FINAL MINERAL ASSESSMENT REPORT

To accompany the

Resource Management Plan
Winnemucca Field Office
Northern Nevada

September 2006

United States Department of Interior

Bureau of Land Management

EXECUTIVE SUMMARY

The Bureau of Land Management (BLM) Winnemucca Field Office (WFO) is in the process of preparing an overall Resource Management Plan (RMP) for the Field Office (FO). As part of the RMP revision process, the BLM is required to prepare a Mineral Assessment Report providing information regarding mineral occurrences and potential within the WFO RMP Planning Area (Planning Area). This report provides an intermediate level of detail for mineral assessment as prescribed in BLM Manual 3060 (BLM 1994). The information presented in this report will be summarized and incorporated into an Environmental Impact Statement (EIS) for the proposed RMP and into the final RMP.

The geologic history of northern Nevada and the Winnemucca FO Planning Area (Planning Area) is very complex, and includes two major cycles of sedimentation (western and eastern facies sources), episodic thrust faulting, mountain building and associated intrusive and igneous activity. More recent geologic history includes a period of crustal extension that was accompanied by bimodal (rhyolite-basalt) volcanism, basin and range block-faulting, resulting in high-levels of shallow crustal heat flow. The regional and local geologic setting has been instrumental in the location of and significant potential for the numerous economic metallic mineral deposits in the Planning Area, as well as the significant potential for the development of economic geothermal resources.

LOCATABLE MINERALS

The Planning Area has a long history of mineral development dating back to the 1860s and contains some of the most famous gold and silver metal mining districts in the US, including: Battle Mountain, Potosi, Marigold, Lone Tree, Getchell, Pinson, Seven Troughs, Awakening, and Hog Ranch (Davis and Tingley, 1999; Peters and others, 1996; and Wallace and others, 2004). Locatable minerals historically or currently mined within the Planning Area include metallic minerals (i.e.: gold, silver copper, mercury, zinc, molybdenum, manganese, uranium, tungsten, etc.) and non-metallic minerals (i.e.: limestone, barite, gypsum, diatomaceous earth, sulfur, fluorspar and opals). Currently there are ten (10) large open pit gold / silver mines, and six (6) other industrial mineral mines in operation in the Planning Area. Over fifty (50) mining plans of operation and 102 notices are currently administered by the WFO. A total of 2,213 mining notices (as of Nov. 29, 2005) have been administered by the BLM since 1981 and nine (9) are current pending decisions. The US Geological Survey identifies more than 1,400 bedrock mines and prospects in the Planning Area, seventy eight percent of which occur within existing established historical mining districts (Sherlock and others, 1996).

Mineral exploration particularly for gold is an ongoing enterprise in Nevada by both operators of existing mines and by other exploration companies. Exploration has been extremely active recently (2004-early 2006) as gold prices have sustained levels above $400/ounce, and exceeded $600/ounce in early 2006. Companies conducting exploration in Nevada in 2004 reported spending some $79.7 million in 2004 (Dreisner and Coyner, 2005). Exploration in large part takes place in areas near known mineral deposits and within historic districts; however, exploration is also conducted in other outlying areas that the mineral industry considers prospective for various reasons (Wallace and other, 2004).

Nevada's total mineral industry production was valued at $3.3 billion in 2004 and precious metal production accounted for about $3 billion of this total (Driesner and Coyner, 2005). Prospects for sustaining these production rates in the short run are excellent and also quite likely in the long run (15-20 years).

Based on mining industry projections it appears that market conditions for gold will remain relatively consistent, with gold priced at sustainable levels in the $400+/ounce range. Within the next 10 years it is anticipated that 2-3 currently active mines will go into closure and be reclaimed. These mine closures would likely be offset with both new projects being developed and placed into production, and the expansion of existing mines.

A significant increase in exploration and mining activity has occurred with increasing metal commodity prices, placing additional demands on permitting and regulatory compliance agencies. This increased activity has also increased the potential adverse effects on watershed and other resources in the planning area. Most of the effects are site specific and potential impacts are minimized by the requirement for environmental analysis during permitting of proposed exploration and mining activities. Other state and federal regulatory requirements include mitigation measures to reduce real or potential impacts, requirements for reclamation and long term closure planning.

There are no large scale commercial placer operations currently operating in Nevada (Fitch 2003) and it is likely that most major placer deposits have already been discovered and developed in the past. Most modern placer mines operate under "Casual Use" criteria and involve individuals or clubs that mine at a small scale using little or no equipment other than hand tools and sluice boxes. Larger scale operations typically mine 60 to 150 ounces (1.7 to 4.3 kilograms) of gold per year under a Notice and are permitted to use mechanized equipment. These types of operations are often restricted and have mitigations in place to protect other resources. Site reclamation work is bonded by the responsible permitting agency to insure completion. The Planning Area should likely anticipate 10 operations operating under a Notice during any given year, with the actual number being a function of the price of gold.

Gems and semi-precious stones will likely continue to be mined on a small scale in the Planning Area. Deposits are small, usually hand-operated as "pay-to-dig" operations, and great care must be taken when extracting the stones so as not to damage and devalue the pieces. Existing deposits will likely be extended and remain small with labor intensive mining methods.

While pluton-related and epithermal deposits hosting gold and silver are commonly associated with metals other than gold and silver, the potential for development of these metals, such as antimony, beryllium, iron, lead, manganese, mercury, uranium, and zinc is low to very low. Potential for copper production is also low with the exception of moderate to good potential for further development of at least one massive sulfide copper deposit at the Big Mike Mine within the Planning Area.

There is no current production, nor has there been any significant historic production of molybdenum from the Planning Area, however, it seems quite likely that the Ashdown Property could be brought into production as a low-fluorine molybdenum porphyry system within the next few years. Other molybdenum deposits may be also developed over the next 15-20 years as well.

There is a moderate potential for the development of tungsten deposits within the Planning Area. The price of tungsten (WO_3) has increased significantly in the last few years and has stimulated the production of tungsten elsewhere in the world where deposits are larger and higher grade than those found in Nevada. It would seem reasonable that if prices were to remain high and demand increases somewhat, that some companies might be encouraged in attempting to bring some of the larger, higher grade deposits of the Planning Area into production.

Locatable industrial mineral deposits of dolomite, gypsum, diatomite and perlite are currently mined within the planning area. Low to moderate potential exists for production of most locatable industrial minerals, however, potential is good for production of carbonate (limestone and dolomite), diatomate, and gypsum from the Planning Area where deposits are located near transportation corridors and are mineable by inexpensive open-cut methods. The Echo Canyon Limestone mine is scheduled to begin production in the near future and is located northeast of Lovelock, east of the Humboldt River and Interstate 80.

SALEABLE MINERALS

Saleable mineral extraction and use will increase along with increasing mining activity, commercial development, recreation activities, and private property development, especially along the Interstate 80 corridor within the Planning Area. The minerals program administers 65 active sales, 112 free-use permits and 168 mineral site rights-of way. Saleable mineral sites with a priority for use will likely include sand, gravel, and rock quarries located along State, County, and BLM managed roads.

There is good potential and considerable demand for continued development of aggregate deposits in the Planning Area. Virtually all of the basins/valleys in the Planning Area have potential aggregate deposits but those deposits adjacent to their end uses or good transportation corridors will have the greatest development potential.

There is good potential for new and continued development of existing clay deposits in the Planning Area. Mining of clay deposits was and is being conducted throughout the Planning Area.

There is low potential for development of pumice and cinder deposits although there are a number of occurrences and former mines within the Planning Area. Currently, pumice deposits are not being mined in Nevada (Nash, 1996).

There is moderate potential for development of building and ornamental stone deposits in the Planning Area, The most desirable building stone is generally from sedimentary or volcanic units that are well-bedded and indurated, with prominent partings, and coloration. Columnar basalt (about 200 tons) and flat slabby volcanic rock (more than 5,000 tons) are both popular and have been sold within the Winnemucca FO Decision Area (areas under actual BLM administration within the larger Planning Area. Mines/quarries in the Planning Area include Trinity Range and Black Mountain in Churchill County and Virgin Valley (Wegman quarry) in Humboldt County.

The demand for boulders for landscaping uses is likely to grow substantially in the future as long as high population growth rates continue in northwestern Nevada. Most of these operations are very small scale and remove a small number of boulders. Trespass taking of boulders may become a more common problem for the BLM in the future.

LEASABLE MINERALS

Nevada has the largest amount of untapped geothermal resources in the U.S., with a potential of 2,500 to 3,700 megawatts of electricity annually (MWe). Six Known Geothermal Resource Areas (KGRAs) are located in the Winnemucca Planning Area; Brady, Gerlach, San Emidio, Rye Patch, New York Canyon, and the northern portion of Dixie Valley. There are three power plants, and two vegetable dehydration plants in operation within the Planning Area (BLM, 2005). The power plants are located at Brady Hot Springs, Desert Peak, and in the San Emidio Desert and range in generation capacity from 5.8 to 30 megawatts.

The Decision Area also contains areas with pending lease applications (typically in the vicinity of the KGRAs); and thirteen (13) areas identified by geologic models as being Prospectively Valuable Areas (PVAs) with respect to geothermal development. The 13 PVAs include the sic KGRAs and encompass approximately 1.9 million acres.

In 1997, the Nevada legislature established a renewable energy portfolio standard. This standard requires that as much as 15% of the total electricity sold sould be derived from renewable energy resources. Based on the energy portfolio, it is anticipated that renewable energy development would increase, which would likely include geothermal, wind and solar resources. A Reasonable Foreseeable Development scenario for geothermal development envisions that over the next 20 years, exploration drilling would occur on all geothermal leases, some of which would lead to more detailed exploration drilling, and a few of which would lead to the discovery of geothermal resources capable of developing five 15 Megawatt Geothermal Power Plants.

With respect to oil and gas, the Winnemucca Planning Area lies within the Western Great Basin Oil and Gas Province and is thought to be somewhat prospective for hydrocarbons because both source rocks and traps are known to occur within the province (USGS, 1995). The assessments conducted by the USGS identifies areas of oil or gas potential (plays), and provide others, including the BLM, with the basis to evaluate the effectiveness of available stipulations in balancing the responsible development of those resources with the protection of other valuable resources in the area. These federal lands inventories also allow resource managers to identify areas of low oil and gas potential but high potential for other resources or uses (e.g., wildlife or recreation). These reports are a critical step in evaluating whether existing rules are appropriate, or need to be changed to provide greater protection to the environment or to promote appropriate resource development (DOI et al 2003).

The USGS uses "play analysis" in the preparation of their national oil and gas resource assessments (USGS, 1995a). A play is a set of discovered or undiscovered oil and gas accumulations that exhibit similar geological settings and characteristics. Therefore, a play is defined by the geological properties responsible for the real or potential accumulations of oil and gas resources. Conventional plays are those in which oil and or gas is generated and migrates from source rocks into traps. Hypothetical plays are those for which the source rocks and stratigraphic traps are known to occur, but for which no discoveries of a certain size (one million barrels of oil, or 7 billion cubic feet of gas) have been discovered in the Planning Area; and therefore, it remains uncertain if any fields of that size will be discovered in the future.

While the geology itself will not change, the understanding and interpretation of geologic data pertaining to oil and gas exploration and development can change dramatically each time a new test well is completed. This is especially true in the deep sediment-filled basin portions of the WFO Planning Area, where only nine wells have been drilled since 1992. In addition, technological advances occurring over the last ten years, such as horizontal and long reach directional drilling can turn previously uneconomic deposits into viable economic ventures.

Four plays occur within the Planning Area and have some, albeit low occurrence potential for oil and gas. These plays include: Eastern Oregon Neogene Basins Play (USGS, 1995 play 1802); Permian-Triassic Source Rocks, Northwestern Nevada, and East-Central and Eastern Oregon Play (USGS, 1995 play 1803); Cretaceous Source Rocks, Northwestern Nevada Play (USGS, 1995 play 1804); and the Neogene Source Rocks, Northwestern Nevada and Eastern California Play (USGS, 1995 play 1804). Each of these plays has been tested by drilling to some degree, but no commercial production has been established in the Winnemucca Planning Area or in the Western Great Basin Province (Barker and others, 1995). These plays also extend beyond the boundaries of the Planning Area.

There are no areas of "high" oil and gas occurrence potential in the Planning Area. The USGS analysis indicates that the chance for the occurrence of a new oil or gas field of a certain size (one million barrels of oil or seven million cubic feet of natural gas) in the Western Great Basin Province study area is low, but not impossible, due to low probability of suitable reservoir or trap rocks being present. No producing fields currently exist in the Planning Area.

A total of nine oil and gas exploration wells have been drilled since 1992 (one as recently as 2004) and three new wells were permitted for drilling in 2005. In spite of the rather small reserve potential, it is the oil and gas shows and the relatively unexplored nature of the Western Great Basin Provinces that draws companies to lease land, despite the complex geological settings, high cost of drilling, and the high probability of failure. These factors combined with changing economic or supply and demand conditions will undoubtedly provide at least a limited interest in leasing and drilling activities within the WFO Planning Area for the foreseeable future.

A Reasonable Foreseeable Development scenario prepared for the Planning Area in this report estimates that as many as twelve wildcat wells (wells drilled in areas with no previous production) may be drilled in Neogene Basins in the next 15 to 20 years. Many of the initial twelve wells would likely be located in the Buena Vista Valley and Kyle Springs areas. Of these twelve wells, it is estimated that 10 will be dry holes (no economically producible oil or gas discovered). It is further estimated that two of the wells drilled in the southeast portion of the Planning Area, probably in the vicinity of the relatively recent leasing activity and within the area nominated for Oil and Gas Competitive Leasing, will produce a discovery. Each of the discovery wells would probably prompt additional step-out wells (a well drilled adjacent to or near a proven well to establish the limits and continuity of the oil or gas reservoir and/or to assist with production). It is estimated that a total of four (4) step-out wells would be drilled, two for each discovery. Finally, it is estimated one of the discoveries (including the two step-out wells) would have limited oil production and occur on BLM administered lands.

Some potential for development of leasable industrial rocks and mineral resources of the WFO Decision Area also exists. There is good potential for the development of salt deposits in the Planning Area from salt deposits occurring in playas. Although there is no current production of salt in the Planning Area, former salt mines include White Plains, Carson Sink, and Eagle Marsh in Churchill County and Buffalo Springs in Washoe County (Nash, 1996). There is low potential for the development of fumarole-related, sulfur deposits in the WFO Planning Area because fumarole environments have been thoroughly prospected (for gold-silver-mercury deposits).

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Acronyms

amsl	Above mean sea level
BBL	Barrels
BCFG	One Billion Cubic Feet of Gas
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
DOI	Department of the Interior
EIS	Environmental Impact Statement
EPCA	Energy Policy and Conservation Act
FS	Forest Service
FO	Field Office
GRC	Geothermal Resource Council
HRMP	Headwaters Resource Management Plan
KGRA	Known Geothermal Resource Area
MCF	Million Cubic Feet
MMBO	One Million Barrels of Oil
NBMG	Nevada Bureau of Mines and Geology
NF	National Forest
RFD	Reasonably Foreseeable Development
RMP	Resource Management Plan
USDA	US Department of Agriculture
USFS	US Forest Service
USGS	US Geological Survey

1. INTRODUCTION

1.1 Purpose and Scope

The Bureau of Land Management (BLM) Winnemucca Field Office (WFO) is managed under the existing Sonoma-Gerlach and the Paradise-Denio Management Framework Plans (MFP) (BLM, 1982) as amended in 1999 (BLM, 1999), and is in the process of preparing an overall Resource Management Plan (RMP) for the Field Office (FO). As part of the RMP revision process, the BLM is required to prepare a Mineral Assessment Report providing information regarding mineral occurrences and potential within the WFO RMP Planning Area (Planning Area). This report provides an intermediate level of detail for mineral assessment as prescribed in BLM Manual 3060 (BLM 1994). The information presented in this report will be summarized and incorporated into an Environmental Impact Statement (EIS) for the proposed RMP and into the final RMP.

For federal public land managing agencies such as the BLM, this Mineral Assessment Report is intended to serve primarily as a planning tool providing land managers with additional information to help them develop management plans for lands under their jurisdiction (DOI et al. 2003). It allows them to identify areas of high mineral or oil and gas potential and to evaluate the effectiveness of available permitting, regulatory, NEPA evaluation procedures, and oil and gas stipulations while balancing the responsible development of those resources with the protection of other valuable resources in the area. The federal lands inventory also allows resource managers to identify areas of low mineral or oil and gas potential, but high potential for other resources or uses (e.g., wildlife or recreation). The report is a critical step in evaluating whether existing rules are appropriate, or need to be changed, either to provide greater protection to the environment or to promote appropriate resource development (DOI et al 2003).

This Mineral Assessment Report is organized into five sections and three appendices. Following this introduction (Section 1.0), Section 2.0 summarizes geological setting as it relates to the development and use of leasable, locatable, and saleable minerals within the Planning Area. Subsections include physiography, geologic history, geologic units and stratigraphy, structural geology and tectonics, and paleontology. Section 3.0 describes the existing mineral occurrences as locatable, leasable, and saleable mineral resources of the Planning Area. Section 4.0 discusses the mineral resource potential of the Planning Area. Section 5.0 lists references used in development of the report.

The report also contains three appendices associated with the leasing, drilling and development of oil and gas, and geothermal resources. **Appendix A** provides a description of oil and gas leasing procedures and program decision points, most of which are also applicable to geothermal development. **Appendix B** describes standard procedures in oil and gas recovery and operations. Standard procedures for geothermal resource development are discussed in the body of the report (Sections 3.3.1 and 4.3.1). **Appendix C** lists state-wide and standardized oil and gas, geothermal and wind generation lease stipulations for the planning area.

1.2 Lands Involved and Records Data

The Winnemucca Field Office Resource Management Planning Area (**Figure 1.1**) is located in northwestern Nevada and includes all of Humboldt and Pershing Counties and portions of Lander, Washoe, Lyon and Churchill counties. The Planning Areas boundaries encompass 11,099,578 acres (4,491,858 hectares); almost 75% (8,276,100 acres: 3,349,232 hectares) of which are public lands. Of this total, the WFO office manages 7.3 million acres (3.0 million hectares) of public land. BLM managed land within the overall Planning Area are considered the Decision Area. Within the Planning Area borders, land is also managed by the United States Forest Service (USFS), US Fish and Wildlife Service, Bureau of Reclamation, Bureau of Indian Affairs for Native American Indian Tribal Lands, State of Nevada and by private landowners. In addition, there are several other resource areas that are administered by the Winnemucca Field Office under a separate RMP, and are therefore, not considered part of the Decision Area for this RMP. These lands include: the Black Rock Desert-High Rock Canyon Emigrant Trails National Conservation Planning area (NCA), three Wilderness Study Areas (WSA) (outside of the NCA), the Lahontan Cutthroat Trout Instant Study Area (ISA), a south playa area near Gerlach, and small irregular areas adjoining the NCA and designated Wilderness areas.

Information sources for this mineral assessment report were obtained from the BLM, the Nevada Bureau of Mines and Geology (NBMG), the US Geological Survey (USGS), the US Bureau of Mines (USBM), Department of Interior Energy Policy and Conservation Act (EPCA) reports, industry reports, personal communication with BLM resource specialists, and other published and unpublished sources listed in the reference section.

Land Use

Management issues and concerns in the Decision Area encompass nearly all resource programs and many different aspects of public lands management. Resources and land uses under particular scrutiny at this time include recreation; minerals; cultural resources; range; wild horses and burros; threatened, endangered, and sensitive species; fire management, and the land and reality programs.

The Planning Area has a long history of mineral development dating back to the 1860s and mining and exploration activities, and the development of geothermal resources are some of the important multiple uses undertaken on these lands. Most metallic minerals are mined from open-pit operations; however, some underground mining occurs as well. Currently there are ten (10) large open pit gold / silver mines, and four (4) other industrial mineral mines in operation within the Planning Area. Over fifty (50) mining plans of operation and 102 notices are administered by the Winnemucca FO. There have been more than 2,213 total mining notices since 1981 and nine notices are currently pending (11/29/05). The mineral program administers 65 active sales, 112 free-use permits and 168 mineral site rights-of way. The geothermal program includes three (3) active geothermal power generation plants that generate a total of about 20 megawatts. Approximately 65 geothermal lease applications have been received by the Winnemucca FO Decision Area within the last 2-3 years. A number of oil and gas parcels, totaling approximately 244,000 acres of public land, were offered for lease sales

1.1 Location Map of the Winnemucca Field Office Planning Area during March of 2006. There were no bids on any of these lands likely due to very strict resource protection Lease Stipulations attached to the parcels. None of these parcels were offered for lease sales in either the June or September 2006 offering.

2. DESCRIPTION OF GEOLOGY

2.1 Physiography

The WFO Planning Area occurs within the Basin and Range Physiographic Province. Topography within the Planning Area is comprised of an alternating series of moderate to high relief, north-south-trending mountain ranges typically 5-15 miles wide, and intervening broad, alluvium-filled valleys or basins from 10 to 20 miles wide. The ranges and valleys were created by faulting that resulted in horst and graben structures (large alternating up thrown and downthrown fault blocks) and large tilted fault blocks that characterize the Basin and Range Physiographic Province. Valley bottoms range from about 3,450 to 4,500 feet in elevation and mountain ranges have elevations from 5,000 to over 9,850 feet above mean sea level (amsl). Star Peak in the Humboldt Range at an elevation of 9850 feet (amsl) is the highest point in the Planning area. Relief of 3,500 to 4,000 feet within a distance of a few miles is common. The principal mountain ranges of the Planning Area are shown on **Figure 2.1**.

Major valleys or rivers within the Planning Area include the Humboldt, Little Humboldt, Quinn, and Kings Rivers. (**Figure 1.1**). The plateaus and mountain ranges are typically drained by short perennial, intermittent and ephemeral streams that disappear into broad alluvial fans at the foot of the mountain ranges. Many of intervening basins are not drained by rivers, but are closed basins with internal drainage. In the western part of the Planning Area in Washoe County, alluvial basins often contain playas in their central portions. The Planning Area includes two extensive playa areas: the Smoke Creek Desert and the Black Rock Desert (Bonham, 1969). A portion of these areas have been set aside as a National Conservation Area. Small, perennial springs, used for watering stock, are present in many canyons at the higher elevations. Hot springs are present along the margin of the Black Rock Desert and many other basins and are the focus of geothermal resources that are being actively explored and in several places used as a major source of power generation within Nevada.

An arid climate is typical of the Basin and Range Province with annual rainfall of about four inches in the valleys and as much as 20 inches or more in the mountains (Johnson, 1977). Valley bottoms are hot and dry in the summer months while cooler temperatures prevail at higher elevations. The Basin and Range Province is the most arid area in the United States; and the potential annual water loss through evaporation exceeds the annual precipitation rate even at the higher elevations. Most of the land in the Planning Area is desert shrubland, although, sufficient water is available to allow livestock to be grazed in some places. Development in the Planning Area has been limited by a scarcity of recoverable freshwater. The individual basin-fill aquifers, which together compose the largest known ground-water reserves, receive little annual recharge and are easily depleted.

2.1 Principal Mountain Ranges

Within the Planning Area, the northernmost margin of Humboldt County is a transition zone between the Basin and Range Province and the Columbia River Plateau to the north. The latter area is part of a broad plateau underlain by flat-lying volcanic rocks that is dissected by streams at grade with the Humboldt River. In the northeast part of Humboldt County, this plateau area (Owyhee Plateau, **Figure 2.1**) has been dissected by numerous deeply entrenched streams related to a lower base level of erosion controlled by the Snake River. Topographic features in this area grade northeastward into the Snake River Plain physiographic province of southern Idaho. In the northwest part of Humboldt County broad valleys exist in the volcanic plateau and the area has the appearance of the Basin and Range Province (Willden, 1964).

2.2 General Geologic History and Setting

The geology of the Planning Area represents a complex history of Paleozoic marine, and Mesozoic marine and non-marine sedimentary deposition in marginal continental accretionary, offshore marine basin settings. The deposition of these sediments was interspersed with periods of folding and thrust faulting as well as contemporaneous intrusive and extrusive activity. This was followed by Cenozoic and Tertiary crustal extension and the formation of horst and graben structures and large tilted fault-blocks that characterize the Basin and Range Physiography Province. This period of crustal extension was also accompanied by coeval magmatic and volcanic activity. **Figure 2.2** illustrates the timing of major tectonic events, sedimentation and igneous activity, and principal periods and types of mineralization within the Planning Area.

During Precambrian time and the early Paleozoic Era, approximately 40,000 feet of marine sediments and basic volcanics were deposited in an accretionary offshore basin setting within the Cordilleran (ancestral Rocky Mountain) geosyncline (**Figure 2.2**). This geosyncline was an elongated trough that extended north to south in western North America and included the area that is now eastern Nevada. Sedimentation was marked by two periods of alternating clastic and carbonate deposition (Price, 2004). These Precambrian and Paleozoic formations are exposed today, primarily in the eastern portions of Humboldt and Pershing Counties of the Planning Area.

These Precambrian and Paleozoic units were deformed in a series of tectonic events characterized by regional east-west compression and associated west-to-east imbricate thrust faulting that in general transported more distal offshore marine sedimentary facies and volcanic rocks over more marginal marine clastic units to the east. Several of these thrust faulting episodes occurred during the Paleozoic and are associated with periods of volcanism and the emplacement of plutons which are temporally and genetically related to major orogenic events (Antler, Sonoma, and Sevier and Orogenies, **Figure 2.2**). These structural relations are discussed in greater detail below in the Structure and Tectonics Section.

By the end of the Paleozoic Era, active volcanoes existed in eastern California and western Nevada and volcanism continued throughout most of the Mesozoic Era (**Figure 2.2**). In addition, a number of shallow marine invasions inundated parts of the region during the early Mesozoic Era and marine sedimentary formations alternated and inter-tongue with non-marine

2.2 Geologic Events in Northern Nevada

deposits derived from erosion of rocks further east in the continental interior. During this time, a coastal strip up to 400 miles wide was formed by a combination of marine sedimentation and igneous activity, granitic intrusions, and sub-aerial volcanism. The early Mesozoic seas spread inland as far as central Utah and Wyoming but were blocked relatively early (Late Triassic period) by a narrow uplift in central Nevada. During the remainder of the Mesozoic Era, only intermittent sub-aerial deposition took place east of this uplift. West of the uplift, a thick sequence of Mesozoic marine and continental sediments was deposited, interspersed with lava flows, volcanic breccia, and tuff (Price, 2004). Sedimentary, plutonic, and volcanic rocks of Mesozoic age are primarily exposed in the central and eastern portion of the Planning Area, in Humboldt and Pershing Counties.

The early Mesozoic Era culminated in the Sonoma Orogeny (**Figure 2.2**) in the western part of North America. Mountain ranges rose and intense deformation of the older rocks occurred across most of Nevada. Late in the Mesozoic Era, the Pacific coastal region was again down-warped and the sea transgressed across the western portion of the Planning Area (Price, 2004).

During the Cenozoic Era, volcanic rocks and sedimentary deposits accumulated over wide areas of western Nevada (**Figure 2.2**) to thicknesses of as much as 50,000 feet. As a result, early in the Cenozoic Era, northwestern Nevada was comprised of a high mountain area with external drainage. During middle to late Cenozoic time, orogenic processes initiated the formation of large-scale block faulting structures that would result in the Basin and Range Physiographic Province (**Figure 2.2**). As described above, these structures generally are a sequence of alternating horsts and grabens or tilted fault blocks that trend north south and are reflected in the present-day topography (Johnson, 1977).

In late Cenozoic time, the basins formed by the grabens of the Basin and Range Province were filled with continental deposits (**Figure 2.2**) and minor predominantly basaltic lava flows to thicknesses of generally less than 2,000 feet, but locally as much as 50,000 feet (USGS, 1995a). Thick sequences of sediments eroded from the block faulted mountains accumulated in these basins, which were intermittently inundated by lakes. Volcanoes formed throughout the Planning Area and frequently erupted flows of volcanic ash and lava. Today, much of the northeastern part of the state is covered with these volcanic rocks (Price, 2004).

The Sierra Nevada Mountains of California rose during the Quaternary, creating a rain shadow and arid desert conditions to the east in Nevada. During the Pleistocene, glaciers sculpted the highest peaks of the mountain ranges across Nevada, and tectonic processes continued the formation of Basin and Range physiography. Valleys continued to grow wider and fill with sediment. Volcanic eruptions continued throughout the state, depositing ash flows and lava (Nevada Paleontology, 2004). Quaternary deposits are present in many of the basin fill areas of the Planning Area and consist predominantly of poorly consolidated to unconsolidated alluvial and lacustrine sediments. Quaternary deposits also include alluvial fan and stream gravels, lake deposits, deposits of Lake Lahontan, and windblown sand (Willden, 1964 and Johnson, 1977).

Thick sequences of lacustrine sediments such as those associated with of glacial (pluvial) Lake Lahontan were deposited throughout the intermountain basins of northern and western Nevada in Pleistocene time. The interbedding of alluvium and colluvium with the lacustrine deposits records the history of high-stand and low-stand cycles of the lake, with beach terraces occurring as high as 4380 feet in elevation. These younger sediments cover large portions of the area, and near-shore facies and beach deposits are sources for many of the mineral material sources in the Planning Area. In addition, tufa deposits are common and occur along stand lines of basins occupied by Lake Lahontan.

Among the youngest regional deposits of Quaternary age are sediments of fluvial, aeolian, lacustrine and alluvial origin associated with reworking of the Lake Lahontan deposits. These younger sediments occur over large portions of the Planning Area, and are sources for many of the material mineral resources of the Planning Area.

2.3 Geologic Units

2.3.1 Introduction

Exposed rocks in the Planning Area range in age from latest Proterozoic-Cambrian to Holocene (Willden, 1964; Doebrich, 1996) and include igneous intrusive rocks; pyroclastic and intrusive/extrusive volcanic rocks; and marine and continental sediments, many of which, particularly the older rocks (pre-Mesozoic) have been metamorphosed, folded, and faulted. Summary descriptions of geologic formations or units were derived from NBMG bulletins including: Geology of Nevada (Stewart, 1980); Geology and mineral deposits of Humboldt County, Nevada (Willden, 1964); Geology and mineral deposits of Pershing County, Nevada (Johnson, 1974); Geology and mineral deposits of Churchill County (Willden and Speed, 1974) and Geology and mineral deposits of Washoe and Storey Counties, Nevada (Bonham, 1969). The Nevada Bureau of Mines and Geology has compiled detailed geologic maps by county at 1:250,000 scale and these are available in NBMG Open-File Report 97-1. A more generalized geologic map of the entire Winnemucca FO Field Planning Area based on the State of Nevada geologic map (Stewart and Carlson, 1977) is presented in this mineral assessment report as **Figure 2.3**.

Table 2-1 is a series of generalized stratigraphic sections, presented by county, of rock formations or units. Geologic ages, unit thicknesses, lithologic descriptions, and paleontological potential are also presented on **Table 2-1**. **Table 2-2** provides additional detail on summarizes paleontological resources.

2.3 Generalized Geologic Map

Table 2-1 Geologic Sections of the Winnemucca RMP Planning Area (one full page)

2.3.2 Paleozoic Units

Paleozoic formations are exposed primarily in three structural windows (erosional breaks in an overlying thrust sheet that exposes underlying rocks) within the Planning Area (**Figure 2.3**). The three windows occur in the Osgood Mountains and in the East Range in easternmost Humboldt and Pershing counties and in the Jackson Mountains of south-central Humboldt County (**Figures 2.1 and 2.3**). In these localities, the units consist of thick, and structurally and lithologically complex, sedimentary and locally volcanic units ranging from Cambrian to Permian in age. The Paleozoic rocks have an aggregate thickness in excess of 50,000 feet in Humboldt and Pershing counties. Most of the rocks are representative of deep-water sedimentation along the western margin of the North American craton and are locally intercalated with marine volcanic rocks. Early Paleozoic formations found in Humboldt and Pershing counties include the Late Proterozoic to Cambrian Osgood Mountains Quartzite, the Middle to Late Cambrian Preble, and the Early to Middle Ordovician Comus Formations (**Table 2-1**). The Osgood is a relatively pure cross-bedded quartzite locally occurring with phyllitic shale (Holtz and Willden, 1964) The Preble Formation consists of a lower predominantly limestone unit overlain by an upper shale and phyllite unit. The Comus Formation consist of calcareous and dolomitic clastic rocks and interlayered basaltic volcanic and volcanoclastics.

Unconformably overlying this sequence of rocks is another sequence of Early Paleozoic rocks consisting of the Paradise Valley Chert, and the Harmony, Valmy, Havallah and Pumpernickel Formations (**Table 2-1**). These units are temporal equivalents of the Osgood-Comus sequence of rocks that were deposited in deeper waters further to the west of the North American craton that have been thrust faulted over the shallower water carbonate and quartzite rocks. Rocks of the upper plate of the thrust fault (the deeper water sediments) were displaced to the east along the Roberts Mountain Thrust and now overlie the shallower water sequences that are exposed in windows through the Roberts Mountain Thrust plate. Movement along the Roberts Mountain Thrust probably took place during a mountain building event that is further evidenced by a structural unconformity between late Silurian and early Mississippian depositional units in throughout northern Nevada (Johnson, 1977 and Willden, 1964) (**Table 2-1**). The structural relationship placing silicic and volcanic rocks over carbonate units along the Robert's Mountain Thrust is a major control for the localization of Carlin-type gold deposits (**Figure 2.3**) in Nevada (Doebrich, 1996).

A sequence of late Paleozoic rock, exposed only in the Osgood Mountains, is called the Antler overlap sequence (Roberts, 1964). This sequence of rocks is interpreted to have eroded from upper plate rocks of the Roberts Mountain thrust in the ancestral Antler Highlands and is evidenced by the deposition of shallow marine sediments along the margins of the highland. The rocks are predominantly calcareous siliciclastic rocks and limestone of the Pennsylvanian Battle Formation, the Pennsylvanian-Permian Antler Peak Limestone and the Permian Edna Mountain Formation (Roberts, 1964) (**Table 2-1**). **Figure 2.4** illustrates the relationship of these thrust faults and allochthonous blocks with respect to various stratigraphic sequences.

2.4 Paleozoic Geologic History

There is additional evidence for a Late Permian-Early Triassic thrusting event associated with the Sonoma Orogeny (Silberling and Roberts, 1962) that thrust rocks of the Pennsylvanian-Permian Havallah and Pumpernickel Formations along the Golconda thrust plate, over older rocks of the Antler overlap sequence (**Figure 2.4**). These units are intercalated with mafic volcanic rocks that are locally associated with volcanogenic massive sulfide deposits (**Figure 2.4**). This thrust fault is also an important tectonic-stratigraphic control for sediment-hosted gold deposits in the Battle Mountain and Potosi Districts (**Figure 2.4**).

In the Washoe county portion of the Planning Area, only one Paleozoic rock unit is exposed. This is a formation of Permian/Triassic-age consisting of contact-metamorphosed sedimentary and volcanic rocks, identified at the margins of the Smoke Creek Desert.

2.3.3 Mesozoic

Sedimentary, plutonic, and volcanic rocks of Mesozoic age are exposed primarily in the central and eastern portion of the Planning Area, in Humboldt and Pershing counties (**Figure 2.3**). These units consist of extremely complex structure involving in-place (autochthonous) and thrust faulted sequences (allochthonous) of sedimentary rock and suites of intrusive rocks. The sedimentary rocks comprise three major groups of strata including: 1) in-place Triassic volcanic arc and shelf sedimentary rocks of the Koipato Formation (**Figure 2.5** and **Table 2-1**); 2) a block of thrust faulted Triassic-Jurassic pellitic and clastic sedimentary shelf and platform rock with minor limestone of the Auld Lang Syne Group (**Figure 2.5** and **Table 2-1**) that are intruded by a Middle Jurassic mafic complex; called the Jungo terrane (Silberling and others (1992) or the Fencemaker Thrust and allochthon (**Figure 2.5**) (Speed, 1978, Oldow and others 1990); and a 3) a diverse sequence of Late Paleozoic to Mesozoic andesitic magmatic arc related volcano-sedimentary rocks called the Black Rock terrane (**Figure 2.5**) (Silberling 1991). The Jungo and Black Rock Terranes were deformed by folding and imbricate thrust faulting during a major crustal shortening event (Fencemaker Allochthon) occurring from Middle Jurassic through Early Cretaceous time (**Figure 2.5**). Intermountain basins that formed during this deformation were the site of Cretaceous deposition of fluvial and lacustrine deposits such as the King Lear Formation (**Figure 2.5**).

In the Washoe county part of the Planning Area, the Nightingale sequence (**Table 2-1**) comprises the Mesozoic strata. The Nightingale sequence consists of metamorphosed, quartz-rich, sandy, and argillaceous sediments with subordinate amounts of limestone and dolomite. Intrusive rocks of Mesozoic age are exposed in many of the mountain ranges in the Planning Area (**Figure 2.3**). These range in composition from gabbro to rhyolite porphyry and range in size from batholiths to small stocks.

2.5 Mesozoic Geologic History

2.3.4 Jurassic and Cretaceous Intrusive Rocks

Jurassic intrusive rocks occur as parts of three magmatic suites (**Figure 2.5**) that include: 1) the middle Jurassic Humboldt mafic complex in the Humboldt and Stillwater Ranges; 2) early to late Jurassic granitic to gabbroic intrusives of the Happy Creek Complex in the Jackson Mountains, and 3) isolated plutons of quartz monzonite granodiorite and syenite in the southwestern part of the Planning Area. The Humboldt mafic complex is associated with the Triassic-Jurassic Fencemaker allochthon and the Happy Creek complex is associated with the Paleozoic-Mesozoic Black Rock Terrane, both of which were discussed above.

Cretaceous (145-65 Ma) intrusive rocks are the most voluminous of all plutonic rocks in the Planning Area and occur in a northeast-striking trend (**Figures 2.3** and **2.5**) from the Nightingale Mountains in the southwest to the Santa Rosa and Montana Mountains in the northeast (**Figure 2.1**). They are predominantly calc-alkaline and granitic and granodioritic in compositions.

2.3.5 Cenozoic Volcanism

During the Cenozoic Period the tectonic character of the Planning Area changed dramatically from one of crustal compression to one of crustal extension with significant related volcanic activity and the emplacement of numerous intrusives (**Figures 2.3 and 2.6**). Tertiary age rocks throughout the Planning Area include a complex sequence of volcanic, pyroclastic, and sedimentary rocks intruded by related dikes, sills, and stocks (**Figures 2.3 and 2.6**). The thickness of Tertiary rocks ranges from less than 10 feet to greater than 3,500 feet with variability attributed to differential erosion and deposition on an irregular pre-volcanic surface.

The Tertiary volcanic and intrusive rocks range in composition from olivine basalt to rhyolite. Fresh water sedimentary rocks exist at several levels in the volcanic sequences and include conglomerate, sandstone, siltstone, tuff, shale, and diatomite. Thick sequences of dominantly volcanic rocks are more common in the north and west portions of the Planning Area.

In Nevada there were three principal volcanic and magmatic episodes that included: 1) a late Eocene to early Miocene period (43 to 17 Ma) of calc-alkaline intrusive (Battle Mountain area and the Kennedy Stock of the East Range (**Figures 2.1 and 2.3**) and volcanic activity (the interior andesite-rhyolite assemblage); 2) a middle to late Miocene (17 to 6 Ma) calc-alkaline assemblage (**Figure 2.3**) (the western andesite assemblage); and 3) a late Miocene to Holocene (<6 Ma) bimodal basalt-rhyolite assemblage (**Figure 2.3**) (Doebrich, 1996).

An east-west-trending volcanic trough (**Figure 2.3**) occurs in the vicinity of the Tobin and East Ranges in the southeast part of the Planning Area (**Figure 2.1**). The Fish Creek Calderas (in the Fish Creek Mountains) and the Kennedy Stock occur along this trough axis and are representative of of interior andesite-rhyolite assemblage volcanism. Rocks of the basalt-rhyolite assemblage were the most voluminous of the three volcanic-magmatic episodes and occur predominantly in the northern and western portions of the Planning Area (**Figure 2.3**). In addition, there are other small basalt flows associated with this assemblage, located to the

2.6 Cenozoic Geologic History

north of the town of Winnemucca. Major calderas associated with the bimodal-basalt-rhyolite assemblage include the McDermitt, Ragged Top, Cottonwood Creek, and Badger Mountain Calderas and the Goosey Lake depression (Doebrich 1996) (**Figure 2.6**).

Some of the Tertiary formations found in Humboldt and Pershing counties include the Pansy Lee conglomerate, Virgin Valley and Thousand Creek Beds of Merriam sediments, Caetano tuff, and Fish Creek Mountains tuff. Some of the Tertiary formations found in Washoe County include South Willow volcanics, Pyramid Sequence and High Rock volcanic and sedimentary rocks, Cañon rhyolite, Coal Valley and Truckee volcanic and sedimentary rocks, and Washington Hill volcanic rocks.

2.3.6 Pleistocene

Quaternary to recent volcanic rocks, principally basalt, are typically interbedded with and overlain by lacustrine, alluvial, colluvial, and aeolian sedimentary deposits of Pleistocene and Holocene age.

In addition, during Pleistocene times, a large inland lake called Lake Lahontan filled most of the large intermountain basins in the Planning Area. Pyramid and Walker Lakes are large remnants of this once much larger lake system and playas in the Black Rock Desert, Desert Valley, Winnemucca Lake and the Carson Sink are also likely remnants of this Pleistocene lake. Lahontan Beach terraces are visible in pediment surfaces along many of the ranges in the Planning Area and the apparent highest stand of the lake was at 4380 feet in elevation (amsl). Limestone and clastic sedimentary rocks accumulated in the Lake Basin which had no outlet, and calcareous tuffa deposits formed as the lake evaporated (Cartwright, 1961).

2.4 Structure and Tectonics

Rocks exposed in the Planning Area range in age from latest Proterozoic-Cambrian to Holocene (Willden, 1964; Doebrich, 1996) and include a variety of intrusive and extrusive rocks; and marine and continental sediments. Many of the pre-Mesozoic rocks have been metamorphosed, folded, and thrust-faulted documenting major periods of tectonic or orogenic activity. The major Paleozoic thrust fault events are diagrammatically depicted on **Figure 2.4**; where allochthonous rocks are shown to be transported by eastward thrusting over another series of rocks. These major periods of thrust faulting have been named by the allochthonous blocks (transported terranes) that have been thrust over other sediments, and by the fault planes along which the blocks were transported. The names of these thrust blocks, the bounding fault structure, the age of the movement of the faults, and the orogenic event responsible for the movement are also illustrated on **Figure 2.4**.

In a regional plate tectonic model, a fold-and-thrust belt forms when an oceanic plate is subducted (shoved under) under a continental plate. Under these conditions a series of mountain ranges tend to form at some distance inland from the leading edge of the continental plate as a result of the compressive stresses involved with subduction. The formation of these ranges is often accompanied by large intrusions of granite, extrusion of volcanic rock, and thrust faulting of sedimentary rocks. Thrust faults occur as packages of sedimentary rock sheets that are sheared into imbricated slabs and stacked one upon another. These slabs can range in thickness from a few hundred feet to many thousands of feet, and lateral displacement distances can range from a few hundred feet to tens of miles. In some cases, these slabs of sedimentary rocks sheared away from hot ductile basement rock and usually move along beds that are very weak, typically shale (but sometimes gypsum, salt or even hot plastically deformed intrusive rocks) which act as glide planes.

The earliest of these thrust faulting episodes in Northwestern Nevada took place during the Antler Orogenic mountain building event where deep water marine sedimentary and volcanic units (Paradise Valley Chert, and the Harmony, Valmy, Havallah and Pumpernickel Formations, **Table 2-1**) were displaced to the east along the Roberts Mountain Thrust (**Figure 2.4**) and now unconformably overlie the coeval, shallower water carbonate and marginal marine quartzite rock units (Osgood-Comus sequence) that are exposed in windows through the Roberts Mountain Thrust plate (**Figure 2.4**). The timing of movement along the Roberts Mountain thrust is further evidenced by a structural nonconformity between late Silurian and early Mississippian depositional units in throughout northern Nevada (Johnson, 1977 and Willden, 1964) (**Table 2-1**).

The Sonoma Orogeny occurred from late Permian to early Triassic time. This event was also characterized by large-scale eastward movement of Paleozoic deepwater sedimentary rocks of the Golconda Allochthon (**Figure 2.4**) along structures such as the Golconda Willow Creek Thrust faults within the Planning Area.

The last pre-Cenozoic event was the Sevier Orogeny, which in the Planning Area included the occurrence of low-grade regional metamorphism, folding, and thrust faulting. This orogenic event culminated with the intrusion of granitic rocks in Cretaceous time (Price, 2004) (**Figures 2.2 and 2.3**). The igneous intrusions, in turn, created additional structural deformation that included folding, faulting, and contact metamorphism.

Cenozoic volcanism, Basin and Range faulting and related folding is superimposed on this complex structural terrane (Johnson, 1977). Cenozoic structural deformation occurred in two distinct periods both of which were accompanied by volcanic activity (**Figure 2.6**). Early Cenozoic deformation began with Basin and Range extensional faulting, about 43 to 35 Ma. This tectonic activity was associated with the formation of calderas and other volcanic centers, concurrent with faulting along linear alignments of volcanic centers, and extensive sequences of andesitic and dacitic lava flows throughout much of central and eastern Nevada. This was followed by thick sequences of dominantly rhyolitic ash flows to 17 Ma (Bonham, 1969, Johnson, 1977, and Price, 2004).

Major structural deformation began about 16 Ma, concurrent with the extrusion of basaltic flows, rhyolite lavas, and ash flows and continuing to present time. Basin and Range faulting was also concurrent and has been intermittently active to present time (**Figure 2.6**). This resulting topography is characterized by north-trending fault-bounded mountain ranges. The north trending system is cut by shorter east west trending faults. The faulting has resulted in displacements, which is, in places, as large as several thousand feet. Late Miocene or Pliocene volcanic rocks are cut by faults that can have considerable post-volcanic displacement (Bonham, 1969 and Johnson, 1977).

A very recent period of volcanism (<6 Ma) and caldera development is associated with and hot springs geothermal systems and hot spring related mineral deposits. Some of these within the Planning Area include McDermitt, Ragged Top, and Cottonwood Creek Calderas and the Goosey Lake depression and mineral deposits such as Sleeper and Florida Canyon (**Figure 2.6**).

In contrast to the basin and range faulting, individual ranges in the northwest margin of the Planning Area can be constructional features formed by late Tertiary volcanism. Most of this area is a highly dissected plateau underlain by flows of the Cañon Rhyolite extruded from numerous vents within the area (Bonham, 1969 and Willden, 1964).

In conclusion then, the geologic structure controlling the Basin and Range topography in the Field Planning Area, as well as all of Nevada, is dominated by faults. Most of the mountain ranges are bounded on at least one side by a fault that has been seismically active during the last 1.6 million years. Mountains and basins have been created by faulting. Over time these basins have filled with sediments that are derived from the erosion of the mountains and the thickness of sediments in these basins can be on the order of tens of thousands of feet (Price, 2004).

2.5 Paleontology

Paleontology combines biology and geology in the study of fossils. Fossils are paleontological resources that include the body remains, traces, or imprints of plants or animals that have been preserved in sedimentary strata during past geologic or prehistoric time. Summary descriptions of fossil bearing rock formations or units were derived from NBMG bulletins Geology and mineral deposits of Humboldt County, Nevada (Willden, 1964; Geology and mineral deposits of Pershing County, Nevada (Johnson, 1977); Geology and mineral deposits of Washoe and Storey Counties, Nevada (Bonham, 1969); The Paleontology Portal, Nevada Paleontology; and the Nevada Division of Museums and History.

Fossils and fossiliferous strata occur in Paleozoic, Mesozoic, and Cenozoic rocks throughout the Planning Area and range in age from about 600 Ma to recent. **Table 2-2** summarizes paleontological resources of the Planning Area. Important fossil resources within the Planning Area are generally considered to be vertebrate fossils (for example: dinosaur skeletons, fish, and mammal remains) that are of scientific interest from a variety of points of view. Fossils of mammalian vertebrates have been collected in Quaternary age lacustrine sediments from several lake shore localities within the Planning Area. Remains found at ancestral lake site localities include bones and teeth of horses, camels, rhinoceros, and occasionally mammoths.

Fossil-bearing, Cambrian age formations in the Planning Area include the Preble, Harmony, and an unnamed chert where fossils including trilobites have been identified. Elsewhere, Cambrian fossils include trilobites, brachiopods, archaeocyaths, and helicoplacoids of which occur throughout much of Nevada.

Fossil-bearing, Ordovician age units within the Planning Area include the Valmy and Comus where fossils including graptolites have been identified. Elsewhere, Ordovician fossils of Nevada include sponges, crinoids, brachiopods, bryozoans, nautiloids, and graptolites. Silurian and Devonian age formations have not been identified in the Planning Area.

Fossil-bearing, Carboniferous (Mississippian and Pennsylvanian) age formations in the Planning Area include many formations where sedimentary rocks are interbedded with volcanic flows. These sedimentary units include the Inskip, Pumpernickel, Havallah, Edna Mountain, Antler Peak, and other unnamed limestone units. Some of the beds in the unnamed limestone units have been identified as richly fossiliferous, where the fossils collected include coral, bryzoans, brachiopods, conodonts, and fusilinids. The Carboniferous chert and shale horizons can also be rich in the skeletal remains of marine plankton.

One fossil-bearing, Permian age formation was identified within the Planning Area and this unit included metavolcanic rocks with interstratified limy shales and chert. Fossils from this unit include well-preserved brachiopods near Black Rock Point in Pershing County.

Some of the fossil-bearing, Triassic age formations in the Planning Area include the Quinn River, Koipato, Prida, Natchez Pass, Winnemucca, and Rasberry. These have corals and fusilinids and early Triassic and ammonites among other fossils. The Triassic was a marine environment in western and central part of Nevada where, today both Ichthyosaur and ammonite fossils can be found.

There is one fossil-bearing Jurassic age formation identified from the Planning Area and this is a limestone unit in Humboldt County. Crinoids are one of the fossils that have been collected from this unit. This marine Jurassic sedimentary unit contains the youngest marine sediments in Nevada. Jurassic age fossils are for the most part limited, but include pectens, oysters, and ammonites.

There is one fossil-bearing, Cretaceous age unit identified in the Field Planning Area and this is the King Lear Formation in Humboldt County. Fresh water fossils were collected from limestone beds of this formation on the east side of Navajo peak in Humboldt County. Due to few Cretaceous sedimentary rocks found in Nevada, relatively few fossils of this age are known from the state.

Tertiary age, fossil bearing formations or units are present in all parts of the Planning Area. These include the Virgin Valley Beds and Thousand Creek Beds of Merriam in Humboldt county and sedimentary rocks interbedded with volcanic units in Pershing and Washoe counties. Vertebrates including fish, mammals, floras, and diatoms are some of the fossils that have been collected.

Fossils of vertebrates and plants have also been collected in Quaternary age sediments within the Planning Area. Collection localities include lacustrine sediments at Winnemucca Lake, Black Rock Desert, and Rye Patch Reservoir in the Humboldt Valley. Mammalian vertebrate remains have been found at these and other ancestral lakes sites and include bones and teeth of horses, camels, rhinoceros, and occasionally mammoths.

Table 2.2 Paleontological Resources of the Winnemucca RMP Planning Area

3. MINERAL RESOURCE OCCURRENCES

Minerals resources within the WFO Planning Area are classified into three major categories: locatable minerals (i.e., base metals, precious metals, and industrial minerals); leasable minerals (i.e., oil and gas, coal, phosphate and geothermal areas); and saleable minerals (e.g., common varieties of sand and gravel and clay). Each of these categories is discussed separately below.

3.1 Locatable Mineral Resource Occurrences

3.1.1 Introduction

Locatable minerals are minerals for which the right to explore, develop and extract mineral resources on federal lands open to mineral entry is established by the location (or staking) of lode or placer mining claims as authorized under the General Mining Law (May of 1872) (as amended). Mining is also regulated under the Wilderness Act, the Wilderness Study Area Act and other applicable federal regulations. Some of these Federal regulations include: 43 CFR 3809, Surface Management Regulations; 6300 Wilderness Regulations; 5860 Wilderness Management Handbook; 43 CFR 3802, Exploration and Mining, Wilderness Review Program and 43 CFR 3715, Use and Occupancy.

Examples of locatable minerals historically or currently mined within the Planning Area include metallic minerals (i.e.: gold, silver copper, mercury, zinc, molybdenum, uranium, tungsten, etc) and non-metallic minerals (i.e.: limestone, barite, gypsum, diatomaceous earth, fluorspar and opals).

Nevada produced more gold, barite and gypsum than any other state in the nation in 2004 and was second in the production of silver, behind Alaska. Nevada is the world's third largest gold producer behind South Africa and Australia. Mining in Nevada also produces a variety of other mineral commodities including aggregates, copper, diatomite, dolomite, gemstone, limestone, lithium and magnesium compounds, perlite, potassium sulfate, salt, silica sand, specialty aggregates and clays. In all, Nevada mineral production in 2004 was valued at about $3.3 billion (excluding oil and geothermal energy) and precious metals accounted for about $3.0 billion of that total.

3.1.2 BLM Locatable Minerals Program

The BLM'S locatable mineral program is reactive to proposals to explore and/or plans to mine an area as submitted by individuals or mining companies. Surface disturbing activities under the jurisdiction of 43 CFR 3809 regulations (43 CFR 3802 if within a wilderness study area) are reviewed on a case-by-case basis and require National Environmental Policy Act (NEPA) evaluation and compliance prior to surface disturbance activities. Occupancy related to mining is regulated under 43 CFR 3715. The intent of these regulations is to prevent unnecessary or undue degradation of surface resources or the environment, to ensure reasonable reclamation of disturbed sites on public land, and to prevent surface occupancy on unpatented mining claims for non-mining purposes.

The regulatory framework necessary for oversight and permitting of mineral exploration and mining operations is in place. Exploration or production activities disturbing more than five acres (two hectares) require a Plan of Operation, Reclamation Plan, and NEPA environmental analysis and compliance. Notices (required for exploration surface disturbances using non-mechanized equipment and no explosives) and Plans of Operation both require reclamation bonding. Notices and "casual use" are not designated federal actions and thus do not require environmental analysis or approval by the authorized officer. However, notices are reviewed and measures applied to prevent unnecessary or undue surface degradation. The Planning Area has a long history of mineral development dating back to the 1860s. Currently there are ten (10) large open pit gold / silver mines, and six (6) other industrial mineral mines in operation. Over fifty (50) mining plans of operation and 102 notices are administered by the WFO. The minerals program administers 65 active sales, 112 free-use permits and 168 mineral site rights-of way.

3.1.3 Geologic History

The structural and geologic history of Nevada, in particular the Paleozoic and early Mesozoic compressional mountain building events with associated thrusting and plutonism, and the later Tertiary crustal extension events with high heat flow into the earth's crust and associated volcanism, has created a variety of mineral deposits in numerous mining districts throughout the state of Nevada and particularly within the Planning Area. Metallic mineral deposits of northwestern Nevada are spatially, temporally, and genetically related to the emplacement of a large number of small stocks and a few larger intrusive bodies (batholiths) associated with these mountain building and crustal extension events. Development of extensive fracture and fault systems associated with mountain building is also spatially related to formation of various vein-type and replacement mineral deposits (as well as with geothermal resources). Intrusive stocks created hydrothermal systems necessary for mobilization and deposition of metallic minerals, and fracture and fault systems provided conduits along which hydrothermal solutions were mobilized. In and near these pathways, valuable ores of native metals (gold and silver) or sulfide minerals containing copper, lead, zinc, and molybdenum were deposited. In many deposits, several different valuable metallic minerals may be present at the same location. Figures 2.4 to 2.6 show the relationship of various types and ages of ore deposit formation with these tectonic mountain building, crustal extension and plutonic or volcanic events.

The US Geological Survey (Sherlock and others, 1996) identifies more than 1400 bedrock mines and prospects in the Planning Area alone. Erosion of these mineralized bedrock areas has locally concentrated gold into economic placer deposits. Seventy eight percent of all deposits occur within existing established historical mining districts (Sherlock and others, 1996).

The Planning Area contains some of the most famous gold and silver metal mining districts in the US, including: Battle Mountain, Potosi, Marigold, Lone Tree, Coeur Rochester, Twin Creeks, Florida Canyon, Getchell, Pinson, Seven Troughs, Awakening and Hog Ranch (Davis and Tingley, 1999; Peters and others, 1996; and Wallace and others, 2004). Other economic deposits of limestone, barite, diatomite, opal and sand and gravel are being mined or have been mined in the past. Mineral deposits are discussed in greater detail by commodity below.

3.1.4 Mining History

Discussion of historic development, exploration, and production is very briefly summarized by geographic areas and counties within the Planning Area.

The western portion of the Planning Area occurs mostly in Washoe County (**Figure 1.1**). Historically, prior to 1969, the mineral deposits of Washoe County had produced metallic ores valued at approximately $4 million (Bonham, 1969). These values were derived from deposits of gold, silver, lead, copper, and zinc and lesser amounts of mercury, uranium, tungsten, arsenic, and antimony. Occurrences of tellurium, manganese, molybdenum, bismuth, titanium, rare earth minerals, and thorium are known from Washoe County, but have not been developed (Bonham, 1969). Deposits in Washoe County that occur within the Planning Area currently include several industrial mineral deposits of aggregate (sand and gravel), clay, sodium minerals, barite, gypsum and sulfur (Nash, 1996; Davis, 2003; and Papke and Castor 2003). The Planning Area also includes a portion of Washoe County that contains gold and silver, mercury, uranium, and tungsten prospects, and deposits of in gold and silver. Significant historical production has been reported from gold and silver deposits of the San Emidio and Deephole Districts (**Figure 3.2**), and copper and tungsten deposits of the Deephole and Cottonwood Districts (**Figure 3.4**) (Bonham, 1969). There is currently no metal production from Washoe County (Davis, 2003).

The southern portion of the Planning Area includes small portions of both Churchill and Storey Counties (**Figure 1.1**). Although the mineral deposits of Storey County had produced ore valued at approximately $400 million, most of this historic production came from the Comstock Lode which is outside of the Planning Area (Willden and Speed, 1974, Davis, 2003). The tiny portion of Storey County within the Planning Area has no significant metal prospects or historic production. The first recorded mineral discovery in Churchill County was soda in the Soda Lakes area in 1855. By the time commercial production of soda commenced, salt deposits had been exploited, metallic mineral deposits, (primarily silver and gold) had been discovered, and mining districts organized in several areas. Most historical production from Churchill County occurred largely from three silver-gold districts located south and east of the Planning Area. Production of other metals, including tungsten and antimony, has been small to negligible (Willden and Speed, 1974). Production from the portion of Churchill County occurring within the Planning Area includes a number of gold and silver prospects (Jessup and Truckee Districts, **Figure 3.2**) and several antimony, copper and tungsten prospects as well (Juniper Ridge, Nightingale, and Copper Valley Districts, **Figure 3.4**). No metals production occurs, at present, from this portion of the Planning Area. Non-metal (industrial) resources in this portion of the Planning Area include clays, sodium minerals, diatomite, dolomite, sand and gravel, pumice and building stone (Willden and Speed, 1974) (**Figure 3.6**).

By far, most of the geographic area within the Planning Area occurs within Humboldt and Pershing Counties. Mineral deposits of Humboldt and Pershing County have historically produced metallic ores valued at $79 (Johnson, 1977) and $167 million (Willden, 1964) respectively, from as many as 90 mining districts (**Figure 3.1**). These include mined deposits of gold, silver, mercury, copper, tungsten, antimony, and iron. In addition, minor amounts of copper, lead, zinc, arsenic, manganese, antimony, gemstones and a very small amount of uranium were also produced.

The first known metal discovery from this part of the Planning Area was in 1856 for copper at the 56 Copper Mine in the Eugene Mountains. Mining activities began in earnest in the 1860's following the discovery of the Comstock Lode. In the late 1800's, high grade silver deposits were mined in the Paradise Valley district and high grade gold and silver deposits were mined in the National District (**Figure 3.2**). Several smelters were erected along the Humboldt River and at least sixteen mills were built in the various districts. The Humboldt range was extensively prospected before 1900. The Sheba and DeSoto mines in the Star District and the Arizona mine in the Unionville District were among the first discovered and worked in this early period. Extensive placer deposits were mined in the Sierra and Spring Valley Districts before 1900. After 1907, there were discoveries of high grade gold in the Seven Troughs District and high grade silver in the Rochester District (**Figure 3.2**). Large scale mining operations began after 1914 and included the development of mercury, tungsten, iron ore, and copper (Johnson, 1977). Among the many mines started, of note was the Getchell gold deposit discovered in 1933, which is actively mined, at present. The Cordero Quicksilver mine began operation in 1941. Exploitation of the iron deposits in the Jackson range began in 1952 (Willden, 1964).

As of the end of 2003, gold and silver was being produced from ten major mines in Humboldt and Pershing Counties (Figure 3.1) (Driesner and Coyner, 2005).

3.1.5 Active Mines

Today, gold and silver are by far the most important metallic minerals mined in Planning Area and gold and silver are currently produced from ten active mines (**Table 3-1). Figure 3.1** is a map showing the names and locations of active metal and industrial mineral mines within the Planning Area plotted on a base map showing historic mining districts. Most of these gold and silver metal mines have been in operation for a number of years and include: Getchell Underground and Turquoise Ridge Mines, Hycroft Mine, Lone Tree Mine, Marigold Mine, Twin Creeks Mine, Coeur Rochester Mine and Florida Canyon Mine (Driesner and Coyner, 2004) (**Figure 3.1, Table 3-1**). These active mines are briefly described below by commodity.

In addition to the metal mines, there are six active industrial mineral mines within the Planning Area including two diatomite mines, two dolomite and a gypsum mine (**Table 3-1 and Figure 3.1**). There is also one opal deposit being mined in the Virgin Valley area in the northwestern portion of the Planning Area on land administered by the U.S. Fish and Wildlife Service. Active mines are discussed in greater detail by commodity below.

3.1 Major Active Mines and Mining Districts

Table 3-1
Major Active Mines in the Winnemucca RMP area in 2005
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

Mine	Commodity	2004 Production ounces Au / Ag	Company
Precious Metals			
Coeur Rochester	Ag, Au	694,566 / 5,669,076	Coeur Rochester, Inc.
Florida Canyon	Au, Ag	73,082 / 60,405	Apollo Gold, Inc.
Hycroft	Au	61 / 0	Hycroft Resources
Lone Tree	Au, Ag	497,065 / 140,144	Newmont Mining, Corp.
Marigold	Au, Ag	141,304 / 2,354	Glamis Gold, Inc.
Nevada Packard	Ag	X	X
Standard	Au, Ag	X	Apollo Gold, Inc.
Trenton Canyon	X	X	X
Turquoise Ridge and Getchell -Underground	Au	162,637	Joint Venture Placer Dome US, Inc. and Newmont Mining Corp.
Twin Creeks Mine	Au, Ag	352,810 / 99,472	Newmont Mining Corp.
Industrial Minerals			
Colado Mine	Diatomite, Perlite		Eagle-Picher Filtration and Minerals, Inc.
Empire Mine	Gypsum		U.S. Gypsum Co.
MIN-AD Mine	Dolomite		MIN-AD, Inc.
Moltan Company	Diatomite		Moltan Company LP
Royal Peacock Opal Mine	Opal		Walter Wilson
W. Glen Sexton Family Trust	Dolomite		Nutritional Additives Corp.

3.1.6 Existing Claims

There are 23,334 active mining claims of various types, covering approximately 563,045 acres, currently located on federal surface estate within the area covered by the Planning Area (**Table 3-2**).

Table 3-2 **Active Mining Claims*** *Mineral Assessment Report Winnemucca Field Office – EIS / RMP* *RMP Planning Area*			
Claim Type	**Number of Claims**	**Acres/ claim**	**Approximate Total Acres**
Mineral Lode	21,576	20	431,520
Mineral Placer	1,444	20	129,960
Mill Site	313	5	1,565
Tunnel Site	1		unknown
TOTAL	**23,334**		**563,045**

* Data provided by BLM, written communication June 2005.

3.1.7 Mineral Exploration

Mineral exploration particularly for gold is an ongoing enterprise in Nevada by both operators of existing mines and by outside exploration companies. Exploration has been extremely active recently (2004-2005) as gold prices have sustained levels above $400/ounce and attained values greater than $600/ounce in early 2006. Companies conducting exploration in Nevada in 2004 reported that they spent some $79.7 million in 2004 (Dreisner and Coyner, 2005). Exploration in large part takes place in areas near known mineral deposits and within historic districts; however, exploration is also conducted in other outlying areas that the mineral industry considers prospective for various reasons (Wallace and other, 2004). Large portions of the Planning Area are difficult to impossible to explore as geographic areas prospective for gold deposits are covered by Late Cenozoic volcanic rocks and sedimentary basin fill sediments.

3.1.8 Precious Metals

The occurrence of precious metal deposits are discussed in this section and some inference with regard to origin of these deposits into plutonic, sediment-hosted and epithermal categories is initiated. However, a more detailed discussion of the models for formation of these deposits and the significance of these models as a guide for estimating potential is deferred to section 4.0 (Mineral Potential).

<u>Gold</u>

Nevada' gold production in 2004 was 6,942,000 troy ounces (Driesner and Coyer, 2005) and was valued at approximately $2.7 billion, which represents 82% of the total U.S. production (Price and Meeuwig, (2004). Nevada is the third largest gold producer in the world, only behind the counties of South Africa and Australia. Estimated gold reserves in the immediate vicinity of currently active mines at the end of 2004 were about 80.3 million troy ounces. Most of the precious metals and many of the other metals are currently being produced from recently developed (since 1982) open-pit mines of varying sizes (some open pits are as much as a kilometer in size) with heap leach technologies being used to recover the precious metals. Use of underground mining methods has increased in recent years (Wallace and others, 2004).

Davis and Tingley (1999) identified a total of 479 lode gold and silver deposits in Nevada. Of these deposits, 112 occur within or immediately adjacent to the Planning Area. **Figure 3.2** shows the locations of these gold and silver deposits and **Table 3-3** lists them by name using the same identification number as that originally used by Davis and Tingley (1999). Deposits in the Battle Mountain area in the southeast portion of Humboldt County and the Hog Ranch deposits in east-central Washoe County were included on **Figure 3.2** and **Table 3-3** for completeness to spite the fact that they lie outside of the Planning Area boundary proper.

Davis and Tingley (1999) and **Figure 3-2** subdivides these deposits by their principal commodity (gold or silver) and by occurrence with respect to interpreted genetic origin: plutonic, sedimentary or volcanic (epithermal) related deposits. This three-fold breakdown seems to be fundamental in the classification of precious metal deposit within the Planning Area, as will be seen under the discussion of mineral potential in section 4.0 where other investigators similarly divided deposits into these three fundamental types (pluton, sedimentary and epithermal depsoits) (Peters and others 1996; and Wallace and others, 2004)

Some of the active gold mines located within the Planning Area are briefly described in this section and include: the Florida Canyon, Getchell Underground, Turquoise Ridge, and Twin Creeks, Hycroft, Marigold and Lone Tree Mines.

Florida Canyon Mine

The Florida Canyon Mine is an open pit epithermal gold and silver mine (locally sediment hosted), owned and operated by Apollo Gold and is located approximately 35 miles northeast of Lovelock and 38 miles southwest of Winnemucca in the Imlay District of Pershing County, Nevada (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b). In 2004, the Florida Canyon Mine produces 73,082 ounces of gold and 60,405 ounces of silver (**Table 3-1**). The mine occurs in the Imlay mining district in Triassic rocks that form the west limb of a complexly faulted anticline. The oldest rocks in the district are felsites and tuffs of the Rochester Rhyolite and rhyolite porphyry intrusive of the Koipato Group. These rocks are overlain by the Prida Formation and locally capped by limestone of the Natchez Pass Formation. Diabase and diorite dikes and sills intrude the Triassic rocks throughout the district. Gold occurs as free gold in quartz veins that also contain subordinate silver, lead, and copper. These veins are typical quartz fissure veins in or near fault zones and also locally occur at contacts with diabasic dikes (NMBG 1977).

Getchell Underground and Turquoise Ridge, and Twin Creeks Mines

The Getchell Underground and Turquoise Ridge Mines are located in Humboldt County approximately 30 miles northeast of Winnemucca, Nevada (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b). Both of these underground gold mines are owned and operated by a joint

3.2 Gold and Silver Deposits and Mining Districts

Table 3-3
Gold and Silver Mines and Prospects
Mineral Assessment Report Winnemucca Field Offices – EIS / RMP
RMP Planning Area

Mine #	County	Mine Name	Mine #	County	Mine Name
4	Churchill	Fireball Ridge	214	Humboldt	Kramer Hill
	Churchill	**Jessup (7-10)**		Humboldt	**Lone tree (215-218)**
7	Churchill	Central Jessup	215	Humboldt	Wayne Zone (Lone tree)
8	Churchill	North Jessup	216	Humboldt	East Zone
9	Churchill	San Jacinto Zone	217	Humboldt	NW-1
10	Churchill	So. San Jacinto Zone	218	Humboldt	Southeast Zone
	Humboldt	**Adelaide Crown (191-192)**		Humboldt	**Marigold (219-232)**
191	Humboldt	North Pit	219	Humboldt	5 North
192	Humboldt	South Pit	220	Humboldt	5 Northeast
193	Humboldt	Ashdown	221	Humboldt	8 North
194	Humboldt	Buckskin National	222	Humboldt	8 South
195	Humboldt	Elder Creek	223	Humboldt	30
	Humboldt	**Getchell (197-200)**	224	Humboldt	31 North
196	Humboldt	Bud Hill	225	Humboldt	31 South
	Humboldt	**Getchell 1978-200)**	226	Humboldt	East Hill
197	Humboldt	Central Pit	227	Humboldt	East Hill South
198	Humboldt	Hansen Creek Pit	228	Humboldt	Old Marigold
199	Humboldt	North Pit	229	Humboldt	Pond
200	Humboldt	South Pit	230	Humboldt	Red Rock
201	Humboldt	Powder Hill	231	Humboldt	Ridge
202	Humboldt	Summer Camp	232	Humboldt	Top
203	Humboldt	Turquoise Ridge	233	Humboldt	Pansy Lee
204	Humboldt	Turquoise Ridge shaft		Humboldt	**Pinson (234-239)**
205	Humboldt	Golden Sage	234	Humboldt	A Zone
206	Humboldt	Golden Shears	235	Humboldt	B Zone
	Humboldt	**Hycroft (207-213)** (Crofoot/Lewis)	236	Humboldt	C Zone
207	Humboldt	Brimstone	237	Humboldt	CX
208	Humboldt	Gap Pit	238	Humboldt	Felix Canyon
209	Humboldt	Graveyard Pit	239	Humboldt	Mag
210	Humboldt	Lewis Pit	240	Humboldt	Preble
211	Humboldt	North Pit (Crofoot)		Humboldt	**Redline(241-242)** (Converse)
212	Humboldt	South Central Pit	241	Humboldt	North Redline

Table 3-3 (continued)
Gold and Silver Mines and Prospects

Mine #	County	Mine Name	Mine #	County	Mine Name
242	Humboldt	South Redline	414	Pershing	Majuba Hill
243	Humboldt	Sandman	415	Pershing	Nevada Packard
	Humboldt	**Sleeper (244-247)**	416	Pershing	Relief Canyon
244	Humboldt	Office		Pershing	**Rochester (417-418)**
245	Humboldt	Sleeper	417	Pershing	East Pit
246	Humboldt	West Wood	418	Pershing	West Pit
	Humboldt	**Trenton Canyon (248-254)**	419	Pershing	Rosebud
248	Humboldt	North Peak	420	Pershing	Standard
249	Humboldt	Northwest Valmy	421	Pershing	Trinity
	Humboldt	**Trenton Canyon (250-253)**	422	Pershing	Wildcat (Tag)
250	Humboldt			Pershing	**Willard (423-428)**
251	Humboldt	East Pit	423	Pershing	Honey Bee Nose Pit
252	Humboldt	South Pit	424	Pershing	Section Line Pit
253	Humboldt	West Pit	425	Pershing	South Pit
254	Humboldt	Valmy	426	Pershing	South West Pit
255	Humboldt	Trout Creek	427	Pershing	Willard Draw Pit
	Humboldt	**Twin Creeks (256-257)**	428	Pershing	Willard Hill Pit
256	Humboldt	Chimney Creek		Washoe	**Hog Ranch (436-444)**
257	Humboldt	Rabbit Creek	436	Washoe	139
258	Humboldt	Winnemucca	437	Washoe	Airport
	Humboldt	**Buffalo Valley (284-288)**	438	Washoe	Bell Spring
284	Humboldt	A/B/O Complex	439	Washoe	East
285	Humboldt	Dore Hill	440	Washoe	Geib
286	Humboldt	North Margin Zone	441	Washoe	Hog Ranch
287	Humboldt	Roof Zone	442	Washoe	Krista
288	Humboldt	South Zone	443	Washoe	West
	Pershing	**Bruce (406-408)**	444	Washoe	White Mountain
406	Pershing	Discovery Zone	445	Washoe	Mountain View
407	Pershing	Santa Fe East Zone		Washoe	**Olinghouse (446-447)**
408	Pershing	Santa Fe West Zone	446	Washoe	Main Pit
409	Pershing	Clear	447	Washoe	North Pit
410	Pershing	Colado	448	Washoe	Wind Mountain
411	Pershing	Florida Canyon			
	Pershing	**Goldbanks (412-413)**			
412	Pershing	KW Zone			
413	Pershing	Main Zone			

venture between Placer Dome and Newmont. Production in 2004 from this these mines included 162, 637 ounces of gold (**Table 3-1**). (http://www.placerdome.com/operations/getchell/getchell.html).

The Twin Creeks Mine is an open pit gold and silver mine located approximately 40 miles northeast of Winnemucca in Humboldt County (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b), this open pit mine is owned and operated by Newmont. Production from the Twin Creeks Mine in 2004 was 352,810 ounces of gold and 99,472 ounces of silver (**Table 3-1**).

The Getchell/Turquoise and Twin Creeks mines are sediment hosted (Carlin-type) gold and silver deposits located in the Potosi mining district at the northern terminus of the Osgood Mountains (Figures 3.1 and 3.2). The Osgood Mountains are composed principally of lower and upper Paleozoic rocks intruded in the east-central part of the range by a "dumb-bell shaped" granodiorite stock. The Paleozoic rocks are overlain by Tertiary volcanic rocks at the north and south ends of the range. The upper Paleozoic rocks occur as isolated erosional remnants in the southern part of the range, as blocks bounded by high-angle faults in the central part of the range, and as elongated thrust slivers in the northern part of the range. The structure of this range is very complex, because the rocks are more complexly faulted than in any other northern Nevada range. High-angle faults, some of which are tear faults related to thrust faults, offset all of the rock units in the range. Some folds are also recognized. These deposits are intimately related to middle and late Paleozoic thrust-faulting associated with Antler Orogeny tectonic events. During this Orogeny, thrust faulting along the Roberts Mountain Thrust superposed fine-grained deep ocean basin sediments over shallow water carbonate sediments to produce an environment favorable for Cretaceous and early Tertiary gold mineralization that form these sediment hosted deposits. Most of the Carlin-type deposits occur in this same tectono- stratigraphic position.

Hycroft Mine

The Hycroft Mine, formerly known as the Crofoot-Lewis Mine, is an open pit epithermal gold and silver mine is located in the Sulfur District of Humboldt County approximately 50 miles west of Winnemucca, Nevada (Mine Development Associates 2004; Tingley, 2004b) (**Figures 3.1 and 3.2**). The mine is owned by Vista Gold who recently entered into an option agreement to sell the mine to Canyon Resources (http://www.canyonresources.com/press/24jan05.html). Production in 2004 was limited (**Table 3-3**).

The Hycroft Mine is located on the western flank of the Kamma Mountains and consists of Tertiary- to recent-age, fault-controlled, low-sulfidation epithermal gold deposits that occur over an area measuring 3 miles in a north-south direction by 1.5 miles in an east-west direction. Mineralization extends to depths of less than 330 feet in the outcropping portion of the Bay deposit on the northwest side of the property and to over 990 feet in the Brimstone deposit in the eastern portion of the Hycroft property (Mine Development Associates 2004). Four major north-northeast-trending, west-dipping, normal fault zones broadly control the epithermal gold mineralization. From west to east, these fault zones are referred to as the Central, Boneyard, Albert, and East faults. Four deposits occurring in the hanging wall of the Central Fault zone are hosted by the Sulfur Group (Mine Development Associates 2004).

Marigold Mine

The Marigold open pit distal, sediment-hosted gold and silver mine is located at the north end of the Battle Mountain District of Humboldt County in central Nevada, approximately 38 miles southeast of Winnemucca and five miles south of Interstate 80 (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b). The property comprises 29 square miles in total and is two-thirds owned by Glamis Gold Ltd. and one-third owned by Barrick Gold Corp. Glamis is the operator. Production in 2004 included 41,304 ounces of gold and 2,354 ounces of silver (**Table 3-3**) (http://www.glamis.com/properties/nevada/marigold.html).

Gold deposits in the Marigold Mine area are hosted in Paleozoic sediments and meta-sediments that have been variably folded and faulted during as many as three major orogenic episodes. Mineralization is generally controlled by steeply dipping north-trending faults conduits for hydrothermal solutions at some distance from their intrusive sources (distal deposits), with the majority of the mineralization hosted in the Antler sequence of quartzites to limestones, and the Valmy quartzite/shale assemblage. Hydrothermal gold was originally deposited in association with pyrite, however, mining in the deposit area is restricted to deeply oxidized zones, with little remnant sulfides, that follow intense structurally deformed zones that limited favorable horizons. Mineralization has been traced over a strike length of seven miles on the property, with parallel north-trending ore zones within a broad band nearly a mile wide (http://www.barrick.com/index.aspx?usesid=-1&sid=53).

Lone Tree Mine

The Lone Tree Mine is located approximately 30 miles southeast of Winnemucca in the Golconda District of Humboldt County, Nevada (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b). This open pit distal, sediment-hosted gold and silver mine is owned and operated by Newmont. Production in 2004 included 497,065 ounces of gold and 140,144 ounces of silver (**Table 3-3**). The Lone Tree mine is located in the Buffalo mining district in a relatively flat topographic position between and slightly north of the Buffalo Mountains and Battle Mountain. The origins of these distal-disseminated, sediment-hosted gold and silver deposits are similar to that described for the marigold deposit above.

Placer Gold Occurrence

Fitch, (2003) identified 130 placer gold districts in the Planning Area. Peters and others (1996) provide the location of some of these placer deposits/districts and these are depicted on **Figure 3.3**. All of the placer deposits shown are located in either Pershing or Humboldt Counties. Historical gold production from placer mines within the Planning Area amounts to 44 percent of Nevada's total placer gold production from the late 1800's to 1968 (Fitch, 2003). Production from the ten largest placer gold producers of the 130 recognized occurrences over this period of time, are summarized in **Table 3-4** below. Although the total production from

3.3 Placer Gold, Hot Springs and Low Sulfide Quartz Veins Occurrences and Potential Placer Deposit Areas

Table 3-4
Largest Gold Placer Districts, Winnemucca FO Planning Area
***Mineral Assessment Report Winnemucca** Field Offices – EIS / RMP RMP Planning Area*

District Name	Production
Spring Valley	480,000
Dun Glen	200,000
Rochester	50,000
Rosebud and Rabbit Hole	8,000
Dutch Flat	4,500
Willow Creek	4,000
Placerites	2,500
Gold Run - Adelaide	2,000
Imlay (Humboldt)	1,000
Sawtooth	1,000
TOTAL	**753,000**

these placers is substantial, 753,000 ounces, it represents only about 10 percent of the 7.3 million ounces gold produced from Nevada in 2003 alone (Tingley, 2004a). None of these placer deposits are currently being mined (Fitch, 2003).

Most of the gold placer deposits are spatially associated with porphyry copper or low-sulfide gold-quartz veins (Peters and others, 1996) and are widely distributed through out the Planning Area. The locations of the Districts with the largest production (**Table 3-4)** are also identified on **Figure 3.3**. The Spring Valley, Rochester, and Imlay Districts are located on the east and north flanks of the Humboldt Range. The Dun Glen and Willow Districts are located on the northeast and west flanks of the East Range, respectively. The Dutch Flat District is on the west flank of the Hot Springs Range. Rosebud, Rabbit Hole, and Placerites Districts are located in the Kamma Mountains, about 25 miles northwest of Mill City. The Gold Run District is located on the east flank of the Sonoma Range. The Sawtooth District is located on the northern flank of the Antelope Range (Fitch, 2003).

Methods to recover the gold from gravels in these districts generally involved small scale methods to include wet washing (sluice box) and dry washing of the gravels. Gravels were also concentrated by hand and dry-washing, and then the concentrate was then hauled to a water source for wet-washing (Johnson, 1977).

Today a number of small scale placer operations continue to operate; however, the combined production probably does not exceed 1000 ounces per year (see small scale Gold Mining section below).

Nugget shooting is a form of recreational mining that uses a metal detector to locate nuggets of gold buried in shallow alluvial gravel deposits associated with historical placer mining operations. Nugget shooting has become increasingly popular in recent years.

Small Scale Gold Mining or Prospecting

Small scale gold mining operations or large scale mineral prospecting has gone on for a long period of time and its popularity is increasing, usually in the form of gold placers or small scale gemstone operations. The BLM divides these sorts of activities into two types of operations "Casual Use" and those requiring "Notices". Casual use activities are very small scale (usually) placer operations using hand tools and gold pans, small scale sluice boxes or occasionally small suction dredges. These operations range in scale from what has recently been called "recreational mining" to small scale operations attempting to make daily wages (usually with only short term and/or marginal success). "Casual use" operations require no special permitting.

Larger scale operations having potentially greater impact and using small pieces of equipment (backhoes, trucks, larger sluice boxes, suction dredges and diversion of surface water) require Notices. Notices are subject to restrictions and mitigating measures applied on a case by case basis as a function of the perceived impact. Activities to be conducted at the "Notice" level are generally bonded for reclamation costs. These bonds are typically determined in conjunction with the State of Nevada.

Silver

Nevada' silver production in 2004 was 10,398,000 troy ounces (Driesner and Coyer, 2005) making it Nevada's 4th leading mineral commodity, valued at $50 million (Price and Meeuwig, 2004).

Davis and Tingley (1999) identified a total of 479 lode gold and silver deposits in Nevada. Of these, six silver deposits occur within or immediately adjacent to the Planning Area. **Figure 3.2** shows the locations of these silver deposits and **Table 3-3** lists them by name using the same identification number as that originally used by Davis and Tingley (1999). Davis and Tingley (1999) subdivides deposits by their principal commodity (gold or silver) and by occurrence with respect to their probable origin: plutonic, sedimentary or volcanic-related (epithermal) deposits (**Figure 3.2**).

Active Silver Mines

Active silver mines within the Planning Area are discussed in this section and include the Coeur Rochester Mine and the Nevada Packard Mine.

The Coeur Rochester Mine is located about 45 miles southwest of Winnemucca in the Rochester District of Pershing County, Nevada (**Figures 3.1 and 3.2**) (Tingley, 2004a and 2004b), this open pit mine is the seventh largest silver mine in the world and also produces a large amount of gold (http://www.nevadamining.org/news/features/fs_1075622400.html). The mine is owned and operated by Coeur D'Alene Mines Corporation. Production in 2004 included 5,669,076 ounces of silver and 694,566 ounce of gold.

The Coeur Rochester Mine epithermal silver-gold mine is located in the Rochester mining district which consists of a complete sequence of volcanic and intrusive units of the Koipato Group, overlain on the west side of the district by sedimentary rocks of the Prida Formation. These rocks form a broad anticline, broken into large blocks by major north-trending faults with numerous cross faults complicating the structure of the area. Silver deposits occur in narrow quartz veins in fissures and faults in rhyolite and trachyte host rock. The major ore deposits of the district are in rocks of the Koipato Group and can be classified into three groups: 1) silver-bearing non-tourmaline-bearing quartz fissure veins with some stock-work bodies; 2) silver-bearing quartz tourmaline veins; and 3) gold-bearing quartz tourmaline veins.

3.1.9 Other Metals

The Planning Area contains numerous other metallic deposits and a number of these have been exploited historically for their intrinsic non-precious metals value. However, much more commonly theses metals were produced as a by-product of gold and silver mining. A map of other metal deposits and occurrences, some with historical production is presented as **Figure 3.4**. This map is modified from a report by Peters and others (1996). The map shows various types of metal deposits and various symbols are used to depict different styles and origins of the mineral deposits. As with the gold-silver deposits, Davis and Tingley (1999) Peters and others (1996), and **Figure 3.4** subdivide these deposits by their principal metal commodity and by occurrence with respect to interpreted genetic origin: plutonic, sedimentary or volcanic (epithermal) related deposits. Most of these deposits are pluton-related and metals occur predominantly as disseminated or stock-work porphyry, skarn-replacement or polymetallic vein deposits.

To put historic non-precious metal deposit mining in perspective with respect to modern large-scale open pit precious metal mining, **Table 3-5** has been developed and presents the historic value of metal deposits (including precious metal deposits, but excluding placer deposits) from mining operations prior to the mid-to late 1960s. Total historic metal production has been about $343.6 million vs. annual gold production in 2004 alone of about $2.7 billion.

Several geological reports discuss mineralization by mining district within the various counties of the Planning Area (Willden, 1964; Bonham, 1969; and Johnson, 1977). These reports present information regarding the geology and historic production of specific mining districts, and a brief description of selected deposits within the districts. In addition, a report by Sherlock and others (1996) discusses known mineral deposits and occurrences state-wide in Nevada. These reports along with that by Peters and others (1996) were used in assembling the following brief discussion of metal deposits and mineral commodities within the Planning Area below.

3.4 Other Metal Deposits and Mining Districts

Table 3-5
Metal Production Humboldt and Pershing Counties, Value in Millions of Dollars
Mineral Assessment Report Winnemucca Field Offices – EIS / RMP
RMP Planning Area

County	Au	Ag	Cu	Pb	Zn	W	Fe	Hg	Total
Humboldt 1963 [1]	11.8	0.7	0.13	0.09	0.007	26.2	3.0	95 (?)[3]	176.3
Pershing 1976 [2]	8.8	8.5	11.60	0.30	0.03	55.0	?	3.6	166.5
TOTAL	**20.6**	**9.2**	**11.73**	**0.39**	**0.037**	**81.2**	**3.0**	**98.6**	**343.6**

1. Wilden, 1964
2. Johnson 1977
3. 95,000 flasks at $1000/flask (approximate price in 1964) = $95 million

Antimony

Veins and replacement deposits of antimony are common in Nevada, where stibnite occurs as massive replacements in beds or lenses, or alternatively, as fissure or fracture filling deposits. In both cases the stibnite typically forms either large bladed crystals or occurs in masses of fine needles. Within the Planning Area, antimony deposits occur in the Antelope Springs, Rye Patch, Battle Mountain and Willard Districts and scattered deposits occur in a number of other districts as well.

Beryllium

Beryllium occurs in crystals of the mineral beryl associated several sheelite-bearing vein deposits and also in pegmatites associated with Late-Cretaceous per-aluminous granites in the Humboldt Range of Pershing County (i.e., Oreana Mine area). There has been no beryllium production within the Planning Area and rather than being a likely source for commercial mining of beryllium metal; beryl occurrences are of value principally to mineral collectors (Nash, 1996).

Copper

Nevada produced 26.9 million pounds of copper in 2004. Copper occurs in copper porphyry, copper skarn and massive sulfide deposits within the Planning Area (**Figure 3.4**) and significant production has occurred from the Battle Mountain District immediately southeast of the Planning Area. However, of the total $11.73 million of copper produced from the Planning Area prior to 1977, $11.60 million came from the Big Mike deposit located nine miles west of the Iron Hat District, south-southeast of Winnemucca. The Big Mike open pit mine is a massive sulfide deposit that occurs in the Pumpernickel Formation that contains chalcopyrite, bornite, and digenite in a massive sulfide zone and tenorite and cuprite in the oxide zone. High grade sulfide copper ore was mined and shipped to Europe for processing and lower grade sulfide and oxide ore was blasted and leached in the pit in1973 (Sherlock and others, 1996).

Iron

Iron-rich skarn deposits (**Figure 3.4**) occur as contact metasomatic deposits containing magnetite or hematite in Triassic and Jurassic limestone in contact with intrusive rock. The Jackson and Red Butte Districts of Jackson Range are located to the east of the Black Rock Desert and about 50 miles northwest of Winnemucca. These deposits were discovered in the early 1950s and one mine, the Iron King Mine, went on to become an important producer of high-grade, hard-lump open hearth ore. These mines produced some 428,000 tons valued at as much as three million dollars worth of iron ore.

Iron-skarn deposits of the Mineral Basin District (**Figure 3.4**), south central Pershing County, produced iron from an endoskarn (intrusive-hosted) hosted in gabbroic intrusives of the Humboldt Complex. These deposits consist of massive magnetite and hematite in veins that have replaced mafic intrusive and volcanic rocks. Iron ore was first shipped from the Mineral Basin District in Pershing County in the 1880s, but major production began in the in the 1940s. The Buena Vista Mine, the largest of these deposits, produced ore grading 54% iron and mined about 350,000 tons of rock in 1945 (Reeves and Kral, 1955; Sherlock and others, 1996). Current reserves at the Buena Vista Mine have been estimated at 18 million tons at a grade of 32.7% iron (Lowe and others, 1985).

Lead and Zinc

There has been no significant lead or zinc production from the Planning Area (**Table 3-5**), and most of the limited production has occurred from polymetallic veins and massive sulfide deposits.

Manganese

Epithermal Manganese deposits (**Figure 3.3**) commonly occur as veins or fracture fillings of faults in subaerial Tertiary age volcanic rock associated with hot spring. These deposits are often associated with other metals such as tungsten, silver and gold. The Golconda deposit (associated with tungsten) is located south of Preble in southeastern Humboldt County and is hosted by calcareous tuffa deposits.

Mercury

Mercury is hosted in two types of deposits within the Planning Area including sediment-hosted and hot springs deposits (**Figure 3.3**). In sediment-hosted deposits, mercury mineralization occurs in limestone or fractures in chert and chert conglomerate. Most deposits are thought to form as replacements, resulting from fluids that migrate along faults and fractures and are ponded or trapped beneath a low permeablity bed. These deposits are typically comprised of high-grade cinnabar. Examples include deposits in the Antelope Spring District (**Figure 3.3**) at the southern end of the Humboldt Range in Pershing County.

Hot springs mercury deposits (**Figure 3.3**) are the most common type of mercury deposit in Nevada and are thought to form at the groundwater table interface in siliceous sinter hot springs deposits. The best example of these types of deposits occur in the McDermmit District in north-central Humboldt County and are associated with fossil hot springs related to the McDermitt Caldera. Mineralogy typically consists of cinnabar, native mercury, and corderoite (a mercury chloride mineral) that occur as blanket-like coatings in fracture sinter or in lacustrine beds overlying a brecciated sinter (Sherlock and others, 1996).

The Cordero Mining Company began production of mercury (quicksilver) from the Cordero and Bottle Creek areas near McDermitt in 1941 (Opalite and Bottle Districts). The Cordero Mine has consistently been one of the leading mercury producers in the country. Reserves in this area are estimated to be in excess of 300,000 flasks. Other deposits occur in the National, Bottle Creek, Spring Valley and Warm Springs Districts (Sherlock and others, 1996). Mercury has historically been one of the most significant metals mined within the Planning Area (**Table 3-5**).

<u>Molybdenum</u>

Two types of molybdenum deposits occur within the Planning Area and are both related to the emplacement and alteration associated with intrusive porphyry systems. These deposit types include Climax-type porphyry deposits and low-fluorine type porphyry deposits (**Figure 3.4**). The only Climax-type deposit within the Planning Area is the Majuba Hill deposit, which is located in the Antelope District in north-central Pershing County (**Figure 3.4**). This deposit is associated with small isolated potassic-rich, high-silica, Tertiary age, intrusive porphyries (Sherlock and others, 1996). The molybdenum occurs in a stockwork of molybdenite-quartz and is associated with fluorite, copper, silver, tin arsenic, lead and zinc mineralization hosted in a multi-stage rhyolite porphyry intrusive.

Low-fluorine molybdenum porphyry systems typically occur in rocks of calc-alkaline granodioritic compositions with lower fluorine and silica compositions relative to the Climax-type deposits. Within the Planning Area, these deposits are often associated with the Late Cretaceous deposits responsible for tungsten skarn development. Several of these deposits are located immediately south of the Planning Area in the Battle Mountain District (**Figure 3.4**) the most famous of which is the Buckingham molybdenum system associated with the Copper Basin deposit (Sherlock and others, 1996). The Copper Basin deposit is a zone of supergene enrichment of chalcocite mined from the weathering of disseminated copper in the distal zone of the Buckingham molybdenum porphyry system. The copper Basin deposit mined an average grade of 0.8% copper, but contained less than 100 ppm molybdenum (Sherlock and others, 1996).

The Ashdown mine, in the Vicksburg District of northwestern Humboldt County was historically mined for free gold in veins of quartz with pyrite, galena and tetrahedrite and produced some 50,000 ounces of gold. More recently, initial exploration drilling located a massive body of molybdenite in a brecciated quartz vein at depth. Golden Phoenix Minerals, Inc. has recently executed an extensive drilling program and announced plans to begin both underground and open pit operations on the Ashdown Mine as a gold-molybdenum property.

Other molybdenum occurrences or prospects within the planning area include the Gregg Canyon Prospect in the Gold Run District southeast of Winnemucca (**Figure 3.4**) and the Snow Creek Prospect in the Leonard Creek District in northwestern Humboldt County. There is no current or historic production of molybdenum from the Planning area.

<u>Polymetallic Veins</u>

Although there are numerous polymetallic vein deposits shown on **Figure 3.4**, the only significant production has occurred from silver-(and locally gold) bearing veins, where other metals were mined as by-products. Polymetallic veins are the most common form of mineralization associated with plutonic deposits and they tend to occur as halos that are spatially related to other types of deposits, and whose mineralogy and metal content varies systematically with distance from these centers. Because of this distribution, polymetallic veins are much more common and widespread than those shown on **Figure 3.4**. Within the Planning Area polymetallic veins of the Buena Vista and Star District of central Pershing County, and the Kennedy and Gold Run Districts of southeastern Pershing County are typical of these types of occurrences.

<u>Tungsten</u>

Tungsten within the Planning Area occurs principally in skarn deposits (**Figure 3.4**). These skarns are contact metasomatic deposits and are generally developed as sheelite-bearing, calc-silicate replacements in calcareous sedimentary rocks adjacent to granitic and granodioritic intrusives of Late Cretaceous and less commonly early Tertiary age. As can be seen from **Figure 3.4**, sheelite-bearing tungsten skarn deposits occur over a large area but tend to cluster in certain districts along a broad northeast-trending belt associated with these Cretaceous stocks. These stocks may represent a northern extension of the Sierra Nevada Batholith (Sherlock and others, 1996). Approximately 150 tungsten mineral occurrences within the Planning Area have been classified as tungsten skarn deposits. Two of the largest tungsten deposits in Nevada occur within the Planning Area, the Springer Mine in the Mill City District and the Riley Mine in the Potosi District, occur along this trend. The Springer and other nearby mines produced a total of about 1.8 million tons of ore grading 0.7% tungsten oxide. At the Riley Mine among others in the Getchell area, tungsten occurs principally in the mineral wollastonite in skarns that group around the margin of a Late Cretaceous granodiorite stock.

Demand for tungsten during and immediately after the Second World War stimulated the development of low-grade deposits of both contact metamorphic and vein deposit origin. Most of these small operations closed at the end of the war with the reduction in price that accompanied the drop in government demand for tungsten. This demand was briefly reinstated in the early fifties by a government stockpiling program. The Getchell Mine in the Osgood Mountains converted from gold to tungsten production during this period, but ceased tungsten production in 1956. Tungsten production from Humboldt County was in excess of $29 million in the years 1953-1956 and about $18 million from Pershing County over a slightly longer period of time. In all, the mines of Humboldt and Pershing Counties produced about $81 million worth of WO_3 from 1911 through 1957 (**Table 3-5**).

Scheelite, popular among mineral collectors, and is found in significant quantities in the Humboldt Range but no commercial deposits of tungsten are known from this area.

Uranium

The uranium boom in the early 1950s saw considerable exploration in Tertiary volcanic host rocks of northern Humboldt County. Here, volcanogenic uranium deposits occur as disseminations and veins of uranium oxide minerals typically associated with shallow young rhyolite intrusives. Within the Planning Area these occur principally in the northwestern portion and north-central portion of Humboldt County in the vicinity of the McDermmit Caldera (**Figure 3.5**). Only one low grade uranium deposit, the Moonlight Mine, saw limited production from rhyolite ring domes and shallow intrusives along the caldera margin.

Other uranium mineralization occurs as veins or alternatively as disseminations in dikes or the margins of alkalic granitic plutons (**Figure 3.5**). Perhaps the best example within the Planning Area is the low-grade uraniferous veins associated with the Majuba Hill molybdenum deposit located in the Scossa District in northern Pershing County (**Figure 3.5**).

3.5 Volcanic and Plutonic related Uranium Deposits

3.1.10 Gems and Semi-Precious Stones

Various gemstones are found in Planning Area including opal, turquoise and specimen gold. Of these three, opal is perhaps the most popular. Both opals and turquoise are principally found in small, localized deposits in altered volcanic terranes in the Black Rock and Virgin Valley areas of northwest Humboldt County. In 2003, active mines producing opals existed principally in the Virgin Valley area and include the Royal Peacock (**Figure 3.1**), Rainbow Ridge, Bonanza and Hidden Valley Mines. The Royal Peacock Mine was the only active opal mine in 2005. Most opals are recovered in "pay-to-dig"operations, and therefore, their total production remains unreported. There is a considerable amount of petrified wood associated with the opal deposits. Turquoise is principally of value only to mineral collectors.

A small deposit of gem quality chalcedony was produced from the Sage Mine in Humboldt County. Other semi-precious stones within the Planning Area are only of value to mineral collectors and include crystals of beryl and sheelite both of which area found the Humboldt Range.

Specimen quality native gold is recovered for resale to collectors from several historically operated quartz vein-type gold mining districts including the Seven Troughs, Awakening, and National Districts.

There is currently no system in place to monitor the value of gems and semi-precious stones taken from deposits.

3.1.11 Industrial Minerals

The occurrence of locatable industrial rock and mineral resources of the Winnemucca Planning Area are summarized by commodity below. These include the following: aluminum minerals, barite, beryl, carbonate minerals, diatomite, dumortierite, fluorspar, gems and precious stones, gypsum, perlite, silica, talcose minerals, wollastonite, and zeolite.

Table 3-6 lists the industrial mineral mines, prospects, and deposits located within the Planning Area. **Table 3-6** can also be used with **Figure 3.6** to determine the location of any particular industrial minerals deposits within the Planning Area.

3.6 Industrial Minerals

Table 3-6
Industrial Mineral Deposits of the Winnemucca FO Planning Area
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

Commodity	Deposit # This Report	County	Mine Name	Deposit # Map #142*
Stone, Building	1	Humboldt	Virgin Valley (Wegman Quarry)	9
Clay	2	Humboldt	Bull Basin (Montana Mountains)	8
Clay	3	Humboldt	Disaster Peak	9
Fluorspar	4	Humboldt	Sunset	7
Zeolite	5	Humboldt	Spring Creek	11
Zeolite	6	Humboldt	Chimney Reservoir	12
Barite	7	Humboldt	Anderson	37
Wollastonite	8	Humboldt	Getchell	3
Clay	9	Humboldt	Barret Springs	10
Silica	10	Humboldt	Stone Corral	13
Barite	11	Humboldt	Redhouse	38
Barite	12	Humboldt	Horton – Little Britches	39
Sulfur	13	Humboldt	Sulphur	3
Carbonate	14	Pershing	W. Glen Sexton Mine	13
Silica	14a	Humboldt	Kramer Hill Mine	none
Clay	15	Pershing	Rosebud Canyon	27
Carbonate	16	Pershing	Min-Ad Mine East Range	14
Fluorspar	17	Pershing	Mammoth	34
Sodium Minerals	18	Washoe	Buffalo Springs	19
Gypsum	19	Pershing	Empire	20
Perlite	20	Pershing	North Trinity Range	16
Sulfur	21	Pershing	Humboldt House	4
Fluorspar	22	Pershing	Piedmont	35
Fluorspar	23	Pershing	Valery	36
Clay	24	Washoe	San Emidio	31
Diatomite	25	Pershing	Rye Patch	20
Limestone	25a	Pershing	Echo Canyon	In Permitting
Carbonate	26	Pershing	Humboldt Range	15
Sulfur	27	Washoe	San Emidio	5
Diatomite	28	Pershing	Colado (Velvet District)	21
Perlite	29	Pershing	Trinity Range	17
Aluminum Minerals	30	Pershing	Champion	3
Fluorspar	31	Pershing	Needle Peak	37
Zeolite	32	Pershing	Lovelock	24
Perlite	33	Pershing	Pearl Hill (Velvet District)	18

Table 3-6 (continued)
Industrial Mineral Deposits of the Winnemucca FO Planning Area

Commodity	Deposit # This Report	County	Mine Name	Deposit # Map #142*
Aluminum Minerals	34	Pershing	Lincoln Hill	4
Talc Minerals	35	Pershing	Humboldt Range Pinite	13
Pumice	36	Pershing	Lovelock	13
Clay	37	Pershing	Coal Canyon Deposits	28
Fluorspar	38	Pershing	Emerald Spar	38
Carbonate	39	Pershing	Buffalo Mountain	16
Zeolite	40	Pershing	Jersey Valley	25
Gypsum	41	Pershing	Lovelock area	21
Fluorspar	42	Pershing	Susie	39
Fluorspar	43	Pershing	Nevada Fluorspar	40
Clay	44	Pershing	New York Canyon (Stoker)	29
Gypsum	45	Pershing	Corn Beef	22
Silica	46	Washoe	Winnemucca Lake	18
Diatomite	47	Churchill	Nightingale (Truckee Range)	1
Zeolite	48	Churchill	Trinity Range	1
Carbonate	49	Churchill	Ocala	1
Stone, Building	50	Churchill	Trinity Range	1
Diatomite	51	Washoe	Nixon	26
Diatomite	52	Churchill	Trinity	2
Sodium Minerals	53	Churchill	White Plains	1
Diatomite	54	Churchill	Moltan Mine Desert Peak (Hot Spring Mountain area)	3
Stone, Building	55	Churchill	Black Mountain	2
Sodium Minerals	56	Churchill	Eagle Marsh	4
Sodium Minerals	57	Churchill	Carson Sink	3
Pumice	58	Churchill	Posalite	2
Diatomite	59	Churchill	Black Butte	4

* Deposit number from Nevada Bureau of Mines and Geology Map 142 Industrial Minerals of Nevada.

Aluminum Minerals

The only aluminum mineral mine identified in the Planning Area occurs in the Lincoln Hill area (**Figure 3.6, number 34**) of the Humboldt Mountains, in Pershing County (Papke and Castor, 2003). Here, the mineral dumortierite, a rare aluminum boron-silicate (Mason and Berry, 1968), has been mined at the Champion Mine (**Figure 3.6, number 30**). The dumortierite mined here was used in spark plugs and other specialty ceramics. Historically, the existence of impurities in the rock and the robust nature of this mineral required milling of the ore, which was costly (Nash, 1996). The Champion Mine closed in 1950 and its reserves are unknown. Other prospects for dumortierite have been identified and evaluated in the Lincoln Hill area and elsewhere in the Humboldt Range.

Dumortierite typically occurs in aluminum-rich metamorphic or contact metamorphic rocks and occasionally in pegmatites (Mason and Berry, 1968). The host rock is generally volcanic or alumina-rich sediment and has been hydrothermally altered and weathered prior to metamorphism. At the Champion Mine, dumortierite occurs in the Triassic Rochester rhyolite (Humboldt Range) that has abundant alumino-silicate minerals, micas, and tourmaline. Here, it is spatially and genetically related to contact metamorphism associated with adjacent intrusives of Jurassic and Cretaceous age (Nash, 1996). In this setting the dumortierite is formed by metasomatic interactions of boron-rich intrusions with aluminous volcanic rock.

Recently, this mottled pink-blue-purple dumortierite-andalusite-quartz-bearing rock has been explored for its potential use as dimension stone.

Barite

Nevada is the United States' largest producer of barite, and production in 2004 was approximately 559,000 tons. Elsewhere in the world (for example, China), larger bedded deposits are mined using open pit methods. These deposit sources dominate the global barite market. Barite is primarily used as a weighting agent for oil and gas well-drilling fluids. Barite production in Nevada is largely dependent on the intensity of domestic oil and gas drilling operations. Additionally, due to its high density; transportation accessibility and cost can significantly influence barite production. Therefore, operations closer to roads and railroads are most economically feasible.

Barite is widely distributed as veins, lenses, cavity fillings, or as bedded replacement deposits in limestones (Mason and Berry, 1968). Significant deposits and current mining of barite in Nevada occur mostly east of the Planning Area, in Elko, Eureka, and Lander counties. These deposits are primarily bedded deposits and occur within Paleozoic marine sedimentary rocks.

Deposits within the Planning Area tend to be vein or replacement deposits, the largest being 6 meters wide and 100 meters long. These replacement deposits typically occur within the Cambrian *Preble* and Ordovician *Comus* formations (Nash, 1996). Former mines and prospects exist in the Osgood Mountains of Humboldt County and include Anderson (**Figure 3.6,**

number 7), Redhouse (**Figure 3.6, number 11**), and Horton-Little Britches mines/prospects (**Figure 3.6, number 12**) (Papke and Castor, 2003).

Carbonate Minerals

Carbonate minerals comprise lime, limestone, and dolomite. Carbonate rocks produced in Nevada are used in gold mining operations, cement making (south of Fernley and just outside of the Planning Area), nutrition, agricultural, and other industrial applications (USGS, 2003). Economic factors include; low magnesium and iron content, transportation accessibility, and in some cases, a natural gas line for kiln operation. Regional gold mining operations have increased the demand for limestone products, which are used to control pH of milling operations.

Favorable limestone and dolomite deposits in Nevada have formed on platforms atop continental margins in Permian strata of the Golconda allochthon and Triassic strata in the Triassic autochthon (Fencemaker Thrust). Carbonate formations mined in the Planning Area are Jurassic and Triassic in age, such as limestones in the Sonoma Range (in Pershing and Humboldt counties) or the lower Auld Lang Syne Group in the Humboldt Range (in Pershing County, Nash, 1996).

Production of dolomite in the Planning Area is principally from the Min-Ad Mine (**Figures 3.1 and 3.6, number 16**) in the northwestern portion of the Sonoma Range of Humboldt County, southeast of Winnemucca. Limestone deposits also occur in the Humboldt Range. Other limestone mines within the Planning Area that were active in of 2003 include the Ocala mine (**Figures 3.1 and 3.6, number 49**) in Churchill County, and Grass Valley and Glen Sexton mines (**Figure 3.1 and 3.6, number 14**) operated by the Nutritional Additives Corporation in Pershing County (Papke and Castor, 2003). The Echo Canyon limestone mine (**Figure 3.6, number 25a**) in Pershing County, north of Lovelock NV is currently in the permitting process.

Clay Minerals

Most of the clay development within the Planning Area is for specialty clays and are acquired under the mining law by location. Nevada clay production in 2003 was estimated at 36,000 short tons, which does not include hallyosite clay mined in Washoe County for Nevada Cement (NBMG, 2003). Clays produced in Nevada include montmorillonite, fullers earth, kaolin, hallyosite, and bentonite. Uses of these clays include drilling additives, oil refining, absorbents, and industrial fillers (Nash, 1996).

Clay deposits form in a variety of rock types and geologic settings. Clay deposits in Nevada are primarily found in hydrothermally altered rocks or in fine-grained, clastic, lacustrine sedimentary rocks and deposits. Clay deposits are also derived from glassy volcanic ash and tuffs (Nash, 1996).

Clay deposits in the Planning Area have been mined in Humboldt, Pershing, and Washoe counties (**Figure 3.8**). Districts or mines include Bull Basin (**Figure 3.6, number 2**), Disaster Peak (**Figure 3.6, number 3**), and Barrett Springs (**Figure 3.6, number 9**)in Humboldt County; Rosebud Canyon (**Figure 3.6, number 15**), Coal Canyon (**Figure 3.6, number 37**), and New York Canyon (**Figure 3.6, number 44**) in Pershing County; and San Emidio (**Figure 3.6, number 24**) in Washoe County. Clay was actively being mined in the Planning Area at Bull Basin, Coal Canyon, and San Emidio (Papke and Castor, 2003). (See discussion of clay under Saleable Minerals: Clay Minerals, section 3.2.2)

<u>Diatomite</u>

Production of diatomite in Nevada accounts for more than 30 percent of domestic production. About 60 percent of the diatomite produced is used in filtration processes and the remainder is used in absorbents, fillers, and cement. Emerging uses include pharmaceutical processing and nontoxic insecticides (NBMG, 2003).

Known and potential deposits in northwestern Nevada are of freshwater lacustrine origin and typically occur in lakes bounded by Miocene extensional faults. The large amount of silica necessary for growth of the diatoms was derived from proximal silicic volcanic rocks and nearby mineral hot springs. Periods of tectonic stability resulted in minimal input of clastic detrital material into the lakes and therefore, the development of thick and pure sequences of diatom deposition. In addition, preservation of the diatom's structure required quiet water deposition and minimal diagenetic alteration. The ages of these deposits in the Planning Area ranges from Miocene to Recent (Nash, 1996).

Deposits of diatomite in the Planning Area include Nightingale (**Figure 3.6, number 47),** Trinity (**Figure 3.6, number 52**), and Moltan (**Figure 3.1 and 3.6, number 54**) mines of Churchill County; Rye Patch (**Figure 3.6, number 25**) and Colado mines (**Figure 3.1 and 3.6, number 28**) in Pershing County; and Duck Flat and Nixon (**Figure 3.6, number 51**) mines in Washoe County (Papke and Castor, 2003). Active mining is conducted at the Colado and Moltan mines. The Eagle-Picher Minerals, Inc. Colado Mine is the most productive mine in Nevada. The Moltan mine is second most productive with a reported 100 years of reserves (NBMG, 2003).

<u>Fluorspar</u>

Fluorspar or fluorite is produced primarily for use as a flux in metallurgical operations and, less so, for optical purposes. Fluorite occurs primarily as a vein and accessory mineral, such as with lead and silver ores. It can also be found in cavities of limestone and dolomite in hydrothermal settings (Mason and Berry, 1968). Fluorite occurrences in northwestern Nevada and in the Planning Area are primarily vein type, favored in limestone, and in or near intrusive rocks of Cretaceous to Miocene age that provided fluorine. Major world class deposits tend to be associated with intra-cratonic rifts (Nash, 1996).

Historically, fluorspar was produced at various locations in the Planning Area. These locations included the Sunset Mine (**Figure 3.6, number 4**) in Humboldt County and the Piedmont (**Figure 3.6, number 22**), Valery (**Figure 3.6, number 23**), Needle Peak (**Figure 3.6, number 31**), and Nevada Fluorspar mines (**Figure 3.6, number 43**) in Pershing County. Other mines, in Pershing County, with insignificant production are the Mammoth (**Figure 3.6,**

number 17), Emerald Spar (**Figure 3.6, number 38**), and Suzie (**Figure 3.6, number 42**) mines (Papke and Castor, 2003). No production occurs from Nevada at this time.

Gypsum

Nevada accounts for more than 10 percent of the domestic gypsum production and was estimated at 1.85 million tons in 2002 and 2003 and 2.31 million tons in 2004. Gypsum is used in the production of wallboard, plaster products, cement, fertilizer, and industrial filler.

Gypsum is an evaporate deposit and is the first salt deposited in the evaporation of sea water (Mason and Berry, 1968). Known deposits in northwestern Nevada are of marine origin and formed in marginal marine basins where periodic influx of sea water provided precipitated salts during periods of evaporation. Gypsum beds can be extensive and exceed 300 feet in thickness. Limestone, dolomite, salts, and clastic rocks can be interbedded with the gypsum beds. The age of most of the gypsum beds within the Planning Area are Triassic and Jurassic (Nash, 1996).

Gypsum is produced from three mines in Nevada (Castor, 2004). Economic gypsum occurrences in the Planning Area exist in Pershing County. The largest mine in Nevada is the Empire mine (**Figures 3.1 and 3.6, number 19**) in the Selenite Range, south of Gerlach in Pershing County. At the Empire mine, deposits exist in a two square mile area and attain a purity of 95 percent gypsum. Two inactive mines in the Planning Area include Lovelock (West Humboldt Range, east of Lovelock) (**Figure 3.6, number 32**) and Corn Beef (Stillwater Range) mines (**Figure 3.6, number 45**) (Papke and Castor, 2003). These mines are also in Pershing County.

Lithium

The economic occurrence of lithium in Nevada is in playa brines at the Silver Peak mine in the Clayton Valley of Esmeralda County (Papke and Castor, 2003). No occurrences of this kind have been noted in the WPA. Lithium is known to occur in lithium alumi-silicate minerals, including spodumene, lepidolite, amblygonite, and petalite, of which these can occur in mineable concentrations (Mason and Berry, 1968). No occurrences of this kind exist in Nevada or the WPA. However, there has been recent production of lithium-rich clay (hectorite) deposits from the Disaster Peak mine in Humboldt County (USGS, 2003). Lithium and/or hectorite is used in cosmetics, ceramics, lubricants, batteries, and drilling additives.

The favorable geology for hectorite clay deposits includes Tertiary volcanic rocks in proximity to normal or ring faults. These rocks would, in turn, be in grabens or caldera moats that have concentrated hydrothermal solutions and alteration. Intrusive plugs would also be ideal to promote circulation of hydrothermal fluids. The McDermitt caldera is recognized as the best structural setting for these deposits. Lithium-rich clay is formed from diagenesis or hydrothermal alteration of volcanic glass resulting in the leaching and concentration of lithium and its incorporation into the clay formed. The McDermitt Caldera, in northern Humboldt County, contains deposits of hectorite clay within the caldera's volcaniclastic sedimentary rocks (Nash, 1996). The Disaster Peak Mine is located in the McDermitt Caldera. The age of the host rocks and hectorite ranges from Tertiary to Recent.

Perlite

Nevada has large perlite resources and several deposits of perlite have been mined. Perlite is used in insulation, filters, filler, and as an aggregate in concrete. Perlite is a hydrated volcanic glass of silicic composition. Hydration may be accomplished with either meteoric or magmatic water derived from nearby intrusives. Deposits are Miocene to Recent in age (Nash, 1996).

Historically, significant amounts of perlite were developed from Pearl Hill in Pershing County. Former mines, prospects, and occurrences of perlite in the include those in the vicinity of the Trinity Range, west of Lovelock, in Pershing County (**Figure 3.6, numbers 20, 29 and 33**) (Papke and Castor, 2003). Prospects also exist approximately 50 miles north of Gerlach (Nash, 1996). Eagle Picher Minerals, Inc. also produces perlite at its Colado diatomite plant in Pershing County from perlite mined from the Popcorn Mine south of Fallon (Castor, 2004). Little perlite production occurs in Planning Area at the present time.

Silica

Silica minerals, mines and prospects in the Planning Area are identified as the Kramer Hill Mine (**Figure 3.6, number 14a**), and Stone Corral (**Figure 3.6, number 10**) in Humboldt County, and Winnemucca Lake (**Figure 3.6, number 46**) in Washoe County. These locations are classified as having had insignificant production of silica (Papke and Castor, 2003).

Talcose Minerals

One talcose mineral mine has been identified in the Planning Area as Humboldt Range Pinite (**Figure 3.6, number 35**) in Pershing County. This location is classified as having significant past production of sericite and pyrophyllite (Papke and Castor, 2003).

Wollastonite

Mining of wollastonite occurred at the Getchell mine (**Figure 3.6, number 8**) in Humboldt County (see Tungsten section above for additional information). This location is classified as having insignificant production (Papke and Castor, 2003).

Zeolites

Several large zeolite deposits exist in Nevada and historic production was significant in Pershing and Churchill Counties. Zeolites are used in various ion exchange and absorbent applications (Nash, 1996).

Zeolites form during diagenetic alteration of silicic glass in tuffs and volcaniclastic rocks. Deposits of zeolites form in tuffaceous rocks that were deposited in subaerial, submarine, and lacustrine environments and subjected to alkaline conditions. The largest deposits are in alkaline lake-type settings frequently located along rifts and block-faulted basins. Deposits range in age from Paleozoic to Recent, although most are of Tertiary age (Nash, 1996).

Zeolite deposits within the Planning Area include those in the Trinity Range (**Figure 3.6, number 48**) in Churchill County, Spring Creek (**Figure 3.6, number 5**) and Chimney Reservoir (**Figure 3.6, number 6**) in Humboldt County, and Lovelock and Jersey Valley (**Figure 3.6, number 40**) in Pershing County (Papke and Castor, 2003). Current large scale production is lacking (NBMG, 2003). The only operating zeolite mine within the Planning Area is the Moltan Mine (**Figure 3.6, number 54**) in the Trinity Range of westernmost Churchill county about 40 miles northeast of Fernley where the Moltan Company mines mordenite to make absorbents at its Fernley Plant (Castor, 2004).

3.2 Saleable Minerals

The Planning Area has an active mineral materials sales program. The primary commodity sold to the public is sand and gravel. A minor quantity of decorative and building stone, clay and decomposed granite is also sold to the public. There are about 65 active sales contracts and 112 Free Use permits issued to state and local government entities. In addition, there are about 170 Material Site Right of Ways issued to the Nevada Department of Transportation (NDOT) for sand and gravel operations.

Salable Minerals are administered by the Bureau of Land Management under the Materials Act of July 31, 1947, the Wilderness Act, the Wilderness Study Act , Mineral Materials Disposal (43 CFR 3600 regulations for sand, gravel, petrified wood, common variety materials, etc.). In addition, Material Site Rights-of-Way are granted to State Departments' of Transportation under title 23, Section 317 of the U.S. Code.

Acquired lands may be withdrawn from salable minerals based on resource objectives. Disposal of salable minerals is a discretionary action and subject to NEPA analysis.

The occurrence of saleable industrial rocks and mineral resources of the Planning Area are summarized below. These include the following: aggregate (including sand and gravel), clay, cinder, decomposed granite, and decorative and building stone.

3.2.1 Aggregate, Sand and Gravel

BLM authorizes the purchase of sand and gravel from the federal government through a contract of sale (by the ton or cubic yard) or a free use permit. Mineral material is sold at a fair market value to the public, but is usually free to state, county, or other local governments when used for public projects. The geologic map (**Figure 2.3**) shows areas of potential for production of sand and gravel as Quaternary or Tertiary alluvial and playa deposits (white) as does **Figure 3.7** (yellow areas). This sand and gravel usually occurs as alluvial channel or terrace deposits, or as basin fill sediments. Actual production of sand and gravel is typically driven by a local, usually municipal or highway construction, need for the material. Therefore, likely areas of production are in the Quaternary of Tertiary alluvial deposit areas shown on **Figure 3.7**, in proximity to communities or along highways and roads.

3.7 Sand and Gravel Sources and Potential Resource Areas

Nevada's construction aggregate production in 2003 was estimated to be 37 million tons (Castor, 2004) with a value of about $166 million. These materials are critical to meet the state's needs for building and infrastructure and are second in economic value only to gold deposits (Driesner and Coyner, 2005). Sand and gravel accounts for about 75% of total aggregate production (**Figure 3.7**) with the remaining amount being comprised of crushed stone and lightweight aggregate (**Figure 3.8**). Aggregate production within the Planning Area, was reported from Churchill, Humboldt, Pershing, Washoe and Storey counties (USGS, 2003). This material is used in concrete, road and railroad beds, and construction (Nash, 1996).

Favorable environments for unconsolidated aggregate, largely free of clays and other fines, include existing and paleo-stream channels, beach terraces, and alluvial fans. Hard, siliceous source rocks are preferred for gravel clasts. The ages of these deposits are generally Pliocene to Recent. In addition, weathered or decomposed "granite" (**Figure 3.8**) with clay is desirable for road construction and this is found in weathered and altered zones of granitic and volcanic source rocks (Nash, 1996).

There are numerous small scale sand and gravel quarries in the Planning Area that are primarily used for local purposes (**Figure 3.7**), including road material, and concrete additive, among others. Well known larger mines and quarries within the Planning Area include Thomas Canyon and Sonoma in Humboldt County (Papke and Castor, 2003) and Gold Butte southwest of Lovelock. Two larger mines/quarries are also identified north of Gerlach. In addition, there are numerous mines/quarries along US Highway Interstate 80 between Fernley and Winnemucca (Nash, 1996), and along other roads within the Planning Area (**Figure 3.7**). The location of sand and gravel deposits are shown on **Figure 3.7**. Deposits are shown as those that are "Authorized" (open and approved for operation and include Nevada Department of Transportation [NDOT] operated pits) and other deposits that have been active in the past but are not at the present time authorized for use. The BLM, because of its extensive land holdings in Nevada, oversees the sales and permitting of small community pits, Nevada Department of Transportation (DOT) pits, as well as providing aggregates for a large portion of local construction in the larger metropolitan areas provides. In addition, the BLM administers Rights-of Way Agreements for access to many of these sand and gravel barrow areas or pits.

3.2.2 Clay

Common varieties of clay minerals have been mined in Nevada under a saleable minerals program primarily for use as low-permeability barriers (see also a discussion of locatable clay minerals in the Industrial Minerals section 3.1.11). Clay minerals have been mined at the Hycroft (gold) Mine (**Figure 3.1**) for use at the mine site, and by the Pinson Mine (located south of Getchell Mine) who mined a deposit along the road to Midas, Nevada for use as a low permeability barrier.

Clay deposits form in a variety of rock types and geologic settings. Clay deposits in Nevada are primarily found in hydrothermally altered rocks or in fine-grained, clastic, lacustrine sedimentary rocks and deposits. Clay deposits are also derived from glassy volcanic ash and tuffs (Nash, 1996).

3.8 Clay and Stone Salable Mineral Materials

3.2.3 Pumice and Cinder

Pumice is currently not produced in Nevada, although there are a number of occurrences and former mines, especially in the Planning Area. Pumice is used in abrasives, lightweight cement aggregate and concrete building blocks.

The properties of pumice are attributed to the vesicular texture in silicic volcanic and pyroclastic rocks ejected in explosive eruptions and then deposited in sub-aqueous to sub-aerial conditions. These deposits can form various-sized cones, or sheets formed by lateral flows. Economically viable beds are thick (to 15 meters), well sorted, and unwelded. Age ranges from Tertiary to Recent (Nash, 1996).

Many of the pumice occurrences within the Planning Area are in the Velvet District (such as the Lovelock mine, **Figure 3.6, number 36**) west of Lovelock in Pershing County (Nash, 1996). Mining historically occurred at the Posalite mine (**Figure 3.6, number 58**) in Churchill County within the Planning Area (Papke and Castor, 2003).

3.2.4 Building, Ornamental and Specialty Stone

Production of building, ornamental and specialty stone occurs in Nevada and in the Planning Area (**Figure 3.8**). Historically at least one deposit was located in the Virgin Valley area (adjacent to the Planning Area) and operated by Pacific Stone Co. and quarried a welded tuffaceous unit. The most desirable building stone is generally from sedimentary or volcanic units that are well-bedded and indurated, with prominent partings, and coloration. Columnar basalt (about 200 tons) and flat slabby volcanic rock (more than 5,000 tons) are both popular and have been sold within the Planning Area. Age is generally Cretaceous to Recent (Nash, 1996). Mines and quarries in the Planning Area include Trinity Range (**Figure 3.6, number 50**) and Black Mountain (**Figure 3.6, number 55**) in Churchill County and Virgin Valley (Wegman quarry, located along the northwestern border of the Winnemucca FO), (**Figure 3.6, number 1**) in Humboldt County (Papke and Castor, 2003).

3.2.5 Petrified Wood

Collector quality petrified wood is widespread and particularly associated with opal deposits in 15 mya rhyolites of the Virgin Valley area.

3.2.6 Boulders, granitic plutons

Another activity carried out under the saleable minerals program is the extraction of boulders for landscaping uses. The BLM has discretion to approve or not approve these activities, and impacts are addressed by mitigations and reclamation requirements on a case-by-case basis. Most of these operations are very small scale, removing a small number of boulders and generating sales of a few hundred dollars. Large scale operations can generate as much as $2,000 to $3,000. It is also thought that many of the boulders removed are simply taken, and many of the sales to date have begun as trespass issues.

Within the Planning Area boulders of granite have been most popular recently and are mined from an area north of Gerlach. Flat, slabby, volcanic boulders and rock are harvested in volcanics in the northwestern part of the Planning Area, another area north of Lovelock and in the McDermitt Caldera area.

3.3 Leasable Minerals

Leasable minerals defined by the Mineral Leasing Act (February 1920; and 43 CFR 3000-3599, 1990) include the subsets leasable solid and leasable fluid minerals. Leasable solid minerals include: coal, oil shale, native asphalt, phosphate, sodium, potash, potassium, and sulfur. Leasable fluid minerals include oil, gas and geothermal resources. The rights to explore for and produce these minerals on public land may only be acquired by competitive leasing. Past exploration activities and current research indicate that occurrences of oil shale, native asphalt, other solid and semi- solid bituminous rock, phosphate, and potash have not been identified in the Field Planning Area (Papke, 2003). Deposits of sodium minerals and sulfur have been mined in the past in the Field Planning Area. Low grade coal deposits have also been identified.

One subset of leasable minerals is called Fluid Minerals and includes: oil, gas, coal bed natural gas, and geothermal resources. BLM has developed more rigorous guidelines to be used in the development of a Resource Management Plan (RMP) for Fluid Minerals that are described in BLM Handbook H-1624-1, Planning for Fluid Mineral Resources (BLM, 1990). This handbook is supplemented by Information Memorandum No. 2004-089 (BLM, 2004) that presents the BLM's Policy for Reasonably Foreseeable Development (RFD) Scenario for Oil and Gas. The occurrences of leasable minerals within the Field Planning Area are discussed by commodity below.

3.3.1 Geothermal Resources

Introduction

Geothermal energy resources are underground reservoirs of heat usually associated with magmatic intrusions into subsurface rock layers. However, the Winnemucca Planning Area is located in the Great Basin, where there are two types of recognized geothermal systems: Magmatically-induced systems as described above, and extensional fault systems associated with regionally high heat flow, and active faulting (Coolbaugh et al, 2002). Groundwater circulating at depth in rocks heated either by magma or by the stress and strain resulting from extensional systems can be used as a medium to transfer heat to the surface to be used either directly for heating buildings or converted into electricity. Geothermal energy resources are considered to be renewable.

Generating electricity with geothermal energy requires very hot water generally found at greater depths below the surface. The technology used to generate electricity from hydrothermal fluids depends on the state of the fluid (whether steam or water) and its temperature. There are three types of geothermal-powered electrical generation plants operating today, each of which ultimately employs steam to drive a turbine. Power plants within the Planning Area are all binary systems. In the binary system, the water from the geothermal reservoir is used to heat another "working fluid" which is vaporized and used to turn the turbine/generator units. The geothermal water and the "working fluid" are each confined in separate circulating systems or "closed loops" and never come in contact with each other. The advantage of the Binary Cycle plant is that they can operate with lower temperature waters (225° F - 360° F), by using working fluids that have an even lower boiling point than water. They also produce no air emissions.

Geothermal water that is not hot enough for electrical generation may be used for general building heating or for other purposes such as growing plants, dehydrating vegetables, fish farming, spas, recreational hot springs, swimming pools, etc.

The current production of geothermal energy places it third among renewable energy sources, following hydroelectricity and biomass, and ahead of solar and wind energy (EIA, 2004a). Nevada has the largest amount of untapped geothermal resources in the U.S., with a potential of 2,500 to 3,700 megawatts of electricity annually (MWe). One MWe powers approximately 1,000 homes per year (U.S. DOE, 2004). Geothermal energy provides about 9% of northern Nevada's electricity, and statewide there are 14 power plants operating at 10 geothermal sites (U.S. DOE, 2004).

Leasing Regulations

Geothermal energy resources are considered a leasable fluid mineral commodity. Administration of competitive and non-competitive leases for geothermal exploration and production is granted under the authority of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1001 *et. seq.*) and the implementing regulations found at 43 CFR 3200 *et. seq*. The BLM is the designated federal administrator of geothermal leases on lands under the jurisdiction of the U.S. Department of the Interior, the U.S. Department of Agriculture (with their concurrence), lands conveyed to the U.S. where geothermal resources were reserved to the U.S., and lands subject to section 24 of the Federal Power Act (16 U.S.C. 818). Leases may be awarded for a primary term of 10 years. If the lease results in a producing resource, the lease term may be extended by an additional 40 years with subsequent renewals granted in the event of continued resource production. Leasing and development is a discretionary action subject to NEPA review. The WFO Planning Area administers geothermal resources under the *Geothermal Resources Leasing Programmatic Environmental Assessment* of 2002 (BLM, 2002).

Other Applicable Regulations

Once a lease has been secured on federal lands, other state regulations apply to the development of geothermal resources. The Nevada Revised Statutes (NRS) Chapter 534A (Geothermal Resources) describes Nevada state laws pertaining to geothermal resources. Implementing regulations concerning drilling permits and fees, production requirements, rules for well abandonment and plugging, and recordkeeping and reporting are found in the Nevada Administrative Code (NAC) Chapter 534A. The lead state agency tasked with implementation of the state's geothermal regulations is the Nevada Commission on Mineral Resources – Division of Minerals. The Nevada Department of Conservation and Natural Resources –

Division of Water Resources (DWR) is responsible for issuing water rights that may be associated with development of geothermal resources and they and the Division of Water Planning have divided up the Planning Area into Hydrographic Basins (**Figure 3.9**) the character of which are described below. The Bureau of Water Pollution Control (BWPC) is the body that regulates underground fluid injection, a common practice for managing extracted geothermal waters, and surface disposal of waste water (including geothermal fluids). Aquaculture projects using geothermal resources have additional permitting requirements administered by The Nevada Division of Wildlife.

General Geologic Setting

Nevada lies within the Basin and Range physiographic province, an area of crustal extension that has remained active since the mid-Miocene. The Basin and Range is characterized by Cenozoic (0 to 65 million years ago) tilted fault blocks forming northeast-trending longitudinal mountain ranges separated by broad valleys. Nevada occupies the area of highest crustal heat flow in North America (NGPI, 2005) and consequently within the Planning Area there are abundant geothermal resources. Nearly all of Nevada's resources are related to deep fluid circulation associated with crustal extension and high heat flow. The highest temperatures are located in the northwestern part of the state overlapping the Planning Area. This area of high heat flow parallels the northeast-trending Humboldt structural zone in northern Nevada (Faulds et al, 2002). Major faults in this region include the Olinghouse fault, faults bounding the Smoke Creek and Black Rock Deserts, faults along the northwestern margin of the Carson Sink, Stillwater fault in Dixie Valley, Midas fault, and Malpais fault near Beowawe (Faulds et al, 2002). Most of the major geothermal fields in the Planning Area, including Desert Peak-Brady, Rye Patch, Dixie Valley, New York Canyon, Gerlach, and San Emidio (**Figure 3.9**) are found along these fault zones.

The lithology and structural features of the mountain blocks and hydrologic basins throughout the assessment area are critical with regard to the occurrence of water, geothermal and mineral resources. Most of the bedrock formations lack permeability except where fault zones or fractures have been created by deformation. Thus, where there are no or few fractures or faults, precipitation tends to run off to the adjacent valleys. Where fractures and faults are present, a portion of the precipitation may infiltrate into deep circulation patterns, which may be sufficiently deep to generate a geothermal resource. Descriptions of the bedrock geology for the various hydrologic basins are presented in the 2002 Geothermal Resources Leasing Programmatic Environmental Assessment (BLM, 2002).

3.9 Geothermal Occurrence Map

Historic Exploration

Exploration and development of geothermal resources in the Planning Area began at least as early as the 1950s in areas now known as the Brady and the San Emidio Known Geothermal Resource Areas (KGRAs) (**Figure 3.9**). As described in the *Geothermal Resources Listing Programmatic EA* (BLM, 2002), geothermal leasing activity within the Planning Area peaked in the early to mid-1980s. Since then, leasing activity for geothermal resources has been relatively slow until the California energy crisis surfaced in 2000. Approximately 60 geothermal lease applications have been received in the past two years, and there are currently 30 pending lease applications in the Planning Area (**Figure 3.9**). In 2001, 16 lease applications were processed for areas of low environmental sensitivity. **Figure 3.9** shows existing authorized leases, cancelled leases, closed (historic) leases and pending leases (as of May of 2006).

Existing Fields and Development of Resources

There are six KGRAs within the Planning Area (**Figure 3.9**). KGRAs are so-named because by definition, there is sufficient evidence indicating the presence of viable resources such that a person who understands geothermal development would spend money developing the area. The KGRAs (**Figure 3.9**) are Brady, located in the southwest corner of the Planning Area in Churchill county; San Emidio located north of Pyramid Lake on the western edge of the Planning Area in Washoe county; Gerlach, located just north of San Emidio, also in Washoe county; Rye Patch, located off of U.S. Interstate 80 near Rye Patch reservoir about 40 miles west of Winnemucca in Pershing county; New York Canyon, located near the southeast corner of the Planning Area, also in Pershing county; and Dixie Valley, which straddles the Planning Area boundary and lies in both Pershing and Churchill counties.

Developing geothermal resources on BLM administered public lands requires issuance of a lease for exploration that creates surface disturbances (geophysical exploration is an exception), field development and operation, and finally, close-out phases. Leasing of geothermal resources confers an implied right to the lessee to explore and/or develop the resource. The act of leasing by itself does not directly result in surface disturbance and is not subject to NEPA review; however, it is reasonable to expect disturbance to occur in the subsequent exploration and development phases, which do require NEPA review prior to initiation.

Nevada has extensive geothermal resources and currently produces about 236 megawatts of electricity from 14 plants at 10 locations and geothermal energy resource exploration and development has increased dramatically in the past 4 years. At the time this Mineral Assessment Report was prepared (summer 2005) there were 109 geothermal leases, 23 pending geothermal applications, and six Known Geothermal Resource Areas (KGRA) located within the Planning Area. In addition, there are three power plants, and two vegetable dehydration plants in operation within the Planning Area administrative boundary (BLM, 2005). The power plants are located at Brady Hot Springs, Desert Peak, and in the San Emidio Desert and range in generation capacity from 5.8 to 30 megawatts. The dehydration plants are located at Brady Hot Springs and San Emidio Desert as well. A 12 megawatt power plant is anticipated to be in production in the near future at the Rye Patch KGRA. There is also one power plant in the Dixie Valley KGRA, but it is located south of the Planning Area**.** **Figure 3.9** illustrates the location of the KGRAs, geothermal leases, and the location of plants using geothermal resources.

3.3.2 Oil and Gas

Introduction

Federal oil and gas leasing authority stems from the 1920 Mineral Leasing Act, as amended, for public lands, and the 1947 Acquired Lands Leasing Act, as amended, for acquired lands. Leasing of federal oil and gas is affected by other acts and regulations contained in 43 CFR 3100 with additional requirements and clarification found in Onshore Operating Orders and Washington office manuals and instruction memorandums. Oil and gas leasing on Federal lands is administered by the Bureau of Land Management through a competitive and noncompetitive leasing system.

An oil and gas lease grants the right to explore, extract, remove, and dispose of oil and gas resources that may be found in the leased lands. Lease rights are controlled by standard lease terms and may be subject to particular lease stipulations (restrictions to further protect other resources) and other permit approval requirements based on a NEPA analysis of proposed disturbances and cumulative impacts. Stipulations and permit requirements describe how lease rights are modified. The lease stipulations and permit conditions of approval allow for management of federal oil and gas resources while giving due consideration to other resources and land uses. Details of the Leasing process are described in Oil and Gas **Appendix A**: Leasing Process and Oil and Gas Program Decision Points.

Knowledge of existing geology of the Planning Area, as it relates to oil and gas deposits, is based on bedrock geologic mapping (**Figure 2.3**), gravity geophysical data (Jachens and Moring 1990, Blakely and Jachens, 1991), and 47 oil and gas test wells drilled in the Planning Area (**Figure 4.6; Table 3-7)**. Detailed bedrock geologic maps of 1:250,000 quadrangles were compiled by the US Geological Survey by county (Willden, 1964; Willden and Speed, 1977; Johnson, 1977 and Bonham, 1969) and are available as electronic files from the Nevada Bureau of Mines and Geology.

Table 3-7 Summary of Oil and Gas Drilling Activity through 2004
(one full page)

Leasing Regulation

Oil and gas leases are issued for public domain lands under the authority of the Mineral Leasing Act of February 25, 1920 (41 Stat. 437; 30 U.S.C. 181 et.seq.) as amended and supplemented, the Act of August 8, 1946 (60 Stat. 950), and the Act of September 2, 1960. Authority for leasing on acquired lands comes from the Leasing Act for Acquired Lands enacted on August 7, 1947 (61 Stat. 913). Upon passage of the Federal Onshore Oil and Gas Leasing Reform Act of 1987 (Pub. L 100-203) the Bureau of Land Management made a major revision to the Federal Oil and Gas regulations in 43 CFR 3100. Made effective on June 17, 1988, the new regulations cover competitive and noncompetitive onshore oil and gas leasing. The general conditions of leasing process are presented in **Appendix A**.

Within the Planning Area, oil and gas management is further defined by the Regional Geothermal/Oil and Gas Leasing Environmental Assessment of June 1982 (EA-NV-020-2-38, N-11821) as amended. This document defines stipulations for the exploration, development and production of oil and gas resources. These stipulations are imposed in addition to the Uniform Standard Lease Stipulations (contained 43 CFR 3100) and site specific Best Management Practices incorporated into Applications for Permit to Drill. These stipulations outline no surface occupancy, timing limitation, and controlled surface use restrictions. Stipulations from the 1982 oil and gas leasing EA (BLM, 1982) and the 2002 Geothermal EA (BLM, 2005) may be found in **Appendix C**.

Other guiding Federal actions include the Wilderness Act, the Wilderness Study Area Act, and other applicable federal regulations. Federal regulations common to all leasable minerals include: 6300 Wilderness Regulations and 5860 Wilderness Management Handbook. Another set of regulations that are administered by the Bureau of Land Management and contained in 30 CFR 270, regulate exploration, development and production operations under federal leases (**Appendix B**).

Historic Production

A number of years of early exploration activity in Nevada by Continental Oil, Gulf Oil, and Standard of California focused on drilling shallow wells to test surface seeps of oil and gas in Churchill, Clark, Elko, Esmeralda, and Lander Counties. The first discovery of oil and gas in Nevada was by Shell Oil Company in the Railroad Valley of Nye County in 1954. Other discoveries followed quickly in the Pine Valley area of Eureka County and Deadman Creek area in Elko County (Peterson, 1994). In 2004 the State of Nevada produced 463,000 barrels of oil. Natural gas has been reported from seeps and water wells in several counties in Nevada including a natural gas seep just south of the Planning Area in the vicinity of Soda Lakes in Churchill County. Although some 46 oil and gas exploration wells have been drilled in the Planning Area there is no recorded production of oil or gas.

Geologic Setting

The WFO Planning Area lies within the Western Great Basin Oil and Gas Province (USGS, 1995a) that includes western Nevada, southeastern/south-central Oregon, and California east of the San Andreas Fault and the Sierra Nevada. The US Geological Survey's Central Energy Team provides periodic assessment of the oil and natural gas occurrences and potential for the US, including Nevada. The most recent U.S. Geological Survey assessment was completed in 1995.

The Western Great Basin Oil and Gas Province is thought to be prospective for hydrocarbons because two major requisites needed to create an economic deposit, source rocks and traps, are known to occur within the province. Source rocks are carbon-rich layers of rocks, usually black shales or coaly material, which generate and release oil and gas at elevated temperatures and pressures at depth as a result of burial, hydrothermal activity, low grade metamorphism or through relatively shallow biologic activity.

Once oil and gas has been generated from a source rock, it tends to migrate upward because of their low density with respect to adjacent rock units and water. Unless a "trap" is encountered, hydrocarbons will continue to migrate upward until naturally seeping out of the ground or floats on top of the groundwater table. To trap hydrocarbons, two geologic conditions must exist. First, a sufficient reservoir rock (which can be thought of as a hydrocarbon sponge) is needed to store the hydrocarbons. In addition, an impermeable seal is needed to prevent the hydrocarbons from continuing to migrate out of the reservoir.

Basement rocks of the Western Great Basin consist of Paleozoic to Mesozoic sedimentary rocks that have been subjected to compression and thrust faulting associated with three major orogenic and metamorphic events during the late Paleozoic to early Mesozoic periods. As a result of these faulting and thermal events, the hydrocarbon-generating potential of the older carbonate and clastic rocks that comprise the mountain ranges and the basin floors has been largely destroyed. Therefore, these rocks generally consist of thermally over-mature source rocks with little or no potential to generate oil and gas.

During the Cretaceous and continuing through the Cenozoic period, erosion of the mountain ranges resulted in lacustrine (lake) and fluvial (stream) sediment deposition that filled the deep structural basins. Organic-rich shales and coaly deposits associated with these basin fill sediments provide hydrocarbon generating potential in the Cenozoic units. These younger sedimentary rocks were subsequently subjected to periodic extensional faulting, volcanism, high heat flow, and hydrothermal alteration during the most recent (Neogene) geologic time period. A few oil shows have been documented that are likely related to contact metamorphism or hydrothermal origin and deeper gas shows are also of likely thermogenic origin. However, except in the deepest sedimentary basins and shallower areas of high heat flow, potential Cenozoic source rocks have reached only marginal thermal maturity with respect to the generation of oil.

Although numerous gas shows are found in most Cenozoic basins in the western Great Basin, these shows are thought to be largely biogenic in origin and to have been generated in the shallow subsurface.

As a result of this complex structural and thermal history, any fields discovered in the Tertiary basins of the Planning Area are likely to be small as high regional heat flow and faulting have worked together to destroy any large stratigraphic or structural traps that may have formed prior to basin and range faulting.

Historical Exploration and Other Activities

Almost all of the historical drilling activity in northwest Nevada, particularly within the Planning Area, has been focused in Tertiary Basins (**Figure 4.6**).

Exploration Drilling

Although there has been considerable exploration drilling (47 wells) within the Planning Area, there are no producing oil or gas wells (**Figure 4.6**). A total of nine oil and gas exploration wells have been drilled since 1992 (one as recently as 2005) and three new wells were permitted for drilling in 2005. **Table 3-7** is a listing of wells drilled within the Planning Area showing Operator, lease name, hole name, field name, county, Permit #, Permit date, drilled depth, spud date, completion date, and last activity date. Although this amount of drilling may seem like an adequate test of the area for oil and gas, even 46 dry holes are not unusual in areas without developed producing fields (Frontier Areas), particularly where the targets may be "blind" (not obvious from the surface), and buried beneath imbricate thrust sheets or deep sediment filled basins.

Leasing

There are three active leases in the Planning Area encompassing approximately 3,799 acres (**Figure 4.6** and **Table 3-8**). These leases are located in Neogene Basin play area of the Buena Vista Valley (west of the Stillwater and East Ranges and east of Unionville) in the southeastern most portion of the Planning Area. **Table 3-8** presents relevant lease data. A number of oil and gas parcels, totaling approximately 244,000 acres of public land in the northeast part of the Carson Sink area (see oil and gas competitive lease area on **Figure 4.6**), were offered for lease sales during March of 2006. There were no bids on any of these lands likely due to very strict resource protection Lease Stipulations attached to the parcels. None of these parcels were offered for lease sales in either the June or September 2006 offering. Some 3,902 historically active, but now closed oil and gas leases are also shown on **Figure 4.6.**

In most areas within the Planning Area it is anticipated that leasing would take place with only standard stipulations. In other areas special stipulations are anticipated to protect seasonal wildlife habitat or other sensitive resource values. In highly sensitive resource areas where the resource could not be protected by special stipulations, it is anticipated that a no surface occupancy stipulation would be attached to the leases (Tetra Tech 2005) (**Appendix C**). In addition, it is assumed that issuance or attachment of appropriate stipulations would continue to be decided on a case by case basis based on existing documents including the Regional Geothermal/Oil and Gas Leasing Environmental Assessment of June 1982 (EA-NV-020-2-38, N-11821) as amended.

Table 3-8
Oil and Gas Leases
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

Lease	Serial No.	Location Township Range Sec	Total Acres	Lease Status
Barton	NVN-060928	0300N 0350E 026	120	Expires 7/2006
Evans	NVN-058388	0290N 0360E 001,002,011,012	2,400	Active as of 8/04
Evans	NVN-058389	0290N 0360E 003,010	1,279	Active as of 8/04

Notes: Location identified by section number only
Information obtained from Winnemucca Field Office on 2/15/2005

As a result of 1987-1988 litigation (Connor vs. Burford) against the BLM's leasing policy and program, the number of leases and the number of acres under BLM lease in the US has dramatically declined. Under the decision handed down in 1988, the BLM has been directed by the U.S. District Court and Ninth Circuit Court of Appeals to make predictions of where oil and gas occurrences and subsequent development *may* occur before leasing public lands in order to evaluate the long-term cumulative impact of individual oil and gas leasing decisions (Connor vs. Burford, 848 F.2d 1441, 9th Cir., 1988). Leasing in the Planning Area has not been significantly impacted by this action; however, one of the goals of the EIS and RMP revision for which this mineral assessment report is being written is to anticipate potential problems with cumulative impacts encountered by historical leasing policies.

Oil and gas occurrence and development potential including a discussion of the development potential of specific oil and gas plays within the Planning Area is considered further under the Mineral Resource Potential Section (4.0, Oil and Gas Potential) below.

3.3.3 Leasable Minerals Occurrence

The occurrence of leasable industrial rocks and mineral resources of the Planning Area are summarized below. These include sodium minerals including salt, and sulfur.

<u>Sodium Minerals (salt)</u>

About 9,000 tons of salt was mined in Churchill County, outside of the Planning Area, in 2003. This salt is primarily used for de-icing roads (USGS, 2003). Salt mines in the Planning Area include White Plains (**Figure 3.6, number 53**), Carson Sink (**Figure 3.6, number 57**), and Eagle Marsh (**Figure 3.6, number 56**) in Churchill County and Buffalo Springs (**Figure 3.6, number 18**) in Washoe County. These mines are characterized as having had significant past production. Although there is potential for mining of salt from playas within the Planning Area (Nash, 1996), there is no current production of salt. The largest playa lakes are shown on **Figure 1.1**.

Sulfur

Sulfur is used to make sulfuric acid, other chemicals, fertilizer, paper products, and explosives (Nash, 1996). There are several mines that produced sulfur as a by-product of gold and/or silver ores in the Planning Area. These include Sulphur (**Figure 3.6, number 13**) in Humboldt County, Humboldt House (**Figure 3.6, number 21**) (also known as Imlay) in Pershing County, and San Emidio (**Figure 3.6, number 27**) in Washoe County (Papke and Castor, 2003; Tingley, 1998).

Volcanic centers, Miocene to recent in age, are most commonly associated with native sulfur deposits (Nash, 1996). Most economic sulfur occurrences in Nevada occur as fumarole-type deposits. These fumarole deposits precipitate sulfur on the surfaces of host-rock in vents, vesicle, breccia, and other open volcanic structures adjacent to volcanoes. Deposits are tabular to pipe-shaped with dimensions of 10 to 100 meters) (Nash, 1966). Often times the fumarole sulfur deposits are small, and ore can contain mercury, arsenic and other difficult to remove impurities which can inhibit their development.

Other documented sulfur sources in the Planning Area are considered secondary deposits of sulfur and are associated with metallic ore deposits. In these deposits, sulfur occurs as common accessory sulfide minerals in mercury and precious metal deposits. These sulfide mineral sources for sulfur are not the most favorable for development, as they require significant processing.

4. MINERAL RESOURCE POTENTIAL

4.1 Locatable Minerals

Nevada was the leading US gold, barite, and gypsum producer in 2004 and the second largest producer of silver. Mines located within the Planning Area produce each of these commodities. In addition, Planning Area mines also produce significant amounts of aggregate, diatomite, gemstones, limestone, dolomite, perlite and specialty clays. In total, Nevada's mineral industry production was valued at $3.3 billion in 2004 and precious metal production accounted for about $3.0 billion of this total (Driesner and Coyner, 2005).

The prospects for sustaining these production rates in the short run are excellent and in the long run (15-20 years) also quite likely. Commodity prices are currently high, as is demand for these products. It is envisioned that as older mines are taken out of production and reclaimed, new mines would be discovered and brought into production. A report of active metal exploration programs is prepared annually by the Nevada Bureau of Mines and Geology the most recent of which was for the year 2003 (Tingley, 2004a). In this report, exploration programs are described for 18 properties within the planning area. Most of these programs are exploring for additional reserves associated with or near actively producing mines, but others occur on outlying properties, both in historical districts and on "grass root" properties. Some of these exploration targets are discussed throughout the remaining text either by property or commodity.

Because of the dominance of precious metals in the mineral economy of Nevada, most of the predictive deposit models for the location of areas of mineral potential have been developed around the gold and silver commodities. As a result most of the discussion of mineral potential is focused on the development of models that look at three principle modes of origin for precious metal deposits: pluton related, sediment-hosted, and epithermal deposits. To some degree these models are predictive of the occurrence, potential for discovery and development of other metals as well. These models are discussed below for precious and other metals. The potential for development of locatable, saleable and leasable industrial minerals are also discussed.

4.1.1 Surface Disturbance Impacts

Impacts from exploration and mining for each of these commodities are similar and somewhat predictable. Impacts from mineral exploration are likely to include surface disturbances related to the construction of exploration drill roads and drilling pads. New and existing large-scale mines, mine expansions, and small-scale mining operations are likely to involve access road construction, increased traffic and surface disturbances associated with various mine facilities (for example: portals, pits, waste rock dumps, ore processing, tailing facilities, heap leach pads, administration and maintenance facilities; and storm water run-off control ponds and diversions structures). On BLM property these disturbance activities are permitted on a case by case basis. These projects require the filing of an operating plan and the proposed activities are evaluated under NEPA and bonded for reclamation and closure. In addition, the State of Nevada Department of Environmental Protection (NDEP) requires the applicant to file a

Reclamation Plan and obtain a Water Pollution Control Permit. The BLM and the State jointly determine bond requirements.

4.1.2 Precious Metals

Lode Gold

The cumulative production of gold from Nevada since 1859 is estimated at about 149.5 million ounces of which 84% has been produced since production began in the Carlin trend in 1965 and 52% of which has been produced in the last decade.

The price of gold has increased over the last few years from an average of $310/ounce in 2002 to $365/ounce in 2003, $460/ounce in August of 2005, and stands at about $600/ ounce today (4/2006). This increase in gold price has initiated a shift in precious metal exploration from high grade, vein type targets to low grade, large tonnage deposit targets. Company dollars spent for exploration have been increasing since 2001 and were about $79.7 million in 2004 and are estimated to be about $111.9 million in 2005 (Driesner and Coyner, 2005). Because of Nevada's favorable geologic setting, its stringent but predictable regulatory climate and the political stability of the US, Nevada continues to receive a very large portion of worldwide exploration expenditures (Price and Meeuwig, 2004)

Estimated gold reserves in the immediate vicinity of currently active mines at the end of 2003 were about 80.3 million troy ounces. Under current production rates this reserve would account for about 11 years of sustained gold production. Reserves associated with major metal deposits are tabulated in a report by individual mining property (Tingley, 2004). In addition to new discoveries, the price of gold and the cost of production are the main reasons for fluctuations between reserves and sub-economic resources.

Based on mining industry projections it appears that market conditions for gold will remain relatively consistent, with gold priced in the $400 to $600/ounce range. It is anticipated that mining and exploration activity would also gradually increase. Within the next 10 years it is anticipated that 2-3 currently active mines will go into closure and be reclaimed. These mine closures would likely be offset with either new projects being developed and placed into production, or expansion of existing mines.

Based on these estimates and projections, permitting demands for both hard rock exploration and mining would likely increase over time.

Lode gold deposits produce almost all of the gold currently mined in Nevada and are related to three general deposit model types including pluton-related deposits, sediment-hosted deposits and epithermal deposits. Models for these types of deposits and delineation of areas of mineral potential for each of the model types are discussed in some detail below.

Placer Gold

There are no large scale commercial placer operations currently operating in Nevada (Fitch 2003). Deposits with historical gold production from placers are shown on **Figure 3.3**. It is likely that most major placer deposits have already been discovered and worked in the past, and that most modern placer mines operate by reworking previously mined deposits or working previously mined deposits deeper. **Figure 3.3** also illustrates areas of potential placer operations for gold. **Figure 3.3** shows placer potential in two categories: areas prospective for placer deposits and areas favorable for placer deposits (Peters and others, 1996). In part these potentially favorable areas are related to the presence of low-sulfide high grade vein-type deposits of gold in nearby bedrock outcrop areas. These vein type deposits are also shown on **Figure 3.3**.

Most modern placer mines operate under "Casual Use" criteria and involves individuals or clubs that mine at a small scale using little or no equipment other than hand tools and sluice boxes. Larger scale operations typically mine 60 to 150 ounces (1.7 to 4.3 kilograms) of gold per year, and do so under a Notice and are permitted to use mechanized equipment. These types of operations are often restricted and have mitigations in place to protect other resources and site reclamation work is bonded by the responsible permitting agency to insure completion. The Planning Area should likely anticipate 10-20 placer operations operating under a Notice during any given year, with the actual number being a function of the price of gold. There is a fairly high turnover in the actual operators over time (some people leave the business and others enter it), many of these operations are undertaken to supplement income on a seasonal basis.

Silver

Most of Nevada's silver production in recent years was produced as a byproduct of gold mining. In order for deposits to qualify as a primary silver deposit it must have silver/gold ratios of about 75:1 (based on average prices of the two commodities). The Coeur Rochester Mine in Pershing County is the only active mine that qualifies as a primary silver producer within the Planning Area with a silver/gold ratio of 107:1. Approximately 10.4 million ounces of silver were produced in Nevada in 2004 and the Coeur Rochester mine produced about 5.6 million ounces of that total or about 55% of Nevada's total silver production (Price and Meeuwig, 2004).

Like gold, the price of silver is gradually increasing. This may affect the expansion potential of the existing silver mines, would likely increase exploration activities for new silver deposits in other areas, and encourage greater recovery of silver produced as a byproduct of gold mining.

Assessment of Potential for Undiscovered Gold Deposits

Introduction: Nevada, in general, and the Winnemucca area, in particular, are some of the best studied areas in the country with respect to the use of individual deposit studies to build deposit models that are developed for predictive mineral resource assessment. There have been at least three relatively recent mineral assessments for the potential occurrences of undiscovered mineral resources within the Planning Area, each of which have many common features with respect to deposit model types, and several differences with respect to how the actual assessment was carried out. As a result each of these studies has its own merits.

The three major studies include: 1) Metallic mineral resources in the US Bureau of Land Management's Winnemucca District and Surprise Resource Area, northwest Nevada and northeast California (Peters and others, 1996, 147p); 2) An Analysis of Nevada's Metal-Bearing Mineral Resources (Singer, 1996); and 3) Assessment of Mineral Resources in the Humboldt River Basin, Northern Nevada (Wallace and others, 2004, 295 p.).

Each of the three studies develops deposit models based on knowledge-based and expert-based information. The knowledge-based information includes characteristics of known deposit types (such as geologic setting, lithology, mineralogy, alteration, geochemical data, geophysical data and structural data) and uses this data to look for other areas with similar characteristics that might indicate favorable areas for undiscovered resources of a similar deposit type. Each of the three studies is also expert-based in that recognized experts are used to interpret the deposit models and to identify prospective areas based on the knowledge-based information and their general and specific knowledge of ore deposits.

Each of these three studies is very detailed and comprehensive in its approach to deposit model development and provides detailed descriptive and, in some cases, quantitative discussion of its assessment methodology before presenting the final result of the mineral assessments. The studies have been conducted by generally recognized experts from the US Geological Survey, the Nevada Bureau of Mines and Geology and various independent geologists, geochemists and geophysicists. In addition, each of the reports is substantial in the amount of text, figures, tables and large format maps presented in order to properly present the assessments. To obtain greater detail and information over the summary level of this report, the reader is encouraged to examine these reports for deposit model types, assessment methodologies, and predictive aspects of the assessments either for various deposit types or potential areas and settings of mineralization.

This section of this report will look very briefly at these resource assessments and will then present some combined results from these studies in order to identify areas with favorable gold and silver and other metal resource potential within the Planning Area. The results are presented at a level of detail sufficient to understand the overall process used, and to provide land managers with assessment of various types of potential mineral occurrences for various areas. This mineral assessment information is provided principally to assist land managers with long and short term land management planning, and for use in conflict resolution between the development (or preservation) of multiple resources.

General Deposit Models: The basic groups of deposit types developed for deposit models in each of the three studies are similar and fall into the following main groups: 1) pluton-related deposits; 2) sediment-hosted deposits; and 3) epithermal (hot springs, volcanic and veins) deposits. The report by Wallace and others (2004) deals principally with gold and silver deposits (other metals by association only) the other two reports look at deposit models for a variety of metals. Wallace and others (2004) emphasize that gold and silver deposits are the most important in the Planning Area and that they are the only major types of deposits likely to be explored for and developed in the present and near-term economic future.

Most of the deposit models have been constructed based on individual models developed elsewhere and many of these were compiled into a descriptive report of deposit model-types by Cox and others (1986). The authors of the reports listed above use many of the deposit models described in Cox's paper as a basis for their analysis.

Assessment: Each of the three reports uses different methods for developing and presenting the mineral potential assessment for their respective study areas. The assessment in the Nevada-wide report (Singer, 1996) develops tonnage and grade curves for various deposit model types and then predicts the number of undiscovered deposits of a certain tonnage and grade that are statistically likely to be contained within the evaluated resource area, based on similar deposit models and favorable geologic characteristics. The report by Peters and others (1996) defines the critical attributes of deposit models, identifies areas with similar characteristics that would support the operation of the model type-within the study areas, and then identifies prospective, favorable, and permissive tracts for that deposit type within the resource assessment area. The Peters and others report (1996) presents the mineral potential as shaded areas of varying degrees of potential on a topographic map base. The report by Wallace and others (2004) also uses the defined deposit models to identify areas with the highest likelihood of containing undiscovered deposits similar to that of the model for the resource assessment area. They then identify areas within the assessment study area that are prospective, favorable, permissive, and non-permissive. This latter report uses a GIS system of evaluation that prepares final figures with colored pixels indicating this degree of favorability to define prospective areas. They also superimpose on their final mineral potential maps, zones or belts of favorable mineral potential based on a coalescence of favorable pixels that define the zones.

This mineral assessment report combines the methods of Peters and others (1996) with those of Wallace and others (2004) to produce mineral assessment maps showing prospective and favorable areas for mineral occurrence or potential of a certain type of deposit models to have operated in a given area. As with the Peters and others report, it also evaluates deposits of metals other than gold and silver in the analysis.

Pluton or Igneous Related Deposits: Pluton-related deposits form during the intrusion of magmas into upper crustal rocks. This group of deposits is very large and contains the greatest variety of deposit and model types. The pluton-related deposit group includes porphyry deposits, intrusive related skarn deposits and vein deposits. Within the Planning area these deposits are most commonly related to Mesozoic and Tertiary age intrusive centers. Deposit models evaluated include: porphyry copper (molybdenum) deposits, Climax–type porphyry molybdenum deposits, low-fluorine-type porphyry molybdenum deposits, porphyry copper-gold deposits, base and precious metal skarn deposits (porphyry-related copper skarns, copper skarns, lead-zinc skarns, iron skarns, gold skarns and tungsten skarns), polymetallic vein deposits, polymetallic replacement deposits, replacement manganese deposits, and distal disseminated gold deposits. Many of these deposits are part of a continuum that includes porphyry deposits, skarn deposits, polymetallic vein deposits and distal disseminated gold-silver deposits, with the porphyry deposit being located at the core of the plutonic mineralizing system (Wallace and others, 2004).

Figure 4.1 illustrates the distribution of gold and silver deposits (Davis and Tingley, 1999) and other metal deposits (Peters and others, 1996) that are interpreted to be related to plutonic activity. As described above, there are a very large number of different types of pluton-related deposits shown on this map (a variety of porphyry systems, various metallic skarn deposits, polymetallic veins and distal disseminated gold deposits). Superposed on these metal deposit occurrences are gold and yellow shaded areas (**Figure 4.1**) depicting areas determined to be prospective and favorable, respectively, for these types of pluton related deposits (Peters and others, 1996). Finally, **Figure 4.1** shows belts determined to be favorable for plutonic deposits based on the analysis by Wallace and others (2004). These belts are interpreted to be zones of shallow and deep crustal weakness that provide pathways for the upward migration of magma along linear trends into the upper crust, where they form large mineralizing systems and create a variety of pluton related deposits. Within the Planning Area, these belts include: 1) Battle Mountain-Eureka plutonic belt; 2) Humboldt-Toulon plutonic belt; 3) Stillwater plutonic belt; and 4) the Osgood plutonic Belt (**Figure 4.1**).

The best examples of pluton-related gold deposits in and adjacent to the Planning Area include: deposits within the Battle Mountain District (southeast corner of Humboldt County, Fortitude, Copper Canyon and Copper Basin), the Kennedy District (southeast corner of Pershing County, **Figures 3.2 and 4.1**), and the Majuba Hill Deposit (**Figures 3.2 and 4.1**). In addition, several of the deposits within the district can be classified as distal disseminated deposits for example the Lone Tree, Marigold and Trenton Canyon deposits (**Figures 3.2 and 4.1**). Distal-disseminated gold deposits are genetically related to intrusive rocks. however, the location of the deposit occurs at some distance from the intrusive center and the deposits are commonly hosted in sedimentary rocks Wallace and others (2004) discuss these deposits under sediment-hosted deposits, however, this report considers them pluton-related deposits. The distinction is somewhat arbitrary. Most distal-disseminated deposits occur in the southeast corner of Humboldt County, north of the Battle Mountain District (**Figure 4.1**). Pluton–related deposits frequently contain a variety of metals other than gold and silver, and the most important of these deposits are briefly discussed by commodity below.

<u>Sediment-hosted Gold Deposits:</u> Sediment-hosted gold and silver deposits are by far the largest precious metal producers within the Planning Area and are also of the greatest economic importance in Northern Nevada and in the US. These deposits are typically low-grade, (as low as 0.7 grams per tonne; 0.02 ounces per ton) and large tonnage deposits that are usually mined in large-scale open pit mines. Sediment-hosted gold deposits commonly occur in thin-bedded carbonate-siliciclastic Paleozoic rock sequences (although host rocks of argillite and volcanic rock are also known). Gold is usually sub-micron in size and is commonly found within the structure of disseminated pyrite grains, or alternatively localized along thin fractures and disseminated throughout the host-rock. Hydrothermal alteration associated with these deposits includes jasper replacements, argilization, decalcification of limestones, and dolomites. Many deposits are localized in sedimentary rocks along the Roberts Mountain Thrust where

4.1 Pluton Related Gold, Silver and Other Metal Deposits carbonaceous deep water sediments have been thrust over shallow water shelf carbonate sediments, with the Roberts Thrust or subsidiary faults presumably acting as conduits for ore-bearing fluids perhaps derived from connate waters associated with distant plutons.

Examples of sediment-hosted gold deposits within the Planning Area include those of the Getchell Trend including Twin Creeks, Getchell, Preble and Pinson; the Standard Mine in the Imlay District, and the Relief Canyon Deposit in the Antelope Springs District (**Figures 3.2 and 4.2**).

Figure 4.2 shows identified sediment hosted gold deposits (Davis and Tingley, 1999) and also indicates areas both prospective and favorable for potential sediment hosted deposits as modified from Peters and others (1996). In addition, to obvious trend of deposits in the Battle Mountain and Getchell trends, Wallace and others (2004) identify another area shown crosshatched as being highly favorable for sediment-hosted deposits within the Planning Area (**Figure 4.2**).

Epithermal, Hot Springs and Volcanic Systems: Epithermal deposits are typically formed from shallow (1 – 2 km), relatively low temperature, fossil hot springs-related hydrothermal systems. The hydrothermal fluids typically move through various faults and fractures and are commonly associated with subaerial volcanic flows or pyroclastic rocks and sub-volcanic intrusions (Sherlock and others, 1996). Epithermal deposits are inferred to have formed at or near the paleo-surface at the time of mineralization. High heat flow from basin and range structures generated from nearby volcanic activity is thought to have created deep hydrothermal circulation along these faults through which the water circulated. These deposits include shallow veins, stock works, breccias, and disseminations (Sherlock and others, 1996). Host rocks are typically volcanics or permeable sedimentary units.

Areas favorable for epithermal gold deposits therefore include areas with deep basin and range-type structures associated with high heat-flow generated from nearby volcanic centers. These criteria fit most of the Planning Area, but in particular, a broad north-south trending zone in the central part of the area (**Figure 4.3**). Very young epithermal systems seem to be concentrated in the northern portion of the Planning Area. **Figure 4.3** depicts the location of shallow (high level) epithermal gold deposits related to hot springs systems as blue dots and those related to Comstock-type epithermal veins as grey diamonds. **Figure 4.3** also delineates areas both prospective and favorable for hot springs deposits in general as gold and yellow shaded areas respectively.

Recently mined epithermal gold deposits within the Planning Area include the Florida Canyon, Rosebud and Sleeper deposits. The Hycroft and Standard mines are currently being mined (**Figures 3.2 and 4.3**).

As with pluton related deposits, epithermal deposits are associated with a variety of metals other than gold and silver including antimony, mercury, manganese, sulfur, and uranium. These deposits are discussed by commodity below.

4.2 Sediment Hosted Gold Deposits

4.3 Epithermal, Volcanic and Hot Springs Related Deposits

Low Sulfide (Chugach-type) Gold-Quartz Veins: These deposits were of historical importance as small high-grade gold deposits that were typically mined by underground methods. These low-sulfide gold-quartz veins typically occur in shear zones interpreted to have been formed and mineralized at much greater depths than the shallow epithermal veins described above. Deposits are typically less than one meter wide and often occur as individual veins, although they may occur in multiple sets. Grades commonly ranged between 0.03 to 3 ounces per ton. Most of the deposits were mined as discrete veins or parallel sets of veins with a notable exception being the silver deposits of the Rochester Mining District. Here a large stockwork zone of high grade silver mineralization is being mined by open pit methods. These deposits are envisioned to have formed from either distal magmatic or metamorphic mineralizing fluids migrating through and depositing gold/silver in the sheer zones (Peters and others, 1996). These deposits are considered by some to have been a major source of gold in placer deposits. Low-sulfide, gold-quartz vein deposits are common in the Imlay, Star, Unionville, and Rochester Districts of the Humboldt Range; in the Ten Mile and North Mill City Districts near Mill City; the Awakening District; and in the northern part of the Planning Area in the Jackson Terrane and Varyville District (**Figure 4.4**). **Figure 4.4** shows existing occurrences and deposits, and important mining districts. **Figure 4.4** also show areas both prospective and favorable for low-sulfide gold-quartz veins and gold and yellow shaded areas, respectively (Peters and others, 1996).

Summary of Gold Potential: This mineral resource assessment report indicates that many areas have produced large amounts of gold and silver both historically and recently and that a very high potential exists for the discovery of many additional deposits based upon conditions of extending geologic favorability identified by deposit models into other areas with similar geologic characteristics. The prospective areas identified, therefore, include areas both within and outside of mineralized areas recognized by historical mining in established districts. This favorability has been presented on a series of maps that identify areas as being either prospective or favorable for the occurrence of deposits from three very general deposit types including 1) pluton-related deposits (**Figure 4.1**); 2) sediment-hosted deposits (**Figure 4.2**); and 3) epithermal hot springs and volcanic deposits (**Figure 4.3**). Favorability for a fourth general deposit model of low-sulfide (Chugach-type) gold-quartz vein deposits is also presented (**Figure 4.4**). In addition, these maps show the actual locations of gold and silver, occurrences and deposits of both historical and recent precious metal production.

4.1.3 Other Metals

The pluton-related and epithermal deposit models described above are also commonly associated with metals other than gold and silver. These deposits are considered further here using deposit models to illustrate favorable areas for other metals. These deposit types are discussed by commodity below.

Antimony

There is a very low potential for the development of antimony deposits within the Planning Area. Veins and replacement deposits of antimony are common in Nevada, where stibnite

4.4 Low Sulfide (Chugach-type) Gold-Quartz Deposits occurs as massive replacements in beds or lenses, or alternatively as fissure of fracture filling deposits. Within the Planning Area small deposits of antimony occur in the Antelope Springs, Rye Patch, Battle Mountain and Willard Districts, however, there is no current production.

Beryllium

There is a very low potential for the future development of beryllium deposits within the Planning Area. Beryllium occurs in crystals as the mineral beryl associated with several sheelite-bearing vein deposits and also in pegmatites. There has been no beryllium production within the Planning Area, and rather than being a likely source for commercial mining of beryllium metal; beryl occurrences are of value principally to mineral collectors (Nash, 1996).

Copper

The Planning Area contains a low potential for the development of porphyry copper or copper skarn-type deposits. Porphyry copper and copper skarn deposits have not been significant producers from the Planning Area in the past; however, there are several occurrences of these types of deposits. A number of these occurrences lie in the northward extension of the Battle Mountain District into the Planning area, and other deposits are known from the Kennedy Mining District and the Antelope District (Majuba Hill Deposit) (Figures 3.4 and 4.1).

There is, however, a moderate to good potential for further development of at least one massive sulfide copper within the Planning Area and this is at the Big Mike Mine. The Big Mike Mine is located about 9 miles west of the Iron Hat District in the Tobin-Sonoma Range, south-southeast of Winnemucca. The Big Bike Mine is responsible for almost 98% of the total $11.73 million of copper produced from the Planning Area prior to 1977. The Big Mike mine shipped high grade copper ore to Europe for processing and lower grade sulfide and oxide ore was blasted and leached in the pit (1973) (Sherlock and others, 1996). In 2003, Goldspring, Inc. announced plans to bring the Big Mike Mine back into production by initially treating 1.2 million tons of ore already mined containing about 25 million pounds of copper in a leaching operation. Although the Big Mike Mine has been the only significant producer from massive sulfide deposits, volcanic Paleozoic and Mesozoic rocks are prospective for the discovery of Kuroko-type massive sulfide deposits in the northwestern portion of the Planning Area and for Cyprus-type massive sulfide deposits in the southeastern portion of the Planning Area.

Iron

There is a low potential for the development of iron deposits within the Planning Area. Iron-rich skarn deposits within the Planning Area have formed by metasomatic process where intermediate to mafic intrusives are in contact with limestone. Significant deposits of iron-skarn containing magnetite or hematite as replacement deposits are known from the Jackson Mountain area (Jackson and Red Butte Districts in west central Humboldt County, **Figure 4.1**) and from massive endoskarn replacement-veins in the Mineral Basin District along the southern boundary of the Planning Area in Pershing County (**Figure 4.1**). The Buena Vista Mine, the largest of the endoskarn deposits, produced ore grading 54% iron and mined about 350,000 tons of rock in 1945 (Reeves and Kral, 1955; Sherlock and others, 1996). Current reserves at the Buena Vista mine have been estimated at 18 million tons at a grade of 32.7% iron (Lowe and others, 1985). There has also been some modest production (about $3 million from 430,000 tons of ore, **Table 3-5**) mostly from mining at the Iron King Mine in the Jackson Range that took place in the 1950s.

There are no producing iron-ore mines in the Planning Area. Most of the deposits identified to date are relatively small by iron-ore deposit standards and the locations of these deposits are remote from both energy sources needed to process the ore and the potential end users for iron products. These factors make for high transportation costs for shipping either ore or finished product. It is highly unlikely that either of these identified deposits described above will be operated in the next 15-20 years and there is no reason to believe that companies would actively explore for iron deposits within the Planning Area.

<u>Lead and Zinc</u>

There is a very low potential for the future development of lead and zinc deposits within the Planning Area. There has been no significant lead or zinc production from the Planning Area (**Table 3-5**), and most of the limited production has occurred as minor byproducts from the mining of polymetallic vein deposits or, more commonly, skarn deposits.

<u>Manganese</u>

The potential to develop manganese deposits within the Planning Area is very low. Epithermal manganese deposits (**Figure 4.3**) commonly occur as veins or fracture fillings of faults associated with hot springs deposits. These deposits are often associated with other metals such as tungsten, silver and gold. There are a number of these deposits in the Golconda District and many other epithermal manganese deposits are known and others are likely in other hot spring areas through out the Planning Area (**Figure 4.3**). There are no producing manganese deposits within the Planning Area and there is little economic incentive to develop manganese deposits. Manganese deposits are likely to be used in the future to identify hot springs areas in which gold and silver mineralization might be present at depth, beneath the lower temperature manganese portion of the geothermal system.

<u>Mercury</u>

There is little potential for the development of epithermal mercury deposits within the Planning Area. Mercury is hosted in two types of deposits within the Planning Area including sediment-hosted and hot springs deposits (**Figure 4.3**). Hot springs mercury deposits (**Figure 4.3**) are the most common and form at the groundwater table interface in siliceous sinter hot springs.

Almost $100 million of mercury has been produced from within the Planning Area (**Table 3-5**). Historically mined deposits include those found in the Antelope Spring, Potosi, Sulfur, National, Bottle Creek, Spring Valley, Warm Springs, and Jackson Mountains Districts (Figure 3.4 and 4.3).

The McDermitt area in north-central Humboldt County is associated with numerous fossil and some recent hot springs deposits related to the McDermitt Caldera. The Cordero Mining Company has been one of the leading mercury producers in the country and produced mercury from the Cordero and Bottle Creek areas near McDermitt. In addition, Placer Amex operated the McDermitt Mine in this area from mid-1970s through about 1990. The McDermitt Mine was a primary mercury producer (did not produce mercury as a by-product of gold production) and produced almost 450 metric tons of mercury during its last year of operations in 1990. Reserves in the McDermitt area are estimated to be in excess of 300,000 flasks.

Despite the fact that mercury is currently valued at over $1,000/flask, and that there are significant reserves within the Planning Area, the prospects for mining mercury in the next 15-20 years are slight. This is in part because of the toxic metal rating given mercury by the EPA in 1971. This rating lead to the development of more environmentally sound replacements for mercury's previous uses.

Molybdenum

There is a high potential for the development of molybdenum deposits within the Planning Area. Two types of molybdenum porphyry deposit models were evaluated for the Planning Area (Peters and others, 1996; and Cox and others, 1996): the Climax-type deposit model and the low fluorine-molybdenum porphyry deposit models model. Climax-type deposits are porphyry systems characterized by molybdenite-quartz-fluorite stockwork vein systems developed in high-silica granite porphyries and rhyolite stocks; whereas, low fluorine-molybdenum porphyry deposit models consist of molybdenite-quartz stockwork vein systems associated with multiphase quartz-monzonite stocks predominantly of Cretaceous age.

The only Climax-type deposit within the Planning Area is the Majuba Hill deposit (**Figures 3.4 and 4.1**). Within and adjacent to the Planning Area, there are several low-fluorine molybdenum porphyries associated with the Late Cretaceous plutons, for example: the Buckingham molybdenum system associated with the Copper Basin deposit and located in the Battle Mountain District (**Figure 3.4 and 4.1)**, two deposits located in the Gold Run District, and a small system in the Leonard District in the northwestern portion of the Planning Area (**Figures 3.4 and 4.1**).

Recently, Golden Phoenix Minerals, Inc. completed an extensive drilling program on the historically mined Ashdown Mine (gold) property in the Vicksburg Distinct of northwestern Humboldt County and announced plans to begin both underground and open pit operations on the Ashdown Mine as a gold-molybdenum porphyry property.

There is no current, nor has there been any historic production of molybdenum from the Planning Area, however, it seems quite likely that the Ashdown Property could be brought back into production as a low-fluorine molybdenum porphyry system within the next few years. Other molybdenum deposits may be also developed over the next 15-20 years as well.

Tungsten

There is a moderate potential for the development of tungsten deposits within the Planning Area. Numerous deposits of tungsten mineralization occur predominantly as sheelite-bearing metasomatic skarn-type deposits associated with Cretaceous age quartz-monzonite intrusives throughout the Planning Area (**Figure 4.1**). As many as 150 tungsten skarn occurrences have been identified within the Planning Area. There are also a few tungsten vein deposits associated with peraluminous granitic stocks (**Figure 4.1**). Tungsten skarn-type deposits occur within Potosi, Mill City, Seven Troughs, Blue Wing, and Staggs Districts (**Figures 3.4 and 4.1**) and are generally aligned along a broad northeast trending zone across the Planning Area

A number of tungsten skarn deposits have been mined historically and a few have had significant production particularly during World War II and during a mid 1950s government stockpiling program. Humboldt and Pershing Counties have produced about $81 million of tungsten since 1911 and more than $40 million in the years 1953-1957 **(Table 3-5**). Many of the deposits in Nevada are small, but a few are of moderate size by world-wide standards (i.e., greater than 1,000,000 tons).

The price of tungsten (WO_3) has increased significantly in the last few years and has stimulated the production of tungsten elsewhere in the world where deposits are larger and higher grade than those found in Nevada. It would seem reasonable that if prices were to remain high and demand increases somewhat, that some companies might be encouraged in attempting to bring some of the larger, higher grade deposits of the Planning Area into production.

Uranium

There is little potential for the development of uranium deposits within the Planning Area. Uranium deposits within the Planning Area are predominantly volcanogenic or pluton-related deposits, although some small discontinuous sediment hosted deposits are also known. Favorable areas include the McDermitt Caldera area and other volcanic or shallow intrusive rocks of the northwestern portion of the Planning Area (**Figure 3.5**). Other favorable areas include veins and disseminations in alkalic intrusives in the scattered about the southern and central portion of the Planning Area (**Figure 3.5**).

The uranium boom in the early 1950s was in large part, driven by government price subsidies and incentives for what was considered a strategic mineral for military use. A second boom in the early 1970s saw additional exploration in Tertiary volcanic host-rocks of northern Humboldt County. As a result of these two periods of exploration, many uraniferous occurrences or deposits were identified. However, only one low-grade uranium deposit, the Moonlight Mine, saw limited production from rhyolite ring domes and shallow intrusives along the McDermitt caldera margin (**Figure 3.5**). Most of the deposits in the planning area are too low grade and small to be economically competitive with higher grade and tonnage deposits located elsewhere in the US. In addition, social and political outfall from the Three Mile Island incident have precluded the need for and the desire to mine uranium in all but a few of the richest deposits located in the US. Because of the quality and size of the known deposits and the other factors discussed above, it is unlikely that uranium deposits will be explored for or economic deposits discovered within the Planning Area in the foreseeable future.

Gems and Semi Precious Stones

Gems and semi-precious stones will likely continue to be mined on a small scale in the Planning Area. Opal and turquoise semi-precious stones occur in Tertiary to recent volcanic rocks. The Black Rock and Virgin Valley areas of northwest Humboldt County have been most productive areas for collecting these materials. Deposits are small, usually hand operated as "pay-to-dig" operations, and great care must be taken when extracting the stones so as not to damage and devalue the pieces. Existing deposits will likely be extended and remain small with labor intensive mining methods. Other small gemstone deposits are found in the Planning Area and produce beryl, scheelite, chalcedony, turquoise, and specimen gold principally for mineral collectors. Specimen quality gold is typically collected from historically mined high grade quartz-vein deposits. It is likely that the same level of demand for gemstones and specimen quality samples will require the same small scale level of activity into the foreseeable future. Gem and semi-precious stone deposits have high unit values and therefore, their viability does not rely on proximity to transportation corridors (Nash, 1996).

4.1.4 Locatable Industrial Minerals Potential

The potential for development of locatable industrial rocks and mineral resources of the Planning Area are summarized below. These include the following: aluminum minerals, barite, beryl, carbonate minerals, diatomite, fluorspar, gypsum, perlite, silica, talcose minerals, wollastonite, and zeolite.

Aluminum Minerals

A low potential exists for further development of aluminum minerals in the Planning Area. The aluminum mineral dumortierite was mined at the Champion Mine in the past. Reserves at this mine are unknown. In addition, there are other known and previously evaluated deposits of dumortierite in the Humboldt Range in Pershing County and based on past production this area is the most prospective location for discovery and development of new aluminum mineral resources. Nevertheless, near-term exploration and development of these deposits is not expected.

Favorable geologic conditions for aluminum-rich minerals include a large pluton of moderate emplacement depth, contact metamorphic conditions, and optimum chemistry to form dumortierite (high aluminum and boron) and/or other aluminum silicate minerals. While there may be a small specialty market for dumortierite, this mineral is no longer in high demand for the ceramic applications that encouraged earlier development. Additionally, costly milling processes were needed to remove impurities that existed in the deposit. Recently this mottled pink-blue-purple dumortierite-andalusite-quartz-bearing rock has been explored for its dimension stone potential (Nash, 1996).

Barite

Low potential exists for further development of barite deposits in the Planning Area. This is because host rock and geologic conditions are not favorable for the formation of currently economic deposits. The potential for barite extraction in Planning Area will largely be affected by the magnitude of domestic oil and gas production. If domestic production of oil and gas increases, the barite veins in the Planning Area may become profitable to develop. However, large and high-grade open-pit mines abroad will continue to be a limiting factor in barite development in Nevada.

The potential for barite development exists in Humboldt County, in the vicinity of former mines and prospects in the Osgood Mountains (Papke and Castor, 2003). The host-rock for bedded barite deposits in the Planning Area is most commonly Paleozoic marine sedimentary rocks, especially those of Cambrian-Ordivician age. Known barite deposits exist within the Cambrian Preble and Ordovician Comus formations and these constitute favorable rock units. However, Paleozoic marine rocks west of Winnemucca do not contain known barite deposits and appear to have low favorability compared with rocks in the Roberts Mountains allochthon to the east (Nash, 1996).

To bring a barite deposit into production, the mines and mills must be located near railroads as the high density of barite contributes to high transportation costs. Beneficiation using screens, jigs, and flotation is required to purify ore prior to shipment to markets (Nash 1996).

Carbonate Minerals

There is good potential for additional development of carbonate minerals deposits in the Planning Area. Favorable thicknesses of limestone and dolomite exist in the Humboldt Range of Pershing County and Sonoma Range of Humboldt County in the vicinity of the Min-Ad and Glen Sexton mines (**Figures 3.1 and 3.6**). Generally, in order to be economic, carbonate mineral deposits must be developed in close proximity to transportation corridors and/or the point of end use. Carbonate rocks should be low in magnesium and iron for most end uses. Limestone and dolomite adjacent to transportation corridors or within proximity of gold mining operations will likely be assessed for economic benefits (Nash, 1996). Geologic maps of sufficient detail can be used to delineate the outcrop patterns of potential carbonate deposits.

The Nevada Cement Company is presently in the process of executing a drilling program in limestone of the Natchez Pass Formation in the Humboldt Range of Pershing County. This limestone deposit will be evaluated for use as raw material for Portland cement. If successful, a new plant may be built near Rye Patch interchange along interstate 80 (Castor, 2004).

Diatomite

There is good potential for additional development of diatomite deposits in the Planning Area. Formation of diatomite requires the availability of great quantities of silica and the Planning Area is an ideal geologic location to find diatomite deposits due to the presence of nearby hot springs and siliceous volcanic rocks. In addition, the Planning Area contains numerous active, historically mined, and currently undeveloped diatomite deposits. Large proven deposits exist, and other likely areas for deposits of diatomite have been identified in association with Miocene normal faults and volcaniclastic-sedimentary rocks within the Planning Area. The Trinity Range northwest of Lovelock (**Figure 2.1**) and a location north of Brady's Hot Spring near the Moltan Mine (**Figure 3.1 and 3.6, number 54**) are two highly prospective deposits/districts for diatomite. Other diatomite occurrences in the western part of the Planning Area appear to be too thin to be viable under current economic conditions (Nash, 1996).

In order to be mineable, deposits generally must have less than 50 meters of cover and be capable of being mined using inexpensive open-cut methods. Deposits must also be close to transportation corridors as crude diatomite can only be economically be trucked from 50 to 100 km to mills (Nash 1996).

Fluorspar

There is a very low potential for development of fluorspar deposits in the Planning Area. Although fluorite occurs in many hydrothermal metallic ore deposits, it is not often present in sufficient quantities to be mined, even as a by-product, profitability. The favorable geologic environment for fluorite within the Planning Area includes Cretaceous to Miocene intrusive rocks and adjacent wall rocks, particularly limestone. In addition, a two-mica granite of Cretaceous age that was enriched in fluorine, was identified in a large, sub-economic fluorspar deposit at McCullough Butte in Eureka County, Nevada. Similar granites have been identified in the Stillwater and Humboldt ranges (**Figure 2.1**) of the Planning Area, but without the associated fluorspar deposits (Nash, 1996). Various other deposits of fluorspar have been identified, but are not proven to be profitable enough to develop. In addition, the development of fluorspar resources is inhibited by the lack of nearby process facilities; therefore transportation cost is an important consideration in the economic feasibility of any operation.

Gypsum

There is good potential for continued development of existing gypsum deposits, as well as the discovery of new, economic gypsum deposits. Although drilling is necessary to determine the quality and depth of deposits, new deposits would likely occur as extensions of or in the vicinity of existing deposits in the Selenite, West Humboldt, and Stillwater ranges in Pershing County. Active and inactive mines include the Empire mine (active) in the Selenite Range, Lovelock (inactive) in the West Humboldt Range, and Corn Beef (inactive) in the Stillwater Range (**Figures 3.1 and 3.6**) (Papke and Castor, 2003).

Favorable geology includes Triassic to Jurassic marine sedimentary rocks of Jungo or Black Rock Terranes within about 200 meters of the surface (Nash, 1996). In addition, surface weathering and impurities must be minimal.

It is expected that most mining will be performed using open-cut methods from deposits located beneath less than 50 m of overburden, although underground mining has been performed in large and thick deposits. Shipping costs can be lessened by solar drying; allowing shipment of ore as far away as 100 kilometers for milling. Deposits generally must be located near rail or other transportation corridor to be considered economically viable (Nash, 1996).

Lithium

There is low to moderate potential for development of a large scale lithium mine in the WPA. The most favorable settings for economic lithium deposits in the WPA include playas of the Black Rock Desert, Humboldt, and Carson sinks. Playa brines are mined for lithium at Silver Peak in Esmeralda County, Nevada and (as a by-product) at Searles Lake, California (Nash, 1996).

Lithium concentrations in hectorite clay in the McDermitt Caldera of Humboldt County are as high as 0.68 %. However, there is low development potential of the hectorite clay deposits due to limitations in extraction technology of lithium from hectorite clay. Economic lithium deposits need to be relatively free of contaminants (such as mercury, uranium, zeolites, and clays typical of volcanic-dominated basins) and close to good transportation corridors (Nash 1996).

Perlite

There is a low to moderate potential that perlite deposits will be developed in the Planning Area. This assessment is based on there being no active perlite mines; however, former mines, prospects, and occurrences of perlite occur in the Trinity Range in Pershing County and prospects approximately 50 miles north of Gerlach in Washoe County. Exploration techniques for perlite deposits have not been well developed and many features that might lead to the discovery of individual perlite deposits are too small to be represented on regional geologic base maps. Local large scale mapping and drill testing is needed to determine locations of potentially desirable deposits.

The favorable geologic environment for perlite is similar to that for clay and diatomite deposits. Host rocks include intrusive volcanic rocks of Miocene to Recent in age. The typical perlite deposit is a volcanic, glass-rich body of uniform composition and sufficient size to permit bulk mining. Product beneficiation (expansion of the product) requires proximity to natural gas to fire kilns. Also, proximity to good transportation corridors is required for significant production (Nash 1996).

Silica

There is low potential for development of silica deposits in the Planning Area. The recognition of low development potential is due to there being only two former mines (Stone Corral in Humboldt County and Winnemucca Lake in Washoe County, **Figure 3.6 and Table 3-6).** Both of these mines had insignificant historical production of silica (Papke and Castor, 2003).

Talcose Minerals

There is low potential for development of talcose mineral deposits in the Planning Area. There exists only one former mine (Humboldt Range Pinite) with limited production in the Humboldt Range of Pershing County (Papke and Castor, 2003).

Wollastonite

There is low potential for development of wollastonite deposits in the Planning Area, with exception of the possibility of it being produced (as a by-product) at the Getchell Mine in Humboldt County (Papke and Castor, 2003).

Zeolites

There is moderate potential for development of zeolite deposits in the Planning Area. Here zeolite occurrences exist along rifts and block-faulted basins in the Tobin and Trinity ranges in Pershing County and Owyhee Plateau in Humboldt County of the Planning Area (**Figures 2.1. and 3.6, and Table 3-6**). Other deposits along similar-type rifts and block-faulted basins in the Planning Area may remain undiscovered. Favorable geologic environments for zeolite deposits are similar to other commodities hosted in Tertiary volcanic and volcaniclastic rocks (diatomite, clays, and perlite) and zeolite deposits are frequently associated with clay or perlite deposits. The alkaline lake-type zeolite deposits are also highly desirable for development. Economic deposits require less than 30 meters of cover and the ability to be mined by open-cut mining methods (Nash, 1996).

Deposit value and end uses for ion exchange resins and for absorbent applications are determined by details of mineralogy and require special testing. Impurities such as quartz and calcite must usually be removed by beneficiation (Nash, 1996).

Other Industrial Minerals

Other locatable industrial rocks and minerals include garnet, graphite, magnesium minerals, and vermiculite. There is low potential for development of these based on no previous (recorded) mining for these commodities and low favorability of host rock and geologic conditions.

4.2 Saleable Minerals

Saleable mineral extraction and use will increase along with increasing mining activity, commercial development, recreation activities, and private property development, especially along the Interstate 80 corridor within the Planning Area. Saleable mineral sites with a priority for use will likely include sand, gravel, and rock quarries located along State, County, and BLM managed roads.

The potential for development of saleable industrial rocks and mineral resources of the Planning Area are summarized below. These include the following: aggregate (sand and gravel), clay, pumice and cinder, and building and ornamental stone.

4.2.1 Aggregate, Sand and Gravel

There is good potential and considerable demand for continued development of aggregate deposits in the Planning Area. The BLM controlled surface areas contain vast amounts of permissive tracts for sand and gravel exploration. Virtually all of the basins/valleys in the Planning Area have potential aggregate deposits. However, because the market value for sand and gravel is not very high and transportation costs are high, those deposits adjacent to their end uses or good transportation corridors will have the greatest development potential. High transportation cost and abundant resources also result in the dominance of small-scale local operations in the sand and gravel market. If local demand exists, small scale operations would not have to sustain large transportation costs, thereby creating an economically feasible and desirable situation for the Planning Area's sand and gravel development. If there is no local demand, only the larger quarries, particularly those near major transportation corridors and urban centers will be economically beneficial.

The source of favorable aggregate would be Pliocene to Recent alluvium. Favorable geologic environments would include existing and paleo-stream channels, beach terraces, and alluvial fans containing hard, siliceous material. Favorable areas containing sediments from these environments are depicted as yellow shaded areas on **Figure 3.7**. Weathered "granite" is also desirable and found in altered intrusive and volcanic rock terranes. Economic value is also dependent upon sorting, grain and clast composition, clast strength, consolidation, and amount of cover (Nash, 1996).

4.2.2 Clay

There is good potential for new and continued development of existing clay deposits in the Planning Area. Former and active mining of clay deposits was and is being conducted throughout the Planning Area. Districts or mines include Bull Basin, Disaster Peak, and Barrett Springs in Humboldt County; Rosebud Canyon, Coal Canyon, and New York Canyon in Pershing County; and San Emidio in Washoe County (Papke and Castor, 2003) (**Figures 3.1, 8.6 and 3.8; Table 3-6**).

Although clay deposits form in a variety of rock types and geologic settings, economic clay deposits in Nevada are primarily hosted in hydrothermally altered, predominantly volcanic rocks or fine-grained, clastic, lacustrine rocks. Clay deposits are also derived from glassy volcanic ash and tuffs (Nash, 1996). The most favorable geologic terranes occur where Miocene-Pliocene volcanic rocks and volcaniclastic sediments outcrop. These rocks have the greatest potential in the vicinity of faulting that provided a pathway for hydrothermal solutions and alteration or in areas of hydrothermal alteration.

The economic feasibility of some deposits has been limited by transportation costs. As a result, more accessible and valuable deposits are developed most frequently. Highly pure clays are used as drilling mud, in oil refining, and ceramics, while lower purity clays may be used for absorbents, such as cat litter, and industrial fillers.

Information on the distribution of potential clay deposits has not been adequately compiled. However, it is expected that low-purity clays exist in large quantities. The existence of undeveloped high-purity specialty clays has not been adequately explored (Nash, 1996).

4.2.3 Pumice and Cinder

There is low potential for development of pumice and cinder deposits although there are a number of occurrences and former mines in the within the Planning Area. Currently, pumice deposits are not being mined in Nevada (Nash, 1996).

Many of the pumice occurrences in the Planning Area occur in the Velvet District (such as the Lovelock mine) west of Lovelock in Pershing County (**Figure 3.6 and Table 3-6**) (Nash, 1996). Mining had also occurred at the Posalite mine in Churchill County in the Planning Area (Papke and Castor, 2003).

Favorable parent rocks include Tertiary volcanic and volcaniclastic rocks and volcanic centers or vents are also favorable sites. These silicic volcanic and pyroclastic rocks must have been deposited in sub-aqueous to sub-aerial conditions for the formation of pumice. Pumice deposits can occur as small to large cones, or sheets extending laterally from the volcanic vents. Economic viability of pumice deposits are controlled by purity, thickness, and lack of consolidation. Economic development requires that these deposits must be amenable to bulk mining and simple screening methods. Low cost transportation is required (Nash, 1996) and a nearby market is desirable.

4.2.4 Building and Ornamental Stone

There is moderate potential for development of building and ornamental stone deposits in the Planning Area, although there is no appreciable current production. Mines/quarries in the Planning Area include Trinity Range and Black Mountain in Churchill County and Virgin Valley (Wegman quarry) in Humboldt County (adjacent to the Planning Area proper) (Papke and Castor, 2003) (**Figures 3.6 and 3.8; Table 3-6**).

Optimal stone includes sandstone, volcanic sandstone, and volcanic rocks that are well-bedded, with prominent partings, and coloration (i.e. flat volcanic rock and columnar jointed rock) Age is generally Cretaceous to Recent. The resource must be at the surface to allow open-cut mining to keep the rock pieces intact. Mining is low volume and labor intensive. The low unit value of this resource generally requires proximity to its end uses with inexpensive transportation (Nash, 1996) in order to be economic.

4.2.5 Boulders

The demand for boulders for sale for landscaping uses is likely to grow substantially in the future as long as high growth rates continue in northwestern Nevada. The BLM has discretion to approve or not approve these activities, and impacts are addressed by mitigations and reclamation requirements on a case-by-case basis. Most of these operations are very small scale, removing a small number of boulders. Trespass taking of boulders may become a more common problem for the BLM in the future.

4.3 Leasable Minerals

4.3.1 Geothermal Resources

Introduction

Geothermal resource exploration and development operations are on the rise and are expected to increase in the future. Department of Energy and State of Nevada grants and tax incentives are encouraging companies to develop geothermal and other renewable energy resources.

Known Geothermal Resource Areas (KGRA), hot springs, existing geothermal lease and lease application areas have the highest potential for future use, however, extensive areas of unexplored relatively high potential exist within the Planning Area.

Characteristics of the KGRAs

The KGRAs located in the Planning Area are Brady, Gerlach, San Emidio, Rye Patch, New York Canyon, and the northern portion of Dixie Valley (**Figures 3.8 and 4.5**). Key features of each of these areas are summarized below.

Bradys Hot Springs: Geothermal wells were drilled in Bradys KGRA as early as the 1950s and a considerable amount of exploration has occurred in the area over the past several decades. A double flash power plant came on line in 1992, producing 21 megawatts of electricity, and a 5 megawatt binary unit was added in 2002 (Garside and Schilling, 2003). The geothermal wells at Bradys produce from permeable zones in the Tertiary volcanic rocks in the hanging wall of Bradys fault. Fluid flow may be controlled by northwest-striking cross faults and hanging-wall faults parallel to the Bradys fault. Temperatures up to 210 C have been reported.

Dixie Valley: Dixie Valley is home to Nevada's largest single geothermal power plant, which lies just south of the Planning Area boundary. Exploration began in the 1980s and a power plant was constructed in this area in 1988, which now produces 66 megawatts of electricity. The production zone lies in fractured Mesozoic meta-igneous rocks and overlying Tertiary volcanics between 2 and 3 kilometers below the surface. Fluid flow is believed to be related to highly permeable fractures in and adjacent to the Dixie Valley fault, the major range-bounding fault on the west margin of Dixie Valley (Garside and Schilling, 2004).

San Emidio: The San Emidio Desert is an east-tilted half graben, with major fault displacement on a fault near the east side of the valley (Garside and Schilling, 2004). Both a vegetable dehydration plant and a binary power plant are operational in the Empire Farms geothermal area in the San Emidio KGRA. Wells for the power plant and dehydration facility produce from Miocene volcaniclastic rocks which overlie Mesozoic metasiltstone and quartzite at

4.5 Geothermal Potential Map

approximately 500 m below the surface (Garside and Schilling, 2004). The productive area is at the intersection of north-northwest and north-northeast-striking faults west of the mountain front fault.

Rye Patch: The Rye Patch KGRA is located in the Humboldt River valley west of a major north-striking range-front fault that bounds the Humboldt Range (Garside and Schilling, 2004). The productive area appears to be sandstones, siltstones, and carbonate rocks in the Triassic Natchez Pass Formation. Fluid migration is believed to be controlled by faults (Garside and Schilling, 2004). Although there are no operating direct use facilities at this time, hot water from wells drilled adjacent to Florida Canyon Mine in the late 1980s were used to heat process fluids for the heap leaching of ore from this gold mining operation. In 2003, U.S. DOE funding enabled the Great Basin Center for Geothermal Energy at the University of Reno to drill and complete five temperature gradient wells (Garside and Schilling, 2004).

Gerlach: The Gerlach thermal area is located at the south end of the Granite Range in the southern Black Rock Desert. The two major groups of springs, Great Boiling Springs and Mud Springs, were first described by explorer John Fremont, in 1845. The hot springs are associated with northeast-striking basin-and-range faults along the east side of the Granite Range and issue from unconsolidated lacustrine and alluvial deposits. Fault scarps that are inches to several feet high appear to control the location of the spring clusters (Garside and Schilling, 2003).

New York Canyon: The thermal water of the New York Canyon KGRA occurs near the mountain front along a fault scarp that cuts alluvium. The fault is probably part of a young basin-and-range fault along the southern Buena Vista Valley (Garside and Schilling, 2004).

Exploration Drilling and Development Scenario

The following exploration and development scenario was presented in the *Geothermal Resources Leasing Programmatic EA* (BLM, 2005) in order to establish a baseline for understanding of the types of potential surface disturbance and other potential impacts that might be anticipated with geothermal development in general. Later a more specific Reasonably Foreseeable Development Scenario (RFDS) will be presented.

Following issuance of a geothermal exploration and development lease permit, exploration and development would likely proceed in four separate and sequential phases along the way toward geothermal development: exploration, development, production, and close-out. The probable sequence, timeframe, activities, and potential surface disturbance associated with each of these phases are described below.

<u>Exploration Phase (1 to 5 Years):</u> This stage includes all activities to explore for geothermal resources. The actions that may occur during exploration could include geologic, geochemical, and geophysical surveys and well drilling. The geologic, geochemical, and geophysical surveys consist of analyzing the surface geology and geothermal potential using various techniques ranging from those that are highly technical (such as thermal infrared remote sensing imagery and airborne and satellite thermal sensors) to standard methods such as collecting water samples from hot springs. These types of activities generally cause negligible surface impacts and tend to cover a broad geographic area. Based on the results of the data collected, inferences are drawn as to whether or not additional, more invasive testing procedures to evaluate temperature and flow properties of the geothermal systems are warranted.

Confirming where higher temperature gradients occur is accomplished by drilling temperature gradient wells. These wells are narrow in diameter and are drilled to depths of several hundred to several thousand feet. Temperature gradient is measured by lowering a thermistor into the well. Fluids encountered during the construction of temperature gradient wells are not produced, nor are any fluids injected into temperature gradient wells. Several temperature gradient wells on a lease may be drilled in order to define the spatial distribution of temperature anomalies. The amount of surface disturbance typically associated with each temperature gradient well site is about 0.07 acre. These types of wells are often installed in areas with relatively easy access; however, new road construction has been required in remote locations.

In addition to temperature gradient wells, exploration wells may be drilled in order to conduct flow tests. These types of wells require greater surface disturbance than temperature gradient wells; possibly as much as 1 acre per site. Road construction may also be required to access these sites.

<u>Development Phase (2 to 10 Years):</u> The type of development that may occur and the associated surface disturbance depends on the intended end use. For electrical generation applications, facilities that may be constructed would include power plants, transmission lines for connection to the power grid, roads, drill pads, pipelines, cooling ponds, and warehouse and maintenance facilities. Direct use facilities would include roads, drill pads, and pipelines, and may include greenhouses and dehydration plants. During the development phase, the producing limits of the field(s) are determined by developmental drilling, which would likely occur at a more intense level (drill hole density) and at a greater scale (over a broader area) than in the exploration phase. Surface disturbance associated with the likely activities occurring during development are described below.

> <u>Road Construction:</u> Access roads to well pad sites may vary in length depending on the location and presence of existing roads. Roads are generally 20-30 feet wide, although additional disturbance beyond that width may occur for installation of erosion control features. Road construction in lease areas would be required to be in accordance with BLM road standards, which generally require that roads follow natural contours; are properly placed with respect to stream channels, riparian areas, and other sensitive resources; have properly engineered sediment control structures and design; and have stabilized cut and fill slopes.
>
> <u>Drill Site Construction:</u> Production wells usually require approximately 2 acres (300 feet by 300 feet for a drill pad). The number of wells typically required depends on the resource available. In a reasonably foreseeable scenario, at least

two wells would be expected, and perhaps as many as 10 during the development phase.

Power Plant and/or Direct-Use Facility Construction: Electrical generation plants would range in generating capacity. Small plants are those that generate less than 5 megawatts, while large plants are those in the 25 to 30 megawatt range. The plant and other required facilities would occupy as much as 30 acres. Direct use facilities could include greenhouses, vegetable dehydration plants, swimming pools, or aquaculture installations. These types of facilities could occupy from 5 to 30 acres.

Electrical Transmission Line Construction: Electrical transmission lines could range in length from under a mile to over 50 miles. Transmission line construction requires temporary disturbance associated with pulling and tensioning sites, staging areas, and temporary access roads. Permanent disturbances are associated with access roads, substation locations (usually about 5 acres), and tower sites. The total disturbance area for tower sites would vary depending on the planned capacity of the line and would be fairly insignificant for single-pole tangent structures (perhaps up to 3 feet by 3 feet per structure) or relatively large for lattice tower installations and for point-of-intersection (angle location) towers with guy wires—perhaps requiring up to 900 square feet per structure (30 feet by 30 feet). The number of structures depends on the length of the line, but it is reasonable to assume that for a medium-sized (15 megawatt) plant, a total of 10 acres of disturbance may be attributable to transmission lines.

Miscellaneous Support Facilities: These facilities could include communication installations, septic systems, fresh water distribution facilities, cooling ponds and towers, and other ancillary structures required to operate and maintain primary use facilities. Cooling ponds may occupy around 5 acres for a typical medium-size (15 megawatt) plant (BLM, 2005), while at other facilities they would likely be less than 1 acre in size.

Production Phase (10 to 30+ Years): The production stage involves the continued operation and maintenance of the field(s) and would potentially include the installation of new drill sites, maintenance of existing facilities, waste disposal, and activities associated with geothermal energy production. Surface disturbance would remain limited to that which occurred during the development phase. As new drill sites are developed, old sites would be abandoned and reclaimed.

Close-Out Phase (1 to 5 Years): The close-out phase involves abandonment after production ceases and includes the following discrete operations: Surface equipment removal, capping and cementing drill holes and wells, and surface rehabilitation. All surface disturbances must be reclaimed to BLM standards. Reclamation includes removing all facilities, grading and contouring all surface disturbances to blend with the surrounding topography, and revegetation.

4.3.1.1 Reasonably Foreseeable Development Scenario

Introduction

In 2000, the DOE's Office of Energy Efficiency and Renewable Energy (EERE) initiated its *GeoPowering the West* program in an effort to dramatically increase the use of geothermal energy in the western United States (Geothermal-biz.com 2005 and U.S.DOE 2005). The goals of *GeoPowering the West* include doubling the number of states producing geothermal electricity to 8 by 2006, reducing the cost of geothermal power to 3 to 5 cents per kilowatt hour by 2007, and ultimately providing seven million homes with geothermal energy by 2010. In addition, in 1997, the Nevada legislature established a renewable energy portfolio standard. This standard requires that up to 15% of the total electricity sold would be derived form renewable energy resources. Considering the high potential for further geothermal development in Nevada, it seems quite likely that the state will experience substantial growth in the geothermal energy production industry. BLM Management action and scrutiny will be necessary to provide for future renewable energy growth while protecting sensitive resource values. Development of geothermal resources on federal lands, as described in Section 2.0, is subject to review under NEPA.

The following Reasonably Foreseeable Development Scenario (RFDS) for geothermal resources was developed in the *Geothermal Resources Leasing Programmatic EA* (BLM, 2005) in order to provide a reasonable estimate of anticipated exploration, development and production activity that might be expected over the next 20 years of developing geothermal resources of the Planning Area. Once the anticipated level of activity is determined the RFDS estimates the potential cumulative impacts of surface disturbance and other environmental impacts associated with geothermal development.

Initially the RFDS looks at the location of KGRAs, historical leasing patterns and geologic models to identify favorable and prospective areas for developing geothermal energy within the planning area. The *Geothermal Resources Listing Programmatic EA* (BLM, 2005) identified at least three areas of varying potential within the Planning Area. These include (**Figure 4.5):** 1) the six Known Geothermal Resource Areas (KGRAs); 2) areas with pending lease applications (typically in the vicinity of the KGRAs); and 3) areas identified by the geologic models as being Prospectively Valuable Areas (PVAs) with respect to geothermal development. In all, the largest area of potential within the Planning Area is included within the 13 PVAs that encompass approximately 1.9 million acres and include the six KGRAs (**Figure 4.5**).

The Reasonably Foreseeable Development Scenario presented here envisions that over the next 20 years, exploration drilling would occur on all geothermal leases, some of which lead to more detailed exploration drilling, and a few of which lead to the discovery of geothermal resources capable of developing five 15 Megawatt Geothermal Power Plants. The discussion below looks at the potential surface disturbances from this scenario, and then the other potential environmental impacts from development of the resources.

Surface Disturbance

Exploration: During the exploration stage, surface disturbance is minimal with few adverse impacts until the decision is made to drill one or more exploration wells. An exploration-drilling impact evaluation is shown below (**Table 4-1**) which lists the maximum degree of anticipated surface disturbance expected during this phase.

If we assume that as many as three temperature gradient and/or exploration flow test wells would be drilled on each lease. This would disturb as much as three acres (one acre per drill site). Three new access roads, each a half-mile in length would disturb an additional 1.5 acres. Therefore, the total disturbance per lease is approximately 4.5 acres (**Table 4-1**). Exploration drilling surface impacts are transitory in that unsuccessful exploration programs are abandoned and the surface impacts are reclaimed usually within a two year period. Successful exploration programs lead on through the development process frequently using the surface disturbances created during exploration for some of the development activities. To spite the fact that there may be numerous leases on which exploration drilling takes place, they would not all be drilled

Table 4-1
Geothermal Exploration Drilling Disturbance
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
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Activity	Acres of Disturbance (Acres)	Units per Lease	Total Acres Disturbed Per Lease	Total Acres Disturbed with Two Leases Explored Per Year
Exploration Roads	1 acre/mile	3, ½ mile roads	1.5	3
Shallow Temperature Gradient or Exploration Flow Test Well (several 100 to several 1000 feet deep)	1 acre/drill site	3 drill sites	3.0	6
		TOTAL	**4.5**	**9**

at the same time. If we assume that over the next 20 years 40 geothermal leases are drilled, a total of 120 exploration holes would be drilled. If we assume that these holes would be drilled evenly over the entire 20 year period, six holes would be drilled per year. If we further assume that unsuccessful exploration holes are reclaimed within a two year period, then there would never be more than 12 drill pads disturbed at any one time. **Table 4-1** summarizes anticipated individual and cumulative impacts for the exploration drilling.

***Development*:** The following describes the construction activities required to develop five, 15-megawatt electrical power generating plants, associated wells, pipelines, roads, and electrical transmission lines. The number of wells includes those used for production, standby, and re-injection. Since development is likely to occur in about 5-megawatt increments over a period of several years, the degree of surface disturbance at any given time is less than that presented in **Table 4-2.** Mitigation and enhancement would have occurred in some portions of the lease before additional portions of the lease are developed.

Up to six production or injection wells could be drilled on each lease. Each well pad would disturb approximately 5 acres, and a mainline road would disturb approximately 10 acres. Each of three pipelines would disturb approximately 5 acres and each of three access roads would disturb approximately 7 acres. A power plant would occupy approximately 30 acres, a disposal pond would disturb approximately 5 acres, and a 25-mile transmission line would disturb approximately 10 acres. Total surface disturbance for each plant for this phase of operation would total approximately 121 acres (**Table 4-2**). Again, not all power plants would be constructed at the same time, and construction would likely be staged in 5-megawatt increments.

Table 4-2
Surface Disturbance From Construction of a Geothermal Power Facility
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RMP Planning Area

Facility or Feature	Facility or Features/Plant	Disturbed Acres Per Feature or Facility	Disturbed Acres for Overall Power Plant Infrastructure	Total Disturbed Acres for 5 Power Plant Facilities
Power Plant	1	30	30	150
Wells	6	5	30	150
Cooling Pond	1	5	5	25
Pipelines	3	5	15	75
Access Road (spurs)	3	7	21	105
Mainline Road	1	10	10	50
Transmission Line	1	10	10	50
TOTAL			**121**	**605**

***Schedule*:** The various time frames for a typical geothermal project are estimated as follows:

Exploration: 1 to 5 years
Development: 2 to 10 years
Production: 10 to 30 years (depending on construction time)

Until actual geothermal exploration and development begin, it is difficult to quantify the resource potential and possible future intensified production measures necessary to develop the resources. In order to assess environmental impacts resulting from an action as general as geothermal exploration, development, and production, it is necessary to assume given levels of intensities of such development.

<u>Environmental Impacts</u>

A number of other environmental impacts must be analyzed and evaluated that relate specifically with the construction and operation of the geothermal power generating facility. These are discussed below. In addition, each of these proposed actions from exploration activities to power plant facility construction must undergo a full NEPA impact analysis through either an Environmental Analysis (EA) or Environmental Impact Statement (EIS) process.

<u>Seismic Impacts:</u> In addition to the direct surface disturbance associated with activities occurring during the likely phases of a geothermal lease development scenario, geothermal energy production has been shown to result in minor seismic activity, producing extremely small weak earthquakes. It has also been shown at times to result in land subsidence (Geothermal-biz.com 2004). Maintaining aquifer pressure by re-injecting geothermal fluids can reduce the propensity for subsidence.

<u>Reduction or Elimination of Geysers and Hot Springs:</u> Geothermal energy production may result in the potential destruction of rare geyser activity or surface hot springs valued by recreationalists as a result of changing water levels. Electricity generation from geothermal resources has ended the eruptions from the second- and third-largest geyser fields in the United States. For example, by 1987, the Beowawe Geyser Field in central Nevada and the Steamboat Springs geyser field, located several miles south of Reno, Nevada, no longer supported geyser activity (U.S.DOE 1996). Stipulations have been developed to mitigate these losses (**Appendix C**).

<u>Geothermal Fluid Production:</u> Most geothermal projects have minimal consumptive water use, and need to dispose of large quantities of geothermal water. Production of geothermal fluids could be expected to vary from 1-6 million gallons per day per well. Assuming 5 million gallons per well per day, a lease with two producing wells would produce 10 million gallons of fluid per day. Water disposal may be accomplished by re-injection it back into the aquifer via an injection well, or by direct discharge to either surface waters or land application. Most of the fluids produced are re-injected; however, at flash steam facilities about 15 – 20 percent of the fluid would be lost due to flashing to steam and evaporation through cooling towers and ponds. Fluids could also be lost due to pipeline failures or surface discharge for monitoring/testing the geothermal reservoir. Binary power plants, on the other hand, are non-consumptive and use a closed loop system (BLM, 2005).

Waste Production

Air Quality: Unlike fossil fuel-powered facilities, geothermal facilities do not use combustion as a means to generate power. Therefore, no combustion products such as mercury or dioxin are released to the atmosphere. However, geothermal facilities do emit small amounts of carbon dioxide, sulfur, and nitrogen oxide. About 0.3 pounds of carbon dioxide are emitted for each megawatt hour of electricity generated (U.S. DOE, 1996), sulfur emissions from geothermal facilities are only a few percent of those from fossil fuel powered facilities (U.S. DOE, 1996), and some geothermal facilities release minor amounts of nitrogen-oxide as a by-product of sulfur-dioxide incineration (Geothermal-biz.com 2004).

Solid Waste: Geothermal facilities that utilize cooling towers generate a sulfur-rich sludge that must be disposed of as a hazardous waste (Geothermal-biz.com 2004).

Stipulations

Stipulations are defined as conditions of approval, standard operating procedures, and/or mitigation measures that become part of the BLM's authorization. Stipulations for exploration, development, and production of geothermal leases for the Planning Area (WFO) include those that are site-specific to protect areas or resources of environmental, recreational, or cultural concern. In addition, resource-specific stipulations have been developed to protect water resources; vegetation; riparian areas; existing land uses; wildlife, fisheries, and migratory birds; threatened, endangered, and special status species; wild horses and burros; cultural resources and Native American Indian Traditional Cultural Properties; and paleontology. Hazardous materials and solid waste would also be managed under these stipulations. These site- and resource-specific stipulations are provided in **Appendix C**.

4.3.2 Oil and Gas

Introduction

The Winnemucca Planning Area lies within the Western Great Basin Oil and Gas Province (USGS, 1995). As stated above, US Geological Survey's Central Energy Team provides periodic assessment of the oil and natural gas occurrences and potential for the US, including Nevada. The most recent US assessment was completed in 1995. From the perspective of the USGS and others, the Western Great Basin Oil and Gas Province is thought to be somewhat prospective for hydrocarbons because both source rocks and traps are known to occur within the province. The assessments conducted by the USGS allows them to identify areas of oil or gas potential (plays), and provide others, including the BLM, with the basis to evaluate the effectiveness of available stipulations in balancing the responsible development of those resources with the protection of other valuable resources in the area. These federal lands inventories also allow resource managers to identify areas of low oil and gas potential but high potential for other resources or uses (e.g., wildlife or recreation). These reports are a critical step in evaluating whether existing rules are appropriate, or need to be changed, either to provide greater protection to the environment or to promote appropriate resource development (DOI et al 2003).

The intensity of oil and gas drilling in the future (if any) will be determined by a combination of economic and geologic factors. The fact that the BLM has land available for leasing does not guarantee that oil and gas drilling will occur within the Planning Area. The economics of oil and gas exploration and development are highly variable and play a very large role in determining the likelihood and the number of exploratory wells that will be drilled in a given area. The consistent availability of lands for leasing and exploration also plays a role in how many wells will be drilled. Over the next 15 to 20 years, companies may decide current economics warrant leasing land in the Planning Area, but may or may not warrant drilling.

While the geology itself will not change, the understanding and interpretation of geologic data pertaining to oil and gas exploration and development can change dramatically each time a new drill test is completed. This is especially true in the deep sediment filled basin portions of the WFO Planning Area, where only seven wells have been drilled since 1992. In addition, technological advances occurring over the last ten years, such as horizontal and long reach directional drilling can turn previously uneconomic deposits into viable economic ventures.

Later in this report a reasonably foreseeable development (RFD) scenario will be developed for the Planning Area. To prepare a RFD, assumptions are necessary to deal with geologic uncertainties. The assumptions must be reasonable, supportable, and based on best present knowledge. Earlier in this mineral occurrence report, the general geologic setting for oil and gas resources (section Geologic Setting) and historical exploration activity (section Historical Exploration and Other Activities) of the area were discussed. This, combined with an analysis of geologic occurrence potential and various oil and gas exploration plays will be used to make a reasonable projection of future oil and gas development activity for the Planning Area.

4.3.2.1 Occurrence Potential

Although remarkable advances in the science of petroleum exploration geology have occurred over the last 50 years, geologists cannot be 100 percent certain where hydrocarbons exist until exploratory drilling is performed. Despite this uncertainty, the BLM has been directed by the U.S. District Court and Ninth Circuit Court of Appeals to make the most reasonable prediction of where oil and gas occurrences and subsequent development *may* occur before leasing public lands. These predictions are necessary to evaluate the long-term cumulative impact of an oil and gas leasing decision (Connor V. Burford, 848 F.2d 1441, 9th Cir., 1988).

To provide guidance to planners on possible future oil and gas activity, the BLM uses a two stage mapping process, called 1) occurrence potential and 2) development potential mapping (BLM 2004). Occurrence potential is a measure of the likelihood of an area to contain oil and gas, regardless of current economics and current accessibility to an area. Development potential is the current estimate of the probability that oil and gas drilling will occur in the future in a particular area. Both types of rankings are dynamic and can change as new data become available. In frontier areas (areas with potential but no discoveries or production) like northwest Nevada where drilling is sparse, one discovery well can rapidly change estimates of the occurrence and development potential of an area.

The following factors are evaluated when creating occurrence potential maps: the existence (or lack) of USGS designated oil and gas plays, the thickness of the sedimentary rock package, the existence (or lack) of producing oil and gas fields, the presence (or lack) of buried source rocks with the potential to generate hydrocarbons, the thermal maturity of the source rocks, the presence (or lack) of reservoir rocks (the hydrocarbon "sponge") and the presence (or lack) of adequate hydrocarbon seals and traps.

Specific Oil and Gas Plays

The USGS uses "play analysis" in the preparation of their national oil and gas resource assessments (USGS, 1995a). A play is a set of discovered or undiscovered oil and gas accumulations that exhibit nearly identical geological settings and characteristics. Therefore, a play is defined by the geological properties responsible for the real or potential accumulations of oil and gas resources. Details of the USGS's play analysis are presented in the Occurrence Potential Section of this report (below).

The USGS (1995a) has identified five different hypothetical / conventional oil and gas plays within the Western Great Basin Province. Conventional plays are those in which oil and or gas is generated and migrates from source rocks into traps. Hypothetical plays are those for which the source rocks and stratigraphic traps are known to occur, but for which no discoveries of a certain size (one million barrels of oil, or 7 billion cubic feet of gas) have been discovered, and therefore it remains uncertain if any fields of that size will be discovered in the future. Four of these five plays occur within the Planning Area and have some, albeit low occurrence potential for oil and gas. These plays include: Hornbrook Basin – Modoc Plateau Play (USGS, 1995, play 1801); Eastern Oregon Neogene Basins Play (USGS, 1995 play 1802); Permian-Triassic Source Rocks, Northwestern Nevada, and East-Central and Eastern Oregon Play (USGS, 1995 play 1803); Cretaceous Source Rocks, Northwestern Nevada Play (USGS, 1995 play 1804); and the Neogene Source Rocks, Northwestern Nevada and Eastern California Play (USGS, 1995 play 1804). The basins in which the conditions that define these plays are present are shown on **Figure 4.6**. These plays are described in the sections immediately following this one. Each of these plays has been tested by drilling to some degree, but no commercial production has been established in the Winnemucca Planning Area or in Western Great Basin Province (Barker and others, 1995).

4.6 Oil and Gas Wells and USGS Plays

Hornbrook Basin – Modoc Plateau Play

This hypothetical play is based on the speculative presence of source rocks buried beneath Cenozoic sediments or volcanic rocks of the Hornbrook Basin – Modoc Plateau (USGS, 1995, play 1801) (**Figure 4.6)**. Potential reservoir rock is known to occur as Cretaceous and Tertiary sandstone as well as in fractured volcanic rock. Traps are defined by large anticlinal structures sealed by overlying mudstone units, and host units that are truncated by Basin and Range type faulting (Barker and others, 1995).

There has been no production associated with this play, however, minor shows of biogenetic gas has been noted. Most exploration drill holes do not penetrate the full thickness of near surface volcanics to access the underlying potential sandstone traps; in addition, exploration drilling in the area is sparse (Barker and others, 1995).

Eastern Oregon Neogene Basins Play

This hypothetical play is based on present-day burial of Neogene source rocks and includes structural basins throughout the Winnemucca Planning Area (USGS, 1995, play 1802) (**Figure 4.6)**.

Source rocks are Neogene coals and carbonaceous lacustrine rocks including organic-rich shale. Drilling has indicated that gas shows are common at shallow depths in these basins and are inferred to be of biogenic origin. No production has been established. Quantities of gas have been observed to increase with proximity to igneous intrusions in some areas, suggesting a thermogenic origin for oil and gas at least locally. Cenozoic lacustrine rocks also have occasional gas shows.

Reservoir rocks include Neogene welded tuff and basalt, Miocene fluvial sandstone interlayered with basalt, and upper Miocene and younger fluvial sandstones. Stratigraphic traps exist as porous reservoir rocks enclosed with carbonate- and zeolite-cemented sandstones or where sandstones grade laterally and vertically into mudstone. Structural traps exist as fault truncation of reservoir rocks and locally small closed anticlines. Other traps include open fracture lattices in volcanic rocks, fluvial sandstone lenses between basalt flows, and lenses of diatomite-rich sandstone.

These Tertiary source rocks are apparently locally mature and have produced oil and gas shows. Geothermal convection, shallow intrusives, and fluid flow up basin faults, especially near the graben boundaries, may contribute to thermal maturation of these source rocks. The source rocks in this play may be mature to over-mature in areas of high heat flow and geothermal activity.

Only small reservoirs are expected in this play, but source rock quality and quantity are high and the source rock has generated oil. Although the resource potential is moderate to high, the probability of occurrence within Neogene source rocks plays in the western Great Basin has been estimated to be 0.05 (USGS 1995a).

In addition, modeling (Barker, 1996) suggests that Tertiary source rocks are only locally rich enough to have expelled oil, at a greater than 1 or 2 kilometer burial depth, in areas of suitable heat flow The small reservoirs and traps found to date suggest a small resource potential (Barker and others, 1995).

Permian-Triassic Source Rocks, Northwestern Nevada, and East-Central and Eastern Oregon Play

This hypothetical play is based on present-day deep burial and sealing of Permian-Triassic source rocks in both down-faulted basins (grabens) and horsts blocks of Nevada and Oregon (USGS, 1995, play 1803). Heating due to deep burial, hydrothermal activity, and contact metamorphism is inferred to contribute to petroleum generation in these rocks. The geologic characteristics that define this play are identified in several basins located principally along the southeastern margin of the Planning Area (**Figure 4.6**).

In west-central Nevada, source rocks in these play areas are typically organic-rich marine Permian to Triassic shales (Brown and Ruth Laboratories, 1983). It is also possible that fractured source rocks can locally form reservoirs. Thermal source rock studies indicate most of the Triassic source rocks are over-mature. That is they have generated all hydrocarbon possible and have gone on at higher temperatures to become thermally altered such that the hydrocarbons may not have migrated out of the source rock or into traps, or may not be recoverable by conventional techniques. There is however, considerable evidence of Neogene oil generation and preservation in the sediments of the mountain ranges or adjacent sedimentary basin traps due to lower heat flow (Barker and others, 1994).

Reservoir rocks include Permian to Triassic sandstones and limestones as well as overlying basin-margin alluvial fan deposits and fractured volcanic rocks. Traps have been created by drag folds, truncation related to imbricate thrust sheets in the Fencemaker and Willow Creek thrust systems, or fault truncation within and/or along the margins of the Neogene basins. Seals can be either mudstones and/or fault truncations.

Wells drilled into basins adjacent to the Augusta and Clan Alpine mountain ranges in the southeastern most portion of the Planning Area (**Figures 2.1** and **4.6**) encountered over-mature rocks and gas shows (Garside and others, 1988 and Barker and others, 1994). Geothermal systems, near these wells, are inferred to have caused local maturation of source rocks. An oil show was identified by a mineral exploration well in Buena Vista Valley, near Kyle Hot Springs in Pershing County. The source of this oil show was inferred to be from Cenozoic lacustrine rocks and was observed in fractured Triassic sediments (Schalla and others, 1994). The probability of occurrence of gas within Permian-Triassic Source Rock Play in the Western Great Basin has been estimated to be 0.17 (USGS, 1995) (**Table 4-3**). Overall, this play was assessed a small resource potential due to the limited volume of source rocks (Barker and others, 1995).

Cretaceous Source Rocks, Northwestern Nevada Play

This hypothetical play is based on Neogene to present-day deep burial of Cretaceous source rocks and includes Neogene basins with deep valley fill in northwestern Nevada (USGS, 1995a, play 1804) (Willden, 1979 and Barker and Peterson, 1991). This play is identified in four basins within the Planning Area (**Figure 4.6**).

Source rocks are inferred to be mature and locally over-mature in areas of thermal processes including geothermal activity and high heat flow. Reservoir rocks include lacustrine sediments interbedded with or laterally adjacent to alluvial fans or sandstones deposits and/or fractured Tertiary volcanic rocks. Structural traps likely exist as fault truncation of reservoir rocks. Overlying seals consist of continental evaporites, mudstones, and altered volcanic flows.

Drilling has produced oil and gas shows but no discoveries. The probability of occurrence of gas within the Cretaceous Source Rock Play in the Western Great Basin has been estimated to be 0.08 (USGS, 1995) (**Table 4-3**). This play was assessed as having a small resource potential due to limited volume and marginal quality of the source rock (Barker and others, 1995).

Neogene Source Rocks, Northwestern Nevada and Eastern California Play

This hypothetical play considers Neogene to recent burial of Neogene source rocks in basins with deep valley fill in northwestern Nevada and eastern California (USGS, 1995, play 1805) (Barker and Peterson, 1991). Characteristics of this play can be identified in many of the basins within the Winnemucca Planning Area (**Figure 4.6**).

Reservoir rocks include lacustrine sediments interbedded with or laterally adjacent to alluvial fans and/or fractured Tertiary volcanic rocks. Structural traps likely exist as fault truncation of reservoir rocks. Overlying seals consist of continental evaporites and mudstone-draped sandstones. Tertiary source rocks are locally mature and have produced both oil and gas shows. Maturation and over-maturation of source rocks has occurred in some areas of geothermal activity and high heat flow. Modeling suggests that Tertiary source rocks require burial depths greater than 1 or 2 kilometer and areas of suitable heat flow in order to mobilize oil from the organic–rich sediment sources (Barker, 1996). Hypothetical boundaries for both of the Neogene plays in the Western Great Basin were defined using areas of deep Tertiary-Quaternary fill (1 to 2 km or so) in basins and included extending the play into areas of shallower fill adjacent to areas of deep fill and areas where hydrocarbon shows or seeps are known.

Neogene source rock quality and quantity are high and there is demonstrated oil generation (Schalla and others, 1994), however, the small reservoirs and traps found so far in this play suggest small resource potential. The probability of occurrence of gas within Neogene basin plays in the western Great Basin has been estimated to be 0.06 (USGS, 1995) (**Table 4-3**). This play was assessed (Barker and others, 1995) as having a moderate resource potential but with only small reservoirs being likely.

Occurrence Potential Summary

Areas with the potential for oil and gas occurrence are shown for the entire Planning Area on **Figure 4.6**. On this map both distinct and overlapping play areas having occurrence potential are presented as defined by the USGS (1995). These areas include congressionally designated wilderness areas, since the occurrence potential is based solely on geology, which continues beyond the wilderness boundaries. Areas classified as having a high potential for occurrence of oil and gas are reserved for proven oil and gas producing provinces. There are no areas of "high" oil and gas occurrence potential in the Planning Area. The USGS analysis indicates that the chance for the occurrence of new oil or gas field of a certain size (one million barrels of oil or seven million cubic feet of natural gas) in the Western Great Basin Province study area is low.

USGS Estimated Resources

The geologic play information presented in previous sections (Occurrence Potential, and Specific Oil and Gas Plays) was the basic unit for calculation of resources of oil and gas. Total resources are contained in four different categories: 1) the in-place resource or total amount of oil and gas thought to exist (discovered and undiscovered), 2) technically recoverable resources are the amount of in-place resources expected to be able to be recovered, 3) economically recoverable resources are thought to be able to be recovered at a profit, and 4) drill proven reserves (none in the Planning Area). The actual methodology for estimating reserves was published by the USGS as Circular 1145 in 1998 (Attanasi 1998), but is beyond the scope of this report.

This report presents province level estimates of economic resources by commodity (oil, and gas) in undiscovered conventional oil and gas fields. The resources were calculated in the Western Great Basin Province (USGS 1995) and **Table 4-3** summarizes the reserve component of the national assessment as it applies to this Province. It should be made very clear that the Western Great Basin Province covers a much larger area than the Planning Area and therefore the analysis presented in **Table 4-3** includes land and oil and gas plays not included in the Planning Area. No attempt has been made to quantify actual reserves within the Planning Area. In addition, three of the four plays evaluated were not quantitatively assessed by the USGS (1995) to provide an estimate of the size or number of undiscovered accumulations of oil or gas that can be anticipated. This is because of a high degree of uncertainty associated with one or more of the three components used to provide the basis for assessment. These three components include: the presence of a charge of oil or gas in the source rock, the presence of suitable reservoir rock, and the presence of suitable traps. For the most part in those plays not quantitatively assessed, the probability of the presence of suitable source rocks was rated high (0.8 – 1.0), but the probability of suitable reservoirs or traps was rated fairly low (0.20 to 0.50, and 0.20 to 0.30, respectively). In these cases the USGS has rated the presence of these hypothetical resources as a probability of their occurring at all (**Table 4-3**). Therefore, this USGS analysis indicates that the chance of a new oil or gas field in the Western Great Basin Province study area is low but not impossible.

Table 4-3
US Geological Survey Total Mean Estimated Oil and Gas Resources -Western Great Basin Province
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

	Total Petroleum Systems and Assessment Units	Field Type	Play Probability	Oil MMBO	Natural Gas BCFG
Western Great Basin Province	Eastern Oregon Neogene Basins	Oil and Gas	0.06	Not quantitatively assessed	
	Permian-Triassic Source Pocks	Oil and Gas	0.17	1.4	10.3
	Cretaceous Source Rocks	Oil and Gas	0.08	Not quantitatively assessed	
	Neogene Source Rocks	Oil and Gas	0.05	Not quantitatively assessed	
	TOTAL			**1.4**	**10.3**

[1] Data reported from 1995 assessment (USGS, 1995).

4.3.2.2 Market Potential

Introduction

The Reasonably Foreseeable Development scenario (RFD scenario) is an estimate of oil and gas activity expected to result from oil and gas leasing in the Planning Area. The scenario is hypothetical in that drilling may occur anywhere in the planning area where an oil and gas lease allowing surface occupancy is issued. Actual drilling proposals that result from leasing, if any, will likely differ in location from those anticipated by this RFD scenario. It is also possible that leasing could result in either more or fewer drilling proposals than presented in the scenario.

The RFD scenario attempts to portray the most reasonable and likely number of wells expected from a leasing decision on the Planning Area. It is derived from knowledge of the USGS plays, oil and gas occurrence and development potential classifications for the Planning Area (**Figure 4.6**), Energy Information Administration (EIA) price forecasts, and historical activity.

Development potential is a ranking system, which is created so planners can evaluate the potential cumulative impacts of an oil and gas leasing decision on a designated area. Bureau of Land Management petroleum geologists rank the development potential of the Planning Area based on the probability, at this point in time, of oil and gas drilling occurring in the future. It is important to understand that development potential is a dynamic ranking system, which changes with time as new data and ideas become available. The development potential can also change as a function of the economics of oil supply and demand.

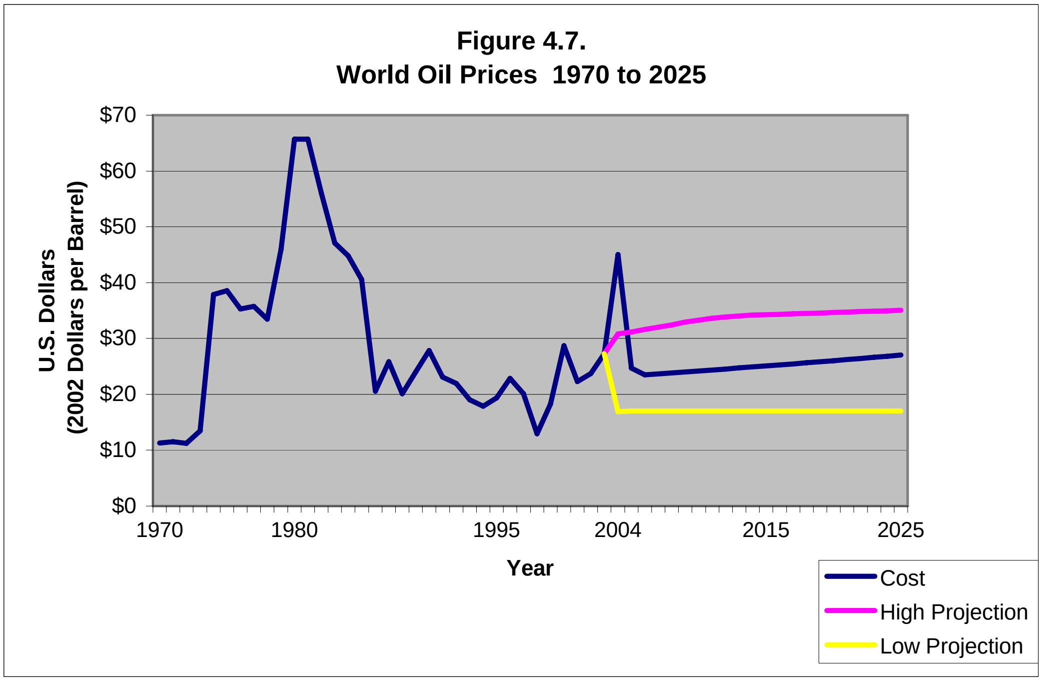
Energy Information Administration (EIA) Price Forecasts

<u>Crude Oil</u>

International Market Conditions

Over the past 25 years, oil prices have been highly volatile and it is expected that price volatility will remain into the future, due to unforeseen natural, political, and economic circumstances. For example, circumstances in the Middle East could create significant disruptions of normal oil production and trading patterns. Conversely, high oil prices may not be sustainable due to decreased consumption and creation of significant competition from marginal (and large) sources of oil and other energy supplies. Low oil prices would have the opposite effect. The world oil price is defined as the annual average U.S. refiner's acquisition cost of imported crude oil (EIA, 2004). **Figure 4.7** depicts past and future estimated oil price to the year 2025 based on EIA's research in 2004 (EIA, 2004).

Figure 4.7 World Oil Prices 1970 to 2025

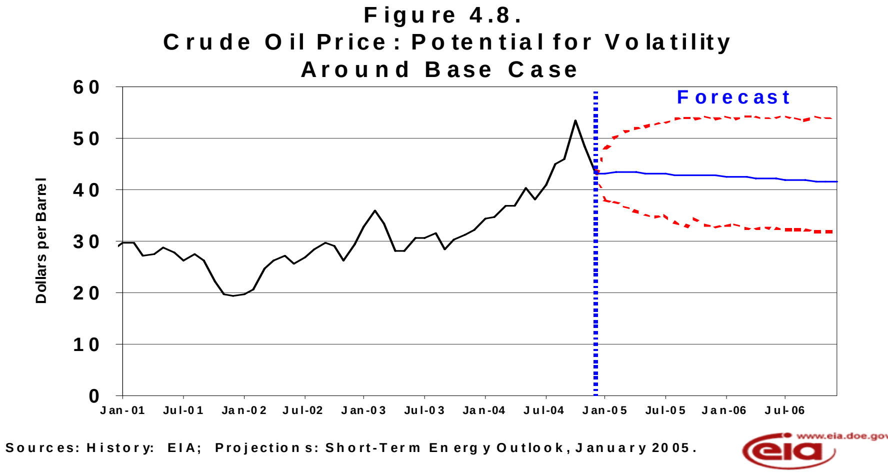


Growth in global oil demand has outstripped that in supply in recent years, decreasing spare production and refining capacities. In addition, prices remained elevated due to surging demand in developing Asia and the situation in Iraq (EIA, 2004).

Three distinct world oil price scenarios are represented in **Figure 4.8** (EIA, *2005a)*. The Cost is the middle trend line and is the United States Energy Information Administration's (EIA) reference case as of early 2005. The trend lines above and below represent high and low cost scenarios.

The average West Texas Intermediate (WTI) crude oil price for the first quarter of 2005 was $49.77 per barrel. WTI prices are projected to remain above $50 per barrel for the rest of 2005 and 2006 (EIA, 2005c). Presently, crude oil futures of $74.61 per barrel, on the New York Mercantile Exchange (NYMEX) (Associated Press, May 2, 2006), substantially exceeds the high cost scenario. In 2004, EIA inferred that OPEC producers, in the mid-term, would adjust production to keep world oil prices in the $22 to $28 per barrel range.

Figure 4.8 Crude Oil Price: Potential for Volatility around the Base Case



OPEC (particularly, the Persian Gulf nations) is expected to be the dominant supplier of oil in the international market in the mid-term, and its production choices will significantly affect world oil prices. The low world oil price case (presented in **Figures 4.7** and **4.8**) represents a future market in which all oil production becomes more competitive and plentiful. The high world oil price case represents a more cohesive and market-assertive OPEC, with lower production goals and other non-financial (geopolitical) considerations. In its revised forecast, EIA expects global crude oil prices to decline modestly this year and next, but remain over $40 per barrel (EIA, 2005). In 2004, world oil demand was about 1.7 million barrels per day.

Worldwide oil demand is forecast to attain 121 million barrels per day by 2025, requiring an increased world production capacity of about 44 million barrels per day over current levels. OPEC producers are expected to be the major suppliers of increased production, but non-OPEC supply is expected to remain significant with major supply coming from offshore resources, especially in the Caspian Basin, Latin America, and deepwater West Africa (EIA, 2004).

Limits to long-term oil price escalation include substitution of other fuels (such as natural gas) for oil; marginal sources of conventional oil that become reserves (i.e., economically viable) when prices rise; and non-conventional sources of oil that become reserves at still higher prices. Advances in exploration and production technologies are likely to bring down prices when such additional oil resources become part of the reserve base. **Figures 4.7** and **4.8** show that low and high world oil price cases suggest the projected trends in growth for oil production are sustainable without severe oil price escalation (EIA, 2004).

The projected increase in oil consumption ranges from a low of 36 million barrels per day in the high price case to a high of 56 million barrels per day in the low price case. There is widespread agreement that resources are not a key constraint on world demand to 2025 (EIA, 2004).

North America's petroleum imports from the Persian Gulf are expected to double over the forecast period. At the same time, more than 50 percent of total North American imports in 2025 are expected to be from Atlantic Basin producers and refiners, with significant increases expected in crude oil imports from Latin American producers, including Venezuela, Brazil, Colombia, and Mexico. West African producers, including Nigeria and Angola, are also expected to increase their export volumes to North America. Caribbean Basin refiners are expected to account for most of the increase in North American imports of refined products (EIA, 2005b).

4.3.2.1 United States Market Conditions

Demand for oil in the United States is projected to increase at an average rate of 1.5 percent per year from 2001 to the end of the forecast, reaching 28.3 million barrels per day in 2025. U.S. petroleum consumption was 20 million barrels per day in 2003 (EIA, 2004).

An average wellhead price for crude oil in the U.S. was $27.56 per barrel in 2003. Projected U.S. crude oil production will increase from 5.7 million barrels per day in 2003 to a peak of 6.2 million barrels per day in 2009 as a result of increased production offshore, predominantly from the deep waters of the Gulf of Mexico. Beginning in 2010, U.S. crude oil production is forecast to decline, falling to 4.7 million barrels per day in 2025 (EIA, 2005b).

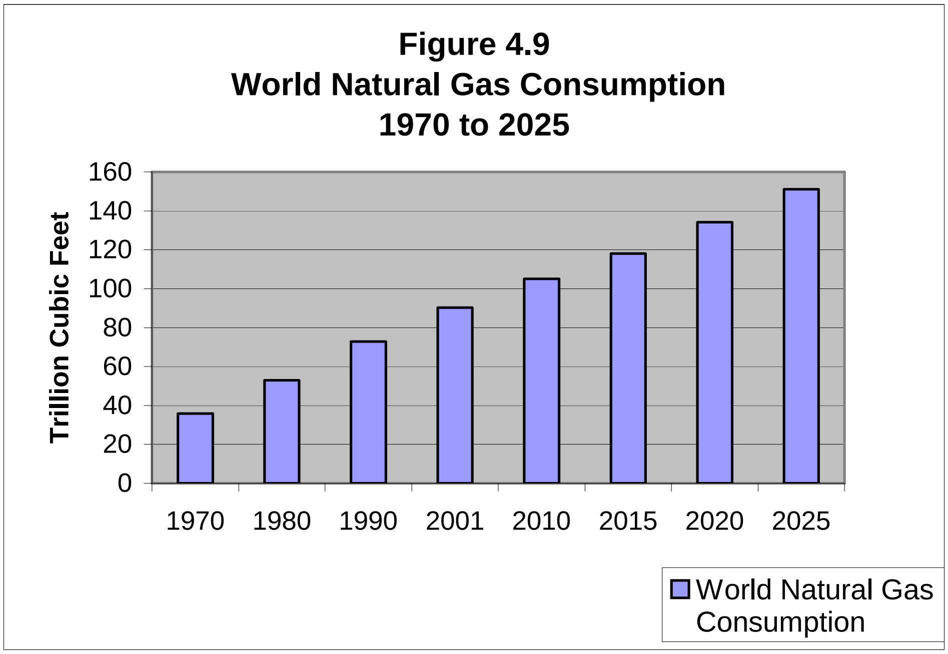
Total U.S. gross petroleum imports are projected to increase from 12.3 million barrels per day in 2003 to 20.2 million barrels per day in 2025. Crude oil will account for most of the increase in imports, because distillation capacity at U.S. refineries is expected to increase and will be 5.5 million barrels per day higher in 2025 than it was in 2003. Gross imports of refined petroleum, including refined products, unfinished oils, and blending components, are expected to increase by almost 60 percent from 2003 to 2025 (EIA, 2005a).

4.3.2.2 Natural Gas

International Market Conditions

Natural gas is expected to be the fastest growing component of world primary energy consumption according to the Energy Information Administration (EIA, 2004) reference case. Consumption of natural gas worldwide is projected to increase by an average of 2.2 percent annually from 2001 to 2025 (**Figure 4.9**), compared with projected annual growth rates of 1.9 percent for oil consumption and 1.6 percent for coal. Natural gas consumption in 2025 is projected to be 151 trillion cubic feet and will be nearly 70 percent higher than the 2001 total of 90 trillion cubic feet. The natural gas share of total energy consumption is projected to increase from 23 percent in 2001 to 25 percent in 2025 (EIA, 2004).

Figure 4.9 World Natural Gas Consumption



The projected increases in world natural gas consumption will require bringing new gas resources to market, and a number of international pipelines are either planned or already under construction. In addition, because many of the natural gas assets of the developing world are remote from major consuming markets, much of the increment in international trade is expected to be in the form of liquid natural gas (LNG). The fact that many sources of natural gas are far from demand centers, coupled with cost decreases throughout the LNG chain, has made LNG increasingly competitive, contributing to the expectation of strong worldwide growth in LNG trade (EIA, 2004).

In the industrialized world, natural gas reserves increased by 0.7 trillion cubic feet between 2003 and 2004. While North America recorded growth of 8.6 trillion cubic feet, Western Europe's reserves declined by 6.1 trillion cubic feet.

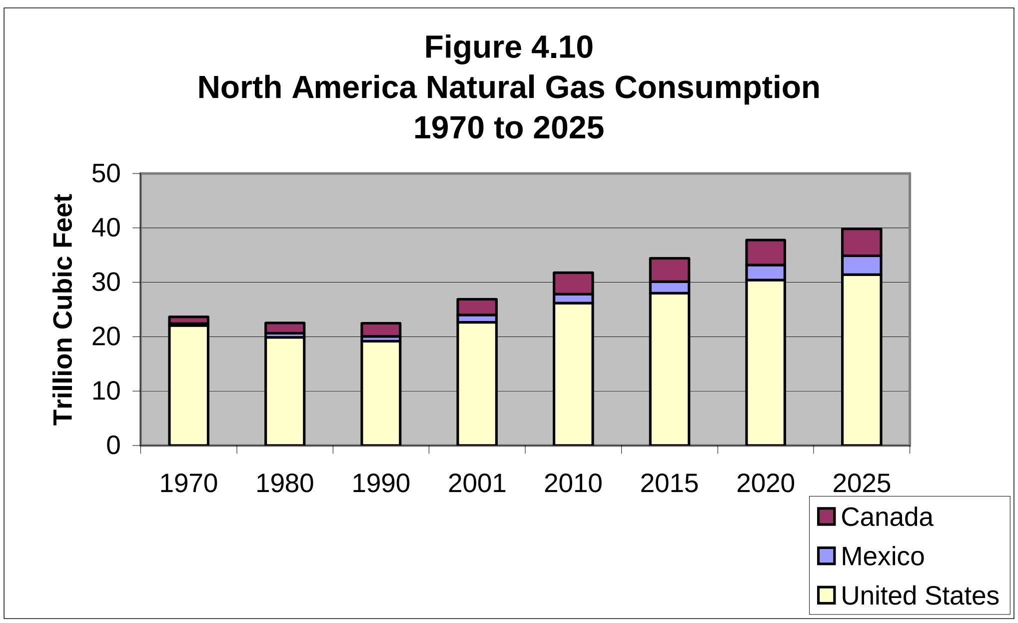
Despite high rates of increase in natural gas consumption, particularly over the past decade, most regional reserves-to-production ratios have remained high. Worldwide, the reserves-to-production ratio is estimated at 60.7 years with the Middle East's reserves-to-production ratio exceeding 100 years (EIA, 2004).

Although the United States has produced more than 40 percent of its total estimated natural gas endowment and carries less than 10 percent as remaining reserves, in the rest of the world reserves have been largely unexploited. Outside the United States, the world has produced less than 10 percent of its total estimated natural gas endowment and carries more than 30 percent as remaining reserves (EIA, 2004).

United States Market Conditions

Although the United States holds only 3.1 percent of the world's natural gas reserves, it consumed more than any other country in 2001. With U.S. production projected to grow more slowly than its consumption, it is expected to import more natural gas, most of which is expected to be in the form of LNG. U.S. production of natural gas in 2003 was about 19 billion cubic feet and its consumption was about 22.4 billion cubic feet (**Figure 4.10**). Total net imports are projected to supply 21 percent of total U.S. natural gas consumption in 2010 (5.5 trillion cubic feet) and 23 percent in 2025 (7.2 trillion cubic feet), compared with recent historical levels of around 15 percent. Nearly all of the increase in net imports, from 3.6 trillion cubic feet in 2002, is expected to consist of LNG. LNG imports already have doubled from 2002 to 2003, based on preliminary estimates that show LNG gross imports at 540 billion cubic feet in 2003, compared with 228 billion cubic feet in 2002. Strong growth in LNG is expected to continue throughout the forecast period, with LNG's share of net imports growing from less than 5 percent in 2002 to 39 percent (2.2 trillion cubic feet) in 2010 and 66 percent (4.8 trillion cubic feet) in 2025 (EIA, 2004).

Figure 4.10 North American Natural Gas Consumption



Average wellhead prices for natural gas in the U.S. are projected to generally decrease, from $4.88 per thousand cubic feet (TCF) in 2003 to $3.64 per TCF in 2010 as the initial availability of new import sources and increased drilling expands available supply. After 2010, wellhead prices are projected to increase gradually to $4.79 per TCF in 2025. Presently, natural gas futures of $6.75 per thousand cubic feet (TCF), on the New York Mercantile Exchange (NYMEX) (Associated Press, May 2, 2006), substantially exceeds the high cost scenario. Growth in LNG imports, Alaska production, and lower 48 production from non-conventional sources are not expected to increase sufficiently to offset the impacts of resource depletion and increased demand (EIA, 2005a).

4.3.2.3 Nevada Market Conditions

The State of Nevada produced 493,330 barrels of oil in 2003 (Davis, 2004). Nevada ranked 26th out of the 31 oil producing states. The average wellhead price for crude oil from Nevada was $24.54 per barrel. No producing fields exist in the Planning Area.

Economics of the 1995 USGS National Oil and Gas Resources Assessment

Information presented earlier in this report (**Table 4-3**) summarized the geologic and reserve components of the 1995 oil and gas resource assessment (USGS 1995) as it applies to the Western Great Basin Province. This section summarizes the economic component of the national assessment as it applies to the Province area. Once again, the reader should be aware that both Western Great Basin Province covers a much larger area than the Winnemucca FO Planning Area and therefore the following analysis includes land and oil and gas plays not included in the Planning Area.

A summary of the methodology used to evaluate the economic component was published by the USGS as Circular 1145 in 1998 (Attanasi 1998). This Mineral Assessment Report presents Province level estimates of economic value of resources for the oil and gas commodities. The analysis uses the anticipated median value of these commodities over the next 20 years presented in the economic analysis above and the USGS Mean Total Resources (**Table 4-3**). The estimated value by commodity (oil and gas) in undiscovered conventional oil and gas fields in the Western Great Basin Province is presented in **Table 4-4**. This estimate uses average estimated cost of $4.80/ MCF for gas, and $40 / barrel for oil, the average estimates by the Energy Information Agency for the next 20 years (through 2025).

Table 4-4
Oil, Gas and Natural Gas Liquids Value Estimates in Billions of Dollars, Western Great Basin Province
Mineral Assessment Report Winnemucca Field Office – EIS / RMP RMP Planning Area

Province	Value of Oil $40 /barrel ($ million)	Value of Gas $4.80 /MCFG ($ million)
Western Great Basin	$ 56	$ 49.5

Circular 1145 (Attanasi 1998), points out that anticipated improvements in technology can increase the quantity of resources found and developed at almost every cost level. This USGS analysis indicates that the chance of discovering new oil or gas fields in the study area is low but not impossible.

Recent Leasing and Drilling Trends

Historical leasing and drilling trends have been discussed above in the Historical Exploration and Other Activities section. In summary, at the present time, there are a total of four active authorized oil and gas leases on BLM lands within the boundaries of the Planning Area covering 5,055 acres (2,046 hectares). A number of oil and gas parcels, totaling approximately 244,000 acres of public land in the northeast part of the Carson Sink area (see oil and gas competitive lease area on **Figure 4.6**), were offered for lease sales during March of 2006. There were no bids on any of these lands likely due to very strict resource protection Lease Stipulations attached to the parcels. None of these parcels were offered for lease sales in either the June or September 2006 offering.

A total of nine oil and gas exploration wells have been drilled since 1992 (one as recently as 2004) and three new wells are permitted for drilling in 2005 (**Table 3-7).**

In addition, several of wells have been drilled in hypothetical oil and gas potential area locations identified by the USGS (**Figure 4.6**); however, no commercial production has been established within the Western Great Basin Province.

A summary of these wells includes the following:

- Sun Exploration and Production Company drilled Sun #1-17 King Lear-Federal in East Arm of the Black Rock Desert in 1983. The well was drilled to 7,931 feet depth and was plugged and abandoned.

- Amoco Production Company drilled the Standard-Amoco #1 in the northeastern part of the Carson Sink, just south of the Winnemucca District boundary (near a proposed oil and gas competitive lease sale area). The well was drilled to a total depth of 11,000 feet and was plugged and abandoned.

- Arco Oil and Gas Company drilled the ARCO #1 Tobin in the north end of Dixie Valley in **1984**. The well was drilled to a total depth of 2,065 feet and was plugged and abandoned.

- Since **1994**, six oil and gas exploration wells have been drilled on federal leases in the north end of Buena Vista Valley, near Kyle Hot Springs. There has been no production from this area.

- BLM Winnemucca Field Office processed 3 Applications for Permit to Drill oil and gas exploration wells in the Kyle Hot springs area. One of these was drilled in December 2004. Testing of this well is pending. A second well was scheduled to be drilled in January 2005. There has been no production from this area.

To spite the rather small reserve potential (**Table 4-3**) it is the oil and gas shows and the relatively unexplored nature of the Western Great Basin Provinces, that draws companies to lease land, despite the high cost of drilling, the high risk of failure, and complex geological conditions. These factors combined with changing economic or supply and demand conditions will undoubtedly provide at least a limited interest in leasing and drilling activities within the WFO Planning Area for the foreseeable future.

Historical State and County Oil and Gas Royalty Income

In 2001, the BLM collected some $7,203,462 in proceeds in the State of Nevada from both Production Royalties (oil, gas, and geothermal) and rents, of this total $3,502,543 was dispersed back to the State of Nevada. **Figure 4.11** shows the oil and gas royalties for the State of Nevada from 1954-2000. There is no oil and gas production in the counties within the Planning Area, so excluding geothermal resources in Churchill and Washoe Counties, most of the money generated in these counties is from rent agreements for leases. **Table 4-5** demonstrates this aspect of the financial impact of historical oil and gas, and geothermal leasing in the counties of the Planning Area. This table shows the total oil and gas, and geothermal leasing revenue collected by BLM and the amount dispersed back to the State of Nevada by county within the Planning Area. The information on income to the Treasury and the State is provided by the Minerals Management Service (http://www.mrm.mms.gov/Stats/fmrd.htm). Information on income is not available before 1987 nor after 2001.

4.11 Federal Oil Royalties for Nevada 1954-2000

Table 4-5
BLM Lease Royalties Dispersed to State and Counties
1996 – 2001
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

County	Total Royalty Value to BLM by County	Amount Dispersed to State by County
Churchill	$ 433,111	$ 216,643
Humboldt	$ 15,738	$ 7,869
Pershing	$ 389,778	$ 188,888
Washoe	$ 80,677	$ 40,315

4.3.2.3 Reasonably Foreseeable Development Scenario

Development Potential Rankings

Development potential is not a prediction of precise future drilling locations and should not be used as a gauge of future interest or lack of interest in leasing. Oil and gas companies have numerous sources of proprietary data not available to the BLM (such as seismic data or internal geologic reports), which they use prior to making financial commitments to lease or drill. Therefore, even though an area is rated as very low development potential at this time with a low probability for any wells being drilled, a company may still be interested in leasing that area, should it be made available.

The analysis of potential for development of oil and gas resources within the Planning Area is based on bedrock geologic mapping, geophysical data and 47 oil and gas tests drilled in the Planning Area (**Table 3-7**). The areas with potential for the occurrence of oil and gas resources within the Planning Area are shown on **Figure 4.6**.

Figure 4.6 is a map depicting development potential for oil and gas resources within the Planning Area. On this map development potential ranges from moderate to very low. As with the occurrence potential, there are no areas of "high" development potential within the Planning Area. High development potential areas occur only within proven producing petroleum provinces or in areas with a significant number of hydrocarbon "shows". Areas of moderate development potential have a significant thickness of sedimentary section present that includes possible source and reservoir rocks. These areas correspond to the USGS (1995) play areas.

Within the Planning Area, areas having a low potential for development typically have a thin sedimentary section present. They may also have limited source rock potential because of shallow burial and/or limited reservoir potential. Areas of low potential are also used to designate areas where there is insufficient data available to analyze the potential. Areas of low potential occur adjacent to areas of moderate potential in the Tertiary basin of the Western Great Basin Province.

An area of very low development potential lacks source or reservoir rocks or is an area predominantly underlain by metamorphosed or intrusive terrane. Areas of very low potential have no sedimentary source rock section thought to be capable of generating oil or gas and/or very limited reservoir potential.

Drilling Activity Forecast

In order for the BLM to be able to analyze the effects of oil and gas leasing, and possible impacts related to exploration, development, and cumulative effects, it is necessary to estimate how many wells industry might drill in the next 15 to 20 years within the WFO Planning Area. The following RFD scenario has been developed using historical oil and gas development, and oil "play" information from the US Geological Survey, potential development map (Figure 4.6) and other data from BLM files, and a number of other technical sources.

The Neogene Source Rock Play areas (**Figure 4.6**, green outlined areas) have a moderate to high resource potential; that is, they have a high probability (0.8 to 1.0) of a suitable oil and gas charge occurring in the source rock (USGS, 1995). Even though the probability of occurrence of suitable reservoir rock and traps in the Neogene Basins Play areas (yellow outlined areas) is relatively low (0.2-0.5) (USGS 1995), it is estimated that as many as twelve wildcat wells (wells drilled in areas with no previous production) may be drilled in these Neogene Basins in the next 15 to 20 years. Many of the initial twelve wells would likely be located in the Buena Vista Valley and Kyle Springs areas (**Figure 4.6**). Of these twelve wells it is estimated that 10 will be dry holes (no economically producible oil or gas is discovered). Dry holes would be plugged and abandoned with surface reclamation occurring shortly afterward.

It is further estimated that two of the wells drilled in the southeast portion of the Planning Area, probably in the vicinity of the relatively recent leasing activity and within the area nominated for Oil and Gas Competitive Leasing, will produce a discovery **(Figure 4.6**). Each of the discovery wells would probably prompt additional step-out wells. A "step-out well" is a well drilled adjacent to or near a proven well to establish the limits and continuity of the oil or gas reservoir and/or to assist with production. It was estimated that a total of four (4) step-out wells would be drilled, two for each discovery. Finally, it is estimated one of the discoveries (including the two step-out wells) would have limited oil production and occur on BLM administered lands.

The general geographic areas within the Planning Area, where oil and gas exploration is predicted to occur are on **Figure 4.6**. Each of the areas is associated with an area identified as a Neogene Basin or Neogene Source Rock Play area described above in the section entitled USGS Hydrocarbon Provinces and Plays. It is anticipated that the 12 projected wildcat wells would be drilled somewhere within the basin boundaries of these four play areas with discoveries likely in the Buena Vista Valley area (in the area currently nominated for Oil and Gas Completive Leasing (**Figure 4.6, Table 4-6**).

Table 4-6
Drilling Activity Forecast (RFD)
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

Area	Wildcat Wells	Discoveries	Step-out Wells	Commodity
Neogene Basins	12			
Buena Vista Valley Area		2	4	oil or gas
TOTAL	**12**	**2**	**4**	oil or gas

Surface Disturbance Impacts

Construction of temporary road access and a drilling location for each wildcat well may disturb about 6 acres for each wildcat well, or 48 acres for all the wildcat wells. No discoveries of commercial quantities of oil or gas are anticipated during the next 10 to 15 years.

This section of the Reasonable Foreseeable Development Scenario describes the anticipated disturbances associated with the Drilling Activity Forecast (**Table 4-6**) predicted in the preceding section. **Table 4-7** describes the tasks involved and the surface disturbances that are likely to result from the successful and unsuccessful drilling of wildcat wells, development or step-out drilling, and field production activities of the Winnemucca RFD drilling forecast. The number of acres of disturbance estimated relies on data derived from wildcat well drilling elsewhere within the Planning Area and on existing small scale production from fields developed elsewhere in Nevada. Reclaimed acres (regraded and seeded) are assumed to be stabilized after 2 years.

Table 4-7
Estimated Cumulative Impacts of Oil and Gas Exploration and Development (RFD)
Mineral Assessment Report Winnemucca Field Office – EIS / RMP
RMP Planning Area

<table>
<tr><th>Type of Disturbance</th><th colspan="2">Required Tasks</th><th>Acres Disturbed Pre-Site Reclamation</th><th>Acres Disturbed Post-Site Reclamation</th></tr>
<tr><td rowspan="2">Ten (10) Unsuccessful Wildcat Wells</td><td colspan="2">Well Site - Maximum area of 3.6 acres (about 380 ft. x 400 ft.) cleared per well pad.</td><td>35</td><td>0 (2 years)</td></tr>
<tr><td colspan="2">Access Roads – 40 ft. width x lineal footage (3.6 miles or 18,480 lineal feet) or about 17 acres per well site.</td><td>170</td><td>0 (2 years)</td></tr>
<tr><td rowspan="4">One (1) Well Drilled with a Gas Field Discovery Two (2) Step-out Wells Drilled with No Production because of distance to Gas Transmission Lines</td><td colspan="2">- Gas field would be discovered in the Buena Vista Valley west of the East Range (Field would be approximately 3 square miles in surface area).
- Compressor stations would normally be necessary along the feeder pipeline route but the distance to the main transmission line is too long, and the field is shut in.
- Condensate, gas, and water separation would occur at the well sites, during production testing. Water disposal would be into a lined pit at the surface or water would be injected into the subsurface through a dry hole converted into a water disposal well. Gas would be flared. Condensate would be shipped by truck (1 truck every 4 days).</td><td>Not Applicable</td><td>Not Applicable</td></tr>
<tr><td rowspan="3">1 discovery well

- 2 additional step out wells per discovery well</td><td>Well Site - Maximum area of 3.6 acres (about 380 ft. x 400 ft.) cleared per well pad.(3 wells total)</td><td>10.5</td><td>3.6 (2 years)</td></tr>
<tr><td>Access Roads – 40 ft. width x lineal footage.
• 1 at 17 acres (3.6 miles long)
• 2at 7.3 acres (1.5 miles long)</td><td>31.6</td><td>16.7 (2 years)</td></tr>
<tr><td>Pipelines – no production, none required
- Trunk lines to existing transmission lines – 25 ft. width x lineal footage (35 miles long).
- Field gathering pipelines will follow access roads and no additional disturbance will result.</td><td>0</td><td>0 (2years)</td></tr>
</table>

Table 4-7 (continued) **Estimated Cumulative Impacts of Oil and Gas Exploration and Development (RFD)**				
Type of Disturbance	**Required Tasks**		**Acres Disturbed Pre-Site Reclamation**	**Acres Disturbed Post-Site Reclamation**
One (1) Oil Field Discovered and Brought into Small Scale Production	- An oil field is possible in the Kyle Springs area - Field would be approximately 1 ½ square miles in surface area. - Oil would be transported by truck to refining facility. - Oil, gas, and water separation would occur at the well sites. Water disposal would be into a lined pit at the surface or water would be injected into the subsurface through a dry hole converted into a water disposal well. Gas would be used on lease to separate oil and water and to heat oil. Gas not used on lease would be reinjected into the formation for pressure maintenance or would be vented / flared to the atmosphere. If sufficient gas quantities are produced this gas may also be captured and sold. For this analysis all unused gas is assumed to be reinjected for pressure maintenance.		Not Applicable	Not Applicable
	- 3 commercially productive wells (one discovery and two step-out wells)	Well Site - Maximum area of 3.6 acres (about 380 ft. x 400 ft.) cleared per well pad.	10.5	3.6 (2 years)
		Access Roads – 40 ft. width x lineal footage. • 1 at 17 acres (3.6 miles long) • 2 at 7.3 acres (1.5 miles long)	31.6	16.7 (2 years)
		Pipelines - Field gathering pipelines will follow access roads and no additional disturbance will result.	0	0

4.3.3 Leasable Minerals Potential

The potential for development of leasable industrial rocks and mineral resources of the WFO Planning Area are summarized below. These include the following: sodium minerals (including salt), and sulfur.

Sodium Minerals (salt)

There is good potential for the development of salt deposits in the Planning Area. The salt deposits occur in the playas of which the Planning Area has several (**Figure 1.1**). Although there is no current production of salt in the Planning Area, former salt mines include White Plains, Carson Sink, and Eagle Marsh in Churchill County and Buffalo Springs in Washoe County (Nash, 1996) (**Figure 3.6, Table 3-6**).

Sulfur

There is low potential for the development of fumarole-related, sulfur deposits in the WFO Planning Area. This is because fumarole environments have been thoroughly prospected for gold-silver-mercury deposits. Undiscovered deposits within 200 meters of the surface are predicted to either be small or buried by younger alluvium. Fumarole sulfur deposits tend to be small in size and can be rich in metals that are costly to remove. An economic deposit must be near an efficient transportation route (Nash, 1996).

There are several mines that produced sulfur as a by product of gold and/or silver ores in the Planning Area. These include Sulfur in Humboldt County, Humboldt House (also known as Imlay) in Pershing County, and San Emidio in Washoe County (Papke and Castor, 2003; Tingley, 1998). Due to the high operating cost necessary for their development, and a technology generally incompatible with heap leach gold recovery operations at large gold mining operations, it is not likely that further large scale development of secondary sulfur mineral deposits will occur in Planning Area.

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