINAL	469.0	46.0	4	5	7	24	2	4		L	Gv	W
PN-14	W	PINAL	NA	37.0	4	5	8	20	2	4	4	L	Gv	W
PN-15	W	PINAL	427.0	46.0	4	5	7	23	3	4		L	Gv	W
PN-16	W	PINAL	591.0	54.0	4	5	7	25	1	4	4	L	Gv	W
PN-17	W	PINAL	NA	52.0	4	5	8	28	3	4	4	L	Gv	W
PN-18	W	PINAL	367.0	42.0	4	5	7	34	1	3	4	L	Gv	W
PN-19	W	PINAL	724.0	54.0	4	5	7	36	1	3	3	L	Gv	W
PN-20	W	PINAL	914.0	65.0	4	6	7	1	1	1	1	L	Gv	W
PN-21	W	PINAL	782.0	72.0	4	6	8	6	1	4	4	L	Gv	W
PN-22	W	PINAL	914.0	46.0	4	6	6	8	2	4	4	L	Gv	W
PN-23	W	PINAL	931.0	49.0	4	6	7	1	4	3		L	Gv	W
PN-24	W	PINAL	126.0	35.0	4	6	7	10	4	3	4	L	Gv	W
PN-25	W	PINAL	914.0	62.0	4	6	7	13	1	4	4	L	Gv	W
PN-26	W	PINAL	995.0	61.0	4	6	8	18	3	4	4	L	Gv	W
PN-27	W	PINAL	989.0	46.0	4	6	8	18	3	4		L	Gv	W
PN-29	W	PINAL	543.0	41.0	4	6	5	19	4	4		L	Gv	W
PN-30	W	PINAL	786.0	43.0	4	6	7	35	1	4		L	Gv	W
PN-31	W	PINAL	774.0	49.0	4	6	7	34	4	4	4	L	Gv	W
PN-32	W	PINAL	2438.0	102.0	4	7	8	8	2	4		M	Gv	W
PN-33	W	PINAL	600.0	46.0	4	7	4	31				L	Gv	W

SOURCES: Witcher et al. (1982); National Geophysical Data Center [NGDC] (2003)

NOTES:

Resource Type: Well (w) or Spring (s)

NA = Not available

1 Reference numbers refer to locations posted on Map 5 - Geothermal Resources Potential

2 See text for discussion of mineral types.

QUAD = Quadrant relative to the intersection of the baseline and meridian

160 = The 160-acre quadrant within the designated Section

40 = The 40-acre quadrant within the designated 160-acre portion of the Section

10 = The 10-acre quadrant within the designated 40-acre portion of the Section

Temperature Type	Geologic Setting Type	Fluid Type
L = low	Gm = magmatic	W = liquid-dominated
M = moderate	Gv = convective	V = vapor-dominated
H = high	Gd = conductive	HDR = hot dry rock dominated
	Gg = geopressured	

2	1
3	4

1 = Northeast quadrant
2 = Northwest quadrant
3 = Southwest quadrant
4 = Southeast quadrant

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Mineral District	Aliases	Classification and Age [1]	Duration of Production	Commodity [2]									
				Base and/or Precious Metal (tons)	Cu (tons)	Pb (tons)	Zn (tons)	Mo (tons)	Au (ounces)	Ag (ounces)	Mn (tons)	W (tons)	U and/or V (tons)
Gila County													
			1875-1981	12,133,000	517,000	1,700	50	NR	107,400	8,263,000	NR	NR	NR
Globe Hills		1a-KT	1982-2002	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Pinto Valley, Globe		1899-1981	759,476,000	5,234,000	462	4.5	10,290	136,000	9,358	NR	NR	NR
Miami-Inspiration	Miami, Inspiration	1a-KT	1982-2002	NR	2,648,512	NR	NR	NR	NR	NR	NR	NR	NR
Pinal Mountains	Pioneer	1a-KT	1904-1966	6,000	59	45	NR	NR	300	60,500	NR	NR	NR
Richmond Basin	McMorris	1a-KT	1875-1885	900	6	4	NR	NR	NR	65,000	24	NR	NR
Summit		1a-KT	1903-1969	58,000	8,750	1	NR	NR	100	23,000	NR	>1	NR
Maricopa County													
Buckeye Hills		10c-eT	no data	NR	NR	NR	NR	NR	NR	NR	NR	NR	U
Estrella	Salt River Mtns	2-?	1937	<100	1	NR	NR	NR	NR	NR	NR	NR	NR
Four Peaks		8-mpC	unknown	NR	NR	NR	NR	NR	NR	NR	NR	26	NR
Gila Bend Mtns	Webb	3-mT?	no data	NR	NR	NR	NR	NR	Au	NR	NR	NR	NR
Goldfield		3-mT	1910-1959	23,000	8	NR	NR	NR	5,100	4,000	NR	NR	NR
Maricopa Mtns Area [4]		1a-?, 3	unknown	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
McDowell		3-mT	1940s	100	1	NR	NR	NR	NR	500	NR	NR	NR
Midway		11-mT	no data	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Painted Rock		4-mT	1913-1923	300	18.5	39.5	NR	NR	10	1,200	NR	NR	NR
Salt River Mtns		3-mT	1913-1942	15,000	14	NR	NR	NR	7,000	5,000	NR	NR	NR
Webb	Gila Bend Mtns	2-mT	1935-1951	400	13.5	NR	NR	NR	50	200	NR	NR	NR
Yuma County													
Mohawk		4-mT	1913-1941	<100	0.4	2	NR	NR	NR	4,700	NR	NR	NR

Sources: Keith et al. 1983; Welty et al. 1985; Richard 2000; Niemuth 2003

1 Classification:
- 1a - Copper, porphyry
- 1b - Copper, stratabound
- 2 - Copper with gold veins
- 3 - Gold, with or without copper
- 3* - Gold and copper; gold and silver
- 4 - Lead-zinc-silver vein and replacement
- 4* - Lead-zinc-silver with significant gold
- 5 - Silver vein and/or replacement with or without lead and zinc
- 5* - Silver and copper with little/no lead, zinc or gold
- 6a - Manganese vein
- 8 - Tungsten
- 10b - Uranium stratabound
- 10c - Uranium vein/fissure
- 11 - Iron
- I - industrial

Age:
- T = Tertiary
- K - Cretaceo
- J - Jurassic
- Dev - Devon
- pC - Precaml
- e - early
- m - middle
- l - late
- y -
- ? - age uncer

2 Commodity: Cu = copper; Pb = lead; Zn = zinc; Mo = molybdenum; Au = gold; Ag = silver; Mn = manganese; W = tungsten; U = uranium; V = vanadium

3 NR = Not reported

4 Districts labeled as areas are not reported in Keith et al. 1983, but are shown on the updated database provided by Arizona Department of Mines and Mineral Resources.

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Mineral District	Aliases	Classi-fication and Age [1]	Duration of Production	Commodity [2]									
				Base and/or Precious Metal	Cu (tons)	Pb (tons)	Zn (tons)	Mo (tons)	Au (ounces)	Ag (ounces)	Mn (tons)	W (tons)	U and/or V (tons)
Pima County													
Agua Dulce Area [4]		3-?	unknown	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aguirre Peak	Baboquivari	8-eT	1957-1963	NR	0.3	NR	NR	NR	NR	NR	NR	>200	NR
Ajo		1a-KT	1899-1979	430,038,000	3,013,190	15	NR	225	1,558,000	19,672,000	NR	NR	NR
Ajo Cornelia	Ajo	1b-KT	1917	<100	3.5	NR	NR	NR	NR	150	NR	NR	NR
Baboquivari	Aguirre Peak, Mildred Peak, Quinlan	3-mT	1895-1972	59,000	8.5	0.5	NR	NR	11,300	136,000	NR	NR	NR
Ben Nevis	Quijotoa	5-mT	1885-1951	300	1	NR	NR	NR	NR	118,000	NR	NR	NR
Black Dragon		6a-mT	unknown	NR	NR	NR	NR	NR	NR	NR	58.5	NR	NR
Brownell	Quijotoa	1a-KT	1927-1957	2,400	38.5	1.3	NR	NR	NR	13,300	NR	NR	NR
Cababi	Comobabi	4*-eT	1864-1974	7,000	86	159.5	1	NR	3,000	72,400	NR	NR	NR
Cadillac		6a-mT	unknown	NR	NR	NR	NR	NR	NR	NR	16.5	NR	NR
Cimarron Mtns		6a-KT	1910-1942	100	1.65	3.5	NR	NR	NR	300	3,745	NR	NR
Comobabi	Cababi	5*-eT	1907-1951	NR	3.75	NR	NR	NR	NR	1,800	NR	NR	NR
Coyote		1a-KT	1916-1964	1,000	70	NR	NR	NR	NR	1,500	NR	NR	NR
Growler		4-eT?	1929-1949	100	1.2	3.8	NR	NR	NR	200	NR	NR	NR
Gunsight	Meyer	5-eT	1881-1966	6,400	1.5	26	NR	NR	100	133,500	NR	NR	NR
Kitt Peak		1a-J	no data	NR	Cu	NR	NR	NR	NR	NR	NR	NR	NR
Mildred Peak	Baboquivari	5*-eT	1911-1956	5,300	105	5.5	NR	NR	1,000	33,600	NR	NR	NR
Montezuma	Puerto Blanco	5*-eT	1915-1954	1,000	99	7.5	NR	NR	<100	9,900	NR	NR	NR
Quijotoa	Brownell, Ben Nevis	3*-eT	1890-1956	5,000	32.5	14	NR	NR	1,500	16,000	NR	NR	NR
Quinlan	Baboquivari	8-eT	1913	NR	NR	0.5	NR	NR	NR	<100	NR	2,210	NR
Quitobaquito		4-eT?	no data	NR	NR	Pb	NR	NR	NR	Ag	NR	NR	NR
Roadside		3-lK	1917-1954	25	NR	NR	NR	NR	10	20	NR	NR	NR
Santa Rosa		1a-KT	1916-1940	200	10.5	3	NR	NR	<100	1,300	NR	NR	NR
Sierra Blanca Area [4]		12-?	unknown	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Waterman	Silver Hill	4-lK	1901-1969	30,000	910	565	410	NR	100	73,000	NR	NR	NR

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Mineral District	Aliases	Classi-fication and Age [1]	Duration of Production	Commodity [2]									
				Base and/or Precious Metal	Cu (tons)	Pb (tons)	Zn (tons)	Mo (tons)	Au (ounces)	Ag (ounces)	Mn (tons)	W (tons)	U and/or V (tons)
Pinal County													
Casa Grande	Sacaton, Vekol, Slate, Silver Reef	1a-KT	1929-1981	28,988,000	151,270	NR	NR	NR	25,400	1,081,000	NR	NR	NR
			1982-1984	NR	44,182	NR	NR	NR	NR	NR	NR	NR	NR
Estrella		2-?	1937	<100	1	NR	NR	NR	NR	<100	NR	NR	NR
Francisco Grande		1a-KT	unknown	NR	Reserves	NR	NR	NR	NR	NR	NR	NR	NR
Goldfield		3-mT	1880s-1959	23,000	8	NR	NR	NR	8,100	4,000	NR	NR	NR
Gold Mine Mtn	Blackwater	3-T?	no data	NR	NR	NR	NR	NR	Au	NR	NR	NR	NR
Greenback	Pinal Grande	3-mT	1939-1940	800	1	NR	NR	NR	100	3,200	NR	NR	NR
Lakeshore		1a-KT	1907-1981	7,329,000	58,170	1	NR	Reserves	1,000	7,000	NR	NR	NR
Mammon	Lakeshore, Slate	3-?	1893-1938	1,400	0.8	NR	NR	NR	2,000	200	NR	NR	NR
Mineral Butte	Blackwater	1a-KT	1920-1953	300	8.25	0.5	NR	NR	NR	100	NR	NR	NR
Mineral Creek	Ray	1a-KT	1905-1981	327,507,000	2,795,000	6,061	142	3,985	57,900	8,789,000	NR	NR	NR
			1982-2002	NR	2,743,189	NR	NR	NR	NR	NR	NR	NR	NR
Mineral Hill	Pima	5-mT	1887-1977	178,000	248	132	10	NR	1,900	2,257,000	Reserves	NR	NR
Mineral Mountain		4-mT	1935-1973	1,200	6.7	81.5	13	NR	100	1,000	NR	NR	NR
Pinal Grande	Greenback, Copperosity	1a-KT	1907-1952	800	86.5	2.5	1	NR	<100	150	NR	NR	NR
Pioneer		1a-KT	1982-1995	NR	111,325	NR	NR	NR	NR	NR	NR	NR	NR
Poston Butte		1a-KT	1970	<100	0.35	NR	NR	NR	200	300	NR	NR	NR
Randolph		5-mT	1941-1954	200	0.75	NR	NR	NR	<100	2,500	NR	NR	NR
Sawtooth		6a-mT	unknown	NR	NR	NR	NR	NR	NR	NR	32.6	NR	NR
Silver Reef	Slate, Sawtooth	5-mT	1914-1965	45,000	30.5	NR	NR	NR	250	473,000	101	NR	NR
Slate	Lakeshore, Mammoth, Silver Reef	4-mT	1900-1981	185,000	5	30.5	NR	NR	600	87,000	NR	NR	NR
Summit		1a-KT	1903-1969	58,000	8,745	1	NR	NR	100	23,000	NR	NR	NR
Superstition Mtns		3-mT	1935-1936	3,000	17.5	NR	NR	NR	1,000	2,400	NR	NR	NR
Vekol	Pinal Grande	1a-KT	1882-1965	100,000	376	47.5	NR	Reserves	2,900	1,000,000	NR	NR	NR
Wood Camp Canyon		2-?	1916-1971	1,000	13.5	NR	NR	NR	NR	3,700	NR	5	NR

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Other (tons)
NR
NR
NR
NR
NR
81
NR
NR
NR
NR
Au
NR
NR
NR
NR
NR
NR
NR
NR

ous

nian
ıbrian

rtain

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Other (tons)
NR
NR
NR
NR
NR
NR
184
6
NR
119
21,243
NR
NR
NR
NR
NR
NR
NR
8
NR
NR
NR
NR
NR
NR

Table 3
Metallic Mineral District Production History
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

Other (tons)
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
NR
108
336
NR
NR
NR
NR
NR

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
1	D000085	IRENE OR LIBERTY DEPOSIT	GILA	MIAMI-INSPIRATION	PINAL	-110.766700	33.416700			
2	D000317	ROSCOE GROUP	GILA	SUMMIT	PINAL	-110.933300	33.383300			
3	D000321	ROWLEY MINE	MARICOPA	PAINTED ROCK	PAINTED ROCK	-113.024200	33.048900	PB CU	T	
4	D000752	LAKESHORE MINE	PINAL	LAKESHORE	SLATE	-111.902500	32.523600	CU	T	MESCAL
5	D000761	FALCON	GILA	SUMMIT	PINAL	-110.850000	33.366700	W		
6	D000765	SUMMIT	GILA	SUMMIT	PINAL	-110.966700	33.366700			
7	D000786	BIG JUANITA MINE	PIMA	BABOQUIVARI	BABOQUIVARI	-111.583300	31.916700	W		
8	D000824	THANKSGIVING	PIMA	-	SHERIDAN	-112.050000	32.350000			
9	D001777	BUCKEYE AREA	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.583300	33.283300			
10	D002165	AJO DISTRICT	PIMA	AJO	LITTLE AJO	-112.866700	32.366700	CU AU AG	eT	
11	D002419	COYOTE CLAIM - ROADSIDE MINE	PIMA	COYOTE	COYOTE	-111.500000	32.016700			
12	D002425	CONFIDENCE CLAIMS 1 - 19	PINAL	-	-	-111.916700	32.750000	CU		
13	D002427	ELDORADO CLAIMS	PIMA	-	-	-112.166700	32.666700			
14	D002508	LITTLE MARY ET AL CLAIMS	PIMA	COMOBABI	-	-111.966700	32.216700			
15	D003013	WHETROCKS, ELEPHANT CO. CU-W	MARICOPA	-	MAZATZAL	-111.220800	33.545800			
16	D003057	GIANT TUNGSTEN PROSPECT	PIMA	BABOQUIVARI	BABOQUIVARI	-111.666700	31.733300			
17	D003242	TWENTIETH CENTURY MINE	GILA	GLOBE	PINAL	-110.916700	33.266700	W ZN PB		PINAL SCHIST
18	D003245	DIXIE COPPER MINE	MARICOPA	WINIFRED	MCDOWELL	-111.766700	33.666700	CU		
19	D003254	RANDOLPH LEAD-ZINC PROPERTY	PINAL	SUPERSTITION MTNS	SUPERSTITION	-111.483300	33.429200			
20	D003611	TUNGSTEN NO. 1 MINE	GILA	GLOBE - MIAMI	PINAL	-110.883300	33.370800	W MO PB		
95	M000001	HIGHTOWER MICA MINE	MARICOPA	SALT RIVER MTNS	SIERRA ESTRELLA	-112.228300	33.196100	MIC		
96	M000002	CARA VACA MINE	PIMA	BROWNELL	BROWNELL	-112.198100	32.180300	AU AG	T?	
97	M000003	COPPER LEDGE MINE	PIMA	AJO	LITTLE AJO	-112.838300	32.353300	CU	K-Pal	
98	M000009	VEKOL MINE	PINAL	VEKOL	TAT MOMOLI	-112.140000	32.603900	AG CU PB ZN M	Mz-Cz	BOLSA;ABRIGO;MARTIN;ESCABROSA;NACO
99	M000011	POMONA MINE	PINAL	VEKOL	TAT MOMOLI	-112.128900	32.588900	PB AG	lK-T	ESCABROSA
100	M000014	SILVER LAKE MINE	PINAL	PINAL GRANDE	TAT MOMOLI	-112.119700	32.556100	PB ZN		
101	M000018	MOCKING BIRD MINE GROUP	PIMA	QUIJOTOA	QUIJOTOA	-112.134200	32.123600	AU AG	eT	
102	M000019	MAN'S DREAM MINE	PIMA	BROWNELL	BROWNELL	-112.175800	32.220000	CU	eT	
103	M000020	MANGANESE KING MINE	PIMA	CIMARRON MTNS	-	-112.126400	32.427500	MN	T	
104	M000021	PEER AND PEERLESS GROUP	PIMA	BEN NEVIS	QUIJOTOA	-112.146400	32.070600	AU AG	T	
105	M000022	ST. PATRICK MINE	PIMA	QUIJOTOA	QUIJOTOA	-112.168100	32.164700	CU AG	eT	
106	M000023	BROWNELL MINE	PIMA	BROWNELL	BROWNELL	-112.138600	32.248100	AG CU	T?	
107	M000024	WELDON MINE	PIMA	QUIJOTOA	QUIJOTOA	-112.151100	32.062800	AU AG	eT	
108	M000025	SILVER BULLION MINE	PIMA	BROWNELL	BROWNELL	-112.118600	32.195300	AG PB CU	eT	
109	M000026	COPPER SQUAW MINE	PIMA	BROWNELL	BROWNELL	-112.103900	32.163900	CU AG	T?	
110	M000027	HORSESHOE PLACERS	PIMA	QUIJOTOA	QUIJOTOA	-112.112800	32.092200	AU	Q	
111	M000028	LINDA LEE CLAIMS	PIMA	QUIJOTOA	QUIJOTOA	-112.126900	32.130000	AU	eT	
112	M000029	MORGAN MINE GROUP	PIMA	QUIJOTOA	QUIJOTOA	-112.141100	32.112500	AU AG	eT	
113	M000031	GOSSAN NO. 4 PROSPECT	PIMA	-	-	-112.109200	32.317800	CU	T?	
114	M000038	PAPAGO MINE	PIMA	-	-	-113.259700	32.095000	AU	T?	
115	M000039	STELLA MARIS NO. 1 MINE	PIMA	CIMARRON MTNS	-	-112.116900	32.432200	MN	Mio-Plio	
116	M000040	AJO PLACERS	PIMA	AJO	LITTLE AJO	-112.854400	32.358600	AU	Q	
117	M000041	STEPP - LAIVE OCCURRENCE	PIMA	QUIJOTOA	QUIJOTOA	-112.145000	32.136900		eT	
118	M000048	TURNING POINT MINE	PINAL	SLATE	SLATE	-111.895800	32.600000	AG CU PB	T	ESCABROSA
119	M000053	SUN GOLD MINE	PIMA	CABABI	NORTH COMOBABI	-111.916100	32.030600	AU PB AG	eT	
120	M000056	UNNAMED PROSPECT	PINAL	CASA GRANDE	SACATON	-111.883300	33.016700	COR TI		
121	M000061	HORSESHOE BASIN OCCURRENCE	PIMA	QUIJOTOA	QUIJOTOA	-112.136900	32.127200		eT	
122	M000064	UNNAMED PROSPECT	PINAL	SILVER REEF	-	-111.784700	32.728600	MN		
123	M000075	CORONA GROUP	PIMA	CABABI	SOUTH COMOBABI	-111.823100	32.008600	AU	eT	
124	M000083	CIMARRON MINE GROUP	PIMA	MONTEZUMA	SONOYTA	-112.889400	31.969200	CU AG	eT	
125	M000084	VICTORIA MINE	PIMA	MONTEZUMA	SONOYTA	-112.837500	31.939400	PB AG	eT	
126	M000085	LUCKY STRIKE	PINAL	GOLD MINE MTNS	SANTAN	-111.642500	33.188300	AU		
127	M000141	ST. JUDE MINE	PIMA	ROSKRUGE	-	-111.453100	32.120600	AG	K-T	
128	M000143	CARLO & ECLIPSE MINES	PIMA	WATERMAN	-	-111.493100	32.326900	SIL CU AG	K-T	
129	M000184	SNOW WHITE PERLITE MINE	PINAL	PIONEER	SUPERSTITION	-111.165300	33.319400	PER		

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
130	M000241	GABITZSCH-OWENS TUNGSTEN GRP	PINAL	SUMMIT	PINAL	-110.983300	33.350000	W		
131	M000244	LAKE SUPERIOR & ARIZONA MINE	PINAL	PIONEER	SUPERSTITION	-111.096700	33.302200	AU CU		TROY QTZT; MARTIN
132	M000245	RAINBOW GROUP	PINAL	SUMMIT	PINAL	-110.989200	33.360000	W		
133	M000284	SILVER QUEEN MINE	PIMA	CABABI	NORTH COMOBABI	-111.936700	32.066400	AG CU	K-T	
134	M000346	SILVER GIANT MINE	PIMA	COMOBABI	NORTH COMOBABI	-111.848300	32.139200	AG	K-T	
135	M000347	OLD TIMER MINE	PIMA	CABABI	NORTH COMOBABI	-111.931100	32.061700	AG		
136	M000364	SAMSEL MINE	GILA	PINAL MOUNTAINS	PINAL	-110.890800	33.278300	W	lK-T	PINAL SCHIST
137	M000365	MADERA PROSPECT	GILA	PINAL MOUNTAINS	PINAL	-110.893100	33.332800	CU	T	PINAL SCHIST
138	M000370	BOBTAIL MINE	GILA	PIONEER	PINAL	-110.863300	33.272800	AU AG CU	eT	PINAL SCHIST
139	M000461	BADGER MINE	PIMA	CABABI	SOUTH COMOBABI	-111.820300	31.992500	AU AG	K-T	
140	M000487	WESTLAKE PROSPECT	GILA	PIONEER	PINAL	-110.858300	33.300800	W	eT	PINAL SCHIST
141	M000542	LUCIDO CLAIM GROUP	PIMA	CABABI	SOUTH COMOBABI	-111.816900	31.985600	AU AG	K-T	
142	M000543	DESERT LODE MINE	PIMA	CABABI	SOUTH COMOBABI	-111.955300	32.040600	AU AG	K-T	
143	M000667	SWEDE MINE	PINAL	SUMMIT	PINAL	-110.991700	33.361100	W	T	PINAL SCHIST
144	M000684	COMOBABI & CRUSADER MINES	PIMA	CABABI	SOUTH COMOBABI	-111.887800	32.013600	AG CU	K-T	
145	M000688	COLUMBIA MINE GROUP	PIMA	CABABI	SOUTH COMOBABI	-111.787500	32.058300	CU AG	K-T	
146	M000692	VENTANA MINE GROUP	PIMA	BABOQUIVARI	BABOQUIVARI	-111.662200	31.780800	CU		
147	M000928	EMMETT AND ELGIN MINE	PIMA	MILDRED PEAK	BABOQUIVARI	-111.655300	31.713100	AU	K-T	
148	M001009	CABABI PLACERS	PIMA	CABABI	SOUTH COMOBABI	-111.809700	31.981700	AU	Q	
149	M001017	SHERWOOD MINE	PIMA	CABABI	SOUTH COMOBABI	-111.863600	31.996900	CU AG	K-T	
150	M001035	LOBOS GROUP	PIMA	AGUIRRE PEAK	BABOQUIVARI	-111.671700	31.644200	U	K-T	
151	M001974	BRONX MINE	GILA	SUMMIT	PINAL	-110.976100	33.366100	MO	eT	
152	M001978	SIXTY-FOUR GROUP	PINAL	MIAMI-INSPIRATION	PINAL	-110.987200	33.380800	CU	T	
153	M001995	HIGHLINE MINE	GILA	GLOBE HILLS	PINAL	-110.805600	33.440300	CU MN	eT	DRIPPING SPRING QTZT
154	M002008	CACTUS MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.981700	33.384200	CU MO	T	PINAL SCHIST;GILA CGL
155	M002102	FERN MAGNETITE PROSPECT	GILA	MIAMI-INSPIRATION	PINAL	-110.965600	33.465000	FE	pC	MESCAL
156	M002259	LUCKY STRIKE MINE	PIMA	GUNSIGHT	GU VO	-112.651100	32.171100	AU	K-T	
157	M002260	GUNSIGHT MINE	PIMA	GUNSIGHT	GU VO	-112.689200	32.203900	PB AG	K-Pal	
158	M002261	LILLY, SAGUARO, EMPIRE MINES	PIMA	GUNSIGHT	GU VO	-112.669200	32.151400	AU AG	K-T	
159	M002262	BULLION BAR MINE GROUP	PIMA	GUNSIGHT	GU VO	-112.643900	32.141400	AU	eT	
160	M002267	AJO GUNSIGHT MINE	PIMA	GUNSIGHT	GU VO	-112.658100	32.136100	AU	T	
161	M002271	ORO GRANDE MINE	PIMA	CIMARRON MTNS	SHERIDAN	-112.112200	32.394700	CU AG AU	K-T	
162	M002272	AJO CORNELIA MINE	PIMA	AJO CORNELIA	LITTLE AJO	-112.846400	32.345000	CU	T	LOCOMOTIVE CGL
163	M002273	NEW CORNELIA MINE	PIMA	AJO	LITTLE AJO	-112.865000	32.353900	CU AU AG	eT	CHICO SHUNI
164	M002274	MONTIZONA MINE	PIMA	CIMARRON MTNS	CIMARRON	-112.108100	32.447200	CU	K-T	
165	M002275	CARDIGAN MINE	PIMA	AJO	LITTLE AJO	-112.891400	32.349400	CU AG	eT	
166	M002277	AJO PEAK MINE	PIMA	AJO	LITTLE AJO	-112.897200	32.338900	CU	K-Pal	
167	M002278	CADILLAC GROUP	PIMA	CADILLAC	POZO REDONDO	-112.711900	32.297800	MN	T	
168	M002279	COPPER GIANT PROSPECTS	PIMA	AJO	LITTLE AJO	-112.870800	32.298900	CU	Mio-Plio	
169	M002280	MONTE CRISTO MINE	PIMA	CIMARRON MTNS	SHERIDAN	-112.109400	32.398300	AU AG CU	K-T	
170	M002281	BLACK JACK MINE	PIMA	CIMARRON MTNS	CIMARRON	-112.121100	32.428100	MN	T	
171	M002282	BLACK DIAMOND GROUP	PIMA	CIMARRON MTNS	CIMARRON	-112.112500	32.485600	MN	T?	
172	M002286	BLACK BESS MINE GROUP	PIMA	GUNSIGHT	GU VO	-112.643300	32.134200	AU AG CU	T	
173	M002287	SAN ANTONIO MINE	PIMA	AJO	LITTLE AJO	-112.950600	32.307500	SIL	Mz	
174	M002288	WHITE PRINCE CLAIM	PIMA	QUIJOTOA	QUIJOTOA	-112.189400	32.118600	BA	Mio-Plio	
175	M002289	STELLA MARIS NO. 2 MINE	PIMA	CIMARRON MTNS	CIMARRON	-112.124700	32.428100	MN	T	
176	M002296	GROWLER MINE	PIMA	GROWLER	GROWLER	-112.969400	32.167500	CU AG	eT	
177	M002297	ISABELLA MINE	PIMA	CIMARRON MTNS	CIMARRON	-112.177200	32.456100	AU AG	K-Pal	
178	M002305	BALLAS MINE AREA	PIMA	QUIJOTOA	QUIJOTOA	-112.148600	32.135600	AG PB	K-Pal	
179	M002326	RED CROSS MINE	YUMA	MOHAWK	MOHAWK	-113.690800	32.674400	AG PB	T	
180	M002332	BEN LOMAND MINES	PIMA	QUIJOTOA	QUIJOTOA	-112.136100	32.049200	AU AG	K-Pal	
181	M002333	EIGHTY-FIVE GROUP	PIMA	AJO	LITTLE AJO	-112.922200	32.349700	CU	K-Pal	
182	M002358	AJO EXTENSION	PIMA	AJO	LITTLE AJO	-112.853600	32.308900	CU	eT	
183	M002696	BUCKHORN-BOULDER CLAIM	PINAL	GOLDFIELDS	SUPERSTITION	-111.466700	33.450000	AU CU		
184	M002818	RED MOUNTAIN MINE	MARICOPA	MCDOWELL MTNS	MCDOWELL	-111.786400	33.654700	CU		
185	M002845	GRANITE REEF MINE	MARICOPA	GOLDFIELD	SUPERSTITION	-111.644400	33.541700	BA		
186	M002856	MONEY METALS MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.914700	33.440800	AG PB	eT	
187	M002857	CEDAR TREE MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.880600	33.437500	PB CU	eT	
188	M002858	TUNGSTEN NO. 1 MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.888900	33.431900	W CU AG		
189	M002862	LIVE OAK	GILA	MIAMI-INSPIRATION	PINAL	-110.906700	33.403900	CU	eT	

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
190	M002863	CASTLE DOME MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.955000	33.411900	CU	T	LOST GULCH QTZ MONZONITE
191	M002887	MCARTHUR GROUP (CONWAY)	MARICOPA	FOUR PEAKS	MAZATZAL	-111.351400	33.681400	W		
192	M002895	RASTAR CLAIMS MINE	GILA	PIONEER	PINAL	-110.752500	33.300000	W	eT	PINAL SCHIST
193	M002898	DARIUS MINE	GILA	GLOBE HILLS	PINAL	-110.788900	33.421100	MN	eT	ESCABROSA
194	M002906	BIG IRON NO. 1 & 2 MINE	GILA	GLOBE HILLS	PINAL	-110.771400	33.447500	MN	eT	
195	M002924	IRON HIVE MINE	GILA	GLOBE HILLS	PINAL	-110.774200	33.448100	MN	eT	
196	M002927	LIVINGSTON GROUP MINE	GILA	GLOBE HILLS	PINAL	-110.772500	33.452200	MN	eT	
197	M002928	VANCE MINE	GILA	GLOBE HILLS	PINAL	-110.777500	33.446700	MN	eT	
198	M002929	NEW ORLEANS MINE	GILA	GLOBE HILLS	PINAL	-110.763300	33.450000	MN	eT	
199	M002940	MAGNET MINE	GILA	GLOBE HILLS	PINAL	-110.761900	33.445300	MN	eT	APACHE GRP;PIONEER
200	M002941	KENO MINE	GILA	GLOBE HILLS	PINAL	-110.760800	33.448900	MN	eT	APACHE GRP;PIONEER
201	M002943	COPPER TRUST MINE	GILA	GLOBE HILLS	PINAL	-110.759400	33.450000	MN	eT	PIONEER
202	M002951	BLACKBELL PROSPECT	GILA	GLOBE HILLS	PINAL	-110.773900	33.462500	MN	eT	PIONEER
203	M002952	PONTIAC MINE	GILA	GLOBE HILLS	PINAL	-110.759200	33.435000	MN CU	eT	MESCAL
204	M002953	HOBSON MINE	GILA	GLOBE HILLS	PINAL	-110.757200	33.436100	MN	eT	MESCAL
205	M002957	CROWN POINT CLAIM	GILA	MIAMI-INSPIRATION	PINAL	-110.985800	33.392200	CU PB	T	PINAL SCHIST
206	M002958	INDIAN SPRING DEPOSIT	GILA	SAN CARLOS	PINAL	-110.732200	33.287800	ASB	pC	MESCAL
207	M002959	LONE PINE PROSPECT	GILA	SAN CARLOS	PINAL	-110.738600	33.283300	ASB	pC	MESCAL
208	M002965	IRON KING & RED OXIDE MINE	GILA	GLOBE HILLS	PINAL	-110.750600	33.426700	MN	eT	
209	M002966	AMSTER PROSPECT	GILA	GLOBE HILLS	PINAL	-110.750600	33.437500	MN	eT	
210	M002969	G AND H NO. 2 PROSPECT	GILA	GLOBE HILLS	PINAL	-110.708900	33.450600	ASB	pC	
211	M002971	BERKLEY MINE	GILA	GLOBE HILLS	PINAL	-110.750600	33.436100	MN	T	
212	M003081	BUFFALO MINE	GILA	GLOBE HILLS	PINAL	-110.783900	33.416900	CU AG	eT	MARTIN
213	M003083	VAN DYKE	GILA	MIAMI-INSPIRATION	PINAL	-110.872500	33.401900	CU	eT	PINAL SCHIST
214	M003084	MIAMI MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.871700	33.404700	CU MO	T	PINAL SCHIST
215	M003091	CARLOTA MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.988900	33.385000	CU	eT	PINAL SCHIST
216	M003099	LAST CHANCE MINE	GILA	GLOBE HILLS	PINAL	-110.777800	33.463900	MN	eT	
217	M003103	TELFAIR MINE	GILA	GLOBE HILLS	PINAL	-110.753300	33.439400	MN	eT	
218	M003106	BIG JOHNNIE MINE	GILA	GLOBE HILLS	PINAL	-110.769700	33.437500	CU	eT	
219	M003107	BRACCO GROUP PROSPECT	GILA	GLOBE HILLS	PINAL	-110.763300	33.457200	MN AG	eT	PIONEER
220	M003135	BUCKEYE MINE	GILA	GLOBE HILLS	PINAL	-110.763600	33.423900	CU	eT	TROY QTZT
221	M003136	ALBERT LEA MINE	GILA	GLOBE HILLS	PINAL	-110.763100	33.409200	PB AG	lK-T	TROY QTZT
222	M003137	JOSH BILLINGS CLAIMS	GILA	MIAMI-INSPIRATION	PINAL	-110.783600	33.420300	CU	eT	TROY QTZT
223	M003145	COPPER CITIES MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.875000	33.441700	CU MO	T	
224	M003146	TIN HORN WASH DEPOSIT	GILA	MIAMI-INSPIRATION	PINAL	-110.861400	33.441700	CU		
225	M003147	AMERICAN MANGANESE MINE	GILA	GLOBE HILLS	PINAL	-110.796400	33.433900	MN	eT	MARTIN
226	M003150	DOUGHBOY MINE	GILA	GLOBE HILLS	PINAL	-110.795300	33.439200	CU	lK-T	APACHE GRP
227	M003151	IRENE MINE	GILA	GLOBE HILLS	PINAL	-110.786400	33.436400	AG PB	eT	
228	M003162	MAGGIE VEIN	GILA	GLOBE HILLS	PINAL	-110.784700	33.420300	CU	eT	
229	M003167	MINERAL FARM MINE	GILA	GLOBE HILLS	PINAL	-110.770000	33.446400	MN CU	eT	
230	M003542	BOSQUE GROUP	MARICOPA	MARICOPA	MARICOPA	-112.510000	32.985800	MN		
231	M030302	UNNAMED MINE	YUMA	MOHAWK DISTRICT	MOHAWK	-113.466900	32.456400	PB MO		
232	M030343	UNNAMED MINE	YUMA	MOHAWK	MOHAWK	-113.626400	32.577200	AG PB		
233	M030485	CLARK PROSPECT	PINAL	SUMMIT	PINAL	-110.990300	33.355800	W	T	
234	M030492	ORIZABA MINE	PINAL	SLATE	TAT MOMOLI	-111.911700	32.619700	AG PB	T	MARTIN
235	M030493	FRANCISCO GRANDE	PINAL	FRANCISCO GRANDE	-	-111.876400	32.890300	CU	T	
236	M030517	HIGH CARD MINE	PIMA	CABABI	SOUTH COMOBABI	-111.841700	31.977800	AU AG		
237	M030519	LOST HORSE GROUP	PIMA	BABOQUIVARI	BABOQUIVARI	-111.576700	31.842200	CU AG AU MO		PITOIKAM
238	M030554	DAY PEAKS AREA VEINS	GILA	MIAMI-INSPIRATION	PINAL	-110.897200	33.423900	MO		PINAL SCHIST
239	M050132	MEGO NOS. 1 & 2 PROSPECTS	PIMA	BABOQUIVARI	QUINLAN	-111.694200	31.980600			
240	M050133	BIG BANANA MINE	PIMA	QUINLAN	QUINLAN	-111.655800	31.908600	W	K-T	ALI MOLINA
241	M050134	LINDA CLAIM	PIMA	QUINLAN	QUINLAN	-111.660600	31.913900	W		
242	M050135	CABLE AND GAJEWSKI CLAIM	PIMA	QUINLAN	QUINLAN	-111.686700	31.936100			
243	M050136	BROWN PROSPECT.	PIMA	QUINLAN	QUINLAN	-111.666900	31.914400	W	K-T	
244	M050137	SPARKS MINE	PIMA	QUINLAN	QUINLAN	-111.670600	31.913100	W		
245	M050138	LAST CHANCE MINE	PIMA	QUINLAN	QUINLAN	-111.675800	31.915800	W		
246	M050139	SAN JUAN MINE	PIMA	QUINLAN	QUINLAN	-111.670800	31.913300	W		
247	M050140	JEZEBEL MINE	PIMA	QUINLAN	QUINLAN	-111.675600	31.926400	W		
248	M050141	YELLOW STAR MINE	PIMA	QUINLAN	QUINLAN	-111.683600	31.929700	W		
249	M050142	INDEPENDENCE GROUP	PIMA	QUINLAN	QUINLAN	-111.686400	31.933300	W		

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
250	M050143	RUSHBEY PROSPECT	PIMA	QUINLAN	QUINLAN	-111.680300	31.936700	W		
251	M050144	SOUTHSIDE MINE	PIMA	QUINLAN	QUINLAN	-111.688100	31.945000	W		
252	M050146	CALVERT PROSPECTS	PIMA	QUINLAN	QUINLAN	-111.690300	31.951100	W		
253	M050147	LONE EAGLE MINE	PIMA	QUINLAN	QUINLAN	-111.695800	31.968300	W		
254	M050195	BLACK PRINCE NO. 1 CLAIM	PINAL	SAWTOOTH	SILVER REEF	-111.777800	32.726900	MN	T	
255	M050196	BLACK JEWEL CLAIM	PINAL	SAWTOOTH	SILVER REEF	-111.777200	32.727200	MN	T	
256	M050220	GOLD KING MINE	PIMA	MILDRED PEAK	BABOQUIVARI	-111.612200	31.707500	AU AG	K-T	
257	M050227	GIANT CLAIMS	PIMA	AGUIRRE PEAK	BABOQUIVARI	-111.674400	31.660000	W MO		
258	M050259	ALLISON MINE	PIMA	BABOQUIVARI	BABOQUIVARI	-111.633600	31.815300	AU SIL	T	YELLOWSTONE WASH
259	M050260	BLACK DRAGON GROUP	PIMA	BABOQUIVARI	BABOQUIVARI	-111.609400	31.853300	MN		MULBERRY WASH
260	M050287	JAEGER GROUP MINE	PIMA	CABABI	SOUTH COMOBABI	-111.813100	31.984700	AU	J-K	
261	M050587	M & M GROUP	PINAL	SILVER REEF	SILVER REEF	-111.837800	32.665800	PER U		
262	M050591	ROADSIDE MINE	PIMA	ROADSIDE	COYOTE	-111.511100	32.045000	CU AG	K-T	
263	M050601	INDIANA-ARIZONA MINE GROUP	PIMA	WATERMAN	WATERMAN	-111.478300	32.355800	PB ZN	T	BOLSA QTZT; MARTIN
264	M050610	MILDREN MINE	PIMA	CABABI	SOUTH COMOBABI	-111.930000	32.037200	PB AG	eT	
265	M050611	SILVER DOLLAR CLAIMS	PIMA	CABABI	SOUTH COMOBABI	-111.952500	32.078100	W BA		
266	M050612	COYOTE HOLE CLAIMS	PIMA	CABABI	SOUTH COMOBABI	-111.953100	32.082500	W	K-T	
267	M050620	PICACHO MINE	PIMA	CABABI	SOUTH COMOBABI	-111.946900	32.056400	AG	K-T	
268	M050621	CUNQUIAN MINE	PIMA	CABABI	SOUTH COMOBABI	-111.965000	32.040600	AU AG		
269	M050622	STEPPE MINE	PIMA	CABABI	SOUTH COMOBABI	-111.912500	32.016100	AU AG CU PB	eT	
270	M050654	BLACK HAWK GROUP	PIMA	COYOTE	-	-111.603100	32.030000	MN	K-T	
271	M050655	JEAN E GROUP	PIMA	COYOTE	-	-111.597200	32.028900	MN	K-T	
272	M050669	SACATON	PINAL	CASA GRANDE	SACATON	-111.813100	32.960300	CU MO	IK-T	PINAL SCHIST;ORACLE GRANITE
273	M051117	UNNAMED PROSPECT VHSE-026N	PIMA	WATERMAN	WATERMAN	-111.565300	32.360300			
274	M051118	UNNAMED PROSPECT VHSE-026N	PIMA	WATERMAN	WATERMAN	-111.518100	32.300000			
275	M051121	UNNAMED PROSPECT VHSE-030N	PIMA	WATERMAN	WATERMAN	-111.513900	32.294200		K-T	
276	M051122	UNNAMED PROSPECT VHSE-031N	PIMA	WATERMAN	WATERMAN	-111.513900	32.291900	MN		
277	M051123	UNNAMED PROSPECT VHSE-036N	PIMA	WATERMAN	WATERMAN	-111.510800	32.299400		K-T	
278	M051124	UNNAMED PROSPECT VHSE-039N	PIMA	WATERMAN	WATERMAN	-111.506100	32.330600		K-T	
279	M051125	UNNAMED PROSPECT VHSE-040N	PIMA	WATERMAN	WATERMAN	-111.505000	32.328300		K-T	
280	M051126	UNNAMED PROSPECT VHSE-041N	PIMA	WATERMAN	WATERMAN	-111.505300	32.331900		K-T	
281	M051127	UNNAMED PROSPECT VHSE-042N	PIMA	WATERMAN	WATERMAN	-111.501900	32.331900			CONCHA
282	M051128	UNNAMED PROSPECT VHSE-043N	PIMA	WATERMAN	WATERMAN	-111.501700	32.334200	CU PB	K-T	SHERRER;ORACLE GRANITE
283	M051129	RAMERO RANCH	PIMA	WATERMAN	WATERMAN	-111.505300	32.327500	CU AU		
284	M051130	UNNAMED PROSPECT VHSE-047N	PIMA	WATERMAN	WATERMAN	-111.502800	32.346700		K-T	
285	M055095	NATIONS MERCURY LOCATION	PINAL	SUPERSTITION MTNS	SUPERSTITION	-111.346700	33.375000	HG		
286	M241167	COPPER STANDARD MINE	PINAL	SILVER REEF	SILVER REEF	-111.795000	32.708100	CU	T	
287	M241168	OLD JONAH MINE	PINAL	SILVER REEF	SILVER REEF	-111.798100	32.714200	CU	T	
288	M241169	SILVER REEF MINE	PINAL	SILVER REEF	SILVER REEF	-111.817500	32.668100	AG	T	
289	M241170	COPPEROSITY MINE	PINAL	PINAL GRANDE	VEKOL	-112.128600	32.558600	CU	IK-T	ABRIGO
290	M241171	GREENBACK MINE	PINAL	GREENBACK	VEKOL	-112.162500	32.517800	AU	T	PINAL SCHIST
291	M241172	CHRISTMAS GIFT MINE	PINAL	VEKOL	VEKOL	-112.048300	32.607800	AU	IK-T	ESCABROSA;MARTIN
292	M241173	GREAT EASTERN MINE	PINAL	VEKOL	VEKOL	-112.137500	32.591400	AG PB	IK-T	ESCABROSA;NACO
293	M241174	PAPAGO MINE	PINAL	VEKOL	VEKOL	-112.180800	32.567800	AU	IK-T	
294	M241175	REPUBLIC MINE	PINAL	VEKOL	VEKOL	-112.048900	32.593600	CU	IK-T	ESCABROSA
295	M241176	REWARD MINE	PINAL	VEKOL	VEKOL	-112.045800	32.600600	CU	IK-T	ESCABROSA;NACO;MARTIN
296	M241177	VEKOL HILLS	PINAL	VEKOL	VEKOL	-112.053900	32.589200	CU	IK-T	PINAL SCHIST;MARTIN;BOLSA QTZT;ABRIGO
297	M241180	CAMINO MINE	PINAL	SLATE	TAT MOMOLI	-111.908300	32.582800	PB	T-mT	ESCABROSA;MARTIN
298	M241181	DESERT QUEEN MINE	PINAL	SLATE	TAT MOMOLI	-111.893600	32.605300	AG	T-mT	ESCABROSA
299	M241182	JACKRABBIT MINE	PINAL	SLATE	TAT MOMOLI	-111.890600	32.606400	AG SIL	T-mT	ESCABROSA
300	M241183	PICO MINE	PINAL	SLATE	TAT MOMOLI	-111.914200	32.623600	AG		BOLSA QTZT
301	M241188	BULLDOG MINE	PINAL	GOLDFIELD	SUPERSTITION	-111.510300	33.461900	AU	T	
302	M241189	SUPERSTITION MINE	PINAL	GOLDFIELD	SUPERSTITION	-111.469700	33.448300	AU	T	
303	M241190	BOMBOY MINE	PINAL	WOOD CAMP CYN	SUPERSTITION	-111.213300	33.319200	CU		
304	M241193	AMERICAN MINE	PINAL	SUMMIT	PINAL	-110.983100	33.331100	CU AG	Pal	
305	M241194	LORRAINE MINE	PINAL	SUMMIT	PINAL	-110.974400	33.321400	CU	K-Pal	PINAL SCHIST
306	M241198	OLD SAMPLE MINE	PINAL	FRANCISCO GRANDE	-	-111.846700	32.921900	CU	IK-T	RUIN GRANITE
307	M241205	SUPERIOR AND BOSTON MINE	GILA	GLOBE HILLS	PINAL	-110.754700	33.435000	CU AG	IK-T	MESCAL;DRIPPING SPRINGS QTZT
308	M241208	RESCUE MINE	GILA	GLOBE HILLS	PINAL	-110.775000	33.455600	AG CU	IK-T	
309	M241209	RAMBOZ MINE	GILA	GLOBE HILLS	PINAL	-110.771900	33.455800	AG CU MN	IK-T	PIONEER

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
310	M241211	IRELAND MINE	GILA	GLOBE HILLS	PINAL	-110.756900	33.413300	PB	lK-T	TROY QTZT;MESCAL
311	M241216	COLE AND GOODWIN MINE	GILA	PINAL MOUNTAINS	PINAL	-110.927500	33.298900	CU PB	eT	PINAL SCHIST
312	M241217	CHARLES MINE	GILA	PINAL MOUNTAINS	PINAL	-110.752200	33.300000	CU AG PB	lK-T	PINAL SCHIST
313	M241218	AL AND HAL MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.987500	33.383600	CU	eT	
314	M241219	OX HIDE MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.923900	33.385800	CU	eT	PINAL SCHIST;SCHULTZE GRANITE
315	M241220	GOLDEN EAGLE MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.863300	33.431100	CU	eT	PINAL SCHIST
316	M241221	GEM MINE	GILA	GLOBE HILLS	PINAL	-110.778100	33.424700	CU	lK-T	TROY QTZT
317	M241222	ARIZONA COMMERCIAL MINE	GILA	GLOBE HILLS	PINAL	-110.758100	33.432200	CU	lK-T	APACHE GRP;PINAL SCHIST
318	M241223	GLOBE MANGANESE MINE	GILA	GLOBE HILLS	PINAL	-110.758100	33.444400	MN	lK-T	PIONEER
319	M241224	IRON CAP MINE	GILA	GLOBE HILLS	PINAL	-110.767800	33.426700	CU AG	lK-T	DRIPPING SPRING QTZT;PINAL SCHIST
320	M241226	NEW DOMINION MINE	GILA	GLOBE HILLS	PINAL	-110.788300	33.425800	CU PB	K-eT	DRIPPING SPRING QTZT;MESCAL;TROY QTZT
321	M241227	STONEWALL MINE	GILA	GLOBE HILLS	PINAL	-110.765800	33.417800	CU	lK-T	TROY QTZT;MARTIN
322	M241228	ELEPHANT BUTTE MINE	PINAL	FLORENCE	SUPERSTITION	-111.277200	33.333600	W		PINAL SCHIST
323	M241230	WARRIOR MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.883900	33.413900	CU	eT	PINAL SCHIST
324	M241234	GIBSON MINE	GILA	SUMMIT	PINAL	-110.941700	33.334200	CU	eT	PINAL SCHIST
325	M241237	BLACK COPPER MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.893100	33.412500	CU	eT	PINAL SCHIST
326	M241238	BLUEBIRD MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.903300	33.391400	CU	eT	PINAL SCHIST;SCHULTZE GRANITE;GILA CGL
327	M241239	CONTINENTAL MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.946900	33.418900	CU	eT	
328	M241240	SO AND SO MINE	GILA	PINAL MOUNTAINS	PINAL	-110.821100	33.271400	AU PB	lK-T	
329	M241371	BUCKEYE MINE	MARICOPA	WEBB	GILA BEND	-112.872200	33.226700	CU	T	
330	M241378	DELTA MINE	MARICOPA	SALT RIVER MTNS	SOUTH	-112.097500	33.328900	AU	T	ESTRELLA GNEISS
331	M241482	OLD DOMINION MINE	GILA	GLOBE HILLS	PINAL	-110.790300	33.414700	CU	eT	TROY;NACO;MARTIN;ESCABROSA;MESCAL
332	M800064	AQUA VERDE MINE	PIMA	COYOTE	-	-111.635600	32.042200	CU AG	lT?	EPITAPH DOLOMITE;COLINA
333	M800076	GRAND CENTRAL MINE	PIMA	CABABI	SOUTH COMOBABI	-111.977200	32.001100	AU	lK-Pal	
334	M800079	HERCULES & MONARCH MINE	PIMA	COMOBABI	NORTH COMOBABI	-111.755000	32.157800	AG		
335	M800081	LA FORTUNA MINE	PIMA	SANTA ROSA	SANTA ROSA	-111.900300	32.352800	CU	K-Pal	
336	M800086	MAUD H. MINE	PIMA	QUIJOTOA	QUIJOTOA	-112.131900	32.115300	AU AG	K-Pal	
337	M800088	MIDNIGHT MINE	PIMA	CABABI	SOUTH COMOBABI	-111.860600	31.981400		lK-Pal	
338	M800089	MORNING STAR MINE	PIMA	GUNSIGHT	GUNSIGHT	-112.686900	32.204700	PB AG	K-Pal	
339	M800090	NEW HOPE MINE	PIMA	SILVER BELL	WATERMAN	-111.542800	32.304400	CU	K-Pal	
340	M800096	RED WING MINE	PIMA	CABABI	SOUTH COMOBABI	-111.853900	32.008300	AU	lK-Pal	
341	M800103	SUNSET MINE	PIMA	CABABI	SOUTH COMOBABI	-111.929700	32.028600	AG	lK-Pal	
342	M800104	TRES METALS MINE	PIMA	BROWNELL	SIERRA BLANCA	-112.268900	32.221900	PB	K-Pal	
343	M800262	TOMBSTONE	MARICOPA	-	MAZATZAL	-111.467800	33.686700	W		
344	M800265	SURPRISE MINE	PIMA	GUNSIGHT	GUNSIGHT	-112.682500	32.203900	AU	K-Pal	
345	M800266	SUNSET LIMITED MINE GROUP	PIMA	GUNSIGHT	GU VO	-112.631700	32.179200	AU	K-T	
346	M800272	ARROWHEAD CLAIM	MARICOPA	SALT RIVER MTNS	BUCKEYE HILLS	-112.604700	33.293300	U TH		
347	M800289	KING NO 1, 2, 3 CLAIMS	GILA	MIAMI-INSPIRATION	PINAL	-110.868100	33.359700	CU MN FE		PINAL SCHIST;SOLITUDE GRANITE
348	M800290	BOYLE GROUP NO 1, 2	GILA	MIAMI-INSPIRATION	PINAL	-110.925000	33.358300	U		
349	M800295	SUNSET NOS. 1, 2, AND 3 CLAIMS	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.600600	33.293300	FE TI		
350	M899861	ORPHAN BOY MINE	PINAL	MINERAL HILL	SUPERSTITION	-111.160300	33.207500	PB	Mio	MADERA DIORITE;PINAL SCHIST
351	M899869	MAMMON MINE	PINAL	SLATE	SLATE	-111.911100	32.543900	AU		PINAL SCHIST
352	M899880	SUPERIOR AND ARIZONA MINE	PINAL	PIONEER	SUPERSTITION	-111.093900	33.297500	CU	K-Pal	TROY QTZT;MARTIN
353	M899881	SILVER KING MINE	PINAL	PIONEER	SUPERSTITION	-111.086900	33.330300	AG PB	K-Pal	PINAL SCHIST;NACO
354	M899882	QUEEN CREEK MINE	PINAL	PIONEER	SUPERSTITION	-111.091400	33.289200	CU	K-Pal	TROY QTZT;MARTIN
355	M899883	MAGMA CHIEF COPPER MINE	PINAL	PIONEER	SUPERSTITION	-111.097500	33.315300	AG	K-Pal	ESCABROSA;MARTIN
356	M899884	MAGMATIC COPPER MINE	PINAL	PIONEER	SUPERSTITION	-111.089400	33.255800	MN	K-Pal	ESCABROSA
357	M899885	MAGMA MINE	PINAL	PIONEER	SUPERSTITION	-111.093300	33.305800	CU AG AU	K-Pal	PINAL SCHIST;DRIPPING SPRING QTZT;MESCAL;M
358	M899886	MICHIGAN AND HANCOCK MINE	PINAL	PIONEER	SUPERSTITION	-111.090300	33.282200	CU	K-Pal	
359	M899887	GRAND PACIFIC MINE	PINAL	PIONEER	SUPERSTITION	-111.070300	33.269700	CU	K-Pal	ESCABROSA;MARTIN
360	M899888	BLACK DIAMOND MINE	PINAL	PIONEER	SUPERSTITION	-111.089400	33.255800	CU	K-Pal	MARTIN
361	M899889	BELMONT MINE	PINAL	PIONEER	SUPERSTITION	-111.075300	33.272500	CU	K-Pal	ESCABOSA;MARTIN
362	M899890	REYMERT MINE	PINAL	MINERAL HILL	SUPERSTITION	-111.201100	33.244400	AG SIL	T	PINAL SCHIST
363	MP00050	DETECTRON AND PEGMATITE CLAIMS	MARICOPA	-	GILA BEND	-112.756100	33.119200	AG AU PT PB		
364	MP90002	MIAMI EAST	GILA	GLOBE HILLS	PINAL	-110.740000	33.420000	CU AG	eT	SCHULTZE GRANITE;PINAL SCHIST
365	TC00202	EL MARMOL CLAIMS	PINAL	WOOD CAMP CYN	SUPERSTITION	-111.186100	33.342500	ASB	pC	MESCAL
366	TC00203	LUCKY LAGER CLAIMS	PINAL	SUPERSTITION MTNS	SUPERSTITION	-111.226400	33.328600	ASB		MESCAL
367	TC00204	HEWITT WASH DEPOSITS	PINAL	WOOD CAMP CYN	SUPERSTITION	-111.222800	33.298600	ASB		MESCAL
368	TC00205	NORTH AMERICAN ASBESTOS CO.	PINAL	PINTO CREEK	SUPERSTITION	-111.077200	33.461100	ASB		MESCAL
369	TC00206	MOUNTAIN OF MYSTERY GROUP	PINAL	PINTO CREEK	SUPERSTITION	-111.070300	33.436700	ASB		MESCAL

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
370	TC00207	LAST TIME GROUP	PINAL	PIONEER	SUPERSTITION	-111.169400	33.433300	ASB	pC	MESCAL
371	TC00209	INDEPENDENCE GROUP	PINAL	PINTO CREEK	SUPERSTITION	-111.058300	33.440000	ASB		MESCAL
372	TC00250	WALLPAI BRICK CO. CLAY DEPOSIT	PINAL	GOLDFIELD	SUPERSTITION	-111.500000	33.436700	CLY3		
373	TC00251	TOLLESON MINE	MARICOPA	-	-	-112.241400	33.461900	CLY7		
374	TC10116	HIGLEY BASIN	MARICOPA	-	-	-111.695000	33.285300	GYP		
375	TC10117	BLACK GAP	MARICOPA	-	SAUCEDA	-112.742500	32.790600	SR GYP	T	
376	TC10169	SIGNAL PEAK DEPOSIT	GILA	PINAL MOUNTAINS	PINAL	-110.835000	33.296900	FLD KYN		
377	TC10188	HOOPES LIME PIT	GILA	GLOBE HILLS	PINAL	-110.825600	33.447200	LST		ESCABROSA
378	TC10198	LIME PIT	PINAL	-	-	-111.986700	33.171700	LST		
379	TC10199	SUPERIOR LIMESTONE QUARRY	PINAL	SUPERIOR	SUPERSTITION	-111.084700	33.300000	LST DOL	Dev	MARTIN
380	TC10204	LAKE PLEASANT MINE	MARICOPA	MARICOPA	MARICOPA	-112.245800	32.863300	DIT	Cz	
381	TC10252	MONTEZUMA CLAIMS	MARICOPA	-	SAUCEDA	-112.776400	32.761100	SR GYP		
382	TC10257	SACATON MOUNTAINS	PINAL	CASA GRANDE	SACATON	-111.694200	33.008300	COR		
383	TC10264	WEARY MINE	GILA	PINAL MOUNTAINS	PINAL	-110.805300	33.336700	CLY3 CLY5		
384	TC10270	FOUR PEAKS MINE	MARICOPA	FOUR PEAKS	MAZATZAL	-111.331400	33.672500	QTZ GEM	mProt?	FOUR PEAKS;MAZATZAL GROUP
385	TC10276	CASTLE DOME	GILA	SUMMIT	PINAL	-110.954700	33.407800	F BA		
386	TC10330	B & H CLAIM NO. 6	MARICOPA	WEBB	GILA BEND	-112.909400	33.240800	BA		
387	TC10333	QUIJOTOA MINE	PIMA	QUIJOTOA	QUIJOTOA	-112.149200	32.070600	AG AU		
388	TC10339	GONZALES PASS DEPOSIT	PINAL	WOOD CAMP CYN	SUPERSTITION	-111.224700	33.278100	BA		PINAL SCHIST
389	TC10712	BUCKEYE HILLS MICA	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.581700	33.312500	MIC1 MIC2		
390	TC10714	ESTERMILL GROUP	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.512500	33.300800	MIC2		
391	TC10720	SIERRA ESTRELLA	PINAL	SALT RIVER MTNS	SIERRA ESTRELLA	-112.191700	33.095800	MIC MIC1 MIC2		
392	TC10721	NORTH SPUR OF PIMA BUTTE	PINAL	-	-	-112.019400	33.154200	MIC		
393	TC10722	BUTTERFLY MOUNTAIN AREA	PINAL	SALT RIVER MTNS	SIERRA ESTRELLA	-112.193300	33.241100	MIC		
394	TC10736	POWERS BUTTE PERLITE DEPOSIT	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.734700	33.306700	PER		
395	TC10746	MARY ANN MINE	PINAL	SUPERIOR	SUPERSTITION	-111.129200	33.273600	PER	T	ARNETT RHYOLITE
396	TC10747	CHICAGO PIT	PINAL	SUPERIOR	SUPERSTITION	-111.124400	33.263300	PER	T	ARNETT RHYOLITE
397	TC10748	ADAMS MINE	PINAL	SUPERIOR	SUPERSTITION	-111.121700	33.270800	PER	T	ARNETT RHYOLITE
398	TC10749	ARNETT AND TELEGRAPH CANYONS	PINAL	SUPERIOR	SUPERSTITION	-111.136100	33.263900	PER	T	ARNETT RHYOLITE
399	TC10750	PICKETPOST MTN PERLITE DEPOSIT	PINAL	SUPERIOR	SUPERSTITION	-111.155600	33.258300	PER	T	ARNETT RHYOLITE
400	TC35374	COPPER HILL MINE	GILA	GLOBE HILLS	PINAL	-110.809200	33.434400	SIL		TROY QTZT
401	TC35376	LITTLE CHIEF MINE	PIMA	GROWLER	-	-112.917800	32.206400	SIL		
402	TC35398	SILVER REEF MTNS.	PINAL	-	-	-111.831100	33.659200	PER		
403	TC35423	ALTUDA	MARICOPA	MARICOPA	SAND TANK	-112.407800	32.798100	AU AG SIL		
404	TC35428	BELL AND UNNAMED PROSPECTS	PIMA	-	-	-113.165000	32.044400	AU CU AG ?	Mz-T	
405	TC35429	COPPER MOUNTAIN	PIMA	-	-	-112.750300	32.096100	CU	Mz-T	
406	TC35430	DEVILS WASH PLACER	PIMA	QUIJOTOA PLACER	QUIJOTOA	-112.150000	32.116700	AU		
407	TC35432	UNNAMED PROSPECT	PINAL	-	TABLE TOP	-112.159400	32.767200	AU ? CU	Prot	
412	TC35703	AJO MOUNTAINS	PIMA	-	AJO RANGE	-112.666700	32.025000	ZEO		
414	TC35752	SIERRA ESTRELLA MTNS WOLLASTON	MARICOPA	SALT RIVER MTNS	SIERRA ESTRELLA	-112.266400	33.213900	WOL		
415	TC35798	BLACK BUTTE GROUP	MARICOPA	WEBB	GILA BEND	-112.952800	33.248600	AU		
416	TC35915	PUMPKIN GLOW PROSPECT	MARICOPA	GILA BEND MTNS	GILA BEND	-113.227800	33.225800	AG AU		
417	TC35916	OLD WASP MINE	MARICOPA	GOLDFIELD	SUPERSTITION	-111.485300	33.458600	AU		
418	TC35917	KEYSTONE NO. 1-4	MARICOPA	-	MESQUITE	-112.403300	31.905300	AU		
419	TC35919	LITTLE LADONNA PROSPECT	MARICOPA	-	-	-111.640800	33.531400	CU AG		
420	TC35925	SURPRISE VENTURE	MARICOPA	-	-	-111.640600	33.532800	W AU		
421	TC38409	SCARFACE MOUNTAIN AREA	PIMA	GROWLER	GROWLER	-112.931400	32.201900	WOL CU		
422	TC38412	DRIFTWOOD	PINAL	WOOD CAMP CYN	SUPERSTITION	-111.190300	33.286100	PER		
423	TC38413	APACHE TEARS	PINAL	SUPERIOR	SUPERSTITION	-111.139200	33.270800	PER GEM2		ARNETT RHYOLITE
424	TC38414	ANTONE CLAIMS	PINAL	MINERAL HILL	SUPERSTITION	-111.105000	33.256900	PER		
425	TC38415	SUPERIOR OBSIDIAN	PINAL	SUPERIOR	SUPERSTITION	-111.122200	33.270800	PER GEM2		ARNETT RHYOLITE
426	TC38428	UNNAMED PROSPECT	PIMA	-	-	-112.083300	32.291700	AU	Mz-T	
427	TC38449	SYLVANIA MICA	MARICOPA	SALT RIVER MTNS	SIERRA ESTRELLA	-112.210300	33.210800	MIC MIC1		
428	TC38454	VARNUM FELDSPAR	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.576400	33.285800	FLD		
429	TC38456	BALANCED ROCK	MARICOPA	BUCKEYE HILLS	BUCKEYE HILLS	-112.587500	33.284700	FLD MIC		
430	TC38457	FROST	MARICOPA	SALT RIVER MTNS	SIERRA ESTRELLA	-112.210300	33.152200	FLD MIC		
431	TC38885	MCDOWELL CLAY DEPOSIT	MARICOPA	MCDOWELL	MCDOWELL	-111.725000	33.676400	CLY		
432	TC38886	AZURITE MINE	GILA	MIAMI-INSPIRATION	PINAL	-110.852800	33.359400	CLY		
433	TC38973	HILLTOP EXTENSION CLAIMS	PINAL	VEKOL	VEKOL	-112.075000	32.572200	CU AG		
434	TC38975	SOFPA CLAIMS	PINAL	SLATE	SLATE	-111.904200	32.625000	AG AU PB		

Table 4
Locatable Mineral Resources and Locations
Phoenix South and Sonoran Desert National Monument RMPs/EIS, Arizona

NUMBER	ID	SITE NAME	COUNTY	DISTRICT	MTN LOCATION	LONG_DEC	LAT_DEC	COMMODITY [1]	AGE [2]	FORMATION
435	TC38983	R AND H GROUP	GILA	MIAMI-INSPIRATION	PINAL	-110.888900	33.430600	AU AG		
436	TC38985	SIERRA ESTRELLA QUARTZ VEINS	PINAL	SALT RIVER MTNS	SIERRA ESTRELLA	-112.193100	33.120800	QTZ		
437	TC38988	ANTELOPE MINE	PIMA	QUINLAN	QUINLAN	-111.676900	31.984200	SIL		
438	TC38991	FIVE MILE PEAK	PINAL	CASA GRANDE	SACATON	-111.743900	33.008900	QTZ SIL		
439	TC38992	LITTLE CHIEF MINE	PIMA	-	-	-112.458300	32.166700	SIL		
440	TC38993	ORIZABA SILICA MINE	PINAL	SLATE	TAT MOMOLI	-111.909700	32.619400	SIL		
441	TC38998	UNNAMED QUARTZ VEINS	PIMA	-	-	-112.483300	32.137500	QTZ SIL		
442	TC39303	FOURTH OF JULY PEAK AGATE FIELD	MARICOPA	WEBB	GILA BEND	-113.114700	33.273100	GEM		
443	TC39716	DIGMORE 2 CLAIMS	PIMA	CABABI	SOUTH COMOBABI	-111.886100	32.062500	BA		
444	TC39717	CRESCENT ET AL CLAIMS	PIMA	-	BATAMOTE	-112.686100	32.468100	BA		
445	TC39720	BUTTE MINE	MARICOPA	WEBB	GILA BEND	-112.945000	33.256400	BA F		
446	TC39727	KERLIN ET AL GROUP	PIMA	-	BATAMOTE	-112.683300	32.455600	BA		
447	TC39728	NORTH MOLLY VEIN AREA	PIMA	-	AJO RANGE	-112.700000	32.050000	BA		
448	TC40001	FREEMAN SILICA	PIMA	CIMARRON MTNS	CIMARRON	-112.125000	32.427800	SIL		
449	TC40004	RIGHT ON GROUP	PIMA	AJO	LITTLE AJO	-112.921400	32.411100	PB CU AU AG		
450	TC40005	OLD HICKLES PROPERTY	PIMA	AJO	LITTLE AJO	-112.906900	32.381700	SIL CU AU AG		
451	TC40006	MICA MINE	PIMA	AJO	LITTLE AJO	-112.955600	32.322800	SIL QTZ		
452	TC40007	JOHNSON MINE	PIMA	QUIJOTOA	QUIJOTOA	-112.166700	32.166700	SIL		
453	TC40008	LIME CHIEF 1 AND 2	PIMA	BROWNELL	SIERRA BLANCA	-112.268900	32.222500	SIL		
454	TC40009	COPPER VALLEY CLAIMS	PIMA	AJO	LITTLE AJO	-112.930000	32.397800	AU AG CU		
455	TC40010	BONNIE LEE GROUP	PIMA	AJO	LITTLE AJO	-112.928600	32.416700	SIL		
456	TC40011	ENDERS SILICA	MARICOPA	MCDOWELL	MCDOWELL	-111.795300	33.720000	SIL QTZ		
457	TC40014	SACATON MTNS SILICA	PINAL	CASA GRANDE	SACATON	-111.780800	33.008100	SIL		
458	TC40084	DIXON GROUP	GILA	MIAMI-INSPIRATION	PINAL	-110.880600	33.429700	ASB		
459	TC40090	UNNAMED ASBESTOS PROSPECTS	GILA	BABOQUIVARI	BABOQUIVARI	-110.903600	33.462800	ASB		MESCAL
460	TC40094	UNNAMED ASBESTOS CLAIMS	GILA	BABOQUIVARI	PINAL	-110.765600	33.259200	ASB		MESCAL
461	TC40096	NORTH AMERICAN	GILA	SUMMIT	PINAL	-110.995800	33.458300	ASB		
462	TC40127	HEWITT CANYON	PINAL	PIONEER	SUPERSTITION	-111.208300	33.333300	ASB STN MBL		
463	TC40219	RANDOLPH GYPSUM	PINAL	-	-	-111.593100	32.919400	GYP		
464	TC40220	GOLD FIELD	PINAL	GOLDFIELD	SUPERSTITION	-111.490800	33.456700	AU		
469	TC41209	LIMESTONE QUARRY	GILA	GLOBE HILLS	PINAL	-110.780600	33.411900	LST	Penn	NACO
470	TC41245	HAPPY JACK	PIMA	QUINLAN	WATERMAN	-111.480300	32.352200	LST DOL	Pal	
471	TC41246	LIME HILL	PIMA	GROWLER	GROWLER	-112.921100	32.227500	LST	M-Dev	
472	TC41249	EL MARMOL CLAIMS	PINAL	SUPERSTITION MTNS	SUPERSTITION	-111.222200	33.329200	LST	pC	MESCAL
473	TC41250	SACATON MOUNTAINS	PINAL	CASA GRANDE	SACATON	-111.777200	33.007200	LST	Dev	
474	U504079	MINERAL BUTTE PROSPECT	PINAL	MINERAL BUTTE	SANTAN	-111.579200	33.113900	CU	lK-T	PINAL SCHIST
475	W002674	MAGMA SUPERIOR MINE	PINAL	PIONEER	SUPERSTITION	-111.100000	33.300000	CU		
476	W002694	FLORENCE	PINAL	BLACKWATER	SANTAN	-111.439200	33.043300	CU	lK-T	ORACLE GRANITE
477	W002708	DIAMOND H MINE	GILA	SUMMIT	PINAL	-110.916700	33.433300	CU		
478	W002713	OLD DOMINION 2 MINE	GILA	GLOBE HILLS	PINAL	-110.783300	33.416700	CU		

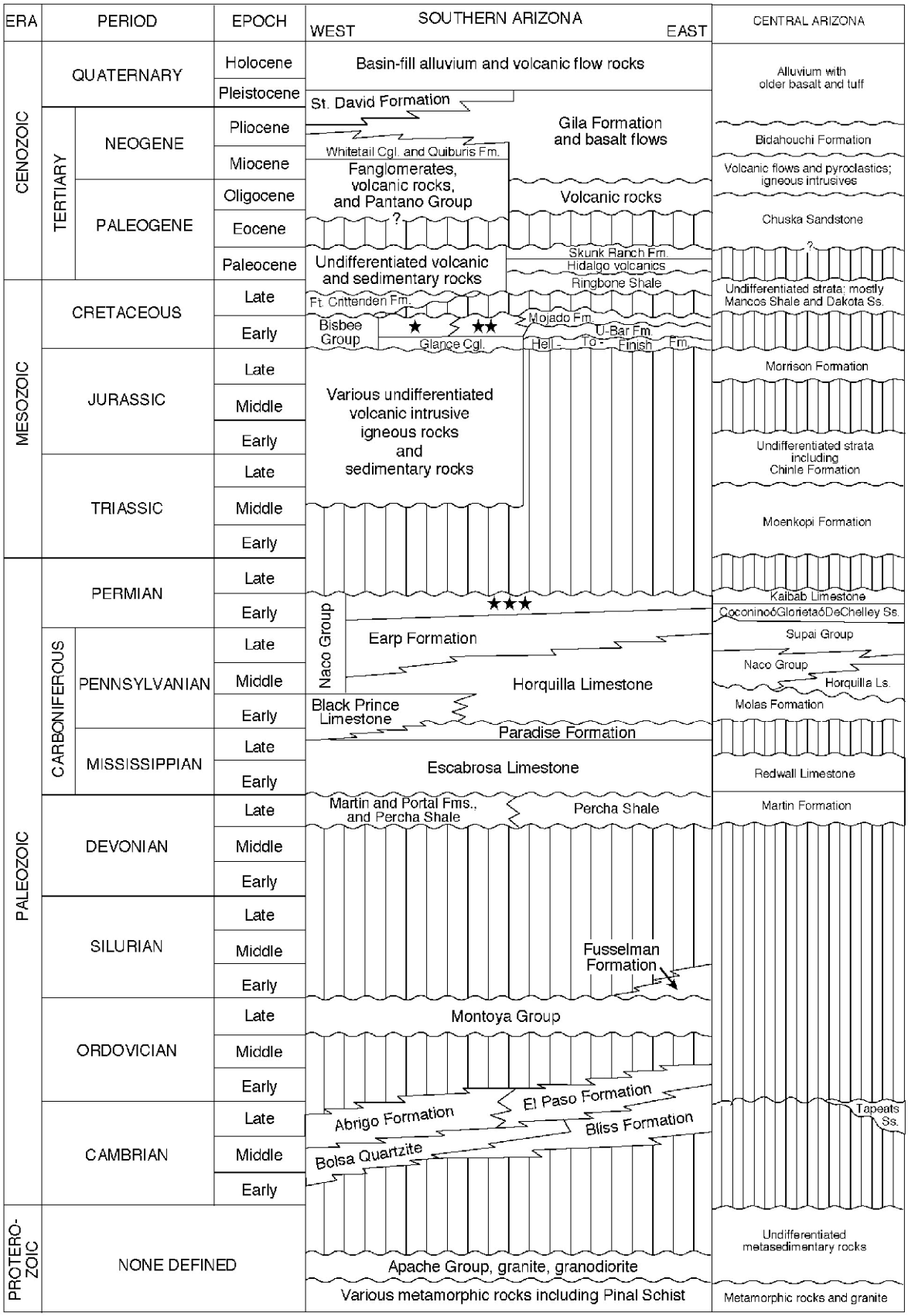
SOURCE: U.S. Geological Survey Mineral Resource Data System (MRDS) 1999.

1 AG - silver, AU - gold, CU - copper, PB - lead, W - tungsten, ZN - zinc, MO - molybdenum, MN - manganese, TI - titanium, COR - corundum, U - uranium, FE - iron, BA - barite
ASB - asbestos, HG - mercury, TH - thorium, PT - plutonium, CLY - clay, GYP - gypsum, FLD - feldspar, KYN - kyanite, LST - limestone, DOL - dolomite, QTZ - quartz, ZEO - zeolite
F - fluorite, MIC - mica, DIT - diatomite, GEM - gemstones, PER - perlite, SIL - silica, STN - stone, MBL - marble

2 Q - Quaternary, T - Tertiary, lT - Late Tertiary, MT - Middle Tertiary, eT - Early Tertiary, Cz - Cenozoic, Plio - Pliocene, Mio - Miocene, Pal - Paleocene, K - Cretaceous, lK - Late Cretaceous,
J - Jurassic, Mz - Mesozoic, Penn - Pennsylvanian, Dev - Devonian, pC - Precambrian, mPROT - Middle Proterozoic, PROT - Proterozoic

FIGURES

Stratigraphic Nomenclature Chart



★ Turney Ranch Fm.
Shellenberger Canyon Fm.
Apache Canyon Fm.
Willow Canyon Fm.

★★ Cintura Fm.
Mural Ls.
Morita Fm.

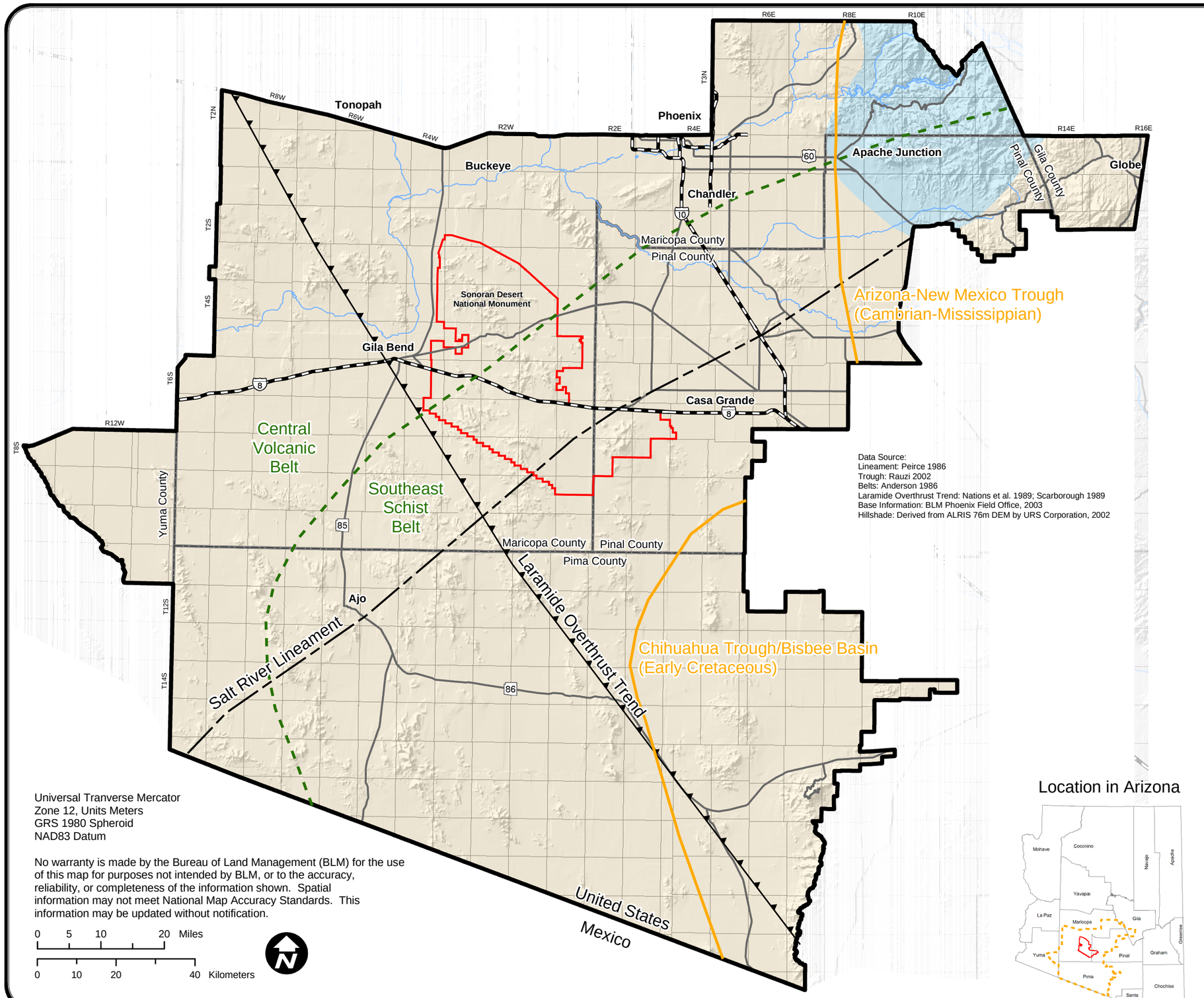
★★★ Rain Valley Formation
Concha Limestone
Scherrer Formation
Epitaph Dolomite
Colina Limestone

Figure 1

MAPS

Physiographic Provinces, Topographic and Tectonic Features

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Data Source:
Lineament: Peirce 1986
Trough: Rauzi 2002
Belts: Anderson 1986
Laramide Overthrust Trend: Nations et al. 1989; Scarborough 1989
Base Information: BLM Phoenix Field Office, 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation, 2002

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\Physiographic_Map.mxd

Location in Arizona

Legend

Physiographic Provinces
- Basin and Range
- Transition Zone

Tectonic Features
- Trough
- Belt Boundary
- Laramide Overthrust Trend
- Salt River Lineament

General Reference
- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas
- Phoenix South
- Sonoran Desert National Monument

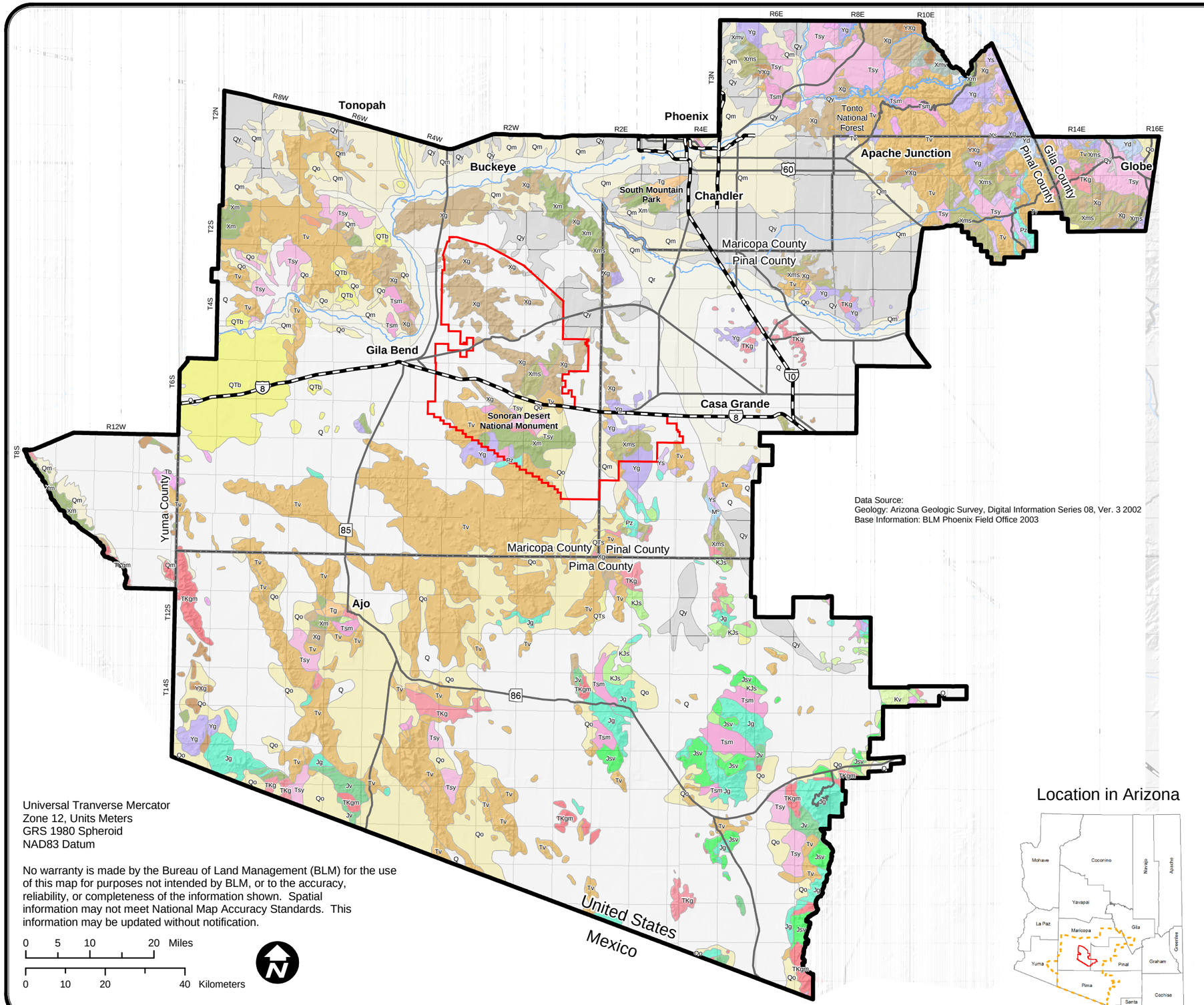
Map Produced : November 2003

URS

Map 1

Geologic Map

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Data Source:
Geology: Arizona Geologic Survey, Digital Information Series 08, Ver. 3 2002
Base Information: BLM Phoenix Field Office 2003

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\Geology.mxd

Location in Arizona

Legend

Geology

- Q [Holocene and Pleistocene] Alluvium
- Qr [Holocene and Pleistocene] Fine-grained Fluvial Floodplain Deposits
- Qy [Holocene to Upper Pleistocene] Alluvium
- Qm [Middle Pleistocene] Alluvium
- Qo [Early Pleistocene to Upper Pliocene] Alluvium
- QTs [Late Miocene to Pliocene] Sandstone and Conglomerate
- QTb [Holocene to Upper Pleistocene] Basaltic Rocks
- Tsy [Pliocene to Middle Miocene] Sedimentary Rocks
- Tb [Upper to Middle Miocene] Basaltic Rocks
- Tsm [Middle Miocene to Oligocene] Sandstone and Conglomerate
- Tvs [Middle Miocene to Oligocene] Sedimentary and Volcanic Rocks
- Tv [Middle Miocene to Oligocene] Volcanic Rocks
- Tg [Lower Miocene to Oligocene] Granitic Rocks
- Ti [Miocene or Oligocene] Fine-grained Intrusive Rocks
- TXgn [Lower Proterozoic through Early Tertiary] Gneiss Complexes
- TKgm [Paleocene or Upper Cretaceous] Leucocratic Granitic Rocks
- TKg [Paleocene or Upper Cretaceous] Granitic Rocks
- Kv [Upper Cretaceous] Volcanic Rocks
- KJs [Cretaceous and Jurassic] Sandstone, Conglomerate, Minor Andesitic Volcanic Rocks
- Jg [Jurassic] Granitic Rocks
- Jsv [Jurassic] Volcanic and Associated Sedimentary Rocks
- Jv [Jurassic and Triassic] Volcanic Rocks
- Pz [Paleozoic] Sandstone, Limestone, Dolomite
- MC [Mississippian to Cambrian] Sandstone, Limestone, Dolomite
- Yd [Middle Proterozoic] Diabase
- Ys [Middle Proterozoic] Apache Group and Troy Quartzite
- Yg [Middle Proterozoic] Granitic Rocks
- YXg [Middle or Lower Proterozoic] Granitic Rocks
- Xg [Lower Proterozoic] Granitic Rocks
- Xq [Lower Proterozoic] Quartzite
- Xm [Lower Proterozoic] Metamorphic Rocks
- Xms [Lower Proterozoic] Metasedimentary Rocks
- Xmv [Lower Proterozoic] Metavolcanic Rocks

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

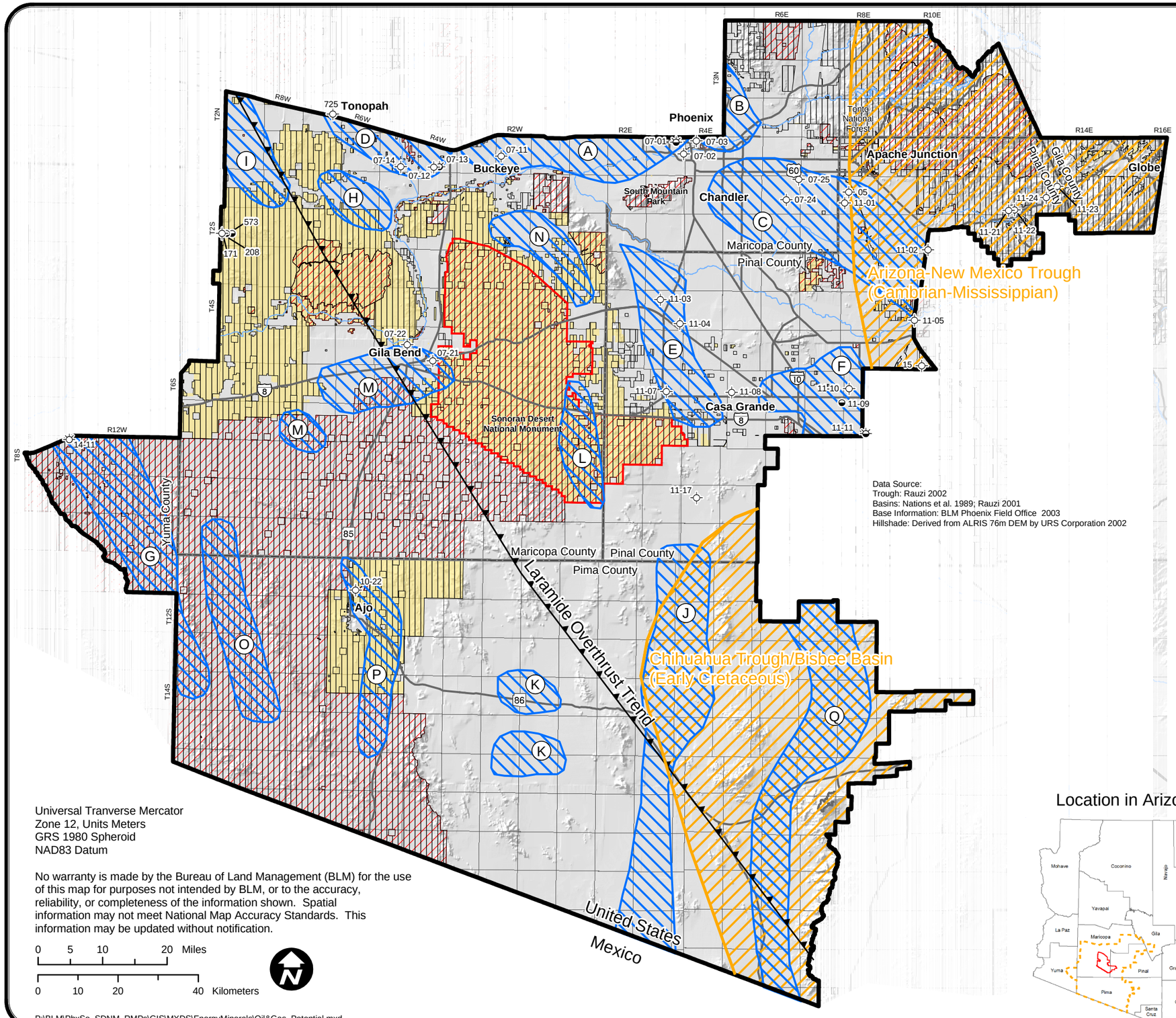
Map Produced : November 2003

URS

Map 2

Oil and Gas Potential

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Legend

Moderate Potential

- Arizona-New Mexico Trough and Chihuahua Trough/Bisbee Basin
- Tertiary Basins with Letter Identification
  - (A) Luke Basin
  - (B) Paradise Basin
  - (C) Higley Basin
  - (D) Tonopah Basin
  - (E) Maricopa-Stanfield Basin
  - (F) Picacho Basin
  - (G) San Cristobal Basin
  - (H) Arlington Basin
  - (I) Harquahala Basin
  - (J) Santa Rosa Basin
  - (K) Quijotoa Basin
  - (L) Vekol Basin
  - (M) Gila Bend Basin
  - (N) Rainbow Basin
  - (O) Growler Basin
  - (P) Ajo Basin
  - (Q) Baboquivari Basin

Low Potential

Tectonic Features

- Laramide Overthrust Trend

Oil and Gas Wells

- Dry Hole
- Oil Show
- Oil & Gas Show
- Oil & Gas Show

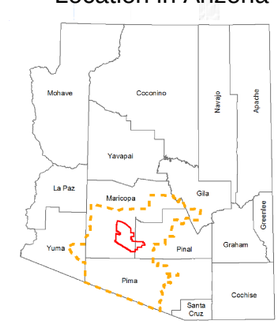
Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

Location in Arizona



General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

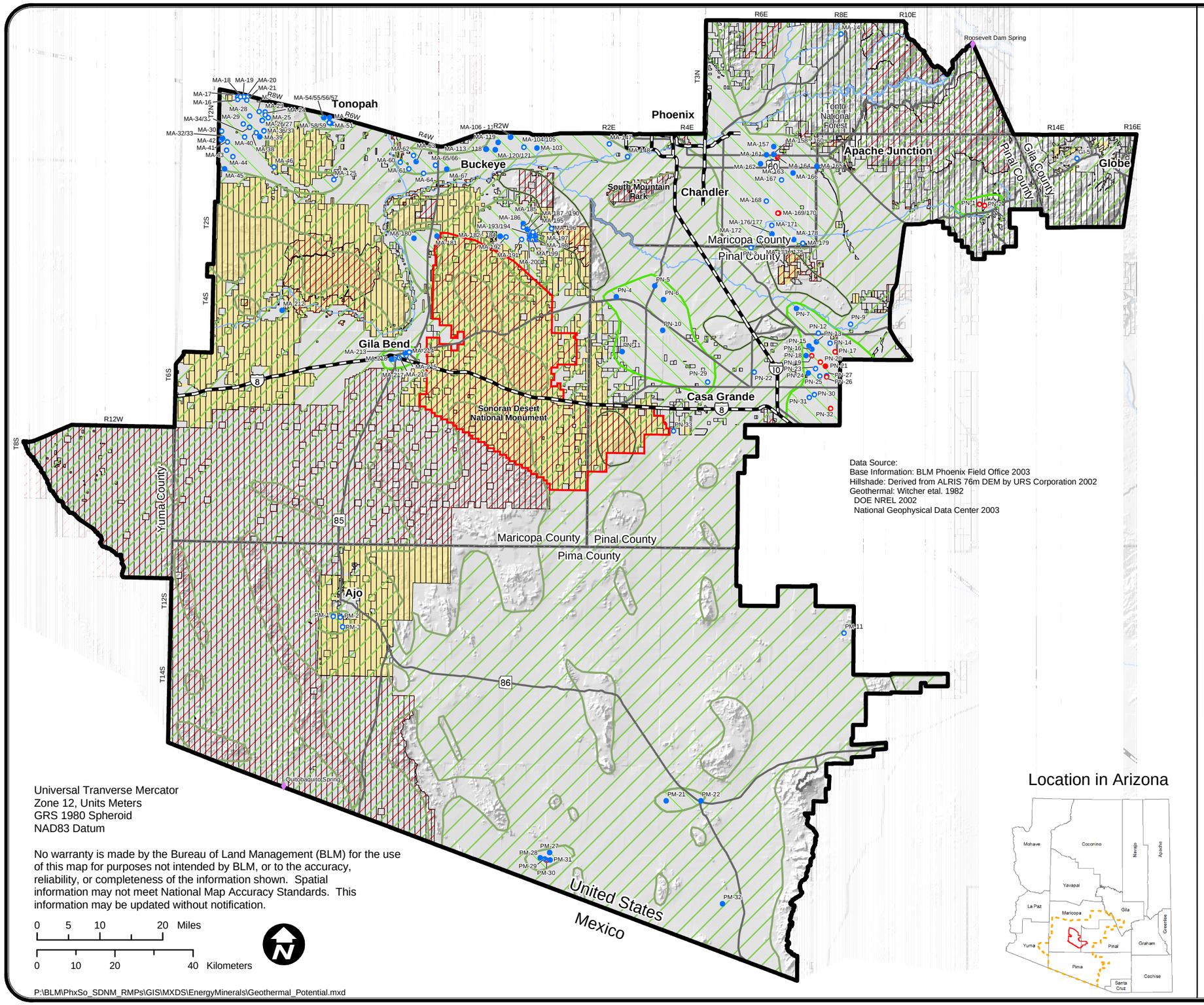
Map Produced : November 2003

URS

Map 3

Geothermal Resources Potential

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Data Source:
Base Information: BLM Phoenix Field Office 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation 2002
Geothermal: Witcher etal. 1982
DOE NREL 2002
National Geophysical Data Center 2003

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\Geothermal_Potential.mxd

Location in Arizona

Legend

Geothermal Resource Potential

- High Potential - low temperature geothermal resource region
- Moderate Potential
- Low Potential

Thermal Wells and Springs

- Temperature 50 degrees C or lower and gradient 50 degrees C/Km or lower
- Temperature 50 degrees C or lower and gradient higher than 50 degrees C/Km
- Temperature higher than 50 degrees C and gradient 50 degrees C/Km or lower
- Temperature higher than 50 degrees C and gradient higher 50 degrees C/Km
- Warm spring - 50 degrees C or lower - low temperature geothermal resource region

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

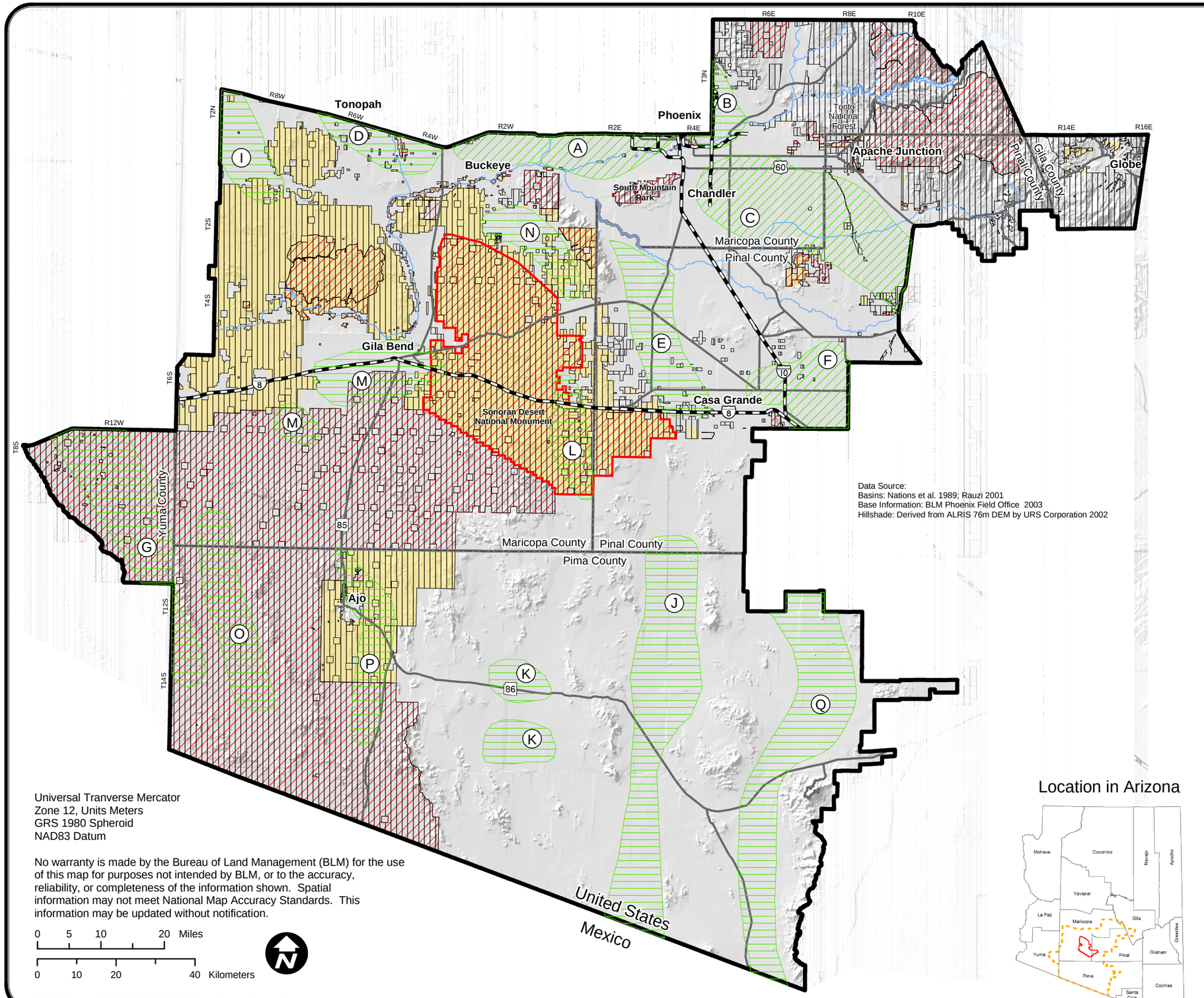
Map Produced : November 2003

URS

Map 4

Sodium Potential

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Data Source:
Basins: Nations et al. 1989; Rauzi 2001
Base Information: BLM Phoenix Field Office 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation 2002

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\SodiumPotential.mxd

Legend

Sodium Potential

- High Potential
- Moderate Potential
- Low Potential

Basins

- (A) Luke Basin
- (B) Paradise Basin
- (C) Higley Basin
- (D) Tonopah Basin
- (E) Maricopa-Stanfield Basin
- (F) Picacho Basin
- (G) San Cristobal Basin
- (I) Harquahala Basin
- (J) Santa Rosa Basin
- (K) Quijotoa Basin
- (L) Vekol Basin
- (M) Gila Bend Basin
- (N) Rainbow Basin
- (O) Growler Basin
- (P) Ajo Basin
- (Q) Baboquivari Basin

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

Location in Arizona

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

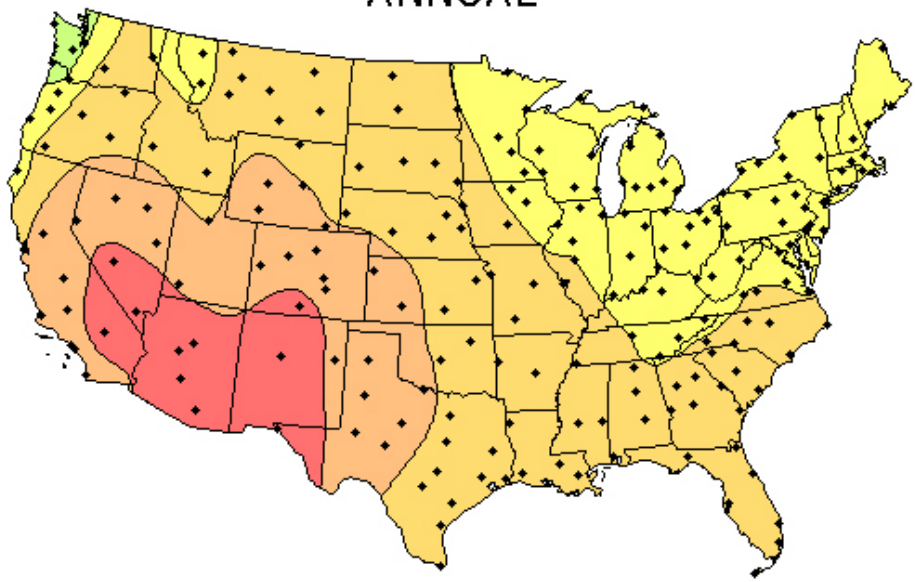
Map Produced : November 2003

URS

Map 5

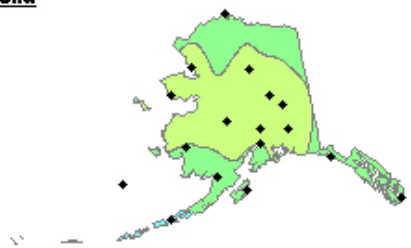
Average Daily Solar Radiation Per Month

ANNUAL

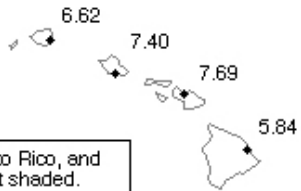


North-South Axis Tracking Flat Plate Tilted at Latitude

Alaska

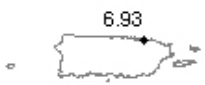


Hawaii



Hawaii, Puerto Rico, and Guam are not shaded.

San Juan, PR



Guam, PI

Collector Orientation

One-axis tracking flat-plate collector with axis oriented north-south at a tilt angle equal to the site's latitude: To achieve maximum annual solar radiation, a tilt angle approximately equal to the site's latitude is recommended.

This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

NREL

National Renewable Energy Laboratory
Resource Assessment Program

kWh/m²/day

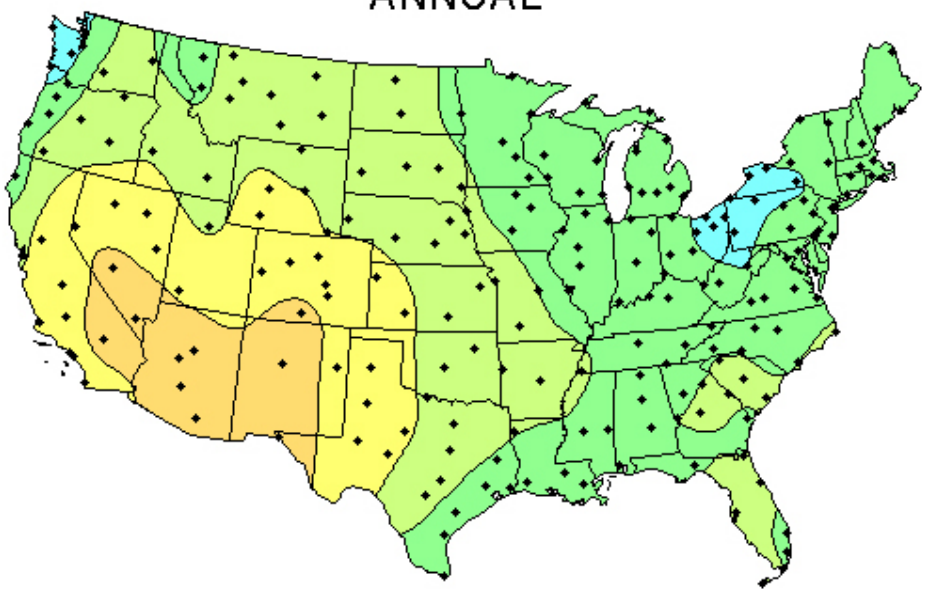
- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2
- none

FXLTA13-442

Source: U.S. Department of Energy, National Renewable Energy Laboratory Website: rredc.nrel.gov/solar

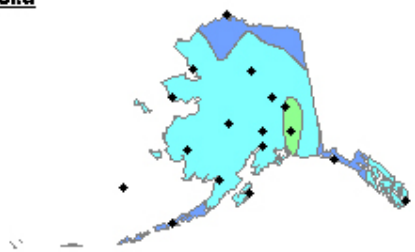
Average Daily Solar Radiation Per Month

ANNUAL

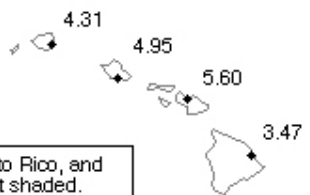


North-South Axis Tracking Concentrator Tilted at Latitude

Alaska



Hawaii



Hawaii, Puerto Rico, and Guam are not shaded.

San Juan, PR

Guam, PI

Collector Orientation

One-axis tracking parabolic trough with a horizontal north-south axis and tilted from the horizontal at an angle equal to the site's latitude

This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

NREL

National Renewable Energy Laboratory
Resource Assessment Program

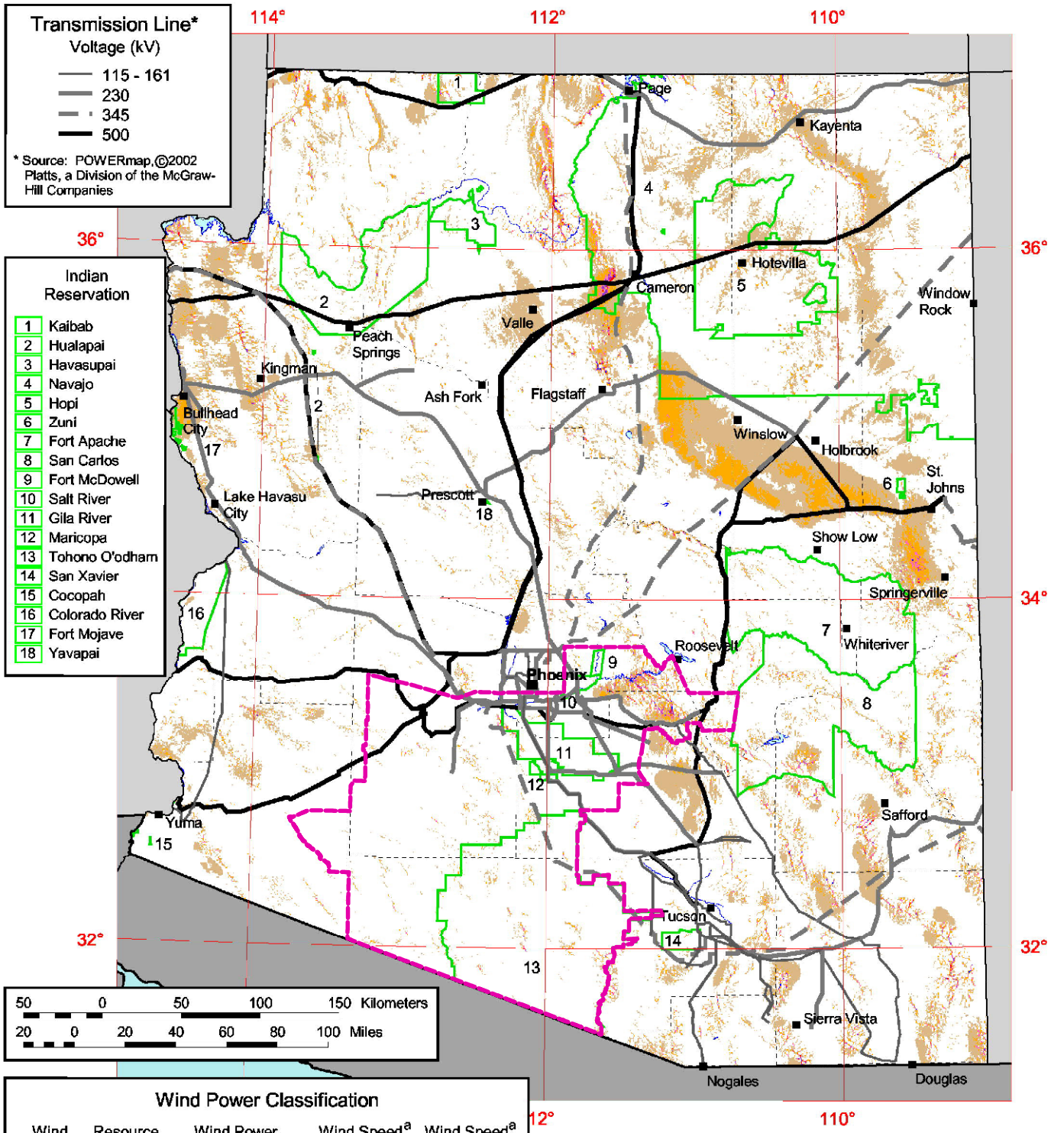
kWh/m²/day

- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2
- none

C1XLA13-52

Source: U.S. Department of Energy, National Renewable Energy laboratory Website: rredc.nrel.gov/solar

Arizona - 50 m Wind Power



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m²	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.5	0.0 - 12.3
2	Marginal	200 - 300	5.5 - 6.3	12.3 - 14.1
3	Fair	300 - 400	6.3 - 7.0	14.1 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

[a] Wind speeds are based on a Weibull k of 1.8 at 1000 m elevation.

The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Phoenix South Planning Area

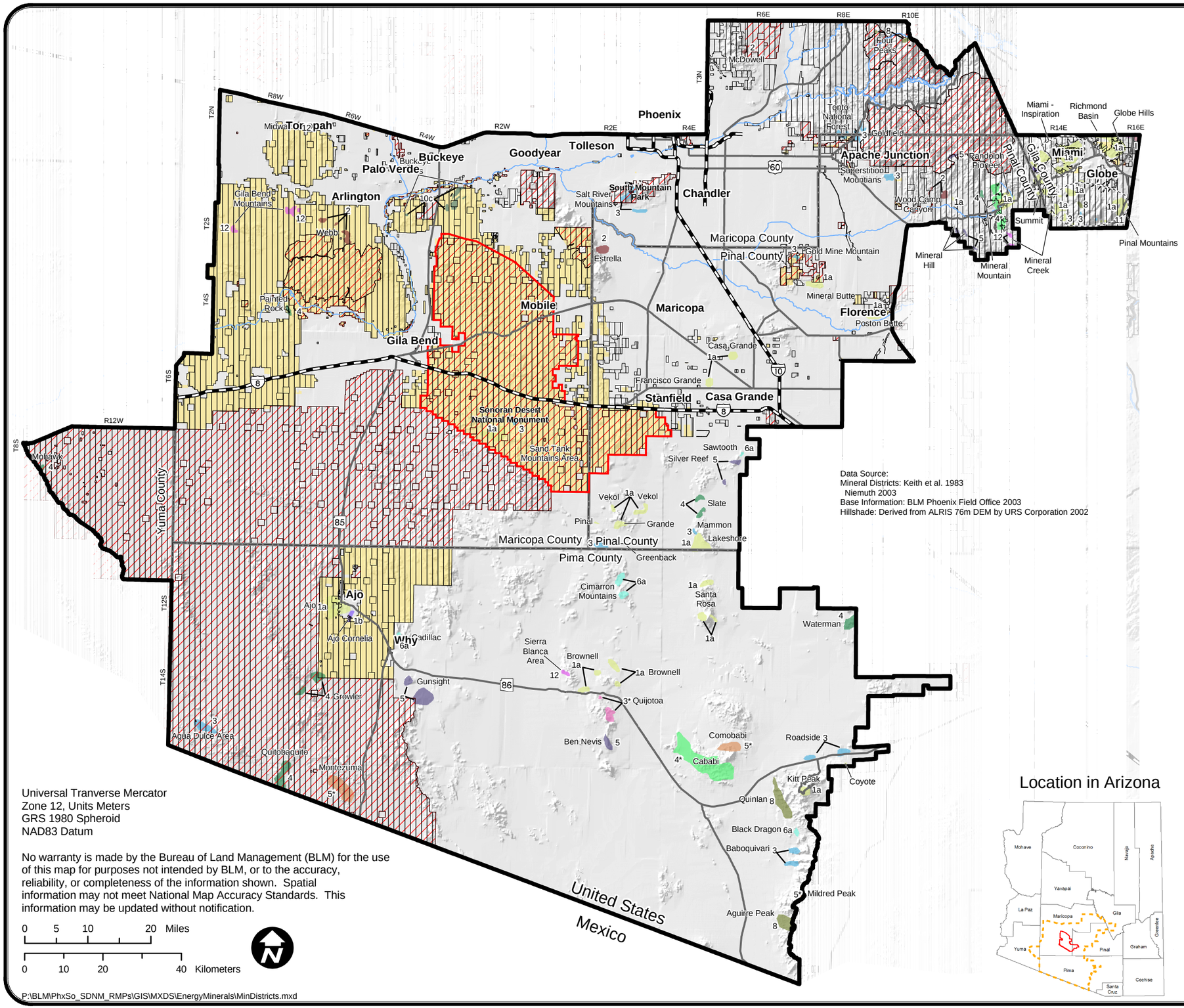
U.S. Department of Energy
National Renewable Energy Laboratory

14-AUG-2003 1.1.1

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\WindPower.mxd

Mineral Districts

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\MinDistricts.mxd

Legend

Mineral Districts

Copper

- 1a Porphyry with or without Molybdenum, Manganese, Gold and Peripheral Lead-Zinc-Silver
- 1b Stratabound in Rock of Age Given
- 2 Copper with or without Gold or Lead; Veins
- 3 Gold with or without Copper or Lead
- 3* Significant Silver Production

} Distinction based on Copper/ Copper and Gold Ratios

- 4 Lead-Zinc-Silver Veins and Replacements
- 4* Significant Production of Copper and Gold
- 5 Silver with or without Lead and Zinc; Veins and Replacements
- 5* Significant Copper Production

} Distinction based on Silver/ Silver, Lead, and Zinc Ratios

Manganese

- 6a Veins with or without Barium, Lead, Silver
- 8 Tungsten; Skarn and Veins or Pegmatites with or without Beryllium or Lithium

Uranium with or without Vanadium

- 10c Veins or Fissures
- 12 Unclassified (Altered Zones, No Production)
- I Industrial Minerals

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

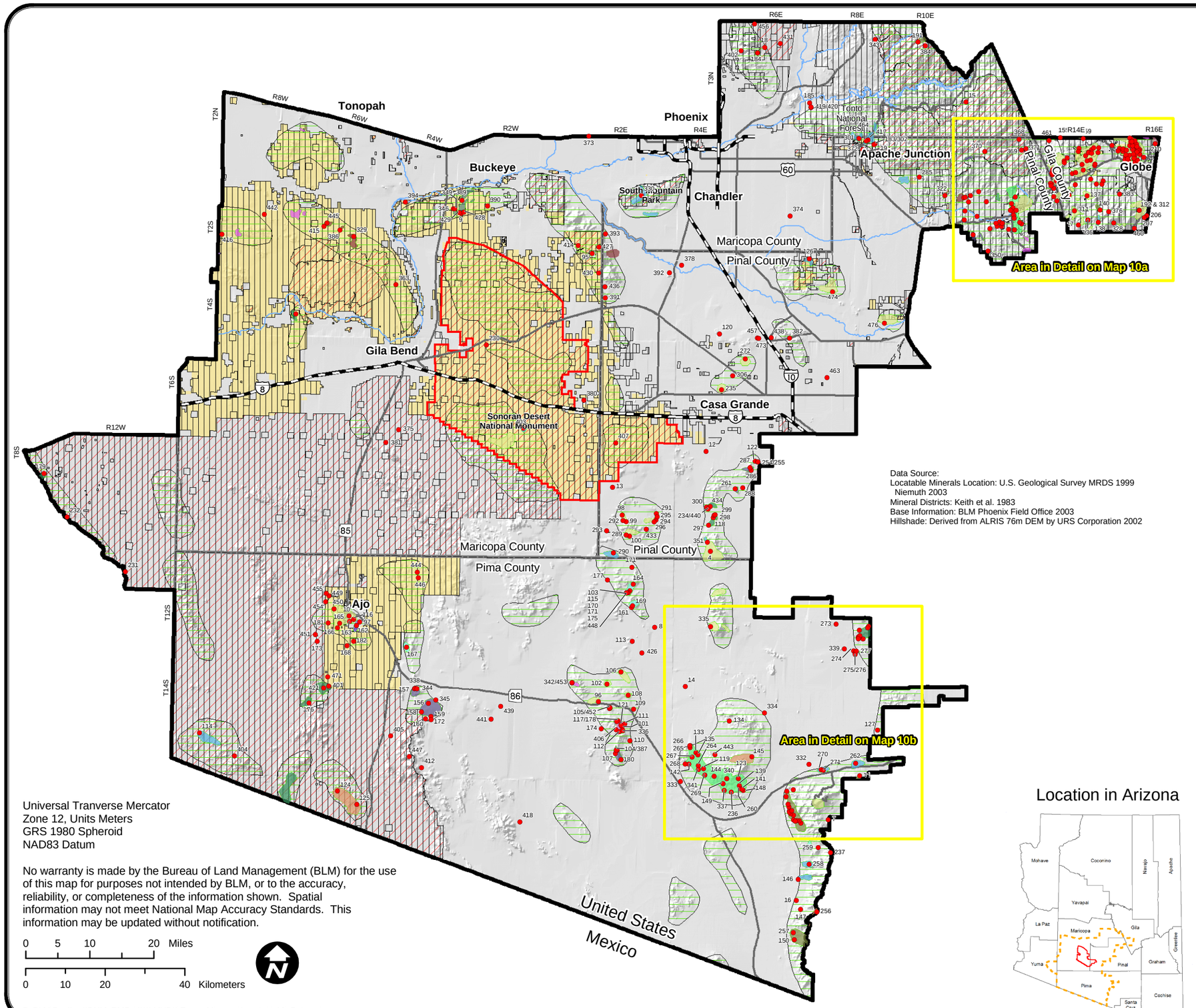
Map Produced : November 2003

URS

Map 9

Mineral Districts and Locatable Minerals Potential

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Data Source:
Locatable Minerals Location: U.S. Geological Survey MRDS 1999 Niemuth 2003
Mineral Districts: Keith et al. 1983
Base Information: BLM Phoenix Field Office 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation 2002

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\LocatableMinPot.mxd

Location in Arizona

Legend

330 Locatable Minerals Location and Reference Number

Use reference number to locate mine information on Table 4.

High Mineral Potential (Mineral Districts)

Copper

- 1a Porphyry with or without Molybdenum, Manganese, Gold and Peripheral Lead-Zinc-Silver
- 1b Stratabound in Rock of Age Given
- 2 Copper with or without Gold or Lead; Veins
- 3 Gold with or without Copper or Lead
- 3* Significant Silver Production

} Distinction based on Copper/ Copper and Gold Ratios

- 4 Lead-Zinc-Silver Veins and Replacements
- 4* Significant Production of Copper and Gold
- 5 Silver with or without Lead and Zinc; Veins and Replacements
- 5* Significant Copper Production

} Distinction based on Silver/ Silver, Lead, and Zinc Ratios

Manganese

- 6 Veins with or without Barium, Lead, Silver
- 8 Tungsten; Skarn and Veins or Pegmatites with or without Beryllium or Lithium

Uranium with or without Vanadium

- 10c Veins or Fissures
- 12 Unclassified (altered zones, no production)
- I Industrial Minerals

Locatable Mineral Potential

- Moderate Mineral Potential
- Low Mineral Potential

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

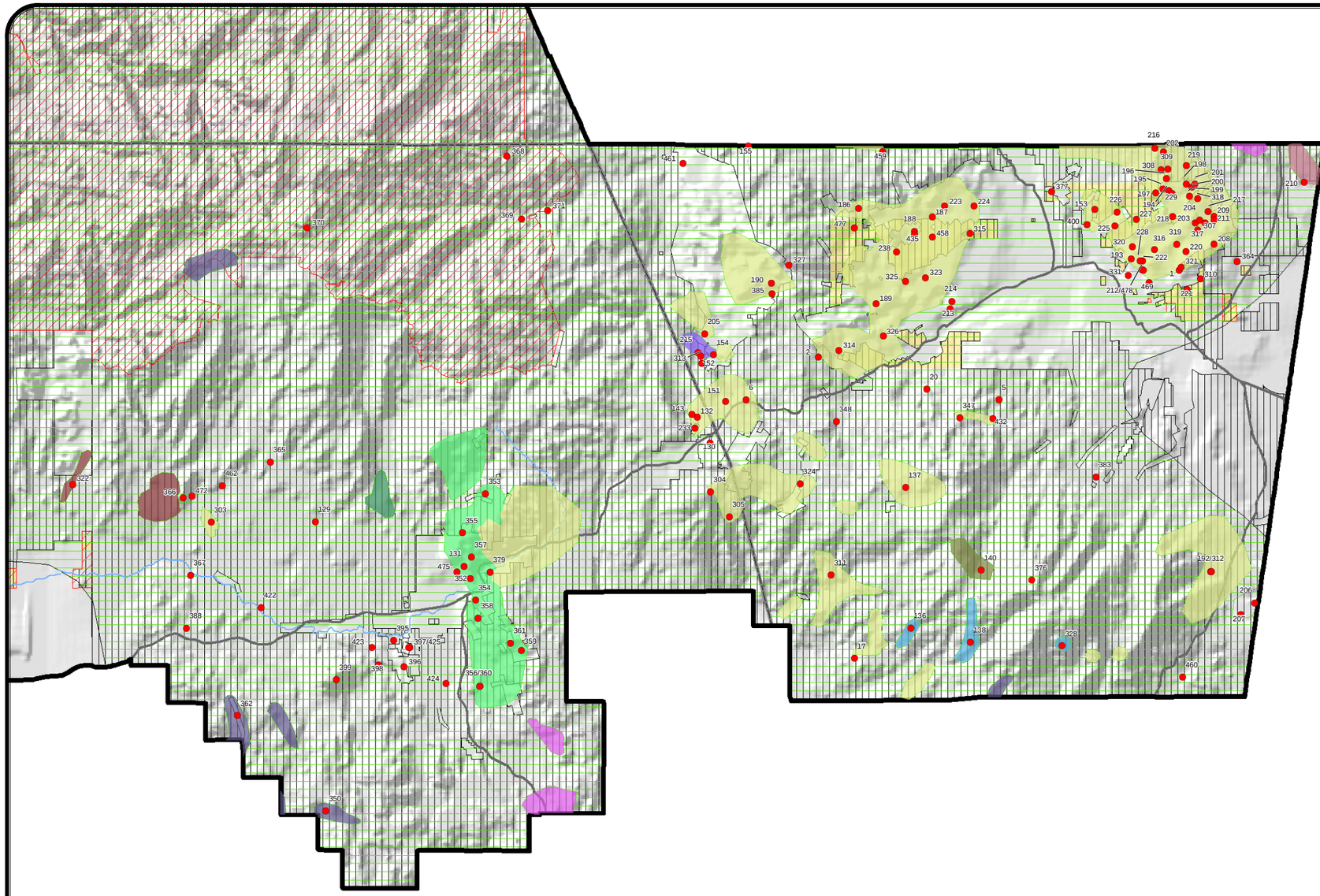
Map Produced : November 2003

URS

Map 10

Mineral Districts and Locatable Minerals Potential for Pinal Mountains Area

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Legend

330 Locatable Minerals Location and Reference Number

Use reference number to locate mine information on Table 4.

High Mineral Potential (Mineral Districts)

Copper

- 1a Porphyry with or without Molybdenum, Manganese, Gold and Peripheral Lead-Zinc-Silver
- 1b Stratabound in Rock of Age Given
- 2 Copper with or without Gold or Lead; Veins
- 3 Gold with or without Copper or Lead
- 3* Significant Silver Production

} Distinction based on Copper/ Copper and Gold Ratios

- 4 Lead-Zinc-Silver Veins and Replacements
- 4* Significant Production of Copper and Gold
- 5 Silver with or without Lead and Zinc; Veins and Replacements
- 5* Significant Copper Production

} Distinction based on Silver/ Silver, Lead, and Zinc Ratios

Manganese

- 6 Veins with or without Barium, Lead, Silver
- 8 Tungsten; Skarn and Veins or Pegmatites with or without Beryllium or Lithium

Uranium with or without Vanadium

- 10c Veins or Fissures
- 12 Unclassified (altered zones, no production)
- I Industrial Minerals

Locatable Mineral Potential

- Moderate Mineral Potential
- Low Mineral Potential

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

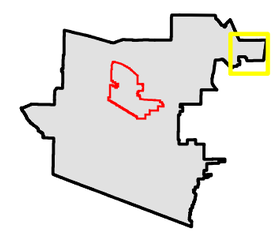
No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 1 2 4 Miles

0 2 4 8 Kilometers

Data Source:
Locatable Minerals Location: U.S. Geological Survey MRDS 1999
Niemuth 2003
Mineral Districts: Keith et al. 1983
Base Information: BLM Phoenix Field Office 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation 2002

Location in Project Area



General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

Map Produced : November 2003

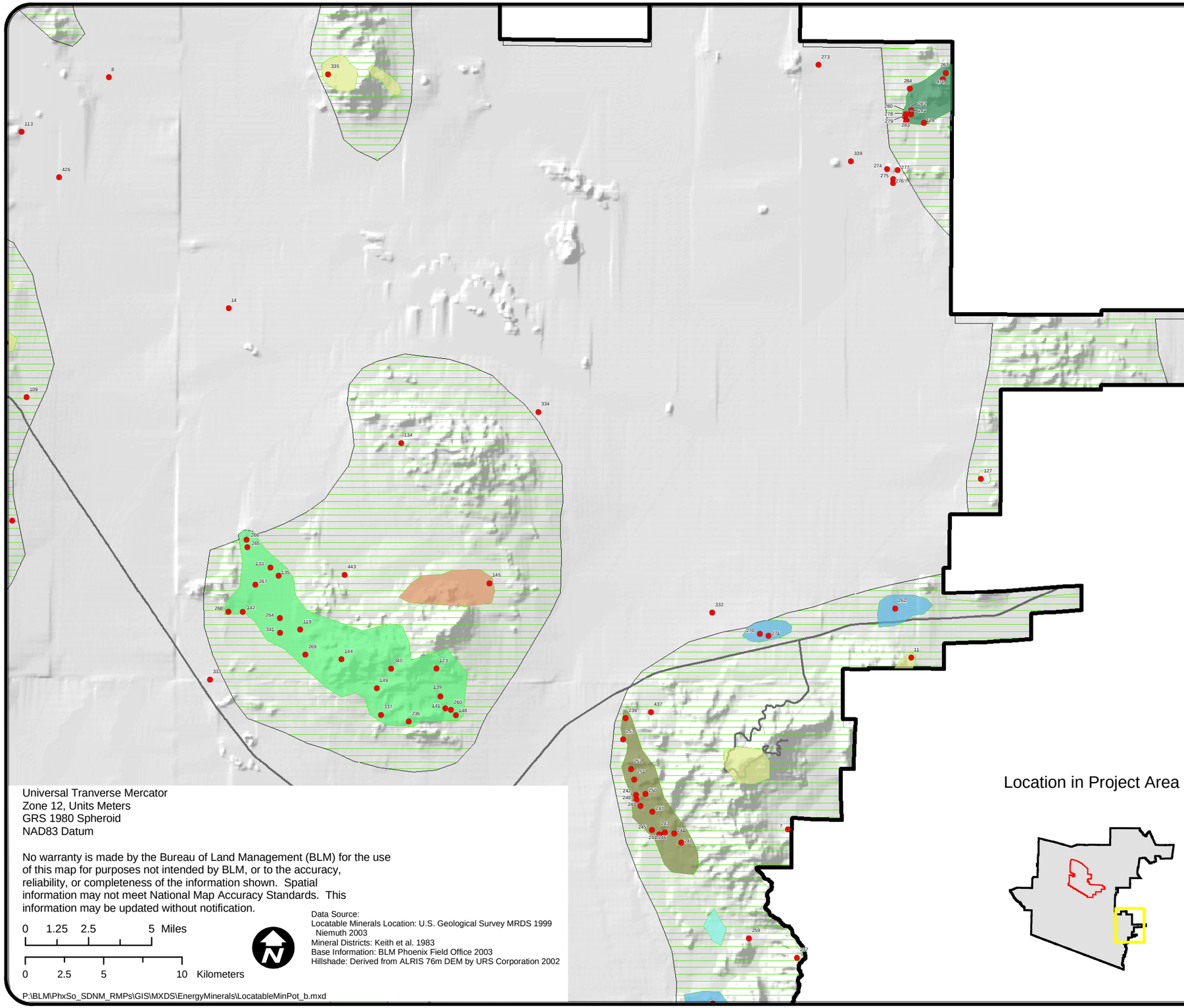
URS

Map 10a

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\LocatableMinPot_a.mxd

Mineral Districts and Locatable Minerals Potential for Baboquivari Mountains Area

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 1.25 2.5 5 Miles

0 2.5 5 10 Kilometers

Data Source:
Locatable Minerals Location: U.S. Geological Survey MRDS 1999 Niemuth 2003
Mineral Districts: Keith et al. 1983
Base Information: BLM Phoenix Field Office 2003
Hillshade: Derived from ALRIS 76m DEM by URS Corporation 2002

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\LocatableMinPot_b.mxd

Legend

330 Locatable Minerals Location and Reference Number
Use reference number to locate mine information on Table 4.

High Mineral Potential (Mineral Districts)

Copper

- 1a Porphyry with or without Molybdenum, Manganese, Gold and Peripheral Lead-Zinc-Silver
- 1b Stratabound in Rock of Age Given
- 2 Copper with or without Gold or Lead; Veins
- 3 Gold with or without Copper or Lead
- 3* Significant Silver Production

(2, 3, 3*: Distinction based on Copper/ Copper and Gold Ratios)

- 4 Lead-Zinc-Silver Veins and Replacements
- 4* Significant Production of Copper and Gold
- 5 Silver with or without Lead and Zinc; Veins and Replacements
- 5* Significant Copper Production

(4, 4*, 5, 5*: Distinction based on Silver/ Silver, Lead, and Zinc Ratios)

Manganese

- 6 Veins with or without Barium, Lead, Silver
- 8 Tungsten; Skarn and Veins or Pegmatites with or without Beryllium or Lithium

Uranium with or without Vanadium

- 10c Veins or Fissures
- 12 Unclassified (altered zones, no production)
- I Industrial Minerals

Locatable Mineral Potential

- Moderate Mineral Potential
- Low Mineral Potential

Surface Management

- Bureau of Land Management

Federal Mineral Estate

- Federal Mineral Estate
- Not Open to Mineral Entry

Location in Project Area

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

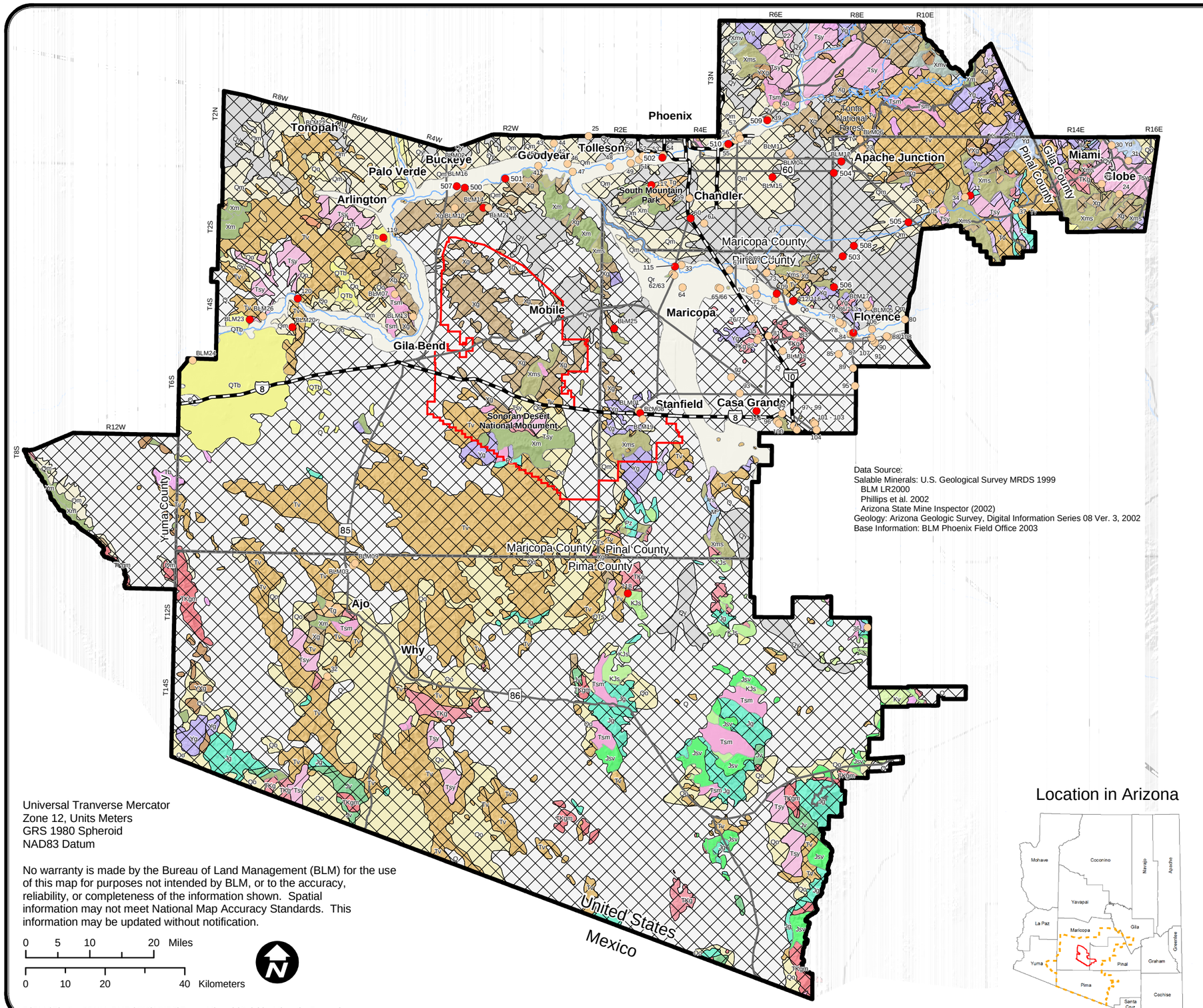
Map Produced : November 2003

URS

Map 10b

Salable Mineral Resources Potential

Phoenix South and Sonoran Desert National Monument RMPs/EIS



Universal Tranverse Mercator
Zone 12, Units Meters
GRS 1980 Spheroid
NAD83 Datum

No warranty is made by the Bureau of Land Management (BLM) for the use of this map for purposes not intended by BLM, or to the accuracy, reliability, or completeness of the information shown. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

0 5 10 20 Miles

0 10 20 40 Kilometers

P:\BLM\PhxSo_SDNM_RMPs\GIS\MXDS\EnergyMinerals\Salable_Minerals_Pot.mxd

Location in Arizona

Legend

- Decorative Rock: Granite, Volcanic, Stone
- Sand and Gravel

Salable Mineral Resource Potential

- High Potential
- Moderate Potential
- Low Potential

Geology

- Q [Holocene and Pleistocene] Alluvium
- Qr [Holocene and Pleistocene] Fine-grained Fluvial Floodplain Deposits
- Qy [Holocene to Upper Pleistocene] Alluvium
- Qm [Middle Pleistocene] Alluvium
- Qo [Early Pleistocene to Upper Pliocene] Alluvium
- QTs [Late Miocene to Pliocene] Sandstone and Conglomerate
- QTb [Holocene to Upper Pleistocene] Basaltic Rocks
- Tsy [Pliocene to Middle Miocene] Sedimentary Rocks
- Tb [Upper to Middle Miocene] Basaltic Rocks
- Tsm [Middle Miocene to Oligocene] Sandstone and Conglomerate
- Tvs [Middle Miocene to Oligocene] Sedimentary and Volcanic Rocks
- Tv [Middle Miocene to Oligocene] Volcanic Rocks
- Tg [Lower Miocene to Oligocene] Granitic Rocks
- Ti [Miocene or Oligocene] Fine-grained Intrusive Rocks
- TXgn [Lower Proterozoic through Early Tertiary] Gneiss Complexes
- TKgm [Paleocene or Upper Cretaceous] Leucocratic Granitic Rocks
- TKg [Paleocene or Upper Cretaceous] Granitic Rocks
- Kv [Upper Cretaceous] Volcanic Rocks
- KJs [Cretaceous and Jurassic] Sandstone, Conglomerate, Minor Andesitic Volcanic Rocks
- Jg [Jurassic] Granitic Rocks
- Jsv [Jurassic] Volcanic and Associated Sedimentary Rocks
- Jv [Jurassic and Triassic] Volcanic Rocks
- Pz [Paleozoic] Sandstone, Limestone, Dolomite
- MC [Mississippian to Cambrian] Sandstone, Limestone, Dolomite
- Yd [Middle Proterozoic] Diabase
- Ys [Middle Proterozoic] Apache Group and Troy Quartzite
- Yg [Middle Proterozoic] Granitic Rocks
- YXg [Middle or Lower Proterozoic] Granitic Rocks
- Xg [Lower Proterozoic] Granitic Rocks
- Xq [Lower Proterozoic] Quartzite
- Xm [Lower Proterozoic] Metamorphic Rocks
- Xms [Lower Proterozoic] Metasedimentary Rocks
- Xmv [Lower Proterozoic] Metavolcanic Rocks

General Reference

- County Boundaries
- Interstate
- State Routes
- Rivers

Planning Areas

- Phoenix South
- Sonoran Desert National Monument

Map Produced : November 2003

URS

Map 11