**US Department of the Interior**
**Bureau of Land Management**
**Carson City District**

Resource Management Plan Revision and
Environmental Impact Statement

# *Mineral Potential Assessment Report*

**June 2013**

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# ACRONYMS AND ABBREVIATIONS

| | Full Phrase |
|---|---|
| BIA | Bureau of Indian Affairs |
| BLM | US Department of the Interior, Bureau of Land Management |
| BOR | US Department of the Interior, Bureau of Reclamation |
| CCD | Carson City District |
| CDFW | California Department of Fish and Wildlife |
| CFR | Code of Federal Regulations |
| DOE | Department of Energy |
| DOI | United States Department of the Interior |
| EA | environmental assessment |
| EIS | environmental impact statement |
| FLPMA | Federal Land Policy and Management Act of 1976 |
| GIS | geographic information system |
| MOU | memorandum of understanding |
| NBMG | Nevada Bureau of Mines and Geology |
| NEPA | National Environmental Policy Act of 1969 |
| NOI | notice of intent |
| NURE | National Uranium Resource Evaluation |
| REE | rare earch element |
| RMP | resource management plan |
| ROD | record of decision |
| USFWS | US Fish and Wildlife Service |
| USFS | US Forest Service |
| USGS | US Geological Survey |

# EXECUTIVE SUMMARY

The Bureau of Land Management (BLM) Carson City District (CCD) is revising the district's resource management plan (RMP). As part of the process, the BLM is required to prepare a mineral potential report providing information about mineral occurrences and their potential to occur within the CCD planning area.

This report provides an intermediate level of detail for mineral assessment, as prescribed in BLM Manual 3060 (BLM 1994). Information presented in this report will be summarized and incorporated into an environmental impact statement (EIS) for the proposed and final RMPs.

The geologic history of central and western Nevada is very complex and the rocks record a history that reaches back more than 600 million years (Ma) to the Late Proterozoic. Until late Devonian time, the area of western Nevada was west of the continental shelf and received eugeoclinal facies (western assemblage); central Nevada, on the continental shelf, received miogeoclinal facies (eastern carbonate assemblage. A shift to eastward compressional tectonics resulted in accretion of oceanic crust onto the shelf and over the craton. This occurred first in the Roberts Mountain Thrust of the Antler orogeny during the Middle Paleozoic. This was overlain and abutted by the Golconda Thrust during the Sonoma orogeny at the end of the Paleozoic and finally by the Luning-Fencemaker thrust during the Middle Jurassic to Early Cretaceous.

Only a few Paleozoic rocks, are represented in the planning area, mainly in southern and southeastern Mineral County. During the Late Triassic, the Pacific crust (Farallon Plate) began subducting, at first at a high angle, and then, beginning in the Upper Cretaceous, at a shallower angle. The high angle subduction resulted in development of a long Cordierran magmatic arc along the continental margin, including emplacement of the Sierra Nevada batholith, the Yerington batholith, and other plutons. The compressional tectonic regime and magmatism migrated eastward into Colorado during this period, but it gradually subsided. With the end of plate subduction in the Mid-Eocene, compression changed to extension, accompanied by low-angle listric and detachment faulting across the insipient Basin and Range Province.

There followed a sweep of Lower Miocene, predominantly felsic calc-alkaline volcanism southward across Nevada, which terminated along the eastern margin of the Sierra Nevada. Extension within the Great Basin resulted in north- to northwest-trending, high-angle, block faulted and tilted ranges. It also resulted in a transition to bimodal rhyolite and basalt volcanism, with increasing amounts of basalt. Transitional between the Sierra Nevada batholith and the Basin and Range, strike-slip faulting developed within the Walker Lane and took up some of the relative plate motion. This formed a zone of thin crust and high heat flow that extends across most of the planning area.

The regional and local geologic setting has been instrumental in the location of and potential for numerous economic metallic mineral deposits in the planning area, as well as development of economic geothermal resources. Magmatic intrusions carried hydrothermal fluids, rich in metals, high into the crust formed of carbonate-poor to carbonate-rich volcaniclastic rocks of accreted terranes and of newly deposited volcanics and physically and chemically distributed them. Subsequent rhyolitic volcanism associated with extension continued to inject fluids into the country rock, and superheated geothermal fluids circulated, creating mineral enriched or depleted zones. Block faulting and tilting then exposed the mineralized rocks, and weathering and supergene processes resulted in further mineral concentrations and additional mineral species.

## Mining And Mineral Activity In The Planning Area

Mining in the planning area dates back to the 1850s, starting with the discovery of the Comstock Lode deposits of gold and silver in Virginia City (Tingley 1990). The Comstock Lode deposits became one of the first mining districts of Nevada. Mineral deposits were found throughout the planning area, and eventually more than 128 mining districts were established for mining such materials as gold, silver, copper, lead, mercury, gypsum, and diatomite (Tingley 1998). The mining boom for the planning area lasted roughly 50 years. It has slowed considerably since 1900 due to more deposit discoveries in eastern and central Nevada, but activity still persists in the planning area (Tingley 1990). **Figure S-1**, Active Mines in the Carson City District, shows some of the locations and types of mineral activities in the planning area.

Mining and exploration and development of geothermal resources are some of the multiple uses in the planning area. Currently in the planning area, there is one gold and silver operation, one magnesium compound operation, four diatomite operations, one gypsum operation, two perlite operations, and two carbonate minerals operations. Approximately 23 plans of operation for

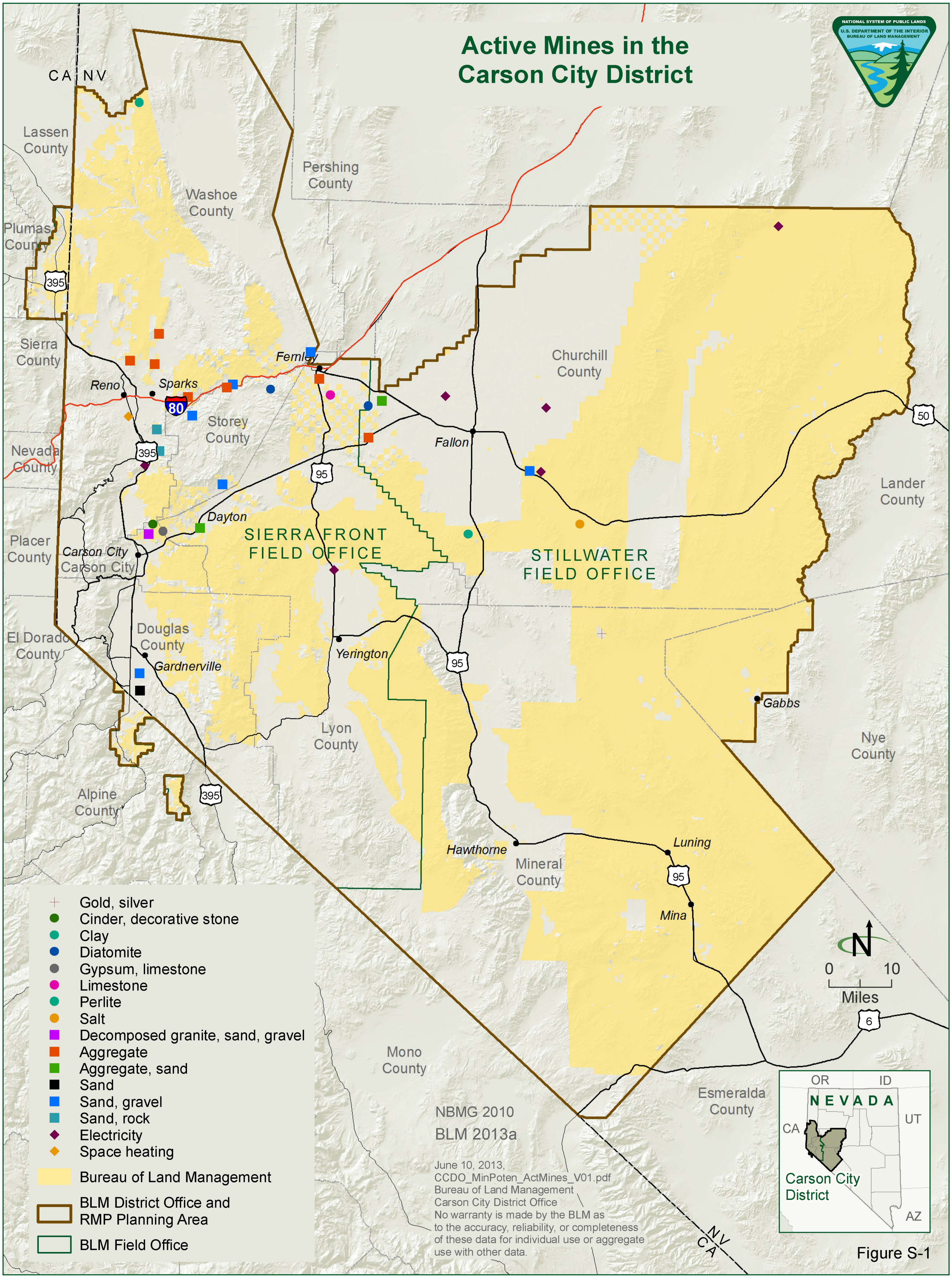
Active Mines in the
Carson City District
CA NV
Lassen County
Pershing County
Washoe County
Plumas County
395
Sierra County
Fernley
Reno
Sparks
80
Storey County
Nevada County
395
Churchill County
Fallon
50
95
Lander County
Dayton
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
Placer County
Carson City
Carson City
El Dorado County
Douglas County
Gardnerville
Yerington
95
Gabbs
Lyon County
Nye County
Alpine County
395
Hawthorne
Mineral County
Luning
95
Mina
0 10
Miles
6
Mono County
Esmeralda County
NBMG 2010
BLM 2013a
June 10, 2013,
CCDO_MinPoten_ActMines_V01.pdf
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
NV CA
OR ID
NEVADA
CA UT
Carson City District
AZ
Gold, silver
Cinder, decorative stone
Clay
Diatomite
Gypsum, limestone
Limestone
Perlite
Salt
Decomposed granite, sand, gravel
Aggregate
Aggregate, sand
Sand
Sand, gravel
Sand, rock
Electricity
Space heating
Bureau of Land Management
BLM District Office and RMP Planning Area
BLM Field Office

Figure S-1

exploration (greater than 5 acres) or mining are currently administered by the BLM within the planning area. The minerals program administers three active competitive contracts for salable minerals operations removing more than 200,000 cubic yards annually, and more than 260 contracts or free-use permits for smaller volume salable minerals operations. There are 148 geothermal leases covering approximately 299,195 acres, with five associated power plants and an active geothermal power production of 183 megawatts.

**Leasable**

Leasable minerals, as defined by the Mineral Leasing Act (February 1920; 43 CFR, Parts 3000-3599, 1990), include the subsets leasable fluid and solid minerals. Leasable fluid minerals include oil and gas and geothermal resources, and leasable solid minerals include coal, oil shale, native asphalt, phosphate, sodium, potash, potassium, and sulfur.

There are no known phosphate deposits or oil shale and natural asphalt in the planning area due to incorrect geologic history and setting for these resources to form. Sulfur occurs in small deposits across the planning area and across Nevada as it is associated with precious metal deposits, evaporite deposits, hydrothermal and geothermal systems, and volcanic deposits. Sulfur is widely distributed in many minerals, including pyrite, galena, gypsum, cinnabar, stibnite, and barite. Large sulfur deposits have not been documented within the planning area boundary, but there are several mines near the boundary.

Significant geothermal resources are found throughout the planning area, particularly in Dixie Valley, Edwards Creek Valley, Carson Desert and the Salt Wells area in Churchill County, the Steamboat Hills area in southern Washoe County, Wabuska in Lyon County, and the Hawthorn and Gabbs Valley areas in Mineral County (Penfield et al. 2010; Map 161 from NBMG).

The CCD has three areas of historical potash production, none of which are currently producing. Sodium minerals were mined in several locations in the planning area and included sodium chloride (six areas), sodium sulfate (four areas), and sodium carbonate (two areas; Tingley 1998; Papke and Castor 2003).

There are limited coal resources in the planning area, and currently there is no effort to explore for or lease areas with potential coal deposits. Oil and gas exploration and development has also been limited.

**Locatable**

Locatable minerals are those for which the right to explore, develop, and extract on federal land open to mineral entry is established by the location (or staking) of lode or placer mining claims (General Mining Law of 1872, as amended). Locatable minerals are divided into metallic minerals and industrial minerals. Examples of metallic minerals that have been historically mined and are currently being mined in the planning area are gold, silver, copper, molybdenum, tungsten, iron, and uranium. Examples of industrial minerals are gypsum, barite, diatomaceous earth, and fluorspar.

There is high potential for metallic minerals in the planning area such as gold and silver as well as copper, iron, lead/zinc, tungsten and gemstones. There is also some high potential in the planning area for locatable industrial minerals such as magnesium, barite, flourspar, gypsum, carbonate minerals, and diatomite.

**Saleable**

Salable minerals, or mineral materials, are sand and gravel, aggregates, dimension stone, petrified wood, cinders, clay, pumice, and pumicite, as described under the Mineral Materials Act of 1947 and the Surface Resources Act of 1955. There is one active plan of operation for pumice and cinder in the planning area, but current or historical production levels are not recorded. In the planning area there is one active clay mine and numerous aggregate pits (in excess of 260 authorized saleable mineral contracts or free-use permits). The planning area is considered to have high potential for aggregate materials, and the western portion has been documented to have reserves of high quality, undeveloped aggregate resources. Although the eastern portion of the planning area has not been thoroughly reviewed, geologic conditions are similar, to the western portion and the BLM-administered lands have vast amounts of permissible tracts for sand and gravel exploration in every basin or valley within the planning area.

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# SECTION 1
# INTRODUCTION

## 1.1 PURPOSE AND SCOPE

The United States Department of the Interior, Bureau of Land Management (BLM) Carson City District (CCD) is preparing a comprehensive resource management plan (RMP) and associated environmental impact statement (EIS) to guide management of BLM-administered land (including surface lands and federal minerals) in the CCD. The RMP/EIS will replace the Carson City Field Office Consolidated Resource Management Plan (2001) and subsequent amendments (BLM 2001, 2007). As part of the RMP process, the BLM is required to prepare a mineral assessment report providing information on mineral deposits and mineral deposits potential within the CCD. The assessment presented in this report is based on published data and other information provided by the BLM Nevada State Office, the BLM CCD Office, the Nevada Bureau of Mines and Geology (NBMG), Nevada state agencies, the US Geological Survey (USGS), and industry. No field studies were conducted. Mineral resources are classified according to the systems found in BLM Manuals 3021, 3031 and 3060 and applicable mining laws: the General Mining Law of 1872, as amended; the Mineral Leasing Acts of 1920, as amended; the Mineral Material Acts of 1947, as amended; the Surface Resources Act of 1955; and the Geothermal Steam Act of 1970.

This mineral potential report is intended primarily as a planning tool, providing land managers with additional information to develop management plans for land under their jurisdictions (DOI et al. 2003). The report evaluates the occurrence and potential of locatable, leasable, and salable mineral resources within the CCD.

This report provides an intermediate level of detail for mineral assessment, as prescribed in BLM Manual 3031 for planning documents. Mineral information in this report will be used in preparing the CCD RMP and EIS required by the Federal Land Policy and Management Act (FLPMA) and the National

Environmental Policy Act (NEPA). Mineral resource occurrence ratings provided in this report are for all lands within the CCD regardless of land ownership. (Note, however, that decisions in BLM RMPs are limited to BLM-administered lands.) This report is not a decision document and does not present specific recommendations on the management of mineral resources.

The report is organized into five sections. Section 1 is an introduction to the Mineral Potential Report; Section 2 summarizes the geological setting as it relates to the occurrence of leasable, locatable, and salable minerals within the planning area; Section 3 describes the known occurrences of leasable, locatable, and salable mineral resources in the planning area, including a brief discussion of occurrence of minerals of strategic or critical importance to the nation. Section 4 discusses the potential for classes of minerals within the planning area; Section 5 includes recommendations relating to the RMP and for additional work; and Section 6 includes references used in developing the report and selected bibliographic materials.

## 1.2 LANDS INVOLVED AND RECORD DATA

The CCD planning area (**Figure 1-1**, Carson City District Planning Area and Land Status) is in western and central Nevada and eastern California. It includes all or part of the counties of Churchill, Nye, Mineral, Lyon, Douglas, Washoe, Storey, and Carson in Nevada and the counties of Alpine, Plumas, and Lassen in California. BLM-administered land within the overall planning area is considered the decision area. Within the planning area, lands are also managed by the US Forest Service (USFS), US Fish and Wildlife Service (USFWS), Bureau of Reclamation (BOR), Bureau of Indian Affairs for Native American Indian Tribal Lands (BIA), Department of Defense (DOD), State of Nevada, and private landowners.

The decision area is more than 5.28 million acres administered by the BLM and representing roughly half of the land area in the CCD planning area. The large contiguous land areas not contained in the decision are much of the Reno-Sparks area within Washoe County and all but the southwest corner of Storey County. Most of the lands within the western half of Carson City and Douglas Counties are not administered by the BLM. Most of Mason Valley north and south of Yerington and a large portion of Lyon County south of Mount Wilson are not in the planning area, and most of the lands within the Carson Desert and Carson Sink are outside the decision area.

The Walker River Indian Reservation (Lyon, Churchill, and Mineral Counties) and Pyramid Lake Indian Reservation (Washoe County) are enclosed within the CCD, but the BLM does not manage those lands. Similarly, the BLM does not manage lands on military reservations, Naval Air Station Fallon (Churchill County) and Hawthorne Ammunition Depot (Mineral County).

# Carson City District Planning Area and Land Status

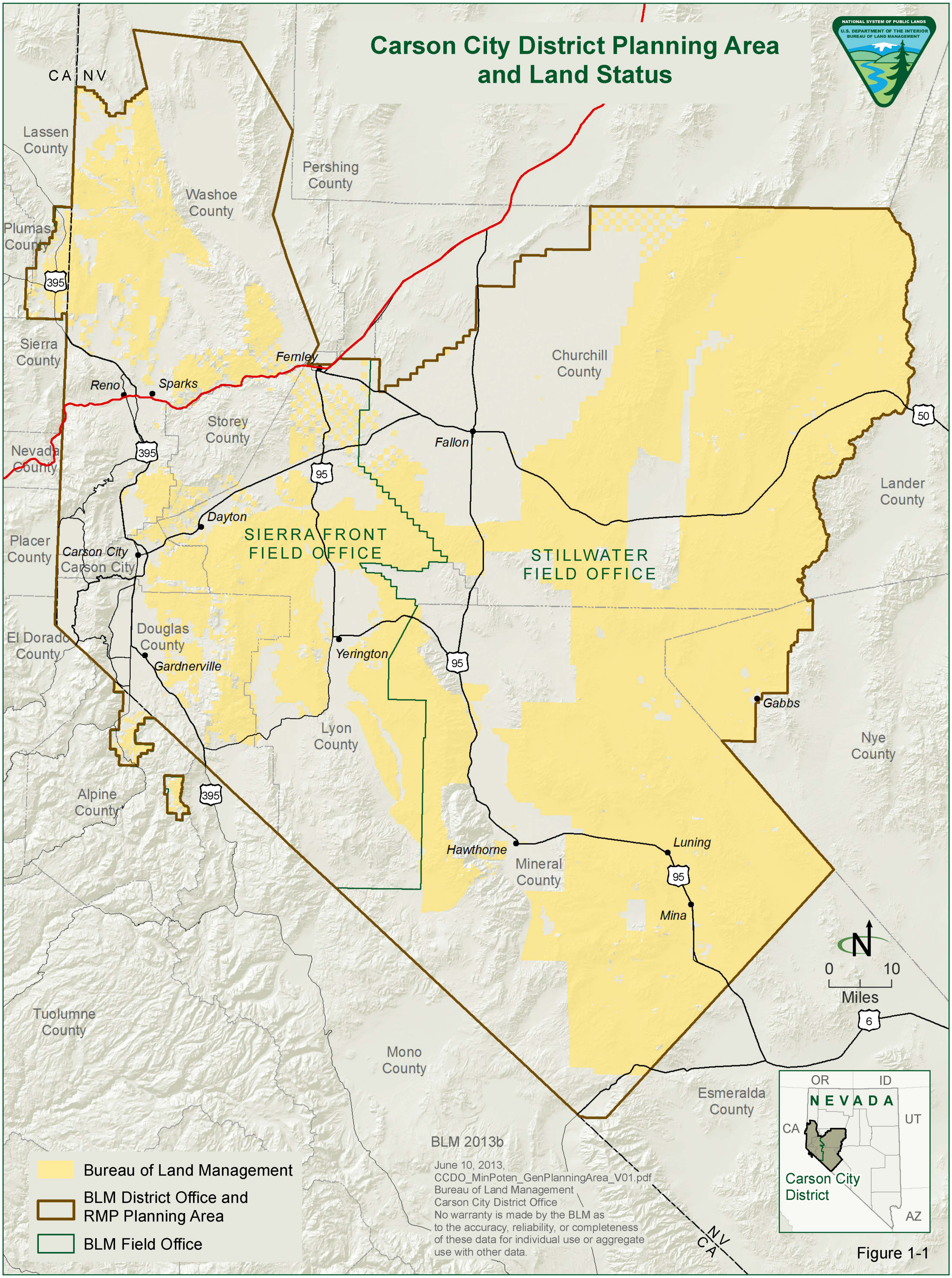


Figure 1-1

Several large areas along the California-Nevada border are within the Toiyabe or Inyo National Forests where the mineral estate is jointly administered by the BLM and USFS. The BLM maintains lead responsibility for permitting and compliance associated with development of leasable minerals (e.g. phosphate, oil and gas, and geothermal resources) and the adjudication of mining claims for locatable minerals on National Forests, while the USFS maintains responsibility for permitting and compliance associated with development of locatable and saleable minerals. The decision area also includes a limited amount of mineral split-estate lands, where the surface is owned by a nonfederal entity but where the subsurface minerals are administered by the BLM. **Table 1-1**, Status of Lands within the Planning Area, lists the land ownership or administration lands within each of the planning area counties.

## 1.3 LAND USE

Management issues and concerns in the decision area encompass nearly all resource programs and many different aspects of public land management. Resources and land uses of particular interest are recreation, minerals, air, water, cultural resources, range, wild horses and burros, fire management, land and realty programs, and threatened, endangered, and sensitive species.

The planning area has a history of mineral development dating back to the 1850s. Mining and exploration and development of geothermal resources are some of the multiple uses undertaken in the planning area. Currently, there is one gold and silver operation, one magnesium compound operation, four diatomite operations, one gypsum operation, two perlite operations, and two carbonate minerals operations. The BLM currently administers 23 plans of operation for locatable mineral exploration (greater than 5 acres) or mining which exceeds the threshold of casual use. The minerals program administers three active sales and 260 free-use permits. There are 148 geothermal leases covering approximately 299,195 acres, with five associated power plants and an active geothermal power production of 183 megawatts.

**Table 1-1**
**Status of Lands within the Planning Area**

| Location | BLM | USFS | Private | BOR | BIA | DOD | USFWS | NV State Parks | NV Regional Parks | Water[1] | CDFW | Unclassified[2] | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nevada** | | | | | | | | | | | | | |
| Carson City | 41,270 | 14,690 | 32,970 | 0 | 320 | 0 | 0 | 1,350 | 2,300 | 7,730 | | | 100,630 |
| Churchill County | 1,811,450 | 0 | 273,060 | 284,410 | 52,400 | 221,930 | 100,160 | 2,900 | 0 | 11,880 | | | 2,758,190 |
| Douglas County | 162,460 | 83,800 | 206,540 | 0 | 3,050 | 0 | 0 | 30 | 790 | 16,230 | | | 472,900 |
| Lyon County | 569,450 | 276,240 | 335,600 | 27,390 | 50,780 | 0 | 0 | 17,140 | 0 | 0 | | | 1,276,600 |
| Mineral County | 1,581,050 | 380,820 | 79,970 | 0 | 224,150 | 118,540 | 0 | 260 | 0 | 57,300 | | | 2,442,090 |
| Nye County | 189,080 | 510 | 3,100 | 0 | 0 | 1,370 | 0 | 0 | 0 | 0 | | | 194,060 |
| Storey County | 15,170 | 0 | 152,760 | 500 | 400 | 0 | 0 | 0 | 0 | 0 | | | 168,830 |
| Washoe County | 390,470 | 108,720 | 433,250 | 710 | 322,980 | 0 | 0 | 2,700 | 12,870 | 159,660 | | | 1,431,360 |
| | | | | | | | | | | | | | 0 |
| **California** | | | | | | | | | | | | | 0 |
| Alpine County | 18,230 | 4,580 | | | | | | | | | 1,900 | 15,420 | 40,130 |
| Lassen County | 26,520 | 120 | | | | | | | | | 430 | 26,700 | 53,770 |
| Plumas County | 710 | 0 | | | | | | | | | 0 | 1,670 | 2,380 |
| *Study Area* | *4,805,860* | *869,480* | *1,517,250* | *313,010* | *654,080* | *341,840* | *100,160* | *24,380* | *15,960* | *252,800* | *2,330* | *43,790* | *8,940,940* |

Source: BLM 2012a
CDFW: California Department of Fish and Wildlife
[1]Water represents lakes and ponds.
[2]Includes BOR, BIA, DOD, regional parks, and private lands, which are not broken out individually for California regions.

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# SECTION 2
# GEOLOGY IN THE RESOURCE AREA

## 2.1 PHYSIOGRAPHY

Most of the planning area is within the Basin and Range Physiographic Province, although the western portion is within the Sierra Nevada section of the Sierra-Cascade-Coast Mountain Province (Lobeck 1975). The two provinces, with their two distinct tectonic styles, are separated by the Walker Lane, a north-northwest trending depression, approximately 30 to 40 miles wide in the CCD planning area. It extends approximately 500 miles, from south-central Oregon to the latitude of the Garlock Fault-Las Vegas area, and contains Pyramid and Walker Lakes.

The Sierra Nevada Range, which extends along the western margin of the CCD, is an approximately 400-mile-long fault block structure that was uplifted during the Pliocene Epoch. The range is tilted up on the east, with a steep east-facing scarp that rises above the Great Basin along the Sierra-Nevada Fault System. It has a long west-facing slope that descends gradually to the Great Valley in California. Lake Tahoe, the largest freshwater lake in California, fills a graben between the Carson Range, which lies almost entirely within the CCD, and the Sierra-Nevada Range, to an elevation of over 6,000 feet. The highest elevation in the Carson Range is Mount Rose, at 10,778 feet. The Carson Range lies outside the decision area.

The Basin and Range Province covers approximately 300,000 square miles, extending from southern Oregon through Nevada, across southern Arizona and New Mexico and into part of Utah. It is characterized by hundreds of relatively parallel and generally north-south trending, tilted, block fault, mountain ranges. These ranges average about 50 miles in length and are separated by broad alluvium-filled valleys. The valley floors are typically at elevations of 3,000 to 5,000 feet, and the ranges rise up to 10,000 feet. The maximum elevation in the planning area is 11,300 feet, at Mount Grant in western Mineral County, near Hawthorne.

The CCD is in the northern portion of the Great Basin and contains closed basins. The principal drainages in the CCD, from north to south, are the Truckee River, which flows from Lake Tahoe to Pyramid Lake; the Carson River, which heads in the Sierra south of Lake Tahoe and drains northward past Carson City and ultimately to the Carson Desert; and the West Walker and East Walker Rivers, which head in the Sierra and converge in Mason Valley south of Yerington in Lyon County. Both rivers ultimately discharge to Walker Lake in Mineral County. Despite being terminal lakes, both Pyramid Lake and Walker Lake are fresh enough to support trout, although their salinity has increased measurably in recent years, partly as a result of reduced inflows. The Carson Desert contains numerous saline lakes, alkali flats, and saline marshes.

## 2.2 Lithology and Stratigraphy

### 2.2.1 Precambrian

Outcrops of Precambrian rocks are restricted to small areas in the southwestern part of the planning area in Mineral County. These rocks consist predominantly of limestone and dolomites, with shale, sandstones, siltstone, quartzite, and small amounts of chert (BLM 2012).

There are several small exposures of rocks that date to the Precambrian Age at the extreme southern end of the CCD; however, the eastern edge is approximately the western extent of a wedge of miogeoclinal sediments that were deposited during Proterozoic to Devonian time into a rift basin developed on the edge of the Laurentian continent. The CCD lies within what was then the paleo Pacific Ocean floor. Evidence of this is approximately 40,000 feet of marine sedimentary and basic volcanic rocks in an accretionary offshore basin setting. This is preserved in central Nevada in the late Precambrian and lower Paleozoic quartzites and conglomerates of the Reed Dolomite, Deep Spring, Campito, Poleta, Harkless, and Saline Valley Formations and Mule Spring limestone. The few Precambrian rocks that are present in the CCD have likely been transported into the region by Cenozoic strike-slip faulting.

### 2.2.2 Paleozoic

Deep water marine sediments continued to be deposited on the western flank of the North American continent during the Lower Paleozoic. These rocks are exposed on the upper plate of the Roberts Mountain Thrust (Stewart and Carlson 1978) in central Nevada.

The Paleozoic rocks exposed in the CCD consist mainly of allochthonous andesitic volcanic flows and flow breccias, tuffs, and sparse sandstone and greywacke (the western siliceous and volcanic assemblage of Stewart and Carlson 1978). These are emplaced with the Golconda Thrust during the Sonoma Orogeny, near the Permian-Triassic time boundary (Dickinson 2006).

The western assemblage is comprised of mafic to felsic volcanic rocks and clastic rocks believed to have been deposited on the western flank of the Antler orogenic belt. During the latest Permian to earliest Triassic time, the Havallah Sequence was thrust over the Antler Sequence (Roberts Mountain Thrust; Dickinson 2006). It consists of Later Mississipian to Early Permean chert, argillite, shale, greenstone, and minor siltsone, sandstone, conglomerate and limestone. Most of this Golconda Allochthon is in north-central Nevada, but remnants are represented in the Pumpernickel and Excelsior Formations in Mineral County.

### 2.2.3 Mesozoic

Throughout the CCD, ranges are dominated by intrusions of Mesozoic granitic rocks (mainly quartz monzonite and granodiorite) into the allochthonous Paleozoic eugeoclinal metasediments. These had been obducted onto the continental margin as a result of a shift to subduction tectonics initiated in the Late Triassic (Mihalasky 2001; Dickinson 2006).

As a consequence of heating of the subducting Farallon Plate, a magmatic arc formed inland of the subduction zone, including under most of the western half of the CCD. The Sierra-Nevada Batholith on the western side of the CCD is the local manifestation of this Cordierran arc that extended from Canada to Central America. A back-arc basin extended to the east of this magmatic arc. It is evidenced in the rocks underlying the northeastern portion of the CCD and extending into central Nevada. Continental sediments, volcanic deposits, and erosional material from the arc uplift were deposited in this basin. The eastern margin of the backarc basin, which roughly coincides with the eastern boundary of the CCD, also marks the western edge of the Luning-Fencemaker Thrust System (Dickinson 2006).

The formation of a magmatic arc was accompanied in the Jurassic by emplacement of plutons in eastern and central Nevada and by volcanism. Continental sediments are interspersed with volcanogenic rocks, including ash-flow tuffs, rhyolite and rhyodacide flows, volcanogenic sandstone, and andesite. This is similar to the upper Luning and Dunlop Formations and the Gabbs and Sunrise Formations (Stewart 1978).

Stewart et al. (1997) noted that west-central Nevada contains an assemblage of lithotectonic terranes (allochthons) that are each characterized by different structures that were once widely separated. They attempted to correlate Mesozoic lithostratigraphic units and found evidence of regionally consistent structures across terrane boundaries occurring within the central and southern portions of the CCD. Stewart et al. focused on two of the Mesozoic lithotectonic terranes in the southern CCD:

- The Pine Nut Terrane, which they show as bounded by an inferred Lake Tahoe Fault at the eastern edge of the Sierra Nevada Batholith and an inferred Pine Nut Fault (a northwest trending fault along what is now the east side of the Wassuk Range) in the west and central portion of the CCD

- The Paradise Terrane, which occupies the southeastern portion of the CCD east of the Pine Nut Fault, including the Garfield Hills and Pilot Mountains

Other Mesozoic lithotectonic terranes identified by Stewart et al. within the area of the CCD include the Gold Range Terrane, which lies south of the Paradise Terrane; the Sand Springs Terrane, which occupies the area east of the Pine Nut Fault and north of the Paradise Terrane; and the Jungo Terrane, which is north of the Sand Springs Terrane in the area that now contains the Stillwater Range and Clan Alpine Mountains in the northeast corner of Churchill County.

Stewart et al. found four major chronostratigraphic and lithostratigraphic successions in the Triassic and Jurassic rocks in the Pine Nut and Paradise Terranes, as follows:

- A Lower to Lower Upper Triassic volcanic and volcaniclastic succession (which includes metavolcanic rocks of Brunswick Canyon in the Pine Nut Mountains the McConnell Canyon Volcanics in the Yerington area, and the lower member of the Pamlico Formation in the Barfield Hills)
- An Upper Triassic carbonate-rich and fossiliferous succession (which shows a high degree of lateral variability and a higher percentage of volcaniclastic rocks in the Pine Nut Terrane; it includes the Mason Valley Limestone and the Malachite Mine Formation in the Pine Nut Terrane, the Pamlico Formation in the western Garfield Hills, and the Luning Formation in the Pilot Mountains and eastern Garfield Hills
- An Upper Triassic to Middle Jurassic clastic succession (which includes the Volcano Peak group and the Dunlap Formation in the Pilot Mountains, the Gabbs and Sunrise Formations in the Garfield Hills, and the Gardnerville Formation and overlying Preachers Formation in the Pine Nut Mountains and elsewhere in the Pine Nut Terrane)
- A Middle Jurassic volcanic and volcaniclastic succession (which is not present in the Paradise Terrane but includes the Artesia Lake and Fulstone Spring Volcanics in the Singatse and Buckskin Ranges and the Veta Grande Formation, Gold Bug Formation, and Double Spring Formation in the Pine Nut Mountains)

The Mesozoic rocks of the Sand Springs Terrane suggest a different depositional environment (deepwater rather than shallow shelf deposits during the Upper Triassic and more volcaniclastic during the Early Jurrasic than the Paradise Terrance, for example). The overall stratigraphic succession is similar to that described above, including a Lower Upper Triassic sequence. This includes thinly bedded deepwater carbonaceous turbidites and carbonate conglomerate and breccia, which grade upward and are interbedded with volcanogenic shale, sandstone, and conglomerate. This is in turn overlain by Lower Jurassic volcanogenic shale and sandstone, and then by carbonate rocks interbedded with volcanic rocks.

The Mesozoic rocks of the Jungo Terrane include a thick sequence of fine-grained continental sediments deposited during the Late Triassic and Early Jurassic. It has been estimated that more than 5,000 feet of these sediments are represented in the Clan Alpine Range, in contrast to the carbonate-rich rocks in the Paradise Terrane. However, Stewart et al. indicate that a fine-grained quartz sandstone belonging to the Boyer Ranch Formation may correlate with a similar quartz arenite of the Dunlap Formation and the Preachers Formation in the Paradise and Pine Nut Terranes, respectively. The youngest rocks in the Jungo Terrane are mafic volcanics associated with a Middle Jurassic gabbro (Stewart et al. 1997).

Stewart et al. presented four competing paleogeographic models to account for the observed juxtaposition of the different Mesozoic Terranes: a fixed position model and three models involving various amounts and different directions of lateral movement along the major terrane-bounding faults. The problem of defining what brought rocks formed in distinctly different depositional environments into their current positions has not been entirely resolved; however, it is now widely accepted that Cenozoic strike-slip faulting had a prominent role.

### 2.2.4 Cenozoic

At the end of the Cretaceous Period, magmatism was intense within the batholith belt underlying the Sierra Nevada and western Nevada. But the oceanic crustal slab began to descend at a shallower angle under the continent at the close of the Mesozoic. This was associated initially with a sharp decline in magmetism in the Great Basin and later with a southward migration of a northwest-trending volcanic front that generally swept across the Great Basin throughout the Paleogene (Dickinson 2006). This also saw the onset of crustal extension in the Great Basin, which Dickinson (2006) attributes to intra-arc or backarc deformation induced by rollback of the subducting oceanic plate.

Tertiary volcanic rocks are exposed in most of the mountain ranges in the CCD. Compositions range from basalt to rhyolite, with volcanic types ranging from small basalt cinder cones or rhyolite domes to large caldera eruptions commonly known as "supervolcanoes" (Miller and Wark 2008). There are numerous named ash-flow tuffs (ignimbrites) in the planning area.

General stratigraphy of the supervolcanoes consists of a basal andesite layer with overlying rhyolitic volcanic rocks (Boden 1986). As a result of the southward migration of the volcanic front, centers of volcanism are generally younger to the southwest; the oldest volcanic rocks are in the northeast part of Nevada and the youngest are along the California border. Many of these volcanic centers are associated with base or precious metals mineralization (John 2008; McKee 1996).

The ranges are densely fractured and intruded by geochemically diverse magmas and hydrothermal fluids. The chemical interactions between the hydrothermal fluids and the country rock, which itself may have undergone previous episodes of mineral concentration, results in highly diverse, complex, and localized mineral deposits. Neogene hydrothermal fluid migration into country rock is one of the primary mechanisms for gold, silver, copper, and base metal mineralization in the CCD.

The extensional regime in the Great Basin during the Paleogene was accompanied by continued subduction under the Great Basin. This resulted in thinning of the crust and detachment faulting associated with ductile flow in the lower crust. With the onset of transform faulting along the San Andreas fault in the mid-Miocene, the style of faulting within the Basin and Range Province changed from detachment faulting to block faulting. Dickinson suggested that this was associated with cooling and stiffening of the crust (Dickinson, W.R. 2006).

As a result of this stiffening of the crust, some of the shear forces of the San Andreas Transform Fault System may have been transferred inland to the Walker Lane. This is a broad northwest-trending zone subparallel to the Sierra-Nevada Range front. The Walker Lane includes most of the CCD and represents a transition zone between the Sierra-Nevada Batholith and the Basin and Range block-faulted region to the east.

The transform shear regime that created the Walker Lane migrated northward in conjunction with the northward migration of the triple plate junction offshore of California during the Neogene. This onset of this right lateral faulting also corresponded in time to the end of the southwestward migration of volcanism in the Basin and Range about 25 million years ago (Ma), followed by the onset of voluminous andesitic magmatism in the Yerington area less than 14 Ma.

The Walker Lane is a zone of active strike-slip and normal (extensional) faulting. Based on argon isotopic age dating of volcanic rocks and subvolcanic intrusions, the initiation of right-transextensional faulting along the Wassuk Range on the eastern side of the Walker Lane has been bracketed between approximately 26 to 14 Ma; faulting at the southwestern side of the Walker Lane started no earlier than 15 Ma (Dilles and Gans 1995).

It is estimated that about one centimeter per year of right slip movement between the Sierra Nevada and the North American craton is currently accommodated by the faults within the Walker Lane. This right slip shear has oriented many of the ranges within the Walker Lane on north-northwest 10 to 20 degree strikes. In addition, there has been significant east-west extension within the Walker Lane on numerous short, left-lateral, east-northeast-trending, strike-slip faults.

### 2.2.5 Quaternary

Quaternary rocks in the planning area consist primarily of basin-fill material with minor amounts of alluvium, colluvium, and landslide deposits. Basin-fill deposits are several thousand feet thick in some basins.

Most of the Quaternary basin-fill materials are coarse to fine-grained clastic sediments shed from adjacent mountain ranges. Alluvial fans from mouths of mountain canyons are an obvious geomorphic feature that attests to erosion of the mountains and deposition in the basins.

The basin fill deposits are in part a product of the dry climatic conditions and structural controls that have resulted in insufficient precipitation to transport sediments out of the deepening basins. The hydrologic regime in the northern Basin and Range has fluctuated over time. Playa lakebeds and salt deposits have formed during periods of dry climate, but there have also been lengthy wet periods when the large lakes connected multiple basins. Walker Lake and Pyramid Lake are both the remnants of Pleistocene Lake Lahontan, a vast freshwater body that extended throughout much of the CCD. Berms and scour features that formed on the shorelines of Lake Lahontan are still visible high up on the slopes of many of the basins. Basin fill deposits consist predominantly of fine-grained clastic sediments, with some salt deposits locally interfingered with sandstone and conglomerate. Quaternary deposits are a source of the sand and gravel throughout the planning area.

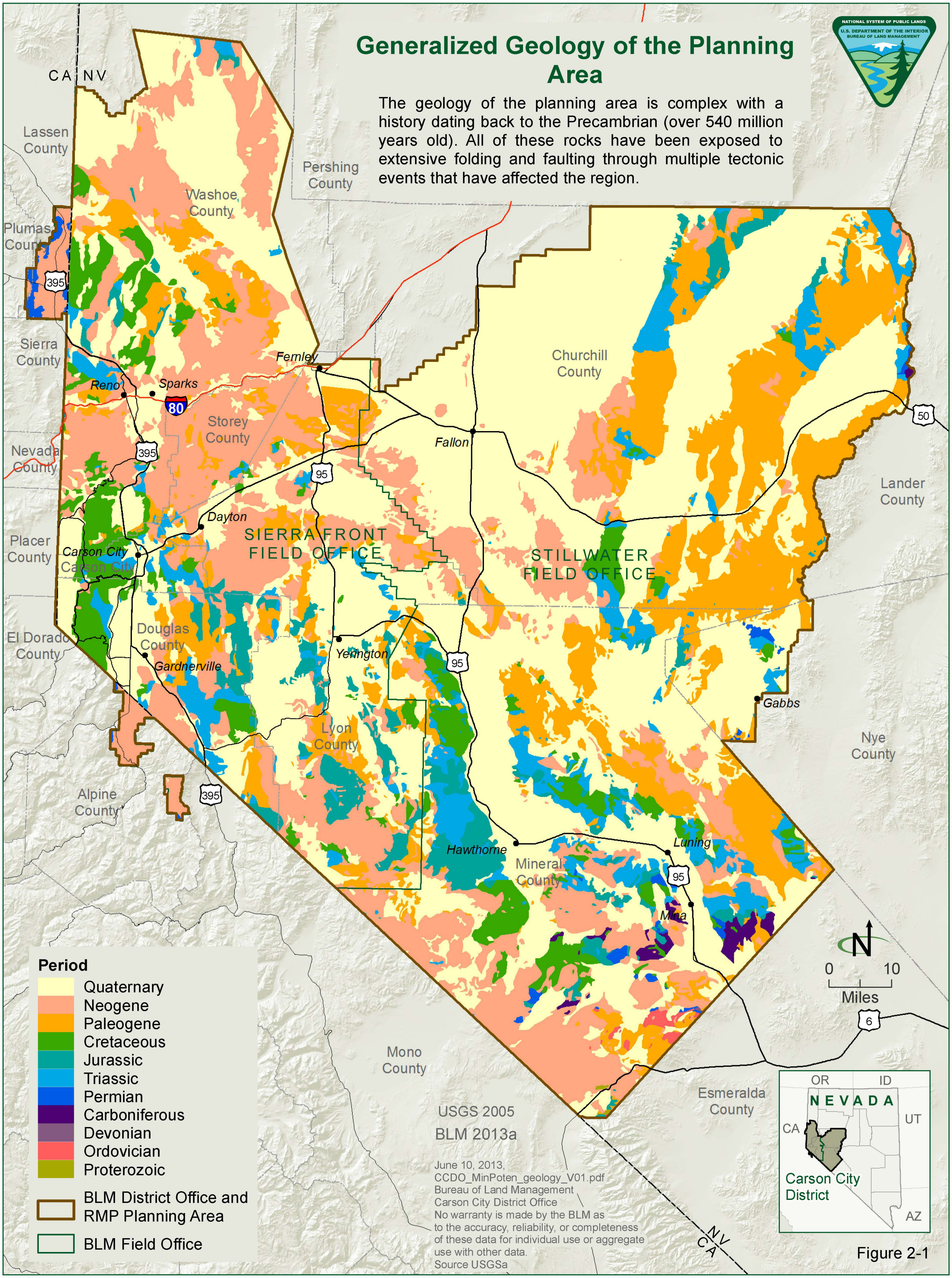
**Figure 2-1**, Generalized Geology of the Planning Area, shows the generalized geology of Nevada; **Table 2-1**, Lithologic Units within the Planning Area, lists the major lithologic units mapped in the planning area.

## 2.3 STRUCTURAL GEOLOGY AND TECTONICS

The structural geology of Nevada is the result of the formation of the Western Cordillera, which is in the western US and extends from Alaska to Mexico. The Western Cordillera can be summarized as a series of mountain-building periods due to accreted terrains, interlaced with periods of sedimentation. It is most recently marked by a failed rift zone. The result of the formation and deformation of the Western Cordillera sequence is the Basin and Range ecoregion characteristic to Nevada.

### 2.3.1 Cordilleran Miogeocline

A western continental margin, similar to the Atlantic coast of today and known as a miogeocline, persisted for hundreds of millions of years before the more active Pacific Coast margin of today began to take shape about 360 million years ago (Price 2005). Repeated and prolonged periods of interactions between the North American Plate and oceanic plates is expressed in folds, thrust faults,



Generalized Geology of the Planning Area
The geology of the planning area is complex with a history dating back to the Precambrian (over 540 million years old). All of these rocks have been exposed to extensive folding and faulting through multiple tectonic events that have affected the region.
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CA NV
Lassen County
Plumas County
Sierra County
Nevada County
Placer County
El Dorado County
Alpine County
Mono County
Esmeralda County
Nye County
Lander County
Pershing County
Washoe County
Storey County
Churchill County
Carson City
Douglas County
Lyon County
Mineral County
Reno
Sparks
Fernley
Fallon
Dayton
Carson City
Gardnerville
Yerington
Hawthorne
Luning
Mina
Gabbs
80
395
95
50
6
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
N
0 10
Miles
Period
Quaternary
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Ordovician
Proterozoic
BLM District Office and RMP Planning Area
BLM Field Office
USGS 2005
BLM 2013a
June 10, 2013,
CCDO_MinPoten_geology_V01.pdf
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
Source USGSa
NV
CA
OR
ID
NEVADA
UT
CA
AZ
Carson City District

Figure 2-1

**Table 2-1**
**Lithologic Units within the Planning Area**

| Map Symbol | Age | Lithotypes and Formation Names | Lithology |
|---|---|---|---|
| Qa | Quaternary | Alluvial deposits; locally includes beach and sand dune deposits | Alluvium; mass wasting; dune sand; lake or marine deposit (nonglacial) |
| Qls | Quaternary | Landslide deposits | Landslide; colluvium; sedimentary rock |
| Qm | Quaternary | Moraine deposits | Glacial drift |
| Qp | Quaternary | Playa, marsh, and alluvial-flat deposits, locally eroded | Playa; alluvium |
| QTs | Pliocene to Quaternary | Sedimentary rocks; mostly lake deposits | Lake or marine deposit (nonglacial); sedimentary rock |
| QTa | Miocene to Quaternary | Intrusive rocks of mafic and intermediate composition | Andesite; rhyodacite; basalt; sedimentary rock |
| QTb | Miocene to Quaternary | Basalt flows; locally includes maar deposits | Basalt; andesite; trachybasalt; latite; andesite |
| QToa | Miocene to Quaternary | Older alluvial deposits | Alluvium; lake or marine deposit (nonglacial) |
| Tba | Early Miocene to Early Pliocene | Andesite and basalt flows; mostly ranging from about 17 to about 6 Ma; may locally include rocks younger than 6 Ma | Basalt; andesite; shoshonite |
| Tr3 | Middle Miocene to Late Miocene | Rhyolitic flows and shallow intrusive rocks | Rhyolite; dacite; trachyte |
| Tr2 | Early Oligocene to Early Miocene | Rhyolitic flows and shallow intrusive rocks | Rhyolite; dacite; trachyte |
| Tri | Eocene to Miocene | Rhyolitic intrusive rocks | Granitoid |
| Tmi | Eocene to Miocene | Intrusive rocks of mafic and intermediate composition | Diorite; monzodiorite; quartz diorite; quartz monzogabbro; tonalite; gabbros |
| Ta3 | Late Miocene to Middle Miocene | Andesite and related rocks of intermediate composition; flows and breccias | Andesite; latite; trachyte; dacite |
| Ts3 | Late Eocene to Late Miocene | Tuffaceous sedimentary rocks; locally includes minor amounts of tuff | Sandstone; limestone; siltstone; conglomerate; mudstone; dolostone (dolomite); felsic volcanic rock; intermediate volcanic rock; mafic volcanic rock; tuff |
| Tt3 | Middle to late Miocene | Welded and nonwelded silicic ash-flow tuffs; locally includes thin unitsof air-fall tuff and sedimentary rock | Rhyolite |
| Trt | Middle to Late Miocene | Ash-flow tuffs, rhyolitic flows, and shallow intrusive rocks | Rhyolite |
| Ta2 | Early Oligocene to Early Miocene | Andesite and related rocks of intermediate composition-flows and breccias | Andesite, trachyte, dacite |
| Tt2 | Early Oligocene to Early Miocene | Welded and nonwelded silicic ash-flow tuffs; locally includes thin unites of air-fall tuff and sedimentary rock | Rhyolite; dacite; trachyte |

**Table 2-1**
**Lithologic Units within the Planning Area**

| Map Symbol | Age | Lithotypes and Formation Names | Lithology |
|---|---|---|---|
| Ts2 | Early Oligocene to Early Miocene | Tuffaceous sedimentary rocks; locally includes minor amounts of tuff | Sandstone; siltstone; limestone; conglomerate; mudstone; debris flow; landslide; tuff |
| Tr1 | Middle to Late Eocene | Rhyolitic flows and shallow intrusive rocks | Rhyolite |
| Tgr | Paleocene to Late Miocene | Granitic rocks; mostly quartz monzonite and granodiorite | Granodiorite; quartz monzonite; granite; monzonite |
| TJgr | Jurassic to Miocene | Granitic rocks, mostly quartz monzonite and granodiorite; inconclusively dated or not dated isotopically | Quartz monzonite; granodiorite; granite; peraluminous granite |
| Kgr | Cretaceous | This unit is grouped with NVMzgr in the literature; the two units are the same types of rocks but those included in this unit have their ages confirmed by radiometric dating. Granodiorite is dominant over quartz monzonite in northern Nevada while the opposite is true in southern Nevada | Quartz monzonite; granodiorite; granite; monzonite; quartz diorite; peraluminous granite |
| MZgr | Jurassic to Cretaceous | Granitic rocks, western Nevada (Mesozoic); mostly quartz monzonite and granodiorite; inconclusively dated or not dated isotopically | Granodiorite; quartz monzonite; granite; quartz diorite; gabbro |
| KJd | Jurassic to Cretaceous | This unit includes both non-quartz and quartz diorite; non-quartz diorite appears more widespread though both are almost equally represented. | Diorite; quartz diorite; gabbro; granite; granodiorite; serpentine |
| JPu | Permian to Jurassic | Volcanogenic sedentary rocks, tuff, andesite and felsic flows, and carbonate rocks; age uncertain; Mineral, Esmeralda, and northwest Nye Counties | Greenstone; sandstone; volcanic rocks (aphanitic); limestone; siltstone; conglomerate |
| Jgb | Lower to Middle Jurassic | Gabbroic Complex; gabbro, basalt, and synorogenic quartz sandstone | Gabbro, basalt, quartz sandstone |
| Jgr | Jurassic | Granitic rocks; mostly quartz monzonite and granodiorite | Quartz monzonite; granodiorite; granite; monzonite; quartz diorite; peraluminous granite |
| Jd | Early Jurassic to Middle Jurassic | Dunlap Formation; conglomerate, sandstone, greenstone, felsite, and tuff; locally contemporaneous with folding and thrusting; Mineral County and adjacent parts of Esmeralda and Nye Counties | Sandstone; conglomerate; volcanic rock (aphanitic); limestone; siltstone; shale |
| JTRsv | Late Triassic to Early Cretaceous | Shale, sandstone, volcanogenic clastic rocks, andesite, rhyolite, and locally thick carbonate units | Rhyolite; andesite; dacite; trachyte; argillite; shale; sandstone; siltstone; carbonate; basalt |

**Table 2-1**
**Lithologic Units within the Planning Area**

| Map Symbol | Age | Lithotypes and Formation Names | Lithology |
|---|---|---|---|
| Trc | Triassic | Limestone, minor amounts of dolomite, shale, and sandstone; locally thick conglomerate units; includes Tobin, Dixie Valley, Favret, Augusta Mountain, and Cane Spring formations and Star Peak Group | Limestone; dolostone (dolomite); shale; sandstone; conglomerate; siltstone; andesite; chert |
| JTRs | Late Triassic to Early Jurassic | Includes Auld Lang Syne Group, Nightingale sequence of Raspberry, Winnemucca, Grass Valley, Dun Glen, and Osobb formations | Claystone; shale; sandstone; siltstone; carbonate; volcanic rock (aphanitic); conglomerate |
| TRPvs | Permian to Triassic | Happy Creek volcanic series composition is mostly andesitic with some basalts; sedimentary rocks are associated with volcanic rocks of certain areas: the limestone and conglomerate with rocks of Washow County, sandstone, conglomerate and calcareous rocks with the Dunlap, and the greywacke and sandstone with the Happy Creek volcanic series | Andesite; basalt; dacite; greywacke; sandstone; shale; chert; limestone; conglomerate |
| TRk | Permian to Early Triassic | Koipato Group and related rocks; altered andesitic flows, rhyolitic tuffs and flows, and clastic rocks; includes rocks mapped by Siberling (1995) as Pablo formation and originally considered to be Permian in the Shoshone Mountains, Nye County; also includes Tallman Fanglomerate (Permian?) in Humboldt County | Rhyolite; andesite; clastic; basalt |
| TRPd | Early Permian to Early Triassic | Conglomerate, sandstone, shake, and dolomite of the Diablo Formation below and shale, sandstone, and conglomerate of Candelaria Formation above; Mineral, Esmeralda, and northwestern Nye Counties | Shale; siltstone; sandstone; dolostone (dolomite); limestone; conglomerate |
| PZsp | Late Devonian to Early Triassic | Serpentinite; Mineral, northwestern Nye, and eastern Humboldt Counties | Serpentinite |
| PMh | Mississippian to Permian | Havallah Sequence of Siberling and Roberts (1962); chert, argillite, shale, greenstone, and minor amounts of siltstone, sandstone, conglomerate, and limestone; includes Schoonober Formation of Fagan (1962) and Reservation Hill Formation in southwestern | Shale; metavolcanic rock; chert; siltstone; sandstone; conglomerate; limestone |

**Table 2-1**
**Lithologic Units within the Planning Area**

| Map Symbol | Age | Lithotypes and Formation Names | Lithology |
|---|---|---|---|
| | | Humboldt County and Havallah and Pumpernickel Formations in Pershing, Lander, and parts of Humboldt Counties; also includes rocks originally considered a part of the Pablo and Excelsior Formations in northern Nye, northern Esmeralda, and southern Mineral Counties | |
| OSv | Ordovician to Devonian | Siliceous and volcanic rocks; chert, shale, quartzite; greenstone; and minor amounts of limestone; includes units such as Valmy Formation of north-central Nevada and some rocks mapped as Palmetto Formation in northern part of Esmeralda County and adjacent parts of Mineral and Nye Counties; locally includes rocks of Silurian and Devonian Age | Chert; quartzite; shale; greenstone; limestone; conglomerate; siltstone; chemical sedimentary rock |
| CZs | Late Proterozoic to Early Cambrian | Phyllitic siltstone, quartzite, and lesser amounts of limestone and dolomite; includes Reed Dolomite; Deep Spring, Campito, Poleta, Harkless, and Saline Valley Formations; and Mule Spring Limestone | |

strike-slip faults, normal faults, igneous intrusions, volcanism, metamorphism, and sedimentary basins, as recorded in the rocks (Price 2005). This geocline was an elongated trough that extended north to south in western North America and included the area that is now eastern Nevada. During Precambrian time and the early Paleozoic Era, marine sediments and volcanics were deposited in an accretionary offshore basin setting within the Cordilleran (ancestral Rocky Mountain) Geocline. Sedimentation was marked by two periods of alternating clastic and carbonate deposition (Price 2004).

### 2.3.2 Antler Orogeny and Roberts Mountain Thrust

The planning area was part of a passive carbonate platform margin environment throughout most of the Early to Middle Paleozoic (Anna et al. 2007). However, as the Late Devonian Antler Orogeny began in the western Cordillera (380 to 370 million years before the present), the passive carbonate platform environment was replaced by clastic sedimentation in a thrust-related foredeep basin. The Roberts Mountain Allochthon formed a north-south trending upland area in central Nevada in Early Mississippian time, with the Roberts Mountain

Thrust leading. The allochthon consisted of an assemblage of lower Paleozoic, deep-basin graptolitic, cherty, and organic shales thrust over an autochthonous assemblage of fine-grained clastics of Mississippian and Devonian carbonates. East-vergent thrusting created an eastward-migrating foredeep trough in front of the thrusting. This was followed by a forebulge or bathymetric high and finally an easternmost back basin (BLM 2012; Dickenson 2006).

### 2.3.3 Antler Overlap Assemblage and the Havallah Basin

On completion of the Antler Orogeny, sedimentation resumed for roughly 100 million years before present and produced the Antler Overlap Assemblage (Dickenson 2006). This is a predominantly siliciclastic assemblage, with erosion of deepwater clastic sediments from the Roberts Mountain Allochton. Farther west, lateral equivalents of the Antler Overlap Sequence formed the Havallah Sequence, which was deposited within a residual oceanic trough lying offshore from the continental margin from latest Devonian to latest Permian time, resulting in a deep water facies (Dickinson 2006).

### 2.3.4 Sonoma Orogeny and Golconda Thrust

The Sonoma Orogeny occurred during Permian and Triassic time, resulting in eastward transport of the Golconda Allochthon, consisting of deepwater clastic sediments of the Havallah Sequence. The allochthon was thrust over the beveled Antler Allochthon highland, although the east-verging Golconda Thrust is west of and generally parallel to the Roberts Mountain Thrust. Little deformation or metamorphism accompanied emplacement of the Golconda Allochthon, and only a modest amount of sediment was shed off of the uplifted fault sheet (BLM 2012; Dickenson 2006).

### 2.3.5 Central Nevada Thrust Belt

The Central Nevada Thrust Belt is a narrow north-south trending zone (at approximately 116.5 degrees longitude) of compressional structures in the hinterland of the Sevier Orogenic Belt (Anna et al. 2007). The thrust system was probably continuous for tens to hundreds of miles in the north-south direction; however, the Neogene Extension segregates the province into basins and ranges, and exposures of the central Nevada Thrust Belt are now observable only in the ranges.

In addition, little evidence exists as to the thrust system's subsurface configuration, including how the Neogene Extension segmented the compressional structures. Although poorly constrained, evidence appears to support an Early Triassic to Mid-Cretaceous age for the thrusting, but the rates and timing of compression probably varied. Taylor (2001) mapped parts of the thrust belt as three stacked thrust sheets, with the hanging walls consisting of Precambrian through Permian strata. Chamberlain and Gillespie (1993) mapped thrust sheets in southeastern Nevada, which they identified as part of the Central Nevada Thrust Belt.

### 2.3.6 Sevier Thrust System

Willis (1999) defined the Cordilleran Thrust System as east-verging and extending from Alaska to Mexico. It was tectonically active from Late Jurassic to Early Tertiary time. It is part of the Cordilleran Thrust System. The name Sevier is limited to the eastern Great Basin of Utah and adjacent areas. The main or frontal part of thrusting is approximately 60 miles wide and extends from southeastern Nevada to the Utah part of the Wyoming Thrust Belt.

The Sevier System is distinguished from the Laramide System in both time and style. The systems overlap the Cretaceous through the Eocene, a sequence of shorter duration than the Sevier System, and involve thick-skinned deformation characterized by uplift and thrusting of Precambrian Basement. The effects of the Sevier emplacement of thrust sheets on autochthonous terrane are typical of thrust systems, with a foredeep basin in front of the leading thrust and a forebulge high and a backbulge basin. The system prograded from west to east, depositing as much as several thousand feet of sediment. It included potential source rocks of the Cretaceous, Mowry, and Hilliard Shales in the foredeep east of the province boundary. By the Late Cretaceous, most of the thrusting had ceased; then, either in the Early Tertiary or as part of the Neogene Extension, compressional stresses relaxed enough to produce backsliding on thrust planes. As a result, the load of the hanging wall was removed from the footwall and may have promoted isostatic rebound in the footwall. This resulted in the formation of extensive fold belts, such as the Sevier Valley and Virgin River Folds. However, these folds may be due to Sevier compression and not from isostatic rebound.

### 2.3.7 Neogene Extension and Related Structures

The Great Basin Province underwent extensional deformation in the Neogene, resulting in the formation of the present-day Basin and Range Province. The Basin and Range extension began about 25 million years before present when the west-moving North American Plate started to override the Pacific Plate before overriding the Farallon Plate (Wernicke 1992). As the North American plate continued migrating westward, a deep seated, relatively stationary, north-trending upwelling of the mantle caused extension in the east-northeast direction. Thin and structurally weak Phanerozoic rocks broke into horst and graben (basin and range) blocks. As in many extensional terranes, individual basins differ in their structural configurations. Some basins are bound by steep to vertical normal faults, some by gently dipping normal faults, and some by steep faults at the surface that become listric at depth (a characteristic that complicates exploration strategies).

## 2.4 GEOPHYSICS AND GEOCHEMISTRY

Geophysical and geochemical methods have been used extensively to investigate the presence and extent of favorable geologic environments for mineral and energy development in the planning area. A comprehensive review of these techniques is beyond the scope of this report, and only a general overview is presented to support the discussion of mineral potential.

### 2.4.1 Geophysical Methods

***Gravity and Magnetic Data***

Geophysical data provide information on geological units and structures that are not visible at the surface, including certain types of igneous rocks, the thickness of alluvial cover, and major faults. The USGS used gravity and magnetic anomaly data, including basement gravity terranes and lineaments and magnetic terranes, to identify favorable areas for gold-silver-copper mineralization in the Humboldt Basin and surrounding areas of northern Nevada (Wallace et al. 2004; Glen et al. 2004). Mihalasky (2004) also used gravity and geomagnetic data as multilayer weights of evidence to identify favorable areas for gold and silver exploration associated with sedimentary and volcanic rock-hosted deposits throughout Nevada.

Gravity data can also be used to indicate the depth of basement rocks beneath young sediments in Quaternary basins. This is because the depth of the basement rocks is considered a limiting factor in exploration and exploitation of mineral deposits.

Magnetic anomalies occur as a result of contrasts in the properties of various rock types. Magnetite is the most important magnetic mineral in the earth's crust, although other iron-bearing minerals contribute. Basalt and intrusive mafic rocks are more magnetic than rhyolites and granitic rocks. Hence, differences in the magnetic properties of shallow rock bodies can be indicators of rocks associated with a targeted mineralization.

Bouguer gravity anomalies are indicative of regional differences in the density of the crust and upper mantle. Isostatic gravity anomaly maps, which involve correcting Bouguer maps for topographic differences, are more indicative of shallow features associated with differences in density of the shallow crust. Mihalasky (2004) used geomagnetic and isostatic gravity anomalies as an indicator of iron-depleted and lower density sedimentary host rocks in the subsurface. Volcanic host rocks are associated with broad and diffuse structural zones and widespread felsic volcanic activity, with intrusion by mafic and intermediate magmas (such as in the Walker Lane). Magnetic and gravity contrasts can indicate structural features that may be associated with fluid movement and host ore deposits.

### 2.4.2 Geochemical Methods

***Trace Metals as an Indicator of Favorable Mineral Zones***

Trace elements in sediments and water can be an indicator of the presence and abundance of targeted ore bodies at the regional scale. Wallace et al. (2004) reanalyzed stream-sediment and soil samples collected for the National Uranium

Resource Evaluation (NURE) program in the 1970s in their assessment of the minerals associated with plutonic rocks in the Humboldt basin and surrounding areas in northern Nevada. (Both the NURE study area and the Humboldt Basin study area extend into the northern portion of the CCD, but neither covers the CCD fully.) Wallace et al. concluded that arsenic, copper, lead, zinc, and the barium/sodium ratio were the most useful indicators of metal mineral potential. The multi-element data were gridded and then, using a series of band-pass frequency filters, resolved into distinct textural components. Anomalies in the dataset were then used to identify favorable areas associated with plutonic rock intrusions. A series of miscellaneous field studies maps were published showing the concentrations of 13 elements.

Mihalasky (2004) used ratios of potassium (K) to sodium (Na) and barium (Ba) to sodium, from data obtained during the NURE program, as an indicator of gold-silver mineralization. In the Great Basin, these ratios tend to increase in rocks that have been altered by hydrothermal or geothermal fluid circulation, which is associated with precipitation of metals. In volcanic rock-hosted gold and silver mineralization, the ratios should increase as barium and potassium are introduced and sodium is removed (the sodium is removed by being dissolved in hydrothermal fluids). These same conditions are also associated with precipitation of other mineral species, such as in porphyry copper deposits.

# SECTION 3
# DESCRIPTION OF ENERGY AND MINERAL RESOURCES (EXPLORATION, DEVELOPMENT, AND PRODUCTION)

This section of the report describes and analyzes the mineral resources of the CCD planning area. The known history of presence and exploitation of important mineral resources is described, along with the likelihood of continued or new development of these resources. These include the leasable geothermal and oil and gas resources; nonenergy leasable minerals of phosphate, sodium, sulfur, and potash or potassium; the locatable minerals of gold, silver, copper, molybdenum, tungsten, lead and zinc, vanadium, uranium, barite, diatomite, carbonate minerals, fluorspar, gypsum, silica, zeolites, and semiprecious stones; and the salable mineral commodities of sand and gravel, clay, and dimension or decorative stone. Several other mineral commodities have been mined or described within the planning area in the past. They are noted for completeness, but all evidence indicates their presence is limited to small or rather low-grade deposits, so they are unlikely to be developed in the period covered by this analysis.

Planning area mining dates to the 1850s, starting with the discovery of the Comstock Lode deposits of gold and silver in Virginia City (Tingley 1990). Economic deposits of minerals resulted in the formation of mining districts. The Comstock Lode deposits became one of the first mining districts of Nevada, leading to further exploration and development of mineral resources. Mineral deposits were found throughout the planning area. Eventually more than 128 mining districts were established for mining such materials as gold, silver, copper, lead, mercury, gypsum, and diatomite (Tingley 1998). The mining boom for the planning area lasted roughly 50 years and has slowed considerably since 1900 due to more deposit discoveries in the eastern and central portions of Nevada. Nevertheless activity still persists in the planning area (Tingley 1990).

**Table 3-1**, Historical Mining Districts in the Planning Area, shows the names and commodities of the historical mining districts in the planning area.

**Table 3-1**
**Historical Mining Districts in the Planning Area**

| Mining District | County | Commodity |
|---|---|---|
| Buckskin | Douglas | Andalusite, copper, corundum, gold, iron, pyrophylite, silver, tungsten |
| Delaware | Douglas, Lyon | Copper, gold, iron, lead, manganese, mercury, silver, tungsten |
| Gardnerville | Douglas | Antimony, copper, gold, molybdenum, silica, silver, tungsten |
| Genoa[1] | Douglas | Copper, gold, silver, uranium |
| Green Valley | Douglas | Gold, silver |
| Mount Siegel | Douglas | Gold |
| Mountain House | Douglas | Copper, gold, iron, lead, silver, tungsten |
| Red Canyon | Douglas | Antimony, copper, gold, lead, silver |
| Risue Canyon | Douglas | Gold, molybdenum, silver, tungsten |
| Wellington | Douglas, Lyon | Antimony, copper, fluorspar, gold, lead, silver, tungsten, zinc |
| Carson City | Carson City | Cinder, gold, sandstone, silver, tungsten, uranium |
| Carson River | Carson City, Lyon | Gold, mercury, silver, thorium and rare earths |
| Eldorado | Carson City, Lyon | Coal |
| Voltaire | Carson City | Arsenic, copper, gold, graphite, silver, tungsten |
| Alpine | Churchill | Gold, silver |
| Aspen | Churchill, Lander | Gold, silver |
| Bell Mountain | Churchill | Gold, silver |
| Bernice | Churchill | Antimony, gold, silver, tungsten |
| Broken Hills | Churchill, Mineral, Nye | Antimony, fluorspar, gold, lead, silver |
| Camp Gregory | Churchill | Diatomite, gold, mercury, silver |
| Carson Sink[1] | Churchill | Sodium chloride |
| Chalk Mountain | Churchill | Gold, molybdenum, lead, silver, vanadium |
| Copper Kettle | Churchill | Copper, iron |
| Copper Valley | Churchill, Pershing | Copper, iron, tungsten |
| Corral Canyon | Churchill | Gold, iron, titanium |
| Desert | Churchill | Gold, mercury, silver |
| Dixie Marsh | Churchill | Borates, sodium chloride, potash |
| Dixie Valley | Churchill | Copper, gold, lead, silver |
| Eastgate | Churchill | Gold, lead, silver, uranium, zeolite |
| Fairview | Churchill | Copper, gold, lead, silver, tungsten |
| Gold Basin | Churchill | Gold, silver |
| Holy Cross | Churchill, Mineral | Copper, gold, lead, manganese, mercury, silver, zinc |
| I.X.L | Churchill | Copper, fluorspar, gold, lead, silver |
| Jessup | Churchill | Diatomite, gold, montmorillonite, silver, tungsten |
| Job Peak | Churchill | Copper, gold, lead, silver |
| Lake | Churchill | Antimony, lead, silver |
| Mineral Basin | Churchill, Pershing | Antimony, iron, mercury, silver |
| Mountain Wells | Churchill | Fluorspar, molybdenum, silver, tungsten |

**Table 3-1**
**Historical Mining Districts in the Planning Area**

| Mining District | County | Commodity |
|---|---|---|
| (La Plata) | | |
| New Pass | Churchill, Lander | Gold, manganese, silver |
| Sand Springs | Churchill | Gold, mercury, silver, titanium, tungsten |
| Sand Springs Marsh | Churchill | Borates, sodium chloride, potash |
| Shady Run | Churchill | Antimony, gold, lead, mercury, silver, tungsten |
| Soda Lake | Churchill | Borates, sodium carbonates |
| Table Mountain | Churchill, Pershing | Antimony, cobalt, copper, fluorspar, gold, lead, mercury, nickel, silver, tungsten |
| Toy | Churchill, Pershing | Antimony, tungsten |
| Truckee | Churchill | Gold, lead, silver |
| Tungsten Mountain | Churchill | Gold, lead, molybdenum, silver, tungsten |
| Westgate | Churchill | Antimony, gold, lead, silver |
| White Cloud | Churchill | Copper, gold, iron, lead, silver, zinc |
| Wild Horse | Churchill, Lander | Antimony, manganese, mercury |
| Wonder | Churchill | Copper, fluorspar, gold, lead, molybdenum, silver, zinc |
| Benway | Lyon | Antimony, copper, gold, silver |
| Churchill | Lyon | Gold, mercury, silver, thorium and rare earths |
| Como | Lyon | Gold, silver |
| Desert Mountains | Lyon | Diatomite, gold, montmorillonite, silver |
| Leete | Lyon | Sodium chloride, borates |
| Eldorado | Lyon | Coal |
| Mound House | Lyon | Gypsum, uranium |
| Ramsey | Lyon | Antimony, gold, mercury, silver |
| Red Mountain | Lyon, Storey | Iron, tungsten |
| Silver City | Lyon | Copper, gold, iron, lead, silver |
| Talapoosa | Lyon | Copper, gold, mercury, silver |
| Wabuska Marsh | Lyon | Sodium sulfate |
| Washington | Lyon, Mineral | Coal, copper, gold, lead, silver, uranium |
| Wilson | Lyon | Gold, iron, lead, molybdenum, silver, titanium, tungsten, zinc |
| Yerington | Lyon | Copper, gold, gypsum, iron, nickel, turquoise |
| Ashby | Mineral | Antimony, copper, gold, lead, silver |
| Aurora | Mineral | Gold, silver |
| Basalt/Buena Vista/Mount Montgomery | Mineral | Diatomite |
| Bell | Mineral | Arsenic, gold, iron, lead, mercury, molybdenum, silver, tungsten, zinc |
| Black Horse | Mineral, Esmeralda | Barite, gold, silver, tungsten |
| Borealis | Mineral | Gold, silver |
| Buckley | Mineral | Copper, gold, iron, tungsten |
| Buena Vista/Mont Montgomery | Mineral | Copper, fluorspar, gold, lead, silver, thorium and rare earths, tungsten, zinc |

**Table 3-1**
**Historical Mining Districts in the Planning Area**

| Mining District | County | Commodity |
|---|---|---|
| Calico Hills | Mineral | Copper, iron |
| Candelaria | Mineral, Esmeralda | Antimony, barite, copper, gold, lead, nickel, silver, turquoise, variscite |
| Double Springs Marsh | Mineral | Sodium carbonate, sodium sulfate |
| Eagleville | Mineral | Barite, gold, silver, tungsten |
| Eastside | Mineral | Copper, mercury, turquoise |
| Fairplay | Mineral | Copper, gold, mercury, tungsten, silver |
| Fitting | Mineral | Andalusite, barite, copper, corundum, gold, iron, lead, montmorillonite clay, silver, thorium and rare earths, tungsten, uranium |
| Garfield | Mineral | Antimony, copper, gold, lead, silver, tungsten |
| Huntoon | Mineral | Gold, silver |
| King | Mineral | Gold, lead, silver |
| Leonard | Mineral | Antimony, gold, tungsten |
| Lucky Boy | Mineral | Antimony, barite, gold, gypsum, lead, molybdenum, silver, tungsten, uranium |
| Marietta | Mineral | Beryllium, copper, lead, silver, tungsten, uranium |
| Masonic | Mineral | Gold, silver, tungsten |
| Mount Grant | Mineral | Gold, molybdenum, silver |
| Mountain View | Mineral | Antimony, copper, gold, gypsum, lead, silver, tungsten |
| Pamlico | Mineral | Barite, copper, gold, iron, uranium, silver |
| Pilot Mountains | Mineral | Antimony, copper, gold, lead, mercury, molybdenum, montmorillonite, silver, turquoise, tungsten |
| Poinsettia | Mineral, Nye | Antimony, copper, gold, mercury |
| Rand/Bovard | Mineral | Copper, gold, lead, molybdenum, potash, silver, turquoise, uranium, zinc |
| Rawhide | Mineral | Antimony, copper, gold, lead, mercury, silver |
| Red Ridge | Mineral | Uranium |
| Rhodes Marsh | Mineral | Borates, montmorillonite, sodium chloride, sodium sulfate |
| Santa Fe | Mineral | Antimony, copper, gold, iron, lead, silver, tungsten, uranium |
| Silver Star | Mineral | Antimony, beryllium, copper, gold, lead, manganese, montmorillonite clay, silver, tungsten, uranium |
| Sodaville | Mineral | Manganese, tungsten |
| Sulphide | Mineral | Gold, tungsten |
| Teels Marsh | Mineral | Borates, Sodium chloride |
| Whisky Flat | Mineral | Copper, gold, silver, tungsten |
| Bruner | Nye | Gold, silver |
| Ellsworth | Nye | Copper, gold, iron, lead, silver, tungsten, zinc |
| Gabbs | Nye | Brucite, copper, iron, lead, magnesite, silver, tungsten, zinc |
| Lodi | Nye | Beryllium, copper, gold, lead, molybdenum, silver, talc-chlorite, tungsten |

**Table 3-1**
**Historical Mining Districts in the Planning Area**

| Mining District | County | Commodity |
|---|---|---|
| Castle Peak | Storey | Mercury |
| Chalk Hills | Storey | Diatomite |
| Clark | Storey | Diatomite, gold, mercury, silver |
| Comstock[1] | Storey | Copper, gold, lead, mercury, silver |
| Cottonwood | Washoe | Antimony, copper, gold, lead, silver, tungsten |
| Dogskin Mountain | Washoe | Uranium |
| Freds Mountain | Washoe | Copper, gold, uranium |
| Galena | Washoe | Arsenic, copper, gold, lead, silver, tungsten, zinc |
| Jumbo | Washoe | Gold, silver, tungsten |
| Lake Range | Washoe | Copper, gold, lead, silver, zinc |
| Little Valley | Washoe | Gold |
| Lone Pine | Washoe | Mercury, gold |
| McClellan | Washoe | Antimony, copper, lead, titanium, uranium |
| Olinghouse | Washoe | Copper, gold, lead, silver, tungsten |
| Peavine | Washoe | Coal, copper, gold, iron, lead, silver, tungsten |
| Pyramid | Washoe | Arsenic, copper, gold, lead, molybdenum, silver, tungsten, uranium, zinc |
| Sand Pass | Washoe | Calcium carbonate, Fuller's earth, gold |
| Sheephead | Washoe | Clay, gold, perlite, sodium chloride, sodium sulfate, zeolite |
| State Line | Washoe | Iron, uranium |
| Stateline Peak | Washoe | Copper, gold, silver, thorium and rare earths, uranium |
| Steamboat Springs | Washoe | Antimony, mercury, sulfur |
| Wedekind | Washoe | Gold, lead, silver, zinc |
| NA | Plumas | Copper |
| Hallelujah Junction | Lassen | Uranium |
| Red Rock | Lassen | Pumice, pumicite |
| Leviathan | Alpine | Sulfur, vanadate (minor), silver |
| Mogul, Monitor | Alpine | Silver, gold, copper |

Source: Tingley 1990, 1998
[1]Most of the district is outside decision area.

## 3.1 LEASABLE MINERAL RESOURCES

Leasable minerals, as defined by the Mineral Leasing Act (February 1920; 43 CFR, Parts 3000-3599, 1990), include the subsets leasable fluid and leasable solid minerals. Leasable fluid minerals include oil and gas and geothermal resources, and leasable solid minerals include coal, oil shale, native asphalt, phosphate, sodium, potash, potassium, and sulfur. The rights to explore for and produce these minerals on public land may be acquired only through leasing. Past exploration indicates that deposits of sodium, potash, sulfur, and coal have been identified in the planning area (Papke and Castor 2003; Tingley 1998).

The BLM has developed more rigorous guidelines to be used in the development of fluid minerals. These guidelines are described in BLM Handbook H-1624-1, Planning for Fluid Mineral Resources (BLM 1990). This handbook is supplemented by Instruction Memorandum No. 2004-110 (BLM 2004), which presents the BLM's Policy for Fluid Mineral Leasing and Related Policy and the NEPA Processes.

Through its Fluid Minerals Program, the BLM reviews and approves permits and licenses from companies to explore, develop, and produce both renewable (geothermal) and nonrenewable (oil and gas) energy on BLM-administered lands. Leases are sold on a noncompetitive or competitive basis, and the BLM issues notices when a lease sale is pending. The BLM Nevada State Office holds competitive sales of federal lands in Nevada for geothermal and oil and gas leasing. Sales include lists of parcel numbers, legal land descriptions, and corresponding stipulations (BLM 2011).

For leasing nominations and exploration/development proposals, the CCD coordinates with the BOR, the USFS (Humboldt-Toiyabe National Forest Bridgeport and Carson Ranger Districts, and Inyo National Forest Service Mono Lake and White Mountain Ranger Districts), and the US Navy on Navy-owned and withdrawn lands. The BLM is the lead for processing these proposals and must coordinate with these agencies and their specialists in developing environmental review documents (BLM 2011).

The CCD ensures that proposed projects meet all applicable environmental laws and regulations, while working with local communities, state agencies, industry, and other federal agencies in the environmental review process (BLM 2011). Currently, there are 148 geothermal leases with five associated power plants, fewer than 30 oil and gas leases, and one active salt mine in the planning area. The historical and current deposits of leasable minerals within the planning area are discussed by commodity below.

### 3.1.1 Geothermal

Geothermal energy is derived from the natural heat of the earth. Geothermal resources are typically underground reservoirs of hot water or steam created by heat from the earth, but they also include subsurface areas of dry hot rock. In cases where the reservoir is dry hot rock, the energy is captured through the injection of cool water from the surface, which is then heated by the hot rock and extracted as fluid or steam. Geothermal steam and hot water can naturally reach the earth's surface in the form of hot springs, geysers, mud pots, or steam vents. Geothermal reservoirs of hot water are also found at various depths beneath the earth's surface (BLM 2008).

Geothermal resources occur most often in areas where there is anomalously high heat flow caused by volcanism, near-surface magma, or some other exceptionally hot subsurface body (Coolbaugh et al. 2002). The resource often occurs along fault or fracture zones, where conduits in the bedrock allow groundwater to circulate to depths for warming before being circulated back to the surface (BLM 2012). The planning area has abundant geothermal resources, including thermal springs, where warm or hot water comes to surface naturally, and thermal wells, which must be drilled, developed, and sometimes pumped.

The 2008 Geothermal Programmatic EIS identified the entire state of Nevada as having potential for geothermal resources. Up to 75 percent of all geothermal leases on federal land in the US are in Nevada (BLM 2011). The EIS stated that as of 2008, there were 45,991,073 acres of BLM-administered lands and 6,221,008 acres of National Forest Service-administered lands with geothermal potential within Nevada. All of the BLM-administered lands within the CCD were identified as having geothermal potential (BLM 2008). Of those lands with geothermal resources, approximately 4.8 million BLM-administered acres with geothermal potential are in the planning area (BLM 2008). Of those, 45,392 acres are closed to geothermal leasing due to key scenic, wildlife, recreation, and historic areas (BLM 2013).

The CCD sits atop one of the most active geothermal resources anywhere. It manages 148 geothermal leases covering approximately 299,195 acres, with five associated power plants, with an active geothermal power production of 183 megawatts (MW), as of February 2013. These power plants are in Steamboat Hills near Reno; Dixie Valley northeast of Fallon; and Soda Lake, Stillwater, and Salt Wells near Fallon. In addition, the Wabuska facility is on private land within the planning area.

Two power plants are under construction on BLM-administered lands in the planning area: The Wild Rose Power Plant in Gabbs Valley will produce 15 to 35 MW, and the Patua Power Plant near Fernley will produce 60 MW. Another three areas with active exploration projects for proposed future energy production are Southern Gabbs Valley, Northern Edwards Creek Valley, and the Hazen area.

Additional areas that have active geothermal leases but minimal or no exploration are Rhodes Salt Marsh near Mina and the Winnemucca Ranch and Honey Lake areas north of Reno. **Figure 3-1**, Geothermal Leases and Power Plants, shows the active leases and existing power plants within the CCD. **Table 3-2**, Geothermal Power Plants in the CCD, shows the locations of geothermal production and the megawatt capacity of each plant.

From January 1990 to February 20, 2013, 204 permit applications have been received; this includes notices of intent for exploration, exploration drilling plans, geothermal drilling permits, sundry notices for facilities changes at existing exploration and production facilities, and geothermal power plant development plans (BLM 2013, LR 2000 Data provided by Sheila Mallory BLM NVSO).

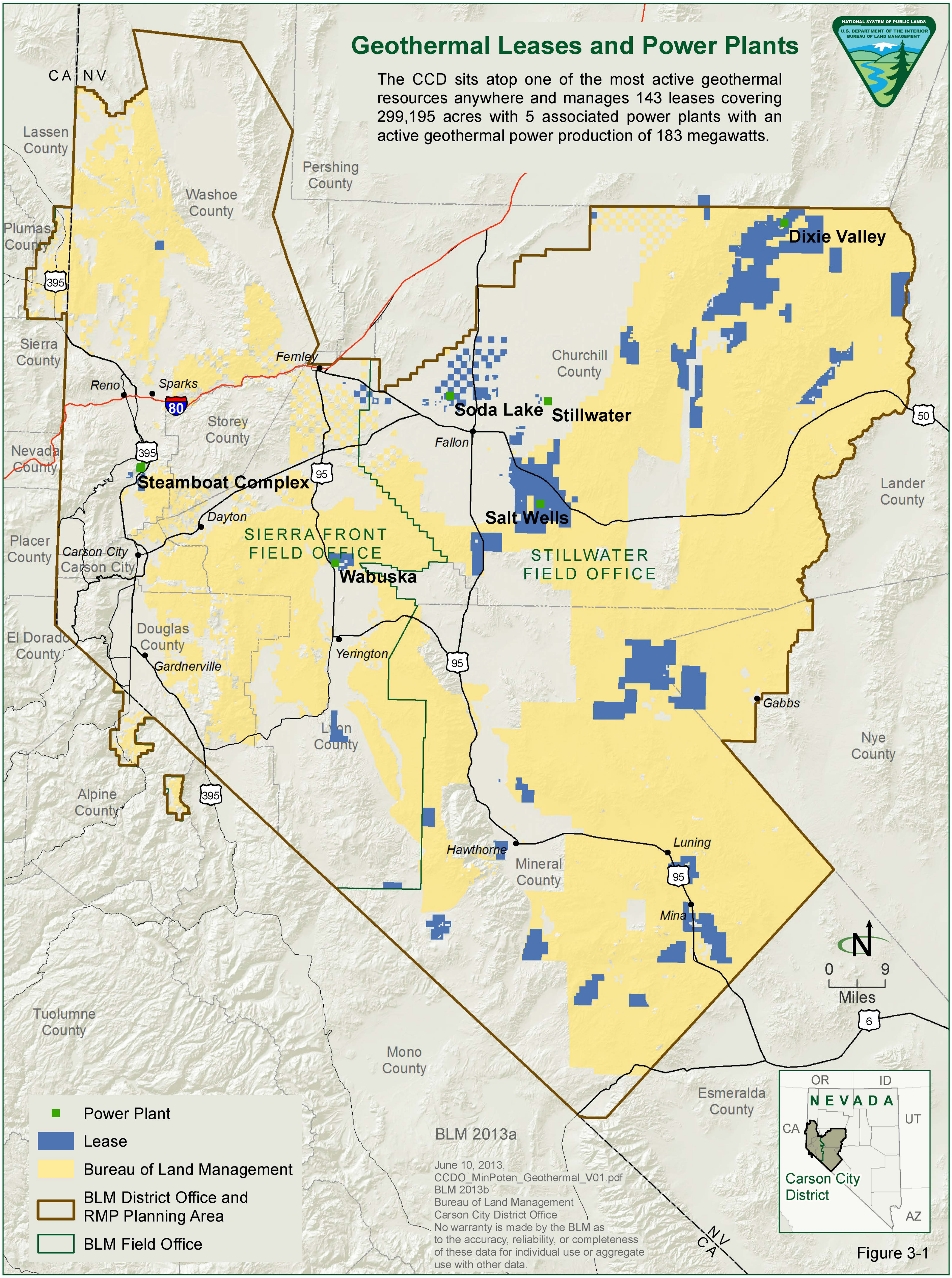

Geothermal Leases and Power Plants
The CCD sits atop one of the most active geothermal resources anywhere and manages 143 leases covering 299,195 acres with 5 associated power plants with an active geothermal power production of 183 megawatts.
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CA NV
Lassen County
Plumas County
Washoe County
Pershing County
Sierra County
Nevada County
Placer County
El Dorado County
Alpine County
Tuolumne County
Mono County
Storey County
Douglas County
Lyon County
Churchill County
Mineral County
Lander County
Nye County
Esmeralda County
Carson City
Reno
Sparks
Fernley
Fallon
Dayton
Yerington
Gardnerville
Hawthorne
Luning
Mina
Gabbs
Dixie Valley
Soda Lake
Stillwater
Steamboat Complex
Salt Wells
Wabuska
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
395
80
95
50
6
N
0 9
Miles
NV CA
OR ID
NEVADA
CA
UT
AZ
Carson City District
Power Plant
Lease
Bureau of Land Management
BLM District Office and RMP Planning Area
BLM Field Office
BLM 2013a
June 10, 2013,
CCDO_MinPoten_Geothermal_V01.pdf
BLM 2013b
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.

Figure 3-1

**Table 3-2**
**Geothermal Power Plants in the CCD**

| Power Plant | Operator | County | MW Capacity |
|---|---|---|---|
| Steamboat Hills (Galena 1, 2, and Steamboat) | Ormat | Washoe | 13.2 |
| Dixie Valley | Terra-Gen Power | Churchill | 67 |
| Soda Lake | Alterra Power | Churchill | 23 |
| Stillwater | Enel Green Power | Churchill | 47 |
| Salt Wells | Enel Green Power | Churchill | 18 |

### 3.1.2 Potash and Sodium

The term potash denotes a variety of mined and manufactured salts, all of which have potassium in them in a water soluble form (USGS 2013a). Potassium is one of three key plant nutrients, so potash is used primarily as an agricultural fertilizer (USGS 2013a). The CCD has three areas of historical potash production, none of which are currently producing (Tingley 1998). Potash is often mined in tandem with sodium minerals, which include sodium chloride (six areas), sodium sulfate (four areas), and sodium carbonate (two areas; Tingley 1998; Papke and Castor 2003). Potash production without sodium minerals occurred in the Rand District, while potash and sodium chloride were mined in the Dixie Marsh and Sand Springs Marsh Districts. The Sheephead and Rhodes Marsh Districts were mined for sodium chloride and sodium sulfate. Sodium sulfate and sodium carbonate were mined in the Double Springs Marsh District. The Carson Sink and Teels Marsh Districts produced sodium chloride, the Wabuska Marsh District produced sodium sulfate, and the Soda Lake District produced sodium carbonate (Tingley 1998, 1990).

Many of the historical mining districts note the presence of salt only and have little to no documentation of the amount of salt produced or when. Of the districts listed above, Carson Sink, Soda Lakes, Dixie Marsh, Teels Marsh, Rhodes Marsh, Wabuska Marsh, Double Springs Marsh, and Sand Springs Marsh are noted for active or significant past production, but actual production amounts are unknown (Papke and Castor 2003). In the Carson Sink District a small amount of salt was produced by solar evaporation in 1909; the Wabuska District is composed of several small playas; and the Teels Marsh District produced salt as early as 1865 from the Buffalo Springs area (Tingley 1998).

The Dixie Marsh District, once part of the Dixie Valley District, is thought to be the earliest commercial source of salt in Nevada. The saline deposits were limited to the Humboldt Salt Marsh, and, from 1861 to 1868, a large amount of salt was hauled by a mule team to various silver mills for ore processing. The deposit of salt is the result of the evaporation of a shallow lake, likely of Pleistocene age. The decline of silver milling and the remote location of the salt deposit led to its abandonment; since then, salt has not been mined at this location (Tingley 1990).

The Sand Springs District also has evaporite deposits, covering about 1,600 acres known as the Fourmile and Eightmile Flats in the Salt Wells Basin (Tingley 1990). The deposits were discovered in 1863 and were originally hauled to silver mills for the reduction of ore. The deposits were later taken to some dairies and ranches and used on highways (Tingley 1990). Salt production in this area has been almost continuous to the present; currently the Huck Salt Plant processes the evaporite deposits (Tingley 1990; Castor and Ferdock 2012). In 2010, the Hulk Salt Plant reportedly produced 25,893 tons of salt and employed nine individuals (NBMG and NDOM 2010; Driesner and Coyner 2011). The Huck Salt Plant has an active plan of operation, as seen in **Table 3-3**, Active Plan of Operation—Salt.

Production totals from the Huck Salt Mine have been made publically available since at least 1997. Salt production varies year to year and is based on the demand for salt, usually for use on highways and other roadways for deicing (USGS 2011). **Table 3-4**, Annual Production of the Huck Salt Mine, shows the history of salt production and employment of the Huck Salt Mine since 1998. Due to the fairly regular production of salt and the annual need for salt to deice roads, salt production in the planning area can be expected to continue.

### 3.1.3 Sulfur

The largest single source of sulfur is in association with salt domes, but other sources include metallic sulfides, hydrogen sulfide gas associated with natural gas and petroleum, and deposits of gypsum and anhydrite. Historically, sulfur was mined along with mercury and antimony in the Steamboat Springs District, located seven miles southwest of Reno in the foothills bordering the Carson Range (Tingley 1990). Mining began in 1875 and lasted only a few years, with later activity focused on mercury deposits in the area (NBMG 1979). Ore deposits were found in a fumarole environment. They consisted of moderately to strongly hydrothermally altered and bleached granodiorite and overlying Tertiary basalt and alluvium. The deposits now consist largely of quartz and cristobalite. Cinnabar and sulfur are present in fracture fillings, disseminated in the veinlets of opal and chalcedony, and as films and encrustations on joints and fracture surfaces (Tingley 1990).

This area is better known for a resort and health spa and associated hot springs and the Steamboat Springs geothermal electric facility. It is no longer associated with sulfur mining (Tingley 1990).

The Leviathan Mine in Alpine County was the largest producer of native sulfur in California. Sulfur occurs as veins and as an impregnation of completely opalized fine-grained andesite tuff. The main production was from 1953 to 1962 to supply sulfuric acid for recovery of copper at Yerington (both the sulfur and copper mines were operated by Anaconda Corp.). The Leviathan Mine, located several miles north of the CCD boundary, is now listed as a hazardous waste site on the EPA's National Priorities List.

**Table 3-3**
**Active Plan of Operation—Salt**

| Serial Number | Type | Commodity | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|---|---|
| NVN 069929 | MINING | SALT | HUCK SALT | 11/19/2002 | FOURMILE FLAT | 16N | 31E | 7,11,12,13 | 16.5 |

**Table 3-4**
**Annual Production of the Huck Salt Mine**

| Year | Tons of Salt Produced | Number of Employees |
|---|---|---|
| 1998 | 18,190 | 4 |
| 1999 | 15,335 | 4 |
| 2000 | 12,964 | 4 |
| 2001 | 15,712 | 4 |
| 2002 | 14,159 | 4 |
| 2003 | 9,054 | 4 |
| 2004 | 14,299 | 5 |
| 2005 | 30,502 | 5 |
| 2006 | 15,000 | 6 |
| 2007 | 15,884 | 8 |
| 2008 | 25,761 | 9 |
| 2009 | 25,053 | 9 |
| 2010 | 25,893 | 9 |

Source: NDOM Major Mines of Nevada 1999-2011

### 3.1.4 Coal

Coal presence has been reported in three historical mining districts in the planning area, including the Eldorado, Peavine, and Washington districts (Tingley 1998). Currently, there is no effort to explore for or lease areas with potential coal deposits in the planning area.

The Eldorado District is in Lyon and Carson Counties, in the drainage of Eldorado Canyon in the Pine Nut Range. The coal-bearing deposits consisted of alternating layers of marl, soft gray sandstones, shales, fire-clay, carbonized vegetable matter, and three beds of weathered lignite that were, counting from the surface, 16 feet, 18 feet, and 6 to 8 feet thick. Before 1865, 9,800 tons of coal were mined from the deposit and an additional 31,400 tons were mined following the formal organization of a mining company in 1872. All of the coal produced was lignite. Later studies found the coal to be about 19 percent moisture, 34 percent ash, 28 percent volatile hydrocarbons, and 19 percent fixed carbon (Tingley 1990)

The Peavine District in Washoe County is centered on Peavine Peak in the Peavine Mountains, northwest of Reno. The Peavine District also held gold and silver, which was the focus of the district, and, as such, coal is not mentioned beyond its present in the area. It is not known what type of coal or associated deposits existed or how much was recovered. The Peavine District is now a residential area and part of a national forest, so further coal recovery is not expected (Tingley 1990).

In 1919, the Washington District was prospected for coal deposits located southeast of the Walker River in Tertiary sedimentary outcrops. These consisted of sandstone, mudstone, shale, marl, diatomite, limestone, and calcareous tufa, with lignitic shale and coaly layers integrated with thin seams of gypsum. In addition, lignitic coal layers up to a foot thick were prospected from areas deeper underground. Due to the poor quality of the coal and the once remote location, these deposits were never developed. Currently, many of the roads leading to this historical district have been closed and access is restricted; therefore, the coal and other local deposits are not expected to be developed (Tingley 1990).

### 3.1.5 Oil and Gas

Since the early 1900s, limited drilling and exploration for oil and gas have taken place in the planning area in Washoe, Lyon, Churchill, and Mineral Counties (BLM 2013, CCD AMS). The CCD currently manages fewer than 30 oil and gas leases in Churchill, Nye, and Mineral Counties (BLM 2011, CCDO AMS). Oil exploration in the planning area has generally been limited to the Carson Desert north and west of Salt Wells Lake and the area surrounding Fallon. Oil discoveries in western Nevada have been limited to a few reported shows identified during drilling, usually in dry holes. The Nevada Bureau of Mines and Geology identified this area as favorable for oil and gas (Garside et al. 1988).

Most of the area identified as favorable, including most of the Carson Sink, is not within the decision area. **Figure 3-2**, Oil and Gas Potential on BLM-Administered Lands, depicts areas with high, medium, and low oil and gas potential. There is a limited amount of exploration on these leases, and no known production has occurred in association with them.

## 3.2 LOCATABLE MINERALS

Locatable minerals are those for which the right to explore, develop, and extract on federal land open to mineral entry is established by the location (or staking) of lode or placer mining claims (General Mining Law 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 are 43 CFR, Part 3809, Surface Management Regulations; Part 6300, Wilderness Regulations; Part 5860, Wilderness Management Handbook; Part 3802, Exploration and Mining, Wilderness Review Program; and Part 3715, Use and Occupancy.

The regulatory framework necessary for oversight and permitting of mineral exploration and mining is in place. Exploration causing more than 5 acres of surface disturbance or any mining activity beyond the threshold of casual use requires a plan of operation, a reclamation plan, and NEPA environmental analysis and compliance. Exploration notices (exploration causing five acres or less of surface disturbance using mechanized equipment) and plans of operation both require reclamation bonding. Exploration notices and "casual use" are not designated federal actions and thus do not require environmental analysis or BLM's approval. Exploration notices are reviewed and "acknowledged" by an authorized officer, and operators are required to prevent unnecessary or undue surface degradation.

Locatable minerals are divided into metallic minerals and industrial minerals. Examples of metallic minerals that have been historically mined and are currently being mined in the planning area are gold, silver, copper, molybdenum, tungsten, iron, and uranium. Examples of industrial minerals are gypsum, barite, diatomaceous earth, and fluorspar.

### 3.2.1 Metallic Minerals

The most important metallic mineral deposits in the planning area are present in pluton-related deposits. They are associated with Cretaceous-Paleogene Laramide magmatism, extensional tectonics that produced basin and range block faulted ranges, and Tertiary volcanism. Sedimentary mineral concentration, such as in placer deposits of gold or titanium minerals, or precipitation of remobilized metals in hot springs, is much less significant as a source of metallic mineral deposits and occurred over a relatively brief period during the Quaternary.

Pluton-related metal deposits occur over a continuum of depositional micro-environments, as illustrated in **Figure 3-3**, Cross-section of Pluton-related Metal Deposit. Due to its tectonic history and location relative to the Paleozoic

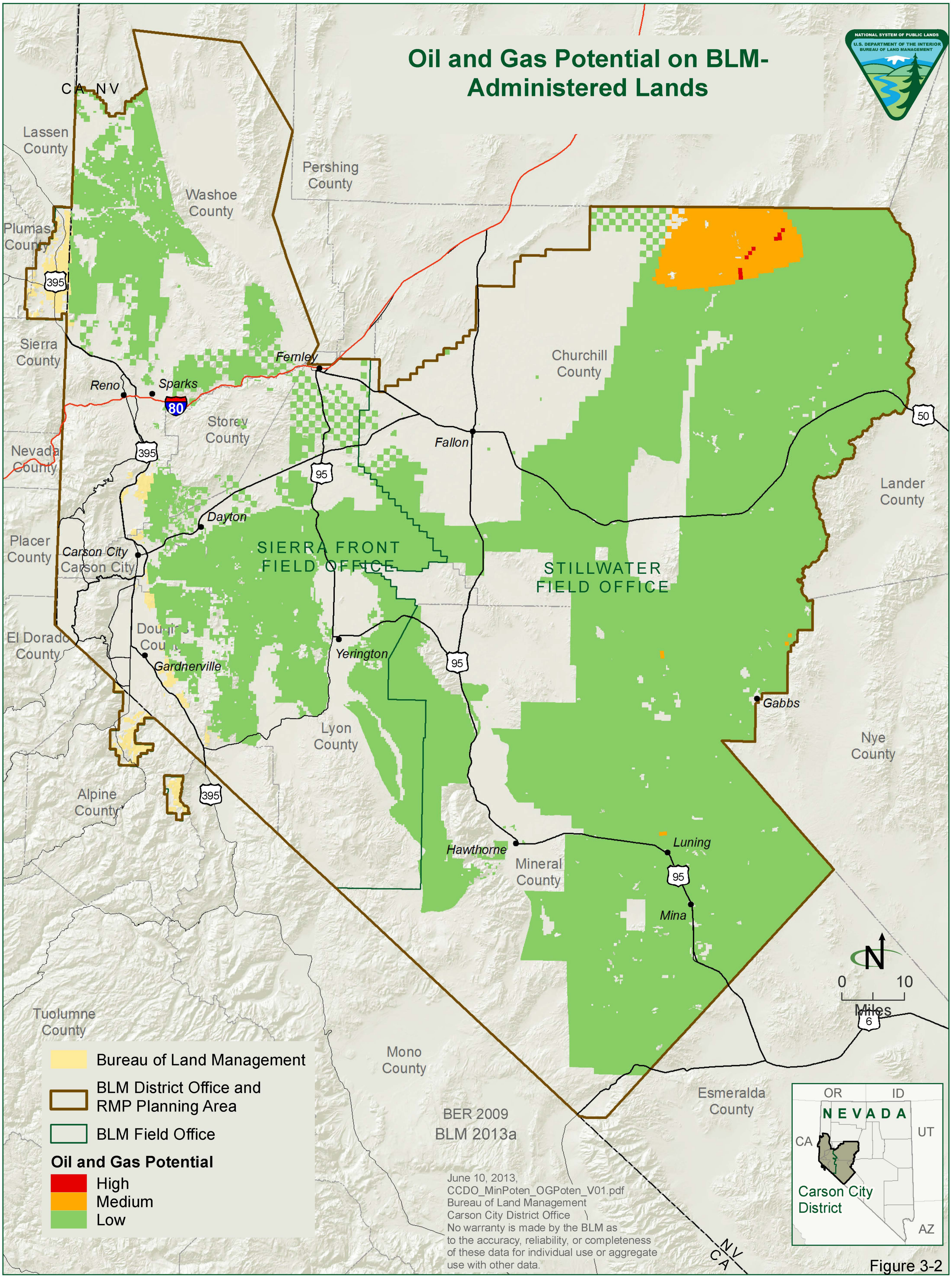

Oil and Gas Potential on BLM-Administered Lands
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CA NV
Lassen County
Plumas County
Sierra County
Nevada County
Placer County
El Dorado County
Alpine County
Tuolumne County
Mono County
Washoe County
Pershing County
Churchill County
Storey County
Lyon County
Mineral County
Lander County
Nye County
Esmeralda County
Carson City
Reno
Sparks
Fernley
Fallon
Dayton
Yerington
Gardnerville
Hawthorne
Luning
Mina
Gabbs
395
80
95
50
6
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
0
10
Miles
N
OR
ID
NEVADA
CA
UT
AZ
Carson City District
Bureau of Land Management
BLM District Office and RMP Planning Area
BLM Field Office
Oil and Gas Potential
High
Medium
Low
BER 2009
BLM 2013a
June 10, 2013,
CCDO_MinPoten_OGPoten_V01.pdf
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
NV
CA

Figure 3-2

Mn, Co, Ni, V and Sc are depleted in altered rock near the ore zone and redistributed to distal alteration zones outside the studied area (Figure 3.15). Zn is also depleted from alteration near the ore zone (<40 ppm) but is enriched (80-140 ppm) in samples from less than 1 km paleodepth. This relative enrichment of Zn is likely redistributed Zn removed from biotite and hornblende during alteration.

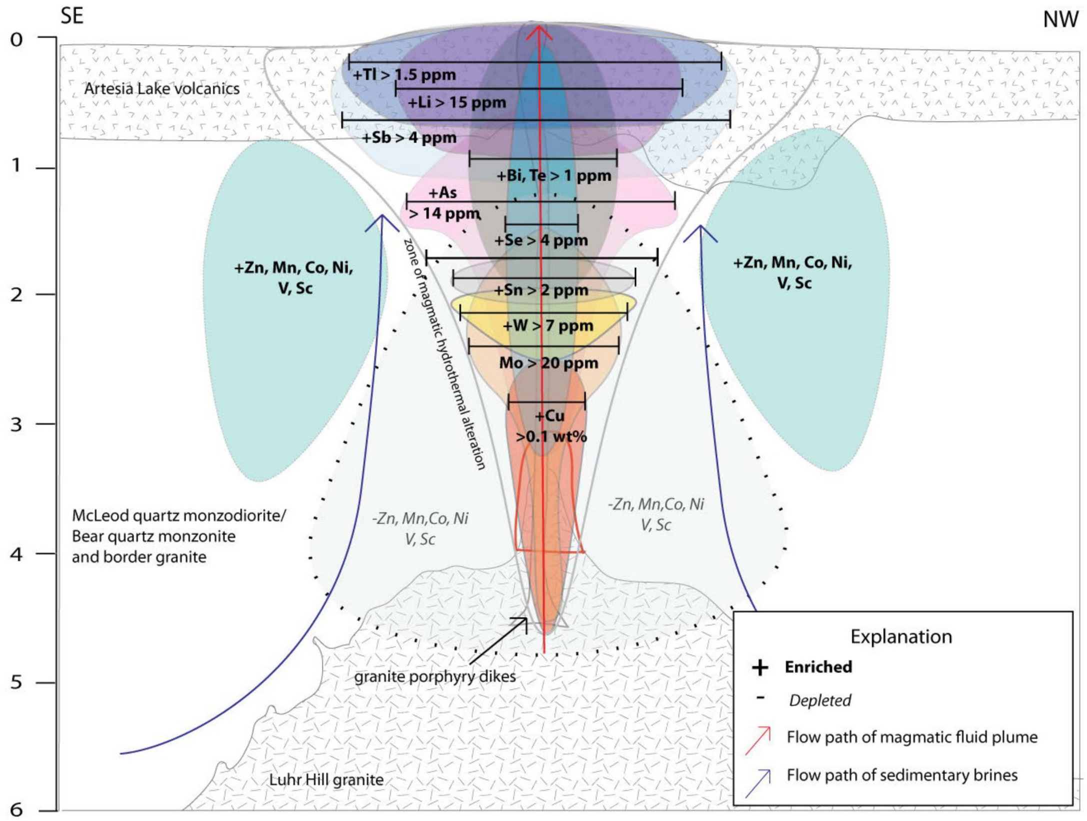



Figure 3.16. Summary figure showing distribution of trace elements as measured in rock chemistry on a cartoon cross-section through the Ann-Mason porphyry copper deposit. Colored shapes represent the spatial extent of trace element anomalies (Table 3.2). The red arrow indicates the path of the magmatic fluid plume while the blue arrow indicates the path of circulating sedimentary brines.

Craton, there are relatively few carbonate rocks in the CCD. Most of those rocks are carbonate-rich volcaniclastic marine sediments deposited in deep or shallow water near island arcs during Mesozoic time; these rocks subsequently accreted onto the continental margin. In addition, these Early to Middle Mesozoic rocks were displaced again by strike slip faulting and were rotated by oblique normal faulting. Because of this, mineral occurrences associated with mineralization that occurred before faulting can be localized and variable. Block faulting and Late Cenozoic extension and strike slip faulting within the Walker Lane has resulted in development of broad sediment-filled basins between ranges. For practical reasons, mining has historically focused on the deposits exposed within the ranges. But similar deposits must also be present in the basement rocks of the grabens.

Gold, silver, and copper, along with associated molybdenum, lead, and zinc, are the principal locatable metals in the CCD. Other associated minerals are also locally important, including iron, mercury, and antimony.

**Antimony** is reported in 29 historical mining districts and is generally associated with precious metal deposits, such as gold and silver, and in some cases mercury. Antimony is found naturally as the sulfide minerals stibnite and jamesonite. Antimony is often a base mineral associated with precious metals, but, it was exploited in such mines as the Hoyt, Arrance, Antimony King, and Lofthouse in the Bernice District. Deposits of antimony are generally associated with sulfide ore. These deposits typically include hydrothermally altered andesites, with deposits of sulfide minerals, altered rock and fault breccia, polymetallic vein deposits, and deposits associated with quartz gauge (Tingley 1990, 1998).

**Arsenic** is limited to the historical Pyramid, Voltaire, Bell, and Galena Districts, most of which do not have production amounts or descriptions of arsenic-specified ore deposits (Tingley 1990, 1998). The Galena District notes oxidized arsenic in the ore deposits containing lead, silver, zinc, and copper (Tingley 1990).

**Beryllium** is reported in historical Lodi, Silver Star, and Marietta Districts, but information beyond that is unavailable (Tingley 1990, 1998).

**Copper.** The western side of the CCD lies near the center of a band of porphyry copper and related deposits. It extends northwest along the Walker Lane from southern Nye County to Plumas County in California.

The Yerington District (and adjacent Buckskin and Pine Nut Districts) in Lyon County is one of the largest copper-producing areas in Nevada. It includes all of the Singatse Range, Mason Valley, and a small portion of the Wassuk Range east of Mason Valley. The district extends from Wilson Canyon on the south end of the Singatse Range to the vicinity of Gallagher Pass on the north end of the range. It includes Pumpkin Hollow, parts of the Gray Hills, and the low foothills of the Wassuk Range along both sides of the Lyon-Mineral county line. The district is known for several highly productive copper deposits; these are the Ludwig, Anna Mason, MacArthur, Lyon, Bear, Lagomarsino, Walker River, and Pumpkin Hollow Deposits, as well as the Bluestone, Mason Valley, Douglas, and Yerington Mines (Tingley 1990, 1998).

Copper was first mined in 1865 when bluestone (a copper sulfate) was mined from oxidized outcrops of the Ludwig copper deposit for reduction works on the Comstock Lode. Mining for copper metal began in 1883, with production from the Douglas District totaling $272,000 between 1883 and 1891. The Yerington Mine, operated by Anaconda Corporation, produced 89 million tons of copper in 25 years of production between 1950 and 1978, when depressed world copper prices brought the mine to a close. Exploration continued in the area in the 1970s, particularly in Pumpkin Hollow, east of Yerington, where several deposits of copper-iron skarn mineralization have been noted (Tingley 1990).

The major ore bodies of the Yerington District are porphyry copper deposits and associated contact metamorphic replacement (skarn) deposits. These develop where the host rocks are carbonate or carbonate-rich. The grades and geometries of ore bodies in porphyry copper deposits depend on a complex sequence of conditions and events that are characteristic of the Walker Lane: shallow magmatism and structurally controlled permeability (Berger et al. 2008). Porphyry copper deposits are commonly found along fault zones where strike-slip faulting is interrupted by normal-oblique faults (pull-apart structures). This is exactly the environment found in the Walker Lane.

The Yerington porphyry copper deposits are believed to have developed from a Jurassic Age intrusion of silicic magma into a quartz monzodiorite batholith (the Yerington Batholith). This intrusion was an approximately three-kilometer-thick sequence of Upper Triassic to Middle Jurrasic arc deposits (the Pine Nut Terrane of Stewart, 1997) that had been obducted onto the continental margin after the onset of subduction (Einaudi 1994).

The potassium-rich granitic intrusion generated an approximately two- to three-kilometer thickness of andesite/quartz-latite flows, interbedded with volcaniclastic deposits that formed a dome over the batholith. This sequence was intruded by porphyritic granite dike swarms in at least three episodes. The dike swarms were controlled by a northwest-striking fracture set. Copper mineralization was the result of chemical and thermal precipitation and remobilization of fractionated magmatic fluids and subsequent hydrothermal circulation, accompanied by alteration of the host rocks.

The highest grade copper ore is associated with potassic alteration at approximately a two- to four-kilometer paleodepth within the Jurassic intrusive complex (Einaudi 1994). The copper is most abundant in low-sulfur quartz-sulfide veinlets. At greater depths within the sequence, sodic-calcic alteration was superimposed on the earlier potassic assemblage during the evolution of the depositional sequence.

Mineralized fluids mobilized in several intrusive episodes, overprinting the effects of earlier events. Increasingly sodic fluids penetrated to shallower depths, resulting in chlorite-albite alteration of the earlier potassic zones. Isotopic ratios in fluid inclusions suggest that the potassic fluids were predominantly magmatic, while subsequent sodic fluids were predominantly deep saline groundwater recirculated in deep convective zones, which leached and transported the soluble species, including copper, iron, sulfur and potassium to outer zones where they precipitated. A late shallow seritized zone less than two kilometers in paleodepth is associated with low temperature hydrothermal fluids that originated from surface water.

The primary ore mineral of these deposits is chalcopyrite associated with pyrite. Secondary ore minerals include chalcanthite, brochantite, azurite, chrysocolla, chalcocite, copper pitch (melaconite), and some native copper (Tingley 1990, 1998). The skarn is typically composed of variable amounts of pyroxene, garnet, and epidote, with quartz and calcite.

Recently there has been renewed interest in developing copper holdings in the Yerington area (See **Table 3-5**, Active Plans of Operations in the CCD—Copper).

***Gold and Silver***

Nevada is a major producer of precious metals and is ranked as the third or fourth largest gold producing region in the world in terms of its annual production (USGS 2012). Therefore, it is not surprising that Nevada ranks first in the nation in gold production, accounting for 5.3 million ounces, or 72 percent, of the gold produced domestically in the US in 2010.

The planning area contains well-known historical gold and silver mining districts, including the Comstock District in Storey County, Jessup in Churchill County, Talapoosa in Lyon County, and Borealis and Santa Fe in Mineral County (Tingley 1998). Most of the historical gold production in the CCD is from lode deposits, and most of the most easily accessible lode deposits have probably been identified and extracted.

Lode deposits, in which metals are precipitated from hydrothermal fluids that have invaded fractured rocks associated with plutonic intrusive bodies, are an important type of mineral occurrence. However, they represent just one end of a continuum of types of metallic mineral deposits associated with Tertiary magmatism in the CCD. Most of the lode deposits were discovered and exploited from the 1850s to the early 1900s and accounted for almost all the precious metal production during that period. Far larger quantities of these metals are present in finer and more distributed deposits or in deposits that are less accessible.

**Table 3-5**
**Active Plans of Operation in the Planning Area—Copper**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 084570 | ENTREE GOLD US INC | 3/2/2010 | ANN MASON | 13N | 24E | 10,11,13,14,15,16,23,24 | 14.22 |
| NVN 085212 | QUATERRA ALASKA INC | 11/20/2009 | MACARTHUR PIT | 14N | 24E | 24,25,26 | 43.34 |
| | | | | 14N | 25E | 19,30 | |

In the CCD, 96 mining districts were established entirely or partially due to discovery of gold deposits. Eighty-four of these districts produced both gold and silver, and an additional five districts produced only silver (Tingley 1998). Many of these districts have also produced associated minerals, such as tungsten, lead, and antimony.

A small amount of gold has also been produced from placer deposits near some of the areas with high-grade deposits.

Large open pit mines were once located in the Aurora, Lucky Boy, Rawhide, Shady Run, and Santa Fe Districts; large, low grade, bulk-mineable, gold and silver deposits were in the Bell Mountain, Comstock, Ramsy, and Talapoosa Districts (Tingley 1990). Exploitation of these large, low grade, precious metal deposits peaked within the CCD in the mid-1990s and continued to decline despite a significant rise in the price of gold.

Many mines that were active in the planning area in the mid-1990s are listed in **Table 3-6**, Active Plans of Operation in the CCD—Gold and Silver.

As of 2011, the Denton-Rawhide Mine in Mineral County (now formally the Buckskin Mine) is the only gold and silver mine operating in the planning area (Driesner and Coyner 2011). This mine is in its final phases of production and has been a residual leach-pad operation since 2004 (Pacific Rim Mining Corp. 2010). In 2010, the mine reportedly produced 20,159 ounces of gold and 342,382 ounces of silver (Driesner and Coyner 2011).

The CCD is within a broad northwest-trending band that is generally coincident with the Walker Lane shear zone and is dominated by volcanic rock-hosted gold and silver deposits (Mihalasky 2001).

Volcanic rock-hosted deposits can be broadly subdivided into low-sulfidation (andularia-sericite) and high-sulfidation (acid-sulfate) types. Low-sulfidation deposits occur under geothermal temperature/pressure conditions. They are significantly more common in the CCD than high sulfidation deposits, which occur under volcanic-hydrothermal conditions. For example, ore deposits in the Comstock District are low-sulfidation deposits, while those in the Paradise Peak area are high-sulfidation deposits (Mihalasky 2001). The volcanic rock-hosted deposits are Upper Oligocene to Early to Middle Miocene in age or younger. They are generally younger than the sedimentary rock-hosted gold and silver deposits that are found in central Nevada.

Long before plate tectonics offered an explanation of what they observed, geologists identified numerous spatial trends in the occurrences of various mineral assemblages, especially those that included gold and silver as a significant component.

**Table 3-6**
**Active Plans of Operation in the Planning Area—Gold and Silver**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 069118 | BARRICK MINING CO | 4/18/1985 | GIROUX VALLEY | 8N | 34E | 1, 3 & 24 | 400 |
| | | | | 8N | 35E | 6 | |
| | | | | 9N | 34E | 36 | |
| | | | | 9N | 35E | 31 | |
| NVN 069126 | ANACONDA MINERALS CO., MIRAMAR GOLD CORP. | 5/12/1994 | SIX-MILE CANYON | 17N | 21E | 23,24,26 | 50 |
| NVN 069128 | CANDELARIA MINING CO., NERCO METALS, INC. | 5/29/1981 | CANDELARIA | 3N | 35E | 3,4 | 600 |
| | | | | 4N | 35E | 25,26,27,32,33,34,35 | |
| NVN 069458 | BARRICK MINING CO. | 3/10/1992 | CALVADA FLAT | 8N | 35E | 4,5 | 260 |
| | | | | 9N | 35E | 28,32,33 | |
| NVN 069458 | PRUETT RANCHES | 6/22/1993 | BUCKSKIN MINE | 13N | 24E | 18 | 18 |
| NVN 069690 | RAWHIDE MINING, LLC | 12/22/1994 | RAWHIDE | 13N | 32E | 4,5,6,7,8,9,10,16,17 | 1,000 |
| NVN 070006 | AMERICAN GOLD CAPITOL, INC. | 2/15/1995 | TALAPOOSA | 18N | 24E | 2,3,10,11 | 120 |
| | | | | 19N | 24E | 34 | |
| NVN 070049 | CUSTOM DETAILS, LLC | 7/12/2002 | BOVIE LEW | 13N | 24E | 8,17,20 | 10.35 |
| NVN 083297 | GEO-NEVADA INC | 1/20/2011 | SPRING VALLEY | 16N | 21E | 20,21,28 | 27.2 |
| NVN 084610 | BONAVENTURE NV, INC. | 11/17/2009 | NEW PASS | 20N | 40E | 6 | 9.32 |
| | | | | 21N | 40E | 31 | |
| NVN 085589 | TNT VENTURES, LLC | 2/17/2010 | MASON PASS | 14N | 25E | 18,19 | 4.4 |

Three northwest-trending mineral belts have long been recognized (USGS and NBM 1964) within the northwest-trending Walker Lane shear zone: from south to north, the Virginia City-Tonapah Belt, the Fallon-Manhattan Belt, and at the extreme eastern edge of the region, the Lovelock-Austin Belt. To these may be added the Aurora Belt, along the California-Nevada border. They are among a series of lineations aligned roughly parallel to the southwestward progression of volcanic fronts across Nevada during the Early to Mid-Cenozoic. Furthermore, they are aligned with the zone of extension and combined strike-slip and oblique normal faulting that developed after initiation of the San Andreas transform fault. During this time, bimodal rhyolitic and basalt volcanism and epithermal mineralization took place. This episodic overprinting of thermal events greatly complicates any attempt at predicting mineral occurrence at the local scale. The overprinting of thermal events itself may have involved complex geochemical variations in mineralization over distance, followed by faulting; this further disrupted the coherency of related structural units. Nevertheless, certain trends are recognizable at different scales.

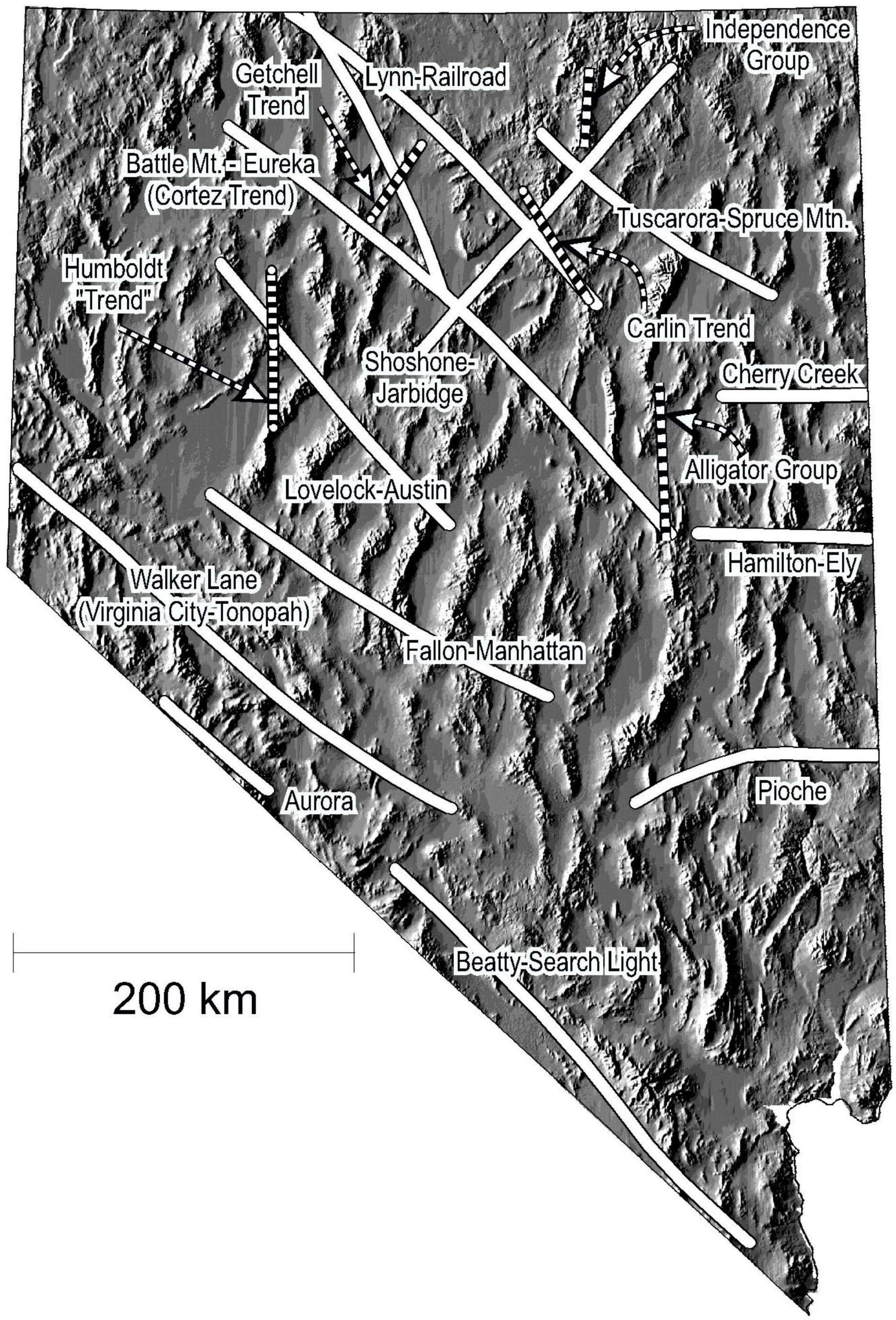
The Aurora Belt is marked by hot spring and Comstock-vein deposits that contain gold and silver. It extends southeast from the Borealis and Aurora Districts along the California-Nevada border. The Virginia City-Tonopah Belt (which is sometimes equated with the Walker Lane) is 350 kilometers long and is characterized by quartz-alunite vein, Comstock-vein, and hot spring deposits. It extends southeast from the Peavine, Wedekind, and Comstock Districts to the Goldfield District in Esmeralda County. It parallels a northwest-trending alignment of geomagnetic highs, a broad isostatic gravity high, and a Bouguer gradient ridge (Mihalasky 2001).

The Fallon-Manhattan Belt is 200 kilometers long and contains primarily Comstock-vein deposits. It extends southeast from the Sandsprings and Fairview Districts to the Round Mountain District, in Nye County.

Just bounding the northeast corner of the CCD is the Lovelock-Austin Belt, which is a 230-kilometer-long, northwest-striking belt. It is marked by Comstock-vein and low-sulfide quartz-gold-vein deposits at the north end and sedimentary rock-hosted deposits to the south. **Figure 3-4**, Mineral Belts and Trends of Nevada, shows the approximate orientation of these belts superimposed on the principal historically active gold and silver mining areas in the planning area.

Although gold and silver mining in the CCD has declined despite a rapid rise in commodity prices in recent years, it is likely that additional deposits will be discovered, especially in areas that are difficult to assess because they are buried under basin fill deposits. Furthermore, gold and silver can be important secondary minerals in some areas, contributing significantly to the economic viability of mining, even if they are not the primary target.

# Mineral Trends and Belts of Nevada




Principal mineral trends and belts of Nevada. Trends and belts are labelled and illustrated as dashed white lines (trends) and heavy white lines (belts) superimposed on a shaded relief map of topography. Mineral belts commonly refer to regional-scale alignments of deposits, which may or may not be of the same age or type, while mineral trends refer to district-scale deposit alignments (Seedorff, 1991). The topography effectively shows the north-northeast trending structural grain of Nevada in contrast to most trends and belts, which are oriented northwest-southeast. Mineral belts from Roberts (1966) and Shawe and Stewart (1976). Trends from Sweeney (1990), with additions from Thorman and Christensen (1991) and Percival et al. (1988).

Figure 3-4

**Graphite** is recorded in the Voltaire District, located near the base of the mountains on the east slope of the Carson Range, three miles west of Carson City (Tingley 1990). Graphite is also recorded as a deposit with no significant past production in the Chedic Area near Carson City (Papke and Castor 2003). Production amounts of graphite are not known but are expected to be small (Tingley 1990, 1998).

***Iron***

Iron is one of the most abundant metals in the earth's crust, and its primary use is in the production of steel. The economics of steel production and the abundance of iron means that transport of the ore is a significant factor in iron production. Iron ore deposits must be located near steel manufacturing sites and to a source of coking coal to make iron production economically feasible.

The principal type of iron ore deposits in the CCD, and in the Great Basin generally, are contact metamorphic deposits, where intrusive rocks came into contact with carbonate rocks. Magnetite is the principal iron mineral.

The presence of iron deposits is recorded in 20 historical mining districts, but exploration for, or production of, iron is not currently occurring in the CCD. Of those 20 historical mining districts, only the Delaware and Buckskin Districts have recorded production (Tingley 1990, 1998).

The Delaware District produced less than 1,000 tons of iron ore from the Bessemer Mine in Brunswick Canyon from 1944 to 1954. It produced a few trial shipments of ore before that. Skarn iron deposits in Brunswick Canyon were extensively explored in the late 1950s and 1960s, but these areas were not developed. Ore deposits in the Delaware District occur as quartz vein deposits in Tertiary andesite flows and older rocks, which contain iron sulfides. Ore deposits also occur as iron and tungsten skarn deposits associated with contacts between Cretaceous granitic intrusive rocks and Mesozoic metamorphic rocks (Tingley 1990).

The Buckskin District was first prospected in 1904 for gold deposits and later for copper deposits. But it did not experience significant iron production until a large iron-ore body was developed on the property in 1917. Large-scale mining did not begin until 1943 when the property was acquired by Strategic Minerals, Inc., and was leased to Standard Slag Co. The property became the Minnesota Mine and by 1966 produced 3,700,000 tons of iron ore valued at nearly $17 million. Market conditions for iron then declined, and Standard Slag Co. ceased operation in January 1971 (NBMG 1970; Tingley 1990).

Large deposits of iron were discovered in the early 1960s when steelmaking facilities opened up on the Pacific Coast. These include buried deposits identified by aeromagnetic surveys in the Buena Vista Hills in Churchill and Pershing Counties on the north edge of the Stillwater Range. Also included are large deposits in the Pumpkin Hollow area in the foothills of the Wassuk Range, east of Yerington, explored by US Steel. The reserves in the Wassuk Range have been estimated at between one-half to one billion tons, averaging 40 percent or more iron (USGS and NBM 1964). The ore was reportedly associated with high-grade sulfide copper.

#### *Lead*

Lead is commonly found in association with deposits of more economically important minerals, such as gold, silver, and copper, but can be an important byproduct. The principal ore mineral of lead is galena (lead sulfide), but anglesite (lead sulfate) and cerrusite (lead carbonate) are also significant.

Lead is widely present throughout the CCD and is present in at least 52 historical mining districts. However, lead and zinc appear to be more abundant in the sedimentary rock-hosted deposits on the east side of Nevada than in the volcanic rock-hosted deposits on the west; here antimony, iron, and mercury are more abundant (USGS and NBM 1964). Production of over one million pounds is noted from six districts in Mineral County and southern Churchill County and of up to one million pounds in many other districts (Horton et al. 1962a). Lead was widely used in the past in paint and gasoline, but its uses have been greatly curtailed due to toxicity concerns. Among the most important current uses is in batteries.

#### *Magnesium Compounds*

The most important magnesium-bearing minerals are dolomite, magnesite, and brucite. A little more than half of US production of magnesium compounds is from seawater and natural brines, and the rest is from magnesite and brucite. Magnesite and brucite are currently mined by Premier Magnesia, LLC, in the Gabbs District in Nye County (Driesner and Coyner 2011; Tingley 1998). This mine is the only producer of hard-rock magnesite in the US and a significant source of magnesium compounds (NBMG 2011; USGS 2013). Magnesium compounds are used in the agricultural, industrial, and water treatment markets for such uses as soil treatments, fertilizers, animal nutrition supplements, metal plating and finishing, potable water treatment, and fire proofing.

The Gabbs District contains Triassic Age limestones and dolomites. Triassic-Jurassic Age limestones and limy-clastic rocks and Jurassic Age sandstones (the Paradise terrane of Stewart [1997]) are complexly folded and thrust-faulted with north to northwest trending fault cuts (Tingley 1990).

#### *Manganese*

Although manganese is abundant in mafic igneous rocks, most of the large deposits of manganese in the world are as secondary concentrations in sedimentary rocks. Most deposits in the US are of low grade. Manganese ore was stockpiled as a strategic mineral during the Korean War because of its use in batteries and the steel industry, but production declined after the war.

Manganese deposits are reported in six historical mining districts, but only one district has a record of production. The historical Wild Horse District contains the Black Devil manganese deposit, which was discovered in 1954 and produced one carload of 47.6 percent manganese ore in 1958. The ore description of the Black Devil manganese deposit is not given. Other districts that are noted for manganese deposits are the Holy Cross, New Pass, Silver Star, Delaware, and Sodaville or Pilot Mountains. Currently, manganese is not mined or produced in the planning area due to the unfavorable cost of production from low-grade deposits (BLM 2012; Tingley 1990).

The potential for discovery of additional manganese deposits is low, based on the small and scattered nature of the known occurrences.

***Mercury***

The principal ore mineral of mercury is cinnabar, a stable form of mercury sulfide. It typically occurs in epithermal deposits associated with Tertiary volcanics, as vein fillings, or through hydrothermal alteration of silica-carbonate rock. Ore bodies tend to be small and irregular and are erratically distributed.

Mercury has a number of unique and useful properties, and because it has no ready substitutes, it has generally been considered a strategic mineral during times of national emergency. Historically, mercury was used to concentrate gold from ore, and most of the early interest in mercury prospecting in Nevada is probably associated with this use. Commercial demand for mercury in the mid-1960s triggered a resurgence in mining. However, most mercury production in the US is from the central Coastal Ranges of California (USGS 1966).

The principal areas of mercury occurrence in the CCD are in the Castle Peak District in Storey County (not in the decision area), the Pilot Mountains District in southeastern Mineral County, and the Buena Vista District in southern Mineral and northern Esmeralda Counties (also not in the decision area; Lawrence and Wilson 1962). Currently, mercury is not explored for or produced within the planning area (Tingley 1990, 1998). Elsewhere, production has been limited and sporadic.

The first recorded mineral discovery of the historical Pilot Mountains District was in 1913 when cinnabar was found in an exposed limestone ledge at an old prospecting pit. The types of deposits found in the Pilot Mountains (hydrothermal replacement of limestone by cinnabar) tend to be high grade but small, with the ore confined in structural traps capped by shale, rather than in vein fillings. The economics of production are not very favorable, and the cost of exploration can exceed revenues. The original prospecting date of the deposit is not known, but from the 1913 rediscovery through 1953, 5,000 flasks of mercury were produced intermittently (Tingley 1990, 1998).

Cinnabar was also discovered in the historical Castle Peak District (Storey County) at the site of the Castle Peak Mine in 1927. The Castle Peak

Quicksilver Co. was formed in 1929 in order to exploit the deposit. Between 1929 and 1943, 2,576 flasks of mercury were produced from tabular and pipe-like ore bodies containing cinnabar, native mercury, and calomel. These deposits were localized along steeply dipping joints and as disseminations along a gently dipping, north-trending fault in argillized and alunitized andesite. The Washington Hill Mine, located three miles north of the Castle Peak Mine, also produced a few flasks during this time from bleached and altered andesite flows, tuffs, and breccias with fine-grained disseminated crystalline cinnabar. Production in this area ended in the 1940s (Tingley 1990, 1998).

Cinnabar deposits were also found in the historical Eastside Area District in Mineral County near Teels Marsh and produced a few flasks (actual number is unknown). The historical Steamboat Springs District produced some mercury in the 1870s and again between 1968 and 1969 when the Old Enterprise Mining Co. produced about 100 flasks from fracture fillings, films, and encrustations. The historical Clark-Derby area produced a small amount of mercury from the Tyler-Branch prospect. Evidence of mercury production is noted at both the historical Gabbs Valley Area District, where the remains of mercury retorts in several locations indicate some production of mercury, and the historical Holy Cross District, where the Cinnabar Hill Mine has a nearby burned-ore pile and a dump that suggest production (Tingley 1990, 1998).

***Molybdenum***

Molybdenum is important as an alloy in steel. Molybdenite (molybdenum di-sulfide) and wulfenite (lead-molybdate) are the principal ore minerals. Molybdenite is typically found in quartz veins associated with copper sulfides (porphyry copper). Most of the known molybdenum deposits in the US are in the Sierra Nevada Province, associated with intrusions into metamorphic rocks enclosing the Sierra Batholith (USGS 1966).

Molybdenum is reported in 14 historical mining districts, and historically it has been encountered during gold and silver exploration. In the CCD, molybdenum is usually associated with porphyry copper deposits, and some of these deposits are molybdenum rich: so-called copper-molybdenum, or copper-molybdenum-gold deposits described by Wendt and Albino (1992) and Berger et al. (2008). Therefore, while molybdenum may not be the target mineral, it can be a significant contributor to the economic viability of mineral production.

A northwest-trending belt of porphyry copper and related deposits lies within the central portion of the Walker Lane extending into Plumas County, California, including the Lights Creek Copper District. A small quantity of molybdenum was reportedly produced in 1916 and 1917 from vein deposits on the southwest slope of Mount Adams, in Plumas County, near the western boundary of the CCD (USGS 1966).

The historical Wilson District has produced gold and silver and was explored for its molybdenum potential in the late 1960s and early 1970s. Results of exploration found that the sulfides were rare and limited to skarn deposits found in the thin septa of metasedimentary rocks surrounded by granitic rocks.

In the historical Gardnerville District a broad zone of molybdenite mineralization, was encountered in drilling tests. This occurs in a stockwork of quartz veins generally related to an underlying quartz monzonite stock near the Gardnerville Tungsten Mine.

The historical Tungsten District first reported the presence of molybdenum at Scott's camp in 1916. It was found in dark bands, containing tetrahedrite, pyrite, and molybdenite, that follow the footwall of several flat-lying lenticular quartz veins. In the historical Lodi District, a molybdenum-bearing sulfide system was discovered and explored in the 1970s at Quartz Mountain. Drilling near the old Calico Mine discovered molybdenite. It was disseminated in intensely silicified hornfels, as a coating in the fractures of the hornfels, and in silicified and sericitized quartz latite porphyry. Grades of 0.6 percent molybdenite were reported in the bottom of the Calico Mine drill hole, with a four-oot interval of 0.34 percent molybdenite. But the overall extent and economic significance of the sulfide system is uncertain (Tingley 1990, 1998).

***Nickel and Cobalt***

Nickel deposits have been reported in the historical mining districts of Candalaria, Yerington, and Table Mountains, but details on the deposit are available for Table Mountain only (Tingley 1990, 1998). Cobalt was also discovered at Table Mountain (Tingley 1998). Neither of these minerals are currently explored for or produced within the planning area.

The Table Mountain District is in the vicinity of Cottonwood Canyon, in the Stillwater Range in the northern portion of Churchill County. Nickel and cobalt deposits were discovered in Cottonwood Canyon in 1882, and the resulting Nickel Mine was worked from this time until 1890, and then from 1904 to 1907, when it was permanently closed. Production amount is not given for the Nickel Mine, but the nearby Lovelock Mine shipped some 500 tons of high-grade nickel-cobalt ore during the early period of mining. Profits are not noted. The ore deposits are described to occur along a shear contact between fine-grained gabbro and albitized Jurassic quartz arenite, with the ore containing mixtures of arsenides and sulfarsenides of nickel with their alteration products of chloanthite and annabergites, as well as tetrahedrite, erythrite, and azurite (Tingley 1990).

**Thorium and Rare Earth Elements (REEs).** Thorium and lanthanide series elements, termed rare earths, have similar chemical properties and are often found in the same minerals. Thorium is radioactive but cannot be used directly in nuclear reactors and must first be converted to fissionable Uranium-233 in breeder reactors. The lanthanides or rare earth series contain cerium and yttrium. There are 15 REEs, plus yttrium. Over 200 minerals are known to contain rare earths. Recent interest in rare earths has centered on lithium, based on demand for its use in batteries.

REEs are relatively abundant in the earth's crust, but they are broadly dispersed and are not often concentrated in mineable quantities. Most such concentrations of REEs are in igneous alkaline rocks and carbonatites, but they are also found in placer deposits, weathered igneous rocks, pegmatites, iron-oxide copper-gold deposits, and marine phosphates. The main REE-bearing minerals in the US are euxenite, bastnasite, xenotime, monazite, and allanite.

Rare earths are noted to occur in the Carson, Fitting, and Stateline Peak historical mining districts; however, the history of exploration and production of these minerals in these areas is not recorded (Tingley 1990, 1998).

In one of the few active mining operations in the US, lithium is currently produced from subsurface brines pumped to the surface and evaporated on the Clayton Valley playa, near the Silver Peak District in Esmeralda County (NMBG 2011). This method was pioneered there but is now used elsewhere, including in Chile, which accounts for a significant amount of world production.

A number of properties on basin areas in the Silver Peak area have recently been explored. Methods include gravity surveys to identify deep basin fill, combined with chemical sampling to identify anomalous lithium concentrations in shallow sediments. Most exploration has reportedly been focused on the Clayton Basin and other areas within Esmeralda County; however, at least one company (Lithium Corp.) reportedly conducted a subsurface survey in the Salt Wells Basin in 2009 with some promising results (NMBG 2011). In Humboldt County, lithium-bearing clays derived from hydrothermal alteration of volcaniclastic rocks have also been targeted for development, using a lithium carbonate equivalent cutoff grade of 0.2 percent. No reports of exploration of similar occurrences within the CCD are readily available.

***Titanium***

Titanium deposits have been recorded in five historical mining districts: Corral Canyon, Sand Springs, Buckskin, Wilson, and McClellan. Only the Corral Canyon District has recorded ore deposit descriptions and exploration of titanium, which occurred in the 1950s and 1960s when the district was explored for lode and placer deposits. There is no current mining or exploration of titanium in the planning area.

The principal titanium ore minerals are rutile and ilmenite, which are found in lode deposits and secondary deposits in sedimentary rocks. Most commercial titanium lode deposits consist of ilmenite associated with magnetite or hematite, found in intrusive rocks or adjacent metamorphic rocks. Scattered titanium-bearing pegmatites are found near Hungry Valley, west of the Virginia Range in Washoe County. They are also found in dikes and sills intruding the eastern flank of the Stillwater Mountains near Corral Canyon and Dixie Valley in Churchill County (Beal 1963). Commercial deposits are scattered.

Secondary deposits of rutile and ilmenite are typically found in aeolean or beach sands or placer deposits. Most of the titanium in the CCD is in sedimentary deposits (placers and beach and dune sands). Churn drilling on placer claims has encountered placer debris containing 4.5 to 30 percent ilmenite, but economical ore bodies were not discovered (Tingley 1990, 1998).

***Tungsten***

Tungsten was produced historically in the CCD in 49 historical mining districts, but it is not currently produced. Several tungsten mines within the CCD generated small to moderate production during periods of high tungsten prices, mainly during World Wars I and II and the Korean War. California and Nevada were the principal tungsten-producing states, but low world prices caused most of the mines to shut down. Tungsten in the US is commonly associated with copper and molybdenum. Numerous deposits of tungsten mineralization occur predominantly as scheelite-bearing, metasomatic, polymetallic, skarn-type deposits associated with Cretaceous Age quartz-monzonite intrusives (BLM 2012; Tingley 1998).

The historical Santa Fe District produced 5,104 units of tungsten trioxide between 1943 and 1988. A series of mines in the historical Sand Springs District produced a total of 3,632 units of tungsten trioxide between 1950 and 1980; the Hilltop Mine in the historical Tungsten Mountain District produced 3,981 units of tungsten trioxide between 1954 and 1978; the Fondaway Canyon property in the historic Shady Run District produced 10,000 units of tungsten trioxide between 1956 and 1978. The Silver Dyke property in the historical Silver Star District produced 50,000 to 65,000 units of tungsten trioxide between 1916 and 1972, while the historical Leonard District produced about 70,000 units, mostly from the Nevada Scheelite Mine during World War II, and 315,000 units overall from 1930 to 1989 when falling tungsten prices closed the mine.

Tungsten deposits were discovered in the historical Pilot Mountains District in 1916, and about 24,000 units were produced from then until 1956. Exploration in the area discovered large tungsten reserves that are estimated at about 8 million tons of ore containing around 0.3 percent tungsten trioxide, along with significant amounts of copper and silver. Due to falling tungsten prices, these deposits have not been exploited (Tingley 1990, 1998).

***Uranium***

Most of the uranium in the US is in stratiform deposits in continental sandstones and conglomerates in New Mexico, Utah, Colorado, and Wyoming; however, vein and other fracture-controlled deposits are present in nearly all kinds of rocks (USGS 1966). Uranium presence is noted in 19 historical mining districts but is not currently explored for or produced in the planning area. Six of those historical districts have recorded ore deposits and exploration, and two have recorded production of uranium minerals. Mining districts that have recorded ore descriptions and exploration are the State Line area, Freds Mountain area, the Washington District, and the Marietta District. Districts that have recorded production are the Pyramid District and the Stateline Peak area (Tingley 1990, 1998).

Uranium mineralization was discovered in the historical Pyramid District in 1954, resulting in large numbers of claims being staked. Only small-scale production of uranium occurred; production was intermittent between 1956 and 1969. Uranium mineralization occurs principally in ash-flow tuffs, but also in high-angle, generally northeast-trending fault zones, which are commonly localized along diabase dikes intrusive to the Hartford Hill Rhyolite. Uranium minerals of this deposit include autunite, sabugalite, uranospinite, phosphuranylite, and uraniferous opal, chalcedony, and hematite (Tingley 1990).

Uranium mineralization in the Stateline Peak area was discovered in 1954 on the west flank of the Peterson Mountain, located in the California portion of the CCD. The area was extensively prospected for uranium, and in 1955 and 1956 400 tons of uranium ore with grades exceeding 0.2 percent uranium were produced. Production was concentrated at the Buckhorn Claims in California. After 1957, uranium production ceased, and activity focused on assessment work and minor exploration. The uranium mineralization occurred in two principal zones within rhyolite tuffs of the Tertiary Hartford Hill Rhyolite, and the uranium minerals included gummite, autunite, and uranophane (Tingley 1990).

Secondary uranium minerals are locally abundant in quartz veins and shear zones in decomposed granitic rocks in the Hallelujah Junction area of Plumas County, California, although no mining has occurred in this area (USGS 1966).

**Vanadium** is noted in the Chalk Mountain District, but ore deposits, time of discovery, and production amounts are not recorded or further noted (Tingley 1998, 1990). Most of the vanadium produced in the US is from deposits in uranium-bearing sandstone in the Four Corners area. Vanadium occurrence, but no production, is noted in one prospect in eastern Alpine County. Most production in California is in the Mojave Desert province (USGS 1966).

***Zinc***

Like lead, zinc is frequently found in association with gold, silver, and especially copper and is extracted mainly as a byproduct of these other mining operations. The principal ore mineral is sphalerite (zinc sulfide), which is typically found in hydrothermal ore bodies. Zinc is noted in 14 of the historical mining districts in the CCD, with production of up to one million pounds reported in five districts in Mineral and Storey Counties (Horton et al. 1962b). Most of the zinc production has been from within the Walker Lane.

### 3.2.2 Industrial (Non-Metallic/Non-Fuel) Minerals

***Barite***

Barite is recorded in six historical mining districts but is no longer produced in the planning area. Three of the six historical mining districts report only the presence of barite and do not have production levels or ore descriptions. These include the historical Lucky Boy, Black Horse, and Pamlico Districts. The Fitting District does not report production but does note barite in two locations as lenses and veins in Triassic metavolcanic rocks, associated with copper mineralization. The Eagleville District is believed to have produced about $35,000 from the Highland Barite deposit in 1932 and 1933. It is noted as an area of significant past production, but the ore description is not known (Tingley 1990; Papke and Castor 2003).

The Candelaria District is associated with the Noquez deposits, which are noted for significant past production. Barite was mined from several deposits in the Candelaria District in the late 1970s and early 1980s. These properties included the Giroux, Noquez, and Noquez No. 2 Mines. The Giroux and Noquez No. 2 Mines are reported to have produced between 10,000 and 25,000 tons of barite, while the Noquez Mine produced between 25,000 and 100,000 tons. The barite ore exists as small replacement deposits hosted in Ordovician chert and in thin-bedded limestone of the Luning Formation. Other deposits with significant past production include the Gravity, Crystal, and Little Summit properties in Mineral County. Production amount and history of these areas are not known (Tingley 1990, 1998).

***Borates***

Borate minerals were discovered in six historical mining districts but are not currently produced in the planning area. The Dixie Valley District once included the Dixie Marsh, where ten cars of borax were produced in the early 1870s from evaporite deposits. Since then, the Dixie Valley District has not had any production. The Marietta District once included the Teels Marsh, where borate evaporite deposits were discovered in 1872. It later became a large producer of borate minerals, but production levels are not recorded.

Borate minerals were discovered in the Fourmile Flat area in the historical Sand Springs District in 1869, resulting in the operation of two plants. One plant produced 0.5 ton per day and the other produced five tons per month until 1872, when demand for borax fell and the plants closed. Since then, there has not been any subsequent production in the district.

The nearby Salt Wells area is noted as having significant past production, but further information is not available (Papke and Castor 2003). Other historical mining districts that record the presence of borate minerals are the Soda Lake District, Leete District, and the Rhodes Marsh area, but production amounts or deposit descriptions have not been recorded. The Rhodes Marsh area is also noted for significant past production (Papke and Castor 2003; Tingley 1990, 1998).

***Carbonate Minerals***

Carbonate minerals are produced in the planning area at the Nevada Cement Mine and Limestone Quarry, south of Fernley, and at the Adams Claim Gypsum Mine, west of Dayton, both in Lyon County. Production amounts are confidential, but the Nevada Cement Mine had 14 employees and the Adams Claim Gypsum Mine had 44 employees in 2010 (Driesner and Coyner 2011; USGS 2008). The Nevada Cement Mine is also producing pozzolan, and has two active Plans of Operation (See **Table 3-7**, Active Plans of Operation—Carbonate Minerals and Pozzolans).

Historic areas with significant (but unknown) past production are the Double Check, Rivermott, and Marble Bluff areas in Washoe County (Papke and Castor 2003). The Yerington area in Lyon County is noted for insignificant past production; the historical Sand Pass District in Washoe County recorded production of carbonate minerals. Calcium carbonate was mined from bog lime deposits in the Sand Pass District near the north end of the Virginia Mountains, on the border of the CCD. These deposits were discovered in 1919 and were first shipped out starting in 1922, then again from 1945 to 1946, and finally from 1952 to 1966. The amount produced was not recorded. This deposit is the remnants of a single flat-lying bed within a sequence of impure diatomite that was deposited in the shallow waters of Pleistocene Lake Lahontan. A number of halloysite clay deposits. They occur in hydrothermally altered pyroclastic rocks, which separate a series of andesitic and basaltic flows (Tingley 1990, 1998).

***Diatomite***

The diatomite mines in production in the planning area are the Celite Diatomite Mine and the Hazen Pit in Lyon County, the Clark Mine and Mill in Storey County, and the Molten Company in Churchill County (Driesner and Coyner 2011). **Table 3-8**, Diatomite Mines in the Planning Area, lists the mines by county and includes the number of employees as of 2010. Diatomite produced in Nevada is used for filtration, absorbents, fillers, and cements (USGS 2004).

In addition to active diatomite mines, there are several active plans of operation for diatomite in the CCD (see **Table 3-9**, Active Plans of Operation—Diatomite).

Other diatomite deposits with significant past production are Russell Spit in Churchill County, Weeks in Lyon County, and Chalk Hills in Storey County. Diatomite deposits with insignificant past production are the Black Butte, Diamond Canyon, Wildhorse, and Buffalo Creek areas in Churchill County; the Snow White and White Horse areas in Lyon County; the Aldrich area in Mineral County; and the Mullen Pass area in Washoe County (Papke and Castor 2003).

**Table 3-7**
**Active Plans of Operation—Carbonate Minerals and Pozzolans**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 069932 | NEVADA CEMENT CO | 1/13/1992 | FERNLEY | 19N<br>20N | 25E<br>25E | 3,4<br>32,33 | 45 |
| NVN 086260 | NV CEMENT CO | 3/1/2011 | NV CEMENT CO | 20N | 24E | 28 | 25.9 |

**Table 3-8**
**Diatomite Mines in the Planning Area**

| Company | County | Number of Employees |
|---|---|---|
| Celite Diatomite Mine | Lyon | 14 company employees<br>1 contract employee |
| Hazen Pit | Lyon | 2 company employees<br>4 contract employees |
| Clark Mine and Mill | Storey | 58 company employees<br>9 contract employees |
| Moltan Company | Churchill | 44 company employees |

Source: Driesner and Coyner 2011

**Table 3-9**
**Active Plans of Operation—Diatomite**

| Serial Number | Type | Commodity | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|---|---|
| NVN 069623 | MINING | DIATOMITE | EAGLE PICHER MINERALS INC | 1/14/1997 | CLARK MINE | 20N | 23E | 34 | 120 |
| NVN 069966 | MINING | DIATOMITE | CELITE CORP | 8/19/1994 | FERNLEY | 19N | 26E | 8 | 103 |
| NVN 070004 | MINING | DIATOMITE | EAGLE PICHER MINERALS INC | 11/6/1996 | HAZEN | 19N | 26E | 6 | 6.64 |

Seven historical mining districts have recorded diatomite in the planning area. Districts that contain diatomite but that do not have any recorded exploration or production are the Jessup District, the Basalt District (also called the Buena Vista or Mount Montgomery District), the Chalk Hills District, and the Churchill District.

The Desert Mountains area shows signs of exploration via diatomite prospects that have been known since 1931, but there is no recorded production for the district. The Dead Camel Mountains area or the Camp Gregory District has a group of mining claims that date from the 1950s, covering an exposed diatomite outcrop; however, little evidence of active production exists, and no production is recorded.

The historical Clark Derby area has a mining history that dates back to 1918, when diatomite outcroppings were first staked. Production of diatomite was intermittent until 1943 when the Nevada Celatom Co. was organized. This company combined the outcroppings into the Celatom Mine and built a small crushing plant at Clark Station. Eagle-Pitcher then leased the property in 1945, constructed the present plant, and has been in operation since then. It is now one of the largest diatomite plants in the state and is known as the Clark Mine and Mill (See Table 3-8, Diatomite Mines in the Planning Area). The deposits at the Celatom Mine occur within the Kate Peak Formation. They are associated with thin interbeds of diatomaceous shale and beds of volcanic tuff that are roughly 350 feet thick (Tingley 1990, 1998).

***Fluorspar***

Fluorspar is a mineral aggregate or mass containing enough fluorite to be of commercial interest, primarily in the chemical, metallurgical, and ceramic industries. Fluorite is the primary source of fluorspar. Most commercially significant fluorspar occurs in veins and irregular bodies, as replacement deposits and cavity fillings, although fluorite also occurs as a gangue mineral (USGS 1966). It is a common gangue mineral in metalliferous deposits and its modes of occurrence are similar to hydrothermal metalliferous deposits.

Fluorspar presence is documented in seven historical mining districts but is not currently explored for or mined in the planning area. Locations of most significant past production are the Fluorspar King and Blue Bell Group at the southern tip of Mineral County; the Spar Dome Mine and Kaiser Mine in northeastern Mineral County; and the Revenue Group and Dixie Mine, in the Stillwater Mountains in Churchill County (Horton 1962). The historical Table Mountain District notes fluorspar deposits but does not report fluorspar exploration or production. The historical Wonder District records fluorspar only as occasionally seen in the gangue of silver-gold ore. Fluorite was found on the properties of the historical La Plata Mining and Wellington districts, but, despite exploration, these properties never produced the commodity (Tingley 1990, 1998)

Fluorite has been produced in the historical Mount Montgomery District, the I.X.L. District, and Broken Hills District. In the Mount Montgomery District, at the extreme southern end of Mineral County, fluorspar was discovered in 1914 at the Fluorspar King and Blue Bell prospects; five carloads were shipped from the area in 1926. The Fluorspar King Mine is noted for significant past production, and the nearby Montgomery Pass area is noted for insignificant past production, but the production levels for either area are not known (Papke and Castor 2003). These deposits exist in vuggy crustified veins in shears and brecciated rhyolite and are distributed in fracture coatings and small pods in rhyolite. Further exploration has occurred in the area intermittently, but no additional production has occurred (Tingley 1990, 1998)

In the I.X.L. District in the Stillwater Range, most fluorite activity occurred in Cox Canyon, starting in 1938, when deposits were discovered at the Revenue Mine. Roughly 1,900 tons of fluorite was produced from this mine in 1942 and between 1952 and 1957. It was mined from a vein along a fault zone that cuts slate and limestone and from fluorite deposits that filled vugs. The fluorite occurred as small irregular masses and veinlets in brecciated silicified rock occurring along bedding in the slate. The Revenue Mine is a location of significant past production in the Industrial Minerals Map of Nevada (Papke and Castor 2003; Tingley 1990, 1998).

In the Broken Hills District, fluorite was discovered in 1922. Fluorite mining began in 1928 and continued until 1957, during which $6 million worth of fluorspar was produced. The fluorite veins, botryoidal coatings, and drusy coatings occur in Tertiary andesitic rock and in rhyolite ash-flow tuff. The fluorite ore is white, pale green, or lavender and ranges from very fine-grained layers in aggregates to euhedral crystals up to one inch across (Papke and Castor 2003; Tingley 1990, 1998). The Kaiser Mine in the Broken Hills District was reportedly played in the early 1960s. It was the major fluorspar producer in western Nevada (the epithermal fluorspar belt described by Horton, in USGS and NBM 1964).

Other areas of fluorspar deposits and production are the Baxter (or Kaiser) area and Spardome in the northeast corner of Mineral County and the Dixie Mine in Churchill County. Areas with insignificant past production are Boulder Hill in Lyon County and Spar in Churchill County (Papke and Castor 2003).

***Gypsum***

Gypsum is produced in the planning area at the Adams Claim Gypsum Mine on the Lyon-Carson City county line, west of Dayton. This site employs 44 people and produced 148,000 tons of gypsum in 2010 (Driesner and Coyner 2011). The Adams Claim Gypsum Mine is on the historic Mound House/Adams property, which is noted for active and significant past production. Other locations noted for active or significant past production are the Ludwig area in Lyon County and the Regan area in Mineral County (Papke and Castor 2003).

Four historical mining districts reporting the presence of gypsum are the Lucky Boy and Mountain View Districts in Mineral County and the Mound House and Yerington Districts in Lyon County. Gypsum has been mined from two locations in the historical Yerington District, with a combined production estimated to be $1 million. The Ludwig property was mined for gypsum between 1911 and 1930, and the Regan quarry was mined intermittently from 1922 to the 1980s. Neither of these properties is currently active. Mining in the historical Mound House District has been underway since 1914, and, between 1914 and 1920, $451,982 of gypsum was produced. Gypsum production became well established in 1959 and has continued since then, currently under the Adams Claim Gypsum Mine operation. The gypsum-anhydrite deposit is exposed through an irregular open pit and is found in Jurassic Age rocks overlain by limestone and igneous rock. The gypsum is thin to very-thin bedded and often highly fractured (Tingley 1990, 1998).

***Kyanite/Aluminous Refractories***

The kyanite group includes high-alumina, nonclay minerals of andalusite, sillimanite, and kyanite, that are resistant to thermal shock and maintain strength at high temperatures. It is commonly found in association with pyrophyllite, pinite, and corundum. These minierals are used in the production of high-temperature refractories. Among the uses are ceramic parts of spark plugs and furnace linings for the metallurgical, glass, and cement industries.

The principal minerals found in the planning area are andalusite and pyrophyllite. Deposits have been identified in the Yerington District, in north-trending shear zones in altered siliceous volcanic rock. Deposits also have been found in blebs and lenses distributed along recrystallized shear zones in altered Triassic Age volcanic rocks in the Gibbs Range, northeast of Hawthorne (USGS and NBM 1964). Recent production has come from Bodie Creek in southwestern Mineral County and from the Popcorn and Noble Mines in the Desert Mountains in western Churchill County (Papke and Castor 2003).

Deposits of corundum and andalusite are present in the historical Fitting District. This district is in central Mineral County and covers the southeastern Gillis Range and a small portion of the Gabbs Valley Range. These minerals were mined from the Dover and Green Talc Mines, where andalusite, corundum, quartz, sericite, and probably a little dumortierite occur as replacement masses in Traissic metavolcanic rock. A few hundred tons of abrasive quality andalusite was mined from the deposit in 1929.

The geologic setting of the Fitting District includes mainly Triassic and Jurassic metavolcanic and metasedimentary rocks. These have been intruded by Cretaceous and Jurassic quartz monzonite to the west and covered by Tertiary volcanic rock in the east, mainly rhyolitic ash flow. Corundum and andalusite are also noted in the Buckskin District, but these are likely base minerals to precious metals deposits (Tingley 1998, 1990)

***Perlite***

Perlite is a high silica volcanic glass, usually with a porous or pumice-like structure. It contains sufficient entrapped water to cause expansion when heated to the point of fusion to cause popping and expansion of the glass. It has been used in plaster and wallboard manufacturing in the past, but production declined in the 1950s (USGS and NBM 1964). Perlite was produced in the historical Sheephead District, but ore deposits or production levels are not recorded (Tingley 1998). Perlite is also noted for active or significant production in the Desert Mountains in Churchill County and at Bodie Creek in Mineral County. Insignificant past production of perlite occurred in Wellington in Douglas County (Papke and Castor 2003).

Perlite is currently mined in the planning area in two locations, but production amounts are not being reported. Current Plans of operation for perlite are shown in **Table 3-10**, Active Plans of Operation—Perlite.

***Pyrophylite***

Pyrophylite is an aluminum silicate present in the historical Buckskin District. Pyrophylite is often present in hydrothermal veins or in bedded deposits in schisctose rocks and can be a variety of colors (Mindat.org 2013). Ore bodies where pyrophylite is present in the Buckskin District are not documented, and it is expected that this mineral is associative rather than a prospected material (Tingley 1990, 1998).

***Silica***

Silica is not currently explored for or mined in the planning area. Silica presence is recorded in the historical Gardnerville District. It is noted for significant past production at Vete Grande in Douglas County, Lucky Boy in Mineral County, and Steamboat in Washoe County. Insignificant past production of silica occurred in the Sand Springs range in Churchill County and the Big Crystal area in Lyon County (Tingley 1998; Papke and Castor 2003).

### 3.2.3 Gems and Semiprecious Stones

No precious gems and only two semiprecious minerals—turquoise (and variscite) and fire opal—are considered important in Nevada, although a variety of other semiprecious gem materials occur (USGS and NBM 1964). Of these, only turquoise is considered important within the planning area.

Turquoise is a hydrated phosphate of copper and aluminum It is the product of supergene processes involving the oxidation of sulfide minerals and reaction with phosphate minerals, such as apatite. It typically forms narrow veinlets or nodules along altered zones in the host rock and, rarely, large slabs or nodules. Both turquoise and variscite (a similarly bluish-green cryptocrystalline phosphate group mineral) are found in the historical Candalaria District; turquoise alone occurs in the Yerington, Pilot Mountains, and Bovard/Rand Districts. In Lyon County, turquoise is associated with porphyry copper in the Yerington District.

Turquoise of gem quality was discovered on the Blue Gem claims in the Eastside Area in 1931, and production was intermittent through 1970. This deposit was related to the visible copper minerals associated with copper veins, which included azurite, chalcocite, cuprite, malachite, and tenorite (Tingley 1990, 1998).

Turquoise and variscite deposits are associated with hydrothermal alteration of Late Devonian and Mississippian host rocks. Morrissey (1968) suggested that most of the turquoise in Nevada occurs in a belt that extends northeast from southeastern Mineral County to Central Elko County; however, the continuity of such a northeast-trending belt is uncertain. Instead it may be the result of independent centers of copper mineralization associated with phosphate occurrence along separate northwest-trending intrusive zones.

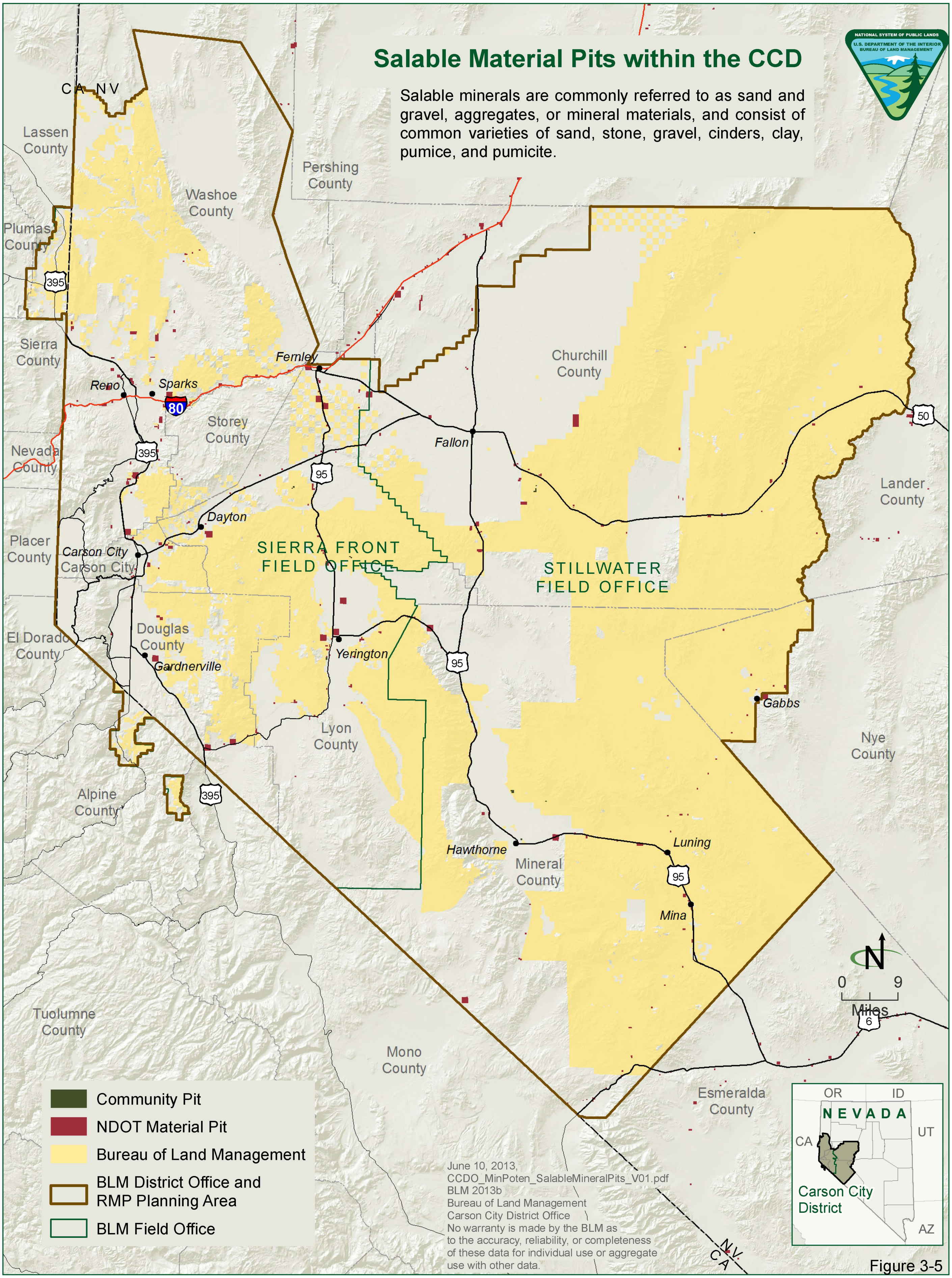
## 3.3 Salable Minerals

Salable minerals, or mineral materials, include sand and gravel, aggregates, dimension stone, petrified wood, cinders, clay, pumice, and pumicite (Mineral Materials Act of 1947 and the Surface Resources Act of 1955). Salable mineral disposals from public land are administered by the CCD under sale contracts or free use permits. The vast majority of these contracts and permits are associated with the sale or free use of small amounts of material, which is used for nearby road jobs or construction projects in rural areas (**Figure 3-5**, Salable Mineral Pits within the CCD). Currently, the CCD has three large contracts that have been issued to operators for the purchase and use of larger amounts of material from public lands (see **Section 3.3.1**, Aggregate, Sand, and Gravel).

### 3.3.1 Aggregate, Sand, and Gravel

Aggregate, sand, and gravel use is permitted through contracts and permits. They are associated with the sale or free use of small amounts of material, which is often used for nearby road jobs or construction projects in rural areas. Currently, there are more than 260 authorized salable mineral contracts and permits issued from public land within the CCD. Aggregates are widely available throughout the planning area. They are often mined from alluvial-covered areas along the lower flanks of mountain ranges and from alluvial deposits near the Truckee, Walker, and Carson Rivers and their tributaries. In addition, terrace sand and gravel deposits left along various levels of ancient Lake Lahontan are often exploited.

In addition to the 260 authorized salable mineral contracts and free-use permits, there are three large "competitive" sale contracts that have been issued to operators within the urban interface of Reno and Carson City. These contracts have been issued on a competitive basis for individual sales of mineral materials which are anticipated to exceed 200,000 cubic yard per year. They supply more material annually than all of the other contracts and permits combined. The general information associated with these larger competitive sale contracts in the CCD is listed in **Table 3-11**, Active Competitive Sale Contracts.


Salable Material Pits within the CCD
Salable minerals are commonly referred to as sand and gravel, aggregates, or mineral materials, and consist of common varieties of sand, stone, gravel, cinders, clay, pumice, and pumicite.
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CA NV
Lassen County
Washoe County
Pershing County
Plumas County
Sierra County
Churchill County
Reno
Sparks
Fernley
Storey County
Fallon
Nevada County
Lander County
Dayton
Placer County
Carson City
Carson City
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
Douglas County
El Dorado County
Gardnerville
Yerington
Gabbs
Lyon County
Nye County
Alpine County
Hawthorne
Mineral County
Luning
Mina
Tuolumne County
Mono County
Esmeralda County
0 9
Miles
N
395
80
95
50
6
Community Pit
NDOT Material Pit
Bureau of Land Management
BLM District Office and RMP Planning Area
BLM Field Office
June 10, 2013,
CCDO_MinPoten_SalableMineralPits_V01.pdf
BLM 2013b
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
NV
CA
OR
ID
NEVADA
CA
UT
AZ
Carson City District
Figure 3-5

### 3.3.2 Clay

The only permitted clay operation is the NCC Limestone Quarry and Mill, in the planning area in Lyon County near Fernley. This mine is a specialty stone operation as well, mining limestone and unspecified clay (Driesner and Coyner 2011). In addition, there is one active plan of operation mining clay in the CCD (see **Table 3-12**, Active Plans of Operation—Clay).

Clay is a general term that includes deposits of montmorillonite, talc-chlorite, fuller's earth, and unspecified clay. Montmorillonite is documented in the historical mining districts of Rhodes Marsh, Pilot Mountains, Silver Star, Fitting, and Desert Mountains. Unspecified clay is present in the Churchill and Sheephead historical mining districts. Fuller's earth is found in the historical Sand Pass District, and talc-chlorite presence is noted in the historical Lodi District. Other than noting the presence of clay in these districts, information on the clays is not available, such as amount of clay mined, when, and for what purpose (Tingley 1990, 1998).

Papke and Castor (2003) reported active or significant past production of clay materials from Salt Wells in Churchill County, Jupiter in Lyon County, Walker Lake, Mina, and Sodaville in Mineral County, and Terraced Hills and Steamboat in Washoe County. Areas with insignificant past production of clay materials are the Some Tuesday area in Churchill County and the Nixon and Hungry Valley areas in Washoe County.

Tingley (1990) reports that bentonite clay deposits in the historical Churchill District in Lyon County have been mined at a rate of about 1,000 to 2,000 tons per year since 1936. This deposit is said to be roughly three miles south of the Carson River, which lines up well with the Jupiter clay area in Lyon County (Papke and Castor 2003). However, this mine is not reported to be in current production from the annual NDOM major mines of Nevada report (Driesner and Coyner 2011). There is an active plan of operation for bentonite materials within the CCD, as seen in Table 3-12.

### 3.3.3 Zeolite

Zeolite is not mined in the planning area but is noted to have been historically mined in two historical mining districts. The Sheephead District only notes the presence of zeolites and does not have a recorded history of ore deposits or production amounts. The Eastgate District is in the southwest end of the Desatoya Mountains in Churchill County. Zeolite deposits were discovered in the Eastgate District in 1959 in a sequence of lacustrine sediments of early to middle Pliocene Age. The zeolite rich beds occur within a stratigraphic thickness of about 15 feet and are underlain by montmorillonitic-illitic mudstones, friable ash, and some tuff and gritty sandstone. Zeolite minerals present are clinoptilolite, erionite, chabazite, mordenite, and phillipsite. Several companies have tested these deposits, but only one small plant was built, for the production of cat litter. Currently, the plant is not in operation (Tingley 1990,1998).

Several other locations are noted for insignificant past production in the Stillwater Range, the Eastgate area (north of the more significant production discussed above), and in the Desatoya Mountains in Churchill County, Hungry Valley in Washoe County, and Silver Springs in Lyon County (Papke and Castor 2003).

### 3.3.4 Pumice and Cinder

Cinder, pumice, and pumicite production has active or significant occurrence in the Cinderlite area in Carson City County and is noted for historical production in the Carson City Mining District. This deposit is currently producing and is operated by Cinderlite Rock (See **Table 3-13**, Active Plans of Operation—Cinder).

Cinder production is also noted for active or significant past production in the Pumco area in Mineral County, the Naturalite area in Storey County, and the CB (Rilite) and Sierra Aggregates in Washoe County. Aa areas of insignificant past production is Cinder Mountain in Storey County (Tingley 1990, 1998; Papke and Castor 2003).

### 3.3.5 Building, Ornamental, and Specialty Stone

Sandstone building stone was mined from the Prison Quarry in the historical Carson City Mining District. This stone was used for many of the historical buildings in Carson City, and the quarry was in use as late as the 1940s. The other area of significant past production of building stone is the Gabbs Valley Range in Mineral County (Papke and Castor 2003). Currently, building stone is not mined in the CCD.

## 3.4 Strategic and Critical Mineral Materials

The USGS is the primary federal agency responsible for researching and providing information on nonfuel mineral resources. This is important in ensuring that the government is able to respond strategically to interruptions in supply.

There is no standard federal government definition of strategic and critical minerals. A working definition of what constitutes a strategic mineral is that it is "a mineral that is important to the Nation's economy, particularly for defense issues; doesn't have many replacements; and primarily comes from foreign countries."

The definition of critical mineral differs somewhat from that for strategic minerals, although the two categories are often considered together. Criticality is based on whether a vital sector of the economy requires a mineral in order to function. If so, then the mineral would likely be deemed critical (USGS 2013b). The list of strategic and critical mineral commodities changes over time.

**Table 3-10**
**Active Plans of Operation—Perlite**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 069957 | EAGLE PICHER MINERALS INC | 3/15/1993 | RUSSELL PASS | 16N<br>16N | 28E<br>29E | 24<br>19 | 24.5 |
| NVN 075839 | NOBLE PERLITE | 4/2/2002 | NOBLE PERLITE | 16N | 29E | 15,16,21,22 | 2 |

**Table 3-11**
**Active Competitive Sale Contracts**

| Operator | Serial Number | Date Issued | Term (Years) | Pit/Quarry Name | LOCATION | | | Acres | Contracted Tons |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Township | Range | Section(s) | | |
| Cinderlite Rock | NVN 077480 | 9/30/2005 | 10 | Goni Pit Expansion | 16N | 20E | 28 and 29 | 28.2 | 2,000,000 |
| Pyramid Materials, Inc. | NVN 085679 | 7/12/2010 | 10 | Tracy | 20N | 22N | 22 | 520 | 1,500,000 |
| Martin Marietta Materials | NVN 087320 | 9/27/2009 | 10 | Spanish Springs | 21N | 20N | 15 | 178.29 | 1,005,520 |

**Table 3-12**
**Active Plans of Operation—Clay**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 070054 | NEVADA BENTONITE ENT | 12/22/1997 | LAHONTAN MTNS | 18N<br>18N | 30E<br>31E | 24,25<br>18,19 | 65.5 |

**Table 3-13**
**Active Plans of Operation—Cinder**

| Serial Number | Operator | Date Authorized | Operation | Township | Range | Section(s) | Acres |
|---|---|---|---|---|---|---|---|
| NVN 069134 | CINDERLITE ROCK | 4/8/1997 | GONI ROAD | 15N | 20E | 4 | 13.8 |

The US is 100 percent dependent on foreign suppliers for 17 mineral commodities; it depends on foreign suppliers for more than half of domestic demand for at least 24 other minerals (USGS 2013f).

The list of critical mineral commodities includes REEs, gallium, and manganese.

The Defense Logistics Agency is responsible for stewardship of 28 strategic materials commodities that are stockpiled at various locations (USGS 2013). Among the mineral materials managed by the agency are chromium, the rare earths germanium, lithium, niobium, and tantalum, silica (crystalline quartz), and tin. No deposits containing significant quantities of these materials have been identified in the CCD.

# SECTION 4
# MINERAL RESOURCES POTENTIAL

Mineral potential is a prediction of the likelihood of the occurrence of a mineral resource in a given area; it does not depend on feasibility of production. This section presents the results of the assessment of the potential for occurrence of leasable, locatable, and salable minerals by location. Different commodities require different approaches to define appropriate subareas for assessment.

Among leasable resources (Section 4.1), geothermal resources are the most significant within the planning and decision areas. Section 4.1.1 summarizes the geothermal resource potential. Geothermal resource potential in the form of heat flows, temperature gradients, and depth is displayed on **Figure 4-1**, Geothermal Resource Potential. Sodium brines and minable sodium deposits represent a relatively small component of the leasable resources in the CCD. Both are found primarily within basins. In addition, coal and oil and gas deposits are not a significant component of leasable resources in the CCD due to incorrect geologic history, over-maturing of carbonate rocks within the planning area, and more promising coal and oil potential east of the planning area.

Section 4.2 summarizes the potential for locatable minerals. The potential for gold and silver across northern Nevada has been evaluated in detail by Mihalasky (2001), using the weight of evidence modeling technique. The GIS-based study calculated the posterior probabilities of occurrence of gold and silver using a seven-layer evidence map-based model. Mihalasky's study covered all of Nevada. Five areas were selected for closer evaluation as target areas for exploration, including most of the CCD (Area 4).

Gold- and silver-bearing mineral occurrences listed in the MRDS were used to "train" the model. Gold and silver occurrences were defined as any lode metallic ore mineral, in any concentration or deposit type, as follows:

- Where gold or silver are the primary commodity listed

## SUMMARY

## AMAGMATIC GEOTHERMAL SYSTEMS — COLOR-SCALED FAVORABILITY RANKING

All known geothermal systems in the Great Basin (51 in total) that are either producing electrical power or have geothermometer temperatures >150°C were used as "training sites" to assess the degree of correlation between the input evidence maps and geothermal activity. Weights-of-evidence statistical analysis (Bonham-Carter and others, 1988; Bonham-Carter, 1996; Raines and others, 2000) was used to convert each real-number-based digital evidence map into a statistically significant number of ranked classes, based on the observed association with the geothermal systems. The gravity/topographic gradient evidence map was converted into five statistically significant classes of increasing gradient, while the crustal dilation. The temperature gradient evidence maps were each converted into maps with three levels of classification, and the earthquake evidence map was converted into a binary class map (favorable vs. unfavorable levels of earthquake occurrence). Logistic regression statistics were then used to combine the individual input evidence maps into an output predictive map of the likelihood of occurrence of a geothermal system. The color ranking on the map is proportional to the log-transformed logistic regression posterior probability. Logistic regression was chosen from many forms of regression because the dependent variable is a dichotomy (presence or absence of a geothermal system) and because the use of logistic regression does not require conditional independence between the independent variables (evidence layers) in regards to the dependent variable (Agterberg and others, 1993). More details on the application of weights-of-evidence and logistic regression analysis for modeling geothermal favorability are provided by Coolbaugh (2003) and Coolbaugh and others (2002).

The posterior probability scale is subdivided into several broad qualitative ranks of favorability, each of which spans roughly three standard deviations of error of the estimate. The lowest rank is "Permissive." Because all portions of the Great Basin are tectonically active to some degree and have an elevated potential for hosting a geothermal system compared to most of North America, all portions of the Great Basin are considered at least permissive for high-temperature geothermal activity. Higher favorability ranks have better combinations of the evidence indicative of geothermal activity. The "Most Favorable" rank is characterized by high gravity/topographic gradients, high strain rates, and high temperature gradients, whereas the "Permissive" rank encompasses areas with lower temperature gradients, strain rates, and gravity/topographic gradients. Where map colors correspond to the "Prior Probability" in the key, the evidential layers have served to neither enhance nor detract from the geothermal potential, with the net effect that these areas have average geothermal potential relative to the Great Basin.

TREATMENT OF REGIONAL AQUIFERS:
Most known high-temperature geothermal systems (>150°C) in the Great Basin occur outside regional groundwater aquifers (fig. 5), including the Snake River Plain and Northwest Basalt aquifers in the northern Great Basin (USGS Principal Aquifers of the 48 Conterminous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands; http://nationalatlas.gov/mld/aquifrp.html) and the Carbonate aquifer in eastern Nevada and western Utah (Prudic and others, 1995). It is hypothesized that lateral groundwater flow could be capturing and dispersing rising thermalfluids, suppressing the occurrence of hot springs and reducing near-surface heat flow, thereby rendering these areas less completely explored than elsewhere in the Great Basin. To minimize potential bias with regard to aquifers in the favorability map, the geological and geophysical maps were preselected for their ability to model geothermal potential independent of the presence of these aquifers (at least at economic depths of <3 km). As a first step, weights-of-evidence and logistic regression model weights for each evidence map were calculated only in the non-aquifer areas (fig. 5). Those weights were then used to extrapolate geothermal favorability beneath areas having overlying regional aquifers. The logistic regression model accurately predicted 33 known geothermal training sites in non-aquifer regions, but predicted 23 training sites in the aquifer areas, whereas only 18 are known. This difference is statistically significant and suggests that the regional aquifers may be somewhat under-explored relative to other areas.

INPUT MAPS (MODEL LAYERS):
Six geological/geophysical maps were combined into four evidence layers to model geothermal favorability. A description of each of these four layers follows:

1) Combined Gravity/Topographic Gradient Map – Figure 1 (Gary Oppliger): Geothermal activity is closely associated with young faults (Koenig and McNitt, 1983; Wisian and others, 1999; Bowen, 1989, p. 70), but not all faults in the Great Basin have been mapped, and the precise locations of many faults in the Great Basin are otherwise obscured by Quaternary sediments and playa deposits. The most active normal faults are likely to have relatively large vertical displacements, and in many cases this displacement will have placed relatively dense basement rocks against relatively light unconsolidated sediments. As a proxy for measuring the effective vertical displacement on late Tertiary and Quaternary faults in the Great Basin, a residual gravity map was combined with a topographic digital elevation model (DEM), and then the total surface slope (horizontal gradient) was calculated. The residual gravity map was further reduced by removing bedrock-only regional gravity trends to produce a basins-only gravity anomaly map. This gravity map was converted to an approximate equivalent amount of subsurface basement relief using 60 m/mgal (equivalent to a density contrast of 0.4 g/cm$^3$), and then added to the 1-km DEM. The combined bedrock surface slope was then calculated by computing the total horizontal gradient for each 1-km cell. Areas on this map with steep gradients correlate well with high-temperature geothermal activity.

2) Crustal Dilation Map – Figure 2 (Corné Kreemer, Geoff Blewitt): Areas in the Great Basin with relatively high rates of crustal dilation, as mapped using GPS velocity measurements, have been shown by Blewitt and others (2002; 2003) to correlate with high-temperature geothermal activity, presumably because high dilation rates correspond to areas of active normal faulting which facilitate deep circulation of meteoric waters. Similarly, high slip rates on Quaternary normal faults, estimated from trench and geomorphological studies, also help delineate elevated geothermal potential. For this map, crustal dilation rates derived from GPS velocity measurements (interseismic strain) were added to dilation rates calculated from Quaternary fault slip-rate data (long-term seismic strain) to produce a more geographically complete map of crustal dilation in the Great Basin. The geodetic strain rates were based on 476 GPS velocity measurements from stations located throughout and just outside the Great Basin. These velocities were compiled from multiple networks, including BARGEN (Bennett and others, 1998), USGS campaigns (e.g., Svarc and others, 2002; Hammond and Thatcher, 2004), and other groups. Velocities affected by known magmatic/volcanic activity were excluded. A USGS Quaternary Fault and Fold Database (Machette, and others, 2003; http://qfaults.cr.usgs.gov/), was updated with slip-rate estimates compiled in 1996 and 2002 (http://eqhazmaps.usgs.gov/html/faults2002.html). Slip-rate parameters were converted to long-term strain-rate tensors, from which dilation was calculated for every 20-km square grid cell in the Great Basin. The methodology used to obtain strain-rate models from GPS velocities and fault parameters (Haines and Holt, 1993; Holt and others, 2000; and Kreemer and others, 2000) is a rapidly evolving science. Significant improvements are expected in the future as the digital databases expand and measurement accuracies improve. Future work should help resolve apparent disparities between short-term and long-term fault slip-rates and clarify the distribution of slip along multiple sub-parallel fault segments. The network of GPS stations is rapidly expanding to provide better representation over a larger portion of the Great Basin.

3) Temperature Gradient Map – Figure 3 (David Blackwell, Maria Richards): Geothermal systems correlate with regions of high heat flow (Sass and others, 1971; Wisian and others, 1999).High heat flow brings more thermal energy close to the Earth's surface where it can heat circulating meteoric fluids. In this study, it was hypothesized that high temperature gradients may also be good predictors of geothermal potential, based on the argument that, the depths necessary to reach economic temperatures will be shallower when the temperature gradient is high, and fractures can more easily stay open at these relatively shallow depths. Weights-of-evidence analysis showed that high-temperature (≥150°C) geothermal systems in the Great Basin correlate somewhat better with temperature gradient than with heat flow, and consequently temperature gradient, rather than heat flow, was chosen as an evidence layer in the model. A shallow crustal (0-1 km) temperature gradient map was generated using the SMU geothermal well database, which includes wells compiled by SMU (http://www.smu.edu/geothermal/), the USGS (Sass and others, 1999; http://pubs.usgs.gov/of/1999/of99-425/webmaps/home.html, http://pubs.usgs.gov/of/2005/1207/), and other sources. These combined databases contain more than 4,000 wells ranging to 5 km in depth. Temperature gradients were derived in a multi-step process beginning with calculation of heat flow at individual wells, interpolation of heat flow between wells to produce a heat flow map (e.g., Blackwell and Richards, 2004), and then conversion of the heat flow map to a temperature gradient map using thermal conductivities assigned for grouped geological formations. Improvements in the spatial resolution of the gradient map were obtained by assigning separate thermal conductivities to graben-filled Quaternary sediments, basement rocks in horst blocks, and regions of late Tertiary and Quaternary volcanic rocks. Purposely excluded from these calculations were wells with heat flows >120 mW/m$^2$ and wells with isothermal or negative gradients. This was done so the predicted temperature gradients would not be overly influenced by geothermal systems.

4) Seismicity Map – Figure 4 (Aasha Pancha): Earthquakes reveal areas of active faulting where pathways for deeply circulating hydrothermal fluids could be present. Weights-of-evidence analysis confirmed that zones of higher seismicity broadly correlate with geothermal activity. The seismicity map (fig. 4) was generated by summing all historical earthquake magnitudes within a 40-km radius of each grid cell. The distance from the epicenter to the center of each cell inversely weighted individual earthquake magnitudes. To avoid bias in the detection of earthquakes, earthquakes were not included in the seismicity calculation unless they were strong enough to be detected regardless of their location relative to seismograph stations. Earthquakes with a magnitude of >4.8 were considered to meet this criterion regardless of the year of occurrence. Pancha and others (in press) compiled these earthquakes from multiple catalogs. Due to improvements in the seismograph network beginning around 1970, all earthquakes with magnitudes of 4.0 and greater that occurred after 1970 were considered detectable regardless of epicenter location, and were added to this compilation. Data for these lower-magnitude earthquakes came from the USGS National Earthquake Information Center and the Berkeley Advanced National Seismic System.

## MAGMATICALLY HEATED GEOTHERMAL SYSTEMS

It has long been recognized that high-temperature geothermal activity in the world is closely associated with Quaternary and/or active silicic volcanism (e.g., Smith and Shaw, 1975). In the Great Basin, geothermal systems with suspected shallow-crustal magmatic heat sources are largely restricted to the margins of the Great Basin and are closely associated with Quaternary silicic volcanic rocks (Koenig and McNitt, 1983). Arehart and others (2003) document that these magmatically heated systems have higher fluid concentrations of some trace metals, including As, Li, Cs, and Rb, and higher temperature gradients, as measured from the surface down to their subsurface geothermal reservoirs, than their amagmatic geothermal system counterparts.

The color-scaled probability map discussed above was not designed to predict the occurrence of magmatically heated geothermal systems. Instead, the locations of Quaternary silicic (rhyolite and rhyodacite) volcanic vents can be used: they were compiled from numerous sources, including the Great Basin Geoscience Database (Raines and others, 1996), and the Geothermal Resources of Utah CD (Blackett and Wakefield, 2002).

## DISCUSSION

The ability of the geothermal potential map to correctly predict areas of geothermal potential is dependent on many factors. One limitation is the detail and accuracy of the digital data. The historical earthquake record spans at best 100 years, which is not enough to properly represent earthquake activities on some fault systems that may have recurrence intervals measured in thousands of years. Similarly, the number of bedrock-anchored GPS stations limits the resolution and accuracy of geodesy-based crustal strain estimates. Fault slip rate estimates are significantly constrained by the small number of detailed trench studies. Additional gravity stations would sharpen the gravity/topographic map. Some types of geological information important for predicting geothermal activity have not been included in the model. For example, some rocks make better reservoir hosts than others (e.g., the Triassic Auld Lang Syne Group and limestones do not make good high-temperature reservoirs (Dick Benoit, personal commun., 2005)). But because host rock lithologies at 1-3 km depths (the assumed range in production depth) are either unknown or are poorly constrained in many areas, host rock compositions were not used.

Another factor potentially limiting the map's predictive potential is the assumption that similar geologic processes control all amagmatic geothermal systems in the Great Basin. This is not likely to be entirely true, because of regional differences in the tectonic setting, style of fracturing, fault-controlled permeability, and the composition of reservoir host rocks. For example, geothermal systems in the Walker Lane may be more closely associated with strike-slip faulting and pull-apart blocks (e.g., the Fish Lake Valley, Stockli and others, 2003) than geothermal systems in the rest of the Great Basin.

In spite of the challenges involved with modeling, the predictive power of the map appears good in many areas, including, for example, Dixie Valley, Surprise Valley, Railroad Valley, Summer Lake, New York Canyon, and the Gerlach area. Several of these areas did not have associated geothermal training sites used for modeling, so were not able to influence the results, but good favorability was predicted anyway. Highly favorable geothermal terrain is predicted for portions of the eastern and northeastern Great Basin near and north of Salt Lake City, and in the southwestern Great Basin in and near Saline Valley, Death Valley, and Clayton Valley--some of these areas may warrant a closer look. In any case, the map contains relatively detailed information and in many places provides a thought-provoking interpretation that should challenge current and future explorationists.

## GEOTHERMAL INFORMATION

A brief explanation of other information displayed on this map follows:

TEMPERATURE GRADIENT (David Blackwell; SMU):
Uncorrected temperature gradient data from wells in the SMU geothermal database (http://www.smu.edu/geothermal/) are shown, including data from John Sass (USGS). Many of these wells are shallow and the quality of the temperature estimates vary, but on a regional basis, good temperature anomalies are often defined with these holes.

HEAT FLOW MEASUREMENT (David Blackwell, SMU; John Sass, USGS):
Heat flow calculations from wells in the SMU and USGS geothermal databases are plotted (http://www.smu.edu/geothermal/, http://pubs.usgs.gov/of/2005/1207/).These wells have been selected for their reliability and are better potential indicators of geothermal activity than the temperature gradient holes above.

WELL AND SPRING GEOTHERMOMETER (Geo -Heat Center compiled database):
Estimated maximum geothermal reservoir temperatures for wells and springs in the Geo -Heat Center database (Boyd, 2002, http://geoheat.oit.edu/) are plotted. The color-coded value represents the average of the silica and Na-K-Ca-Mg geothermometers, using the algorithms employed by Mariner and others (1983). A database of the geothermometer temperatures shown on the map is available at the web site of the Great Basin Center for Geothermal Energy at http://www.unr.edu/geothermal/geochem.html (see files GeoHGB_0.xls or GeoHGB_0.shp).

QUATERNARY FAULTS (USGS):
Quaternary faults from the web site (http://gldims.cr.usgs.gov/qfault/viewer.htm) of the USGS Quaternary Fault and Fold Database are plotted in two different slip-rate categories. This fault database is a work in progress. Some areas have been more completely mapped than others, and some faults are missing. The USGS plans to periodically update this database with more accurate fault locations and slip -rate data.

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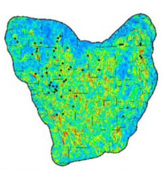
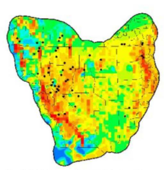
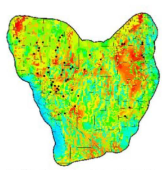






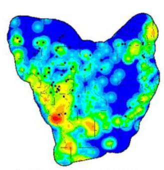


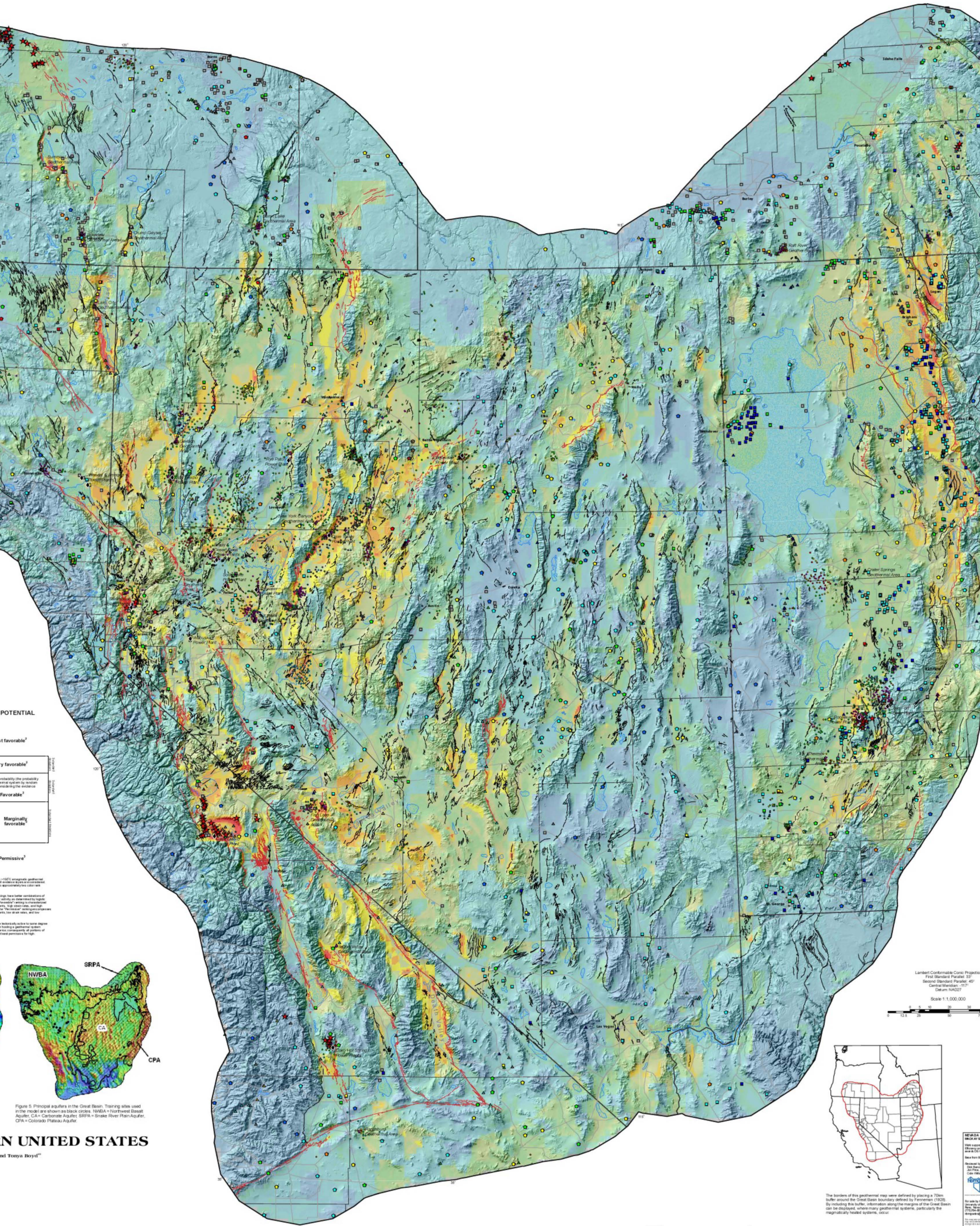
Figure 1. Combined gravity/topographic gradient map with training sites (black circles).

Figure 2. Crustal dilation map with training sites (black circles).

Figure 3. Temperature gradient map with training sites (black circles).

Figure 4. Seismicity map with training sites (black circles).

Figure 5. Principal aquifers in the Great Basin. Training sites used in the model are shown as black circles. NWBA = Northwest Basalt Aquifer, CA = Carbonate Aquifer, SRPA = Snake River Plain Aquifer, CPA = Colorado Plateau Aquifer




# GEOTHERMAL POTENTIAL MAP OF THE GREAT BASIN REGION, WESTERN UNITED STATES

Mark Coolbaugh, Richard Zehner, Corné Kreemer, David Blackwell, Gary Oppliger, Don Sawatzky, Geoff Blewitt, Aasha Pancha, Maria Richards, Catherine Helm-Clark, Lisa Shevenell, Gary Raines, Gary Johnson, Tim Minor, and Tonya Boyd

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Nevada Geodetic Laboratory at Nevada Bureau of Mines and Geology (NBMG), UNR
Southern Methodist University (SMU) Geothermal Laboratory
Arthur Brant Laboratory for Exploration Geophysics (ABLE Lab), Department of Geological Sciences and Engineering, UNR
Nevada Seismological Laboratory, UNR
Idaho National Laboratory
Nevada Bureau of Mines and Geology (NBMG), UNR
Reno Field Office, United States Geological Survey (USGS)
Desert Research Institute
Geo-Heat Center, Oregon Institute of Technology

2005

Figure 4-1

- Where they were a secondary commodity with a platinum group element as the primary commodity
- Where the primary commodity is a precious metal pathfinder element (such as antimony or arsenic)
- Where the primary commodity is a nonmetal

Mihalasky determined the posterior probabilities for sediment rock-hosted and volcanic rock-hosted deposits separately. The CCD contains predominantly volcanic rock-hosted deposits. Sediment rock-hosted deposits generally do not occur in the same regions where volcanic rock-hosted deposits are found. Mihalasky's model found only a few areas favorable for sedimentary rock-hosted gold and silver deposits, including in the Candelaria Hills adjacent to existing deposits. The detailed study area for the assessment of sedimentary-hosted gold and silver included only a portion of the eastern side of the CCD; it did not include the northern Stillwater Range, where one known sedimentary rock-hosted occurrence is documented.

The modeling results showing predicted posterior probabilities of favorable areas for volcanic and sediment rock-hosted gold and silver are presented on **Figure 4-2**, Volcanic Hosted Gold and Silver Deposits, and **Figure 4-3**, Sedimentary Rock Hosted Gold and Silver Deposits. Favorable areas are considered to be those where the posterior probability exceeds the prior probability (the average of the randomly distributed probabilities of gold and silver occurrence based on known occurrence).

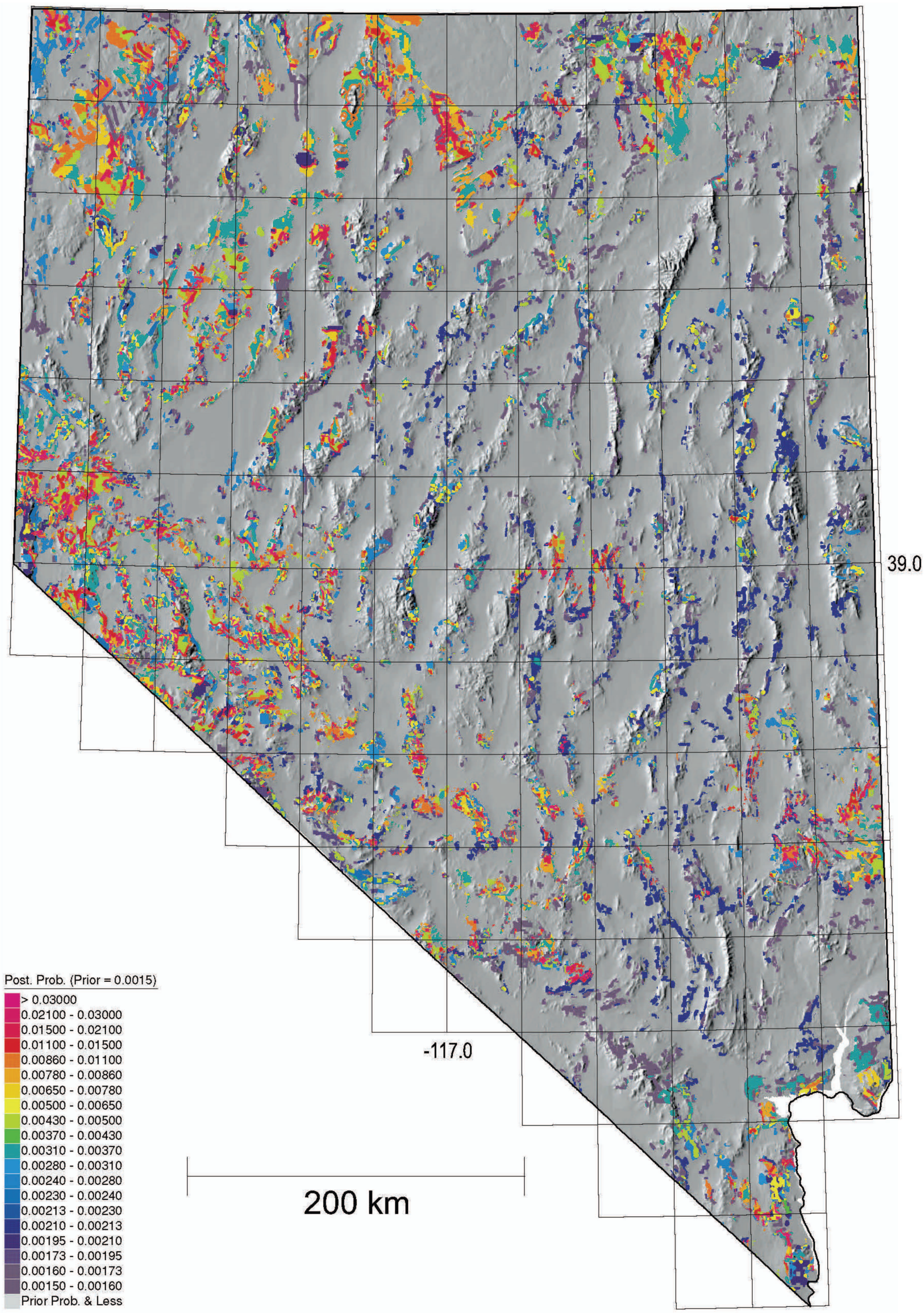
Wallace et al. (2004) identified favorable pluton-related areas at a regional scale (1:500,000 to 1:1,000,000) in northern Nevada, with a focus on the Humboldt Basin. A number of minerals and mineral deposition models are associated with plutonic intrusions. Among them are porphyry copper (Cu), porphyry copper-molybdenum (Cu-Mo), porphyry molybdenum (Mo), low fluorine (F), Climax Mo, porphyry copper-gold (Cu-Au), tungsten skarn, tungsten vein, porphyry Cu-skarn and related deposits, and polymetallic vein deposits.

The occurrence and potential of other metals, and of the broader range of industrial (nonmetallic, nonfuel) minerals, is summarized on **Figure 4-4**, Industrial Minerals of Nevada, and in Section 4.4, based on the descriptive information presented in Section 3.0.

Section 4.3 summarizes the potential for salable minerals. There are several salable materials mine sites within the planning area, primarily sand, gravel, and aggregate pits developed in response to the construction industry as summarized in **Figure 3-3,** Saleable Mineral Pits in the CCD. The commodity potential of the salable material in the planning area is outlined in Section 4.4. Sand and gravel represents the largest salable resource in the CCD. The BLM-administered lands have vast amounts of permissible tracts for sand and gravel

# Areas of Volcanic Rock Hosted

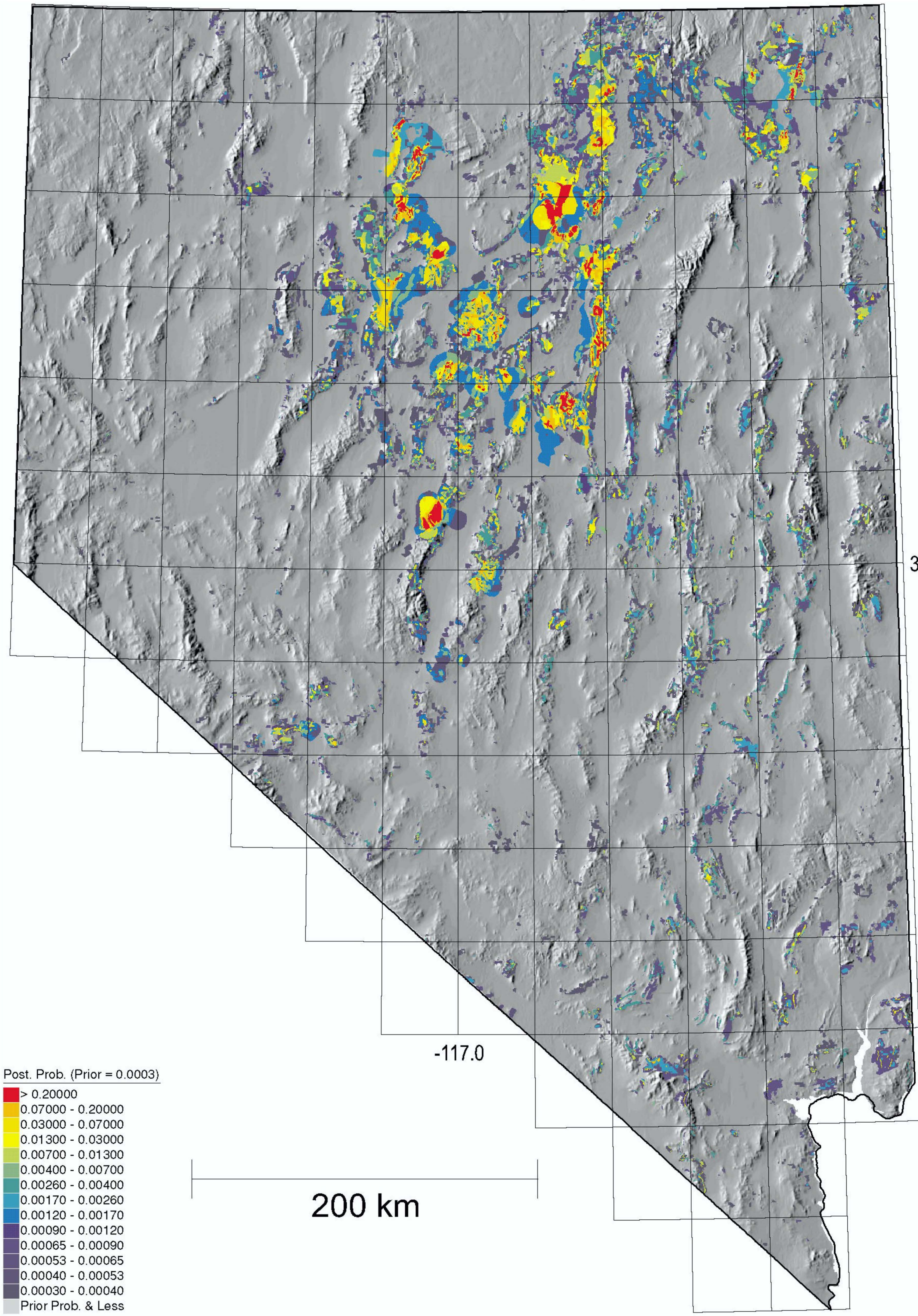
# Gold and Silver Deposits




Volcanic rock-hosted occurrence-type posterior probability map, overlain on shaded relief of topography. The favorability map is based on the weights of evidence volcanic rock-hosted 7-layer mineral potential model. Latitude-longitude grid spacing is half a degree.

Figure 4-2

# Areas of Sedimentary Rock Hosted Gold and Silver Deposits




Sedimentary rock-hosted occurrence-type posterior probability map, overlain on shaded relief of topography. The favorability map is based on the weights of evidence sedimentary rock-hosted 8-layer mineral potential model. Latitude-longitude grid spacing is half a degree.

Figure 4-3

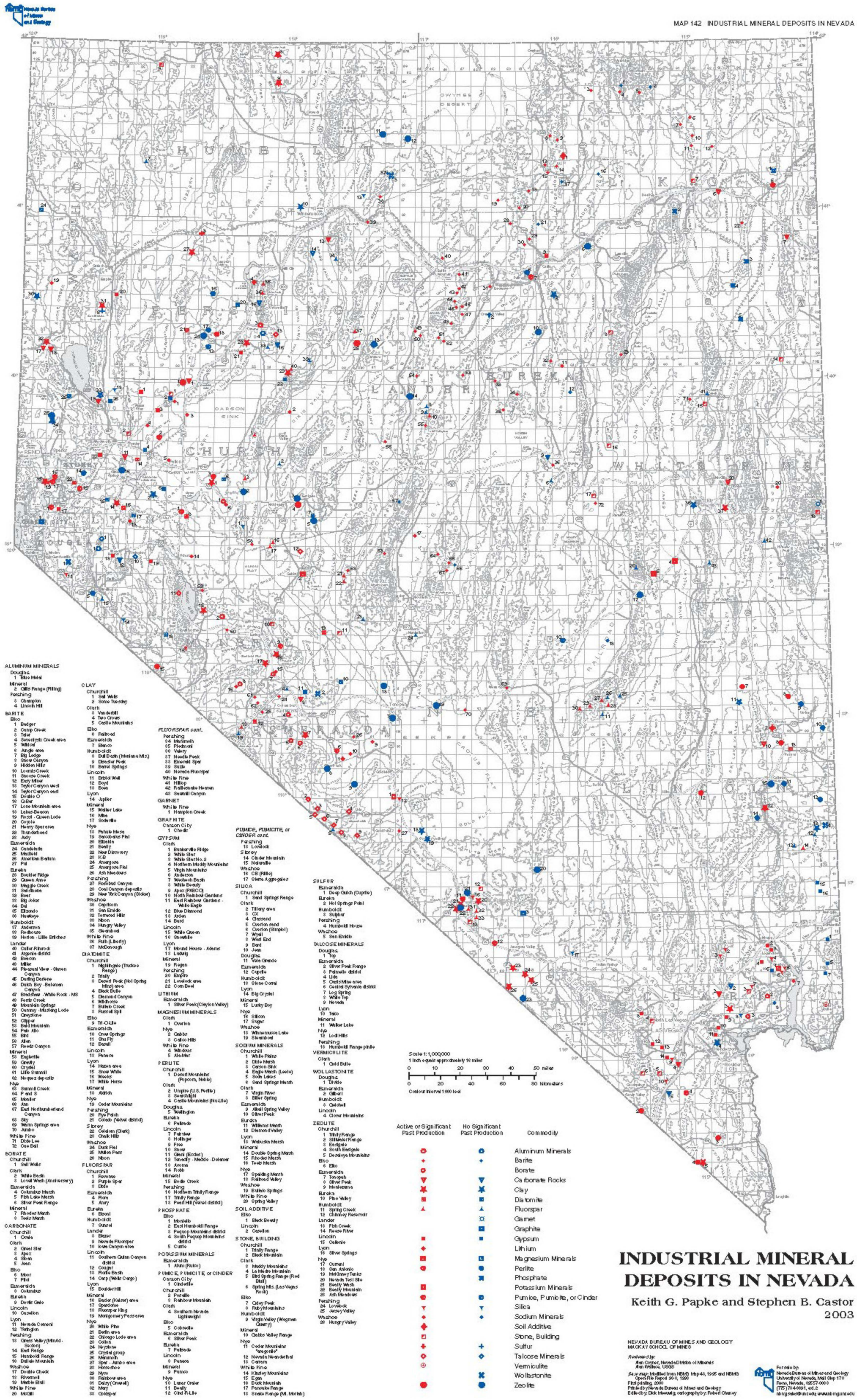

MAP 142 INDUSTRIAL MINERAL DEPOSITS IN NEVADA
Active or Significant Past Production
No Significant Past Production
Commodity
Aluminum Minerals
Barite
Borate
Carbonate Rocks
Clay
Diatomite
Fluorspar
Garnet
Graphite
Gypsum
Lithium
Magnesium Minerals
Perlite
Phosphate
Potassium Minerals
Pumice, Pumicite, or Cinder
Silica
Sodium Minerals
Soil Additive
Stone, Building
Sulfur
Talcose Minerals
Vermiculite
Wollastonite
Zeolite
INDUSTRIAL MINERAL DEPOSITS IN NEVADA
Keith G. Papke and Stephen B. Castor
2003
NEVADA BUREAU OF MINES AND GEOLOGY
MACKAY SCHOOL OF MINES

Figure 4-4

exploration in every basin or valley within the planning area (see Quaternary deposits in yellow on **Figure 2-1**, Generalized Geology of the Planning Area). Clay and pumice and cinder deposits represent relatively smaller portions of the salable minerals program within the CCD.

Section 4.4 summarizes strategic minerals using the Mineral Potential Classification System as defined in BLM Manual #3031. This assessment provides a comprehensive evaluation for all minerals that have a reasonable possibility of occurring within the planning area. Any minerals that are not specifically mentioned and evaluated are considered to have no potential to occur, based on a lack of identification anywhere within the planning area. **Table 4-1**, Summary of Commodity Potential for the CCD, summarizes the resource potential and the level of confidence in the assessment.

## 4.1 Leasable Minerals

Table 4-1 is a summary of the Mineral Potential Classification Rating of Leasable Minerals for a variety of commodities found within the planning area. Other minerals and materials that are included in the leasable category by the Mineral Leasing Act of 1920, as amended, are phosphate, oil shale, and native asphalt and are discussed below.

Phosphate typically forms in anoxic or oxygen minimal environments associated with coastal upwelling currents, continental margin settings, and deep sea oozes (Fililppelli 2011). There are no known phosphate deposits in the planning area; the nearest known Nevadan phosphate deposits are in Elko. Even though occurrence is noted and documented for Elko, there has not been any significant production (Papke and Castor 2003).

Oil shale and natural asphalt are not found within the planning area due to incorrect geologic history and setting for these resources to form. Generally, these types of deposits are formed under deep lakes or oceans over thousands to millions of years through the accumulation of marine organisms, such as algae and plankton. Eventually the water on top of these deposits recedes and exposes them to sediment, which over time covers the deposits. Depending on the geologic conditions after exposure and the resulting heat and pressure combination after burial, the marine accumulation can form into oil shale or native asphalt deposits. The potential for oil shale development in Nevada is found north and east of the planning area, mainly in Elko County within the Elko, Vinny, and Chaimen Formations (NBMG 2013). The potential for native asphalt development has not been widely studied; the nearest known deposit of native asphalt is La Brea tar pits in Los Angeles, California, well outside of the planning area (Natural History Museum of Los Angeles County 2002).

Sulfur occurs in small deposits across the planning area and across Nevada. It is associated with precious metals deposits, evaporite deposits, hydrothermal and geothermal systems, and volcanic deposits. Sulfur is widely distributed in many minerals, including pyrite, galena, gypsum, cinnabar, stibnite, and barite. Large sulfur deposits have not been documented within the planning area, but there are several mines outside of the planning area boundary. The 240-acre open pit Leviathan Mine is nine miles north of the planning area boundary in Alpine County, California (EPA 2012). This mine's main production took place from 1953 to 1962 and was later abandoned. The mine site is now an EPA Superfund site due to acid mine drainage. Other nearby large sulfur sites are north of the planning area in the Winnemucca District: at the Rabbit Hole Mine in Humboldt County (Nevada), which produced pea and powdered sulfur into the 1950s; the San Emidio Mine north of the planning area in Washoe County; the Sulphur Mine in Pershing County; and the Deep Gulch Cuprite Mine in Esmeralda County (Russell 2008; Papke and Castor 2003). Potential for sulfur production is low due to lack of interest in solely sulfur mines, as most sulfur production is the result of fossil fuels processing (USGS 2013e).

### 4.1.1 Geothermal

Significant geothermal resources are found throughout the CCD planning area, a particularly in Dixie Valley, Edwards Creek Valley, Carson Desert and Salt Wells area in Churchill County, the Steamboat Hills area in southern Washoe County, Wabuska in Lyon County, and the Hawthorn and Gabbs Valley areas in Mineral County (Penfield et al. 2010; Map 161 from NBMG). Most of these areas have documented hot wells (>37 centigrade [°C], or 98.6 Fahrenheit [°F]) and hot heat-flow wells (>100°C/km or 212°F); Edwards Creek Valley has hot wells only. In addition, these areas have warm wells (20-37°C, 68-98.6°F) and warm heat-flow wells (20-100°C/km, 68-212°F; Penfield et al. 2010). These areas are in the valleys of the Great Basin and Range System and are underlain by Tertiary Age rocks. Geothermal productivity in the Great Basin is related to traditional igneous magmatic intrusions in the subsurface rock layers, and more recently studied high geothermal gradients associated with active crustal thinning, extension, and faulting (Arehart et al. 2002). However many of these areas have been leased, and many have geothermal power plants already located in these high potential areas; this could limit new growth (geothermal lease and power plant map).

The Mineral Potential Classification Rating (Table 4-1) for geothermal resources in the CCD is H-D. This is due to known geothermal resources, the favorable geologic environment, and the presence of geothermal reservoirs of hot water found at various depths beneath the earth's surface (BLM 2008).

To further inform the RMP process, a reasonably foreseeable development scenario has been developed and is included in this report as Appendix B.

### 4.1.2 Potash and Sodium

Potash and sodium salts are evaporite deposits formed through the evaporation of water bodies over time, eventually resulting in present-day salt marshes or playas.Evaporite deposits typically accumulate in a climate where evaporation occurs at a faster rate than precipitation. As the water body evaporates, sodium, potassium, and magnesium salts precipitate out of solution in their order of solubility. Evaporite deposits such as this are found on the salt flats, playas, and salt marshes that dot the planning area.

The CCD has three areas of historical potash production, none of which are currently producing (Tingley 1998). The Mineral Potential Classification Rating for potash (Table 4-1) in the planning area is H-D.

Sodium minerals mined in the planning area are sodium chloride (six areas), sodium sulfate (four areas), and sodium carbonate (two areas; Tingley 1998; Papke and Castor 2003). The Mineral Potential Classification Rating for sodium (Table 4-1) in the planning area is H-D.

### 4.1.3 Coal

There are limited coal resources within the planning area. Currently, there is no effort to explore for or lease areas with potential coal deposits, due to inaccessibility to some deposits, disagreeable land status of some deposits, and the inferior quality of the coal. Three historic occurrences were recorded, and only one small mine near Eldorado Canyon in the Pine Nut Range recorded production of coal material considered inferior to lignite (less than necessary 25 to 35% carbon material to be considered lignite). Otherwise no exploration information is available on the coal occurrences within the area.

The formation of coal begins in a peat-forming environment, characterized by a poorly drained system with a high water table that intermittently or permanently covers the environment. This results in a stagnant anoxic environment that prevents the complete decomposition of plant debris. This plant debris must accumulate over thousands of years (3 feet over 500-600 years in a tropical climate, and 3 feet over 1,500-1,700 years in a cool climate) before it is converted into coal. This process compacts the 3 feet of peat into 1/10$^{th}$ the thickness for the highest quality coal, or down to 3.6 inches. The process of converting peat into coal is called coalification. This results when the peat is buried under other types of sediments from marine or freshwater systems that eventually become sedimentary rocks, such as the sandstones and shales observed in beds around the coal in Eldorado Canyon. Upon burial, the peat deposits undergo heat and pressure. Depending on the levels of heat and pressure and the length of time that these levels remain, various grades of coal are formed, starting with metamorphosis to lignite and ending with the highest grade, anthracite (Crowell et al. 2008; Tingley 1990).

The necessary long uninterrupted periods of peat compilation is not a feature of the planning area's geology, nor is the long-term heat and pressure combination necessary for coalification. Coal beds within the planning area are 6 to 8 feet thick. The beds are composed of a coal material considered inferior to the lowest rank of coal, lignite, because they have a 19 percent carbon content and a high moisture, ash, and volatile carbon content (Tingly 1990).

The Mineral Potential Classification Rating (Table 4-1) for coal throughout the planning area is L-C because of a lack of occurrences and an unfavorable geological environment.

### 4.1.4 Oil and Gas

To date, oil production in Nevada has been limited to the area of Railroad Valley in eastern Nye County, where oil was first discovered in Nevada in 1954, and to Pine Valley, in northeastern Eureka County, where oil was discovered during a resurgence in exploration, in 1982 (Garside et al. 1988). In the Sans Springs field in Railroad Valley, oil is reportedly found in hydrothermally altered rhyolitic tuff containing secondary fractures and vesicles. The tuff contains both structural and diagenetic traps, which resulted in discrete reservoirs of limited extent. Many dry holes were drilled around the reservoirs, with no significant show of oil.

There are few if any in-place Paleozoic rocks in the planning area, and most of the carbonate rocks present are within Mesozoic accreted terranes. These rocks are overmature. Heating related to orogenic events has mostly destroyed their hydrocarbon-generation potential, although Triassic carbonate rocks are believed to have oil potential in portions of the Stillwater Range and Clan Alpine Mounts (Barker et al. 1995).

Oil exploration in the planning area has generally been limited to the Carson Desert north and west of Salt Wells Lake and the area surrounding Fallon. Oil discoveries in western Nevada have been limited to a few reported shows identified during drilling, usually in dry holes. The Nevada Bureau of Mines and Geology identified this area as favorable for oil and gas (Garside et al. 1988). Most of the area identified as favorable, including most of the Carson Sink, is not within the decision area.

Barker et al. (1995) identified two hypothetical oil plays in western Nevada that may be reasonable models for oil potential in the planning area. One hypothetical play assumes that Permian-Triassic rocks in some ranges have the potential for petroleum generation and that Permian to Triassic sandstones and limestones, alluvial fans on the margins of ranges, or fractured volcanic rocks have the porosity to act as reservoirs. Traps may be formed by drag folds and truncation related to Fencemaker thrust sheets or by displacement of normal fault blocks. This play has very limited potential due to small volume of source rocks.

A more likely scenario is for oil produced by heating organic-rich Neogene basin fill sediments, which have produced shows but no recoverable oil or gas, by geothermal convection, shallow intrusions, or heat flow along basin faults near graben boundaries. These fill sediments are then be trapped by lacustrine beds that are laterally interbedded with alluvial fans, or by altered volcanic tuffs or flows, or by normal faults. This is the principal type of play that has been explored, and to date it has been found to be dry (Barker et al. 1995).

The Mineral Potential Classification Rating for Oil and Gas (Table 4-1) in the planning area is L-C due to the unfavorable geology within the planning area, more favorable geology outside of the planning area, and unsuccessful results of prior exploration.

To further inform the RMP process, a reasonably foreseeable development scenario has been developed and is included in this report as Appendix B.

## 4.2 Locatable Minerals

The result of modeling the potential of volcanic rock-hosted gold and silver deposits is presented in a map portraying favorable areas for exploration. It includes regions of strong potential where known occurrences are absent or few in number (Figures 4-2 and 4-3). The study culminated in the preparation of maps portraying the mineral potential within discrete areas as posterior probabilities. This potential was determined with respect to estimates of the conditional relationships between measured indicators and known conditions, using weights of evidence modeling methods. The factors used to predict mineral potential were structural, geochemical, geomagnetic, gravimetric, lithologic, and lithotectonic data. The Mineral Potential Classification Rating for gold and silver are H-D (Table 4-1).

The Mineral Potential Classification Rating for all other Locatable Minerals vary by commodity and are outlined in Table 4-1.

## 4.3 Salable Minerals

There are several salable materials mine sites within the planning area, primarily sand, gravel, and aggregate pits developed in response to the construction industry (Figure 3-3, Saleable Mineral Pits in the CCD). The commodity potential of the salable material in the planning area is outlined in Table 4-1.

### 4.3.1 Aggregate, Sand, and Gravel

Due to the low unit value of aggregates, sand, and gravel deposits, these materials are generally not transported long distances. However, sand and gravel operations are expected to continue to be developed as close to the consuming areas as possible. The largest operations within the CCD are close to the urban interface surrounding Reno and Carson City. Numerous smaller operations are next to smaller towns and at regular intervals along transportation corridors. Development of aggregate deposits has slowed due to the reduction in demand from the construction industry, but it is expected to rise as the housing and other markets recover from the recent recession.

The Mineral Potential Classification Rating (Table 4-1) for sand, gravel, and crushed aggregate in the planning area is H-D. This is based on the high level of production and expansion of demand for this material by the construction industry as well as the presence of this resource, based on geologic conditions.

The western portion of the planning area has been documented to have sufficient reserves of high quality, undeveloped, aggregate resources to support and satisfy projected demand well into the twenty-first century (NBMG 2000). In 2000, the projected consumption rates for 2020 were estimated to be between 12 and 13 million tons for the Reno-Carson City-Gardnerville area. The most recent USGS production amounts were 7.8 million tons in 2008, indicating that production levels are on par with the projected continuous supply (NBMG 2000; USGS 2008).

The data analysis of this report is displayed in **Figure 4-5,** Aggregate Potential on BLM-Administered Lands. While the eastern portion of the planning area has not been thoroughly reviewed, geologic conditions are similar. The BLM-administered lands have vast amounts of permissible tracts for sand and gravel exploration in every basin or valley within the planning area (see Quaternary deposits in yellow on Figure 2-1, Generalized Geology of the Planning Area). Borrow material, or lower quality aggregates, are expected to be even more abundant.

The development potential of aggregate resources within the planning area depends on the deposits' distance from the market and the road type available between the resource and the market. Aggregate resources, even of high quality, that are too far from the market or that require the improvement of access roads before exploitation for economic development will likely not be developed (NBMG 2000).

The 2000 NBMG aggregate report shows that there are two types of aggregates: Hard rock/bedrock materials are worth more and are less abundant and must be mechanically broken into aggregates particles; aggregate sand and gravel resources are plentiful and may require washing but do not usually require mechanical breakdown.

Of the aggregate group, there is a ranking of quality of material based on particle size, clay content, and source type (either glacial till or river bed sediment). Potential of bedrock and sand and gravel sources are broken down into three categories: high, moderate, and low. Areas that are not classified for potential are urbanized areas and water bodies. Bedrock sources for high quality aggregate are primarily igneous rocks, which include both granitic and volcanic rocks, such as rhyolite, basalt, and andesite. Sand and gravel aggregates primarily come from sources along the floodplain of the Truckee and Carson Rivers and tributary drainages. It predominantly includes river gravels, glacial outwash, and glacial terraces.

In addition, minor amounts of good quality sand and gravel come from beach deposits, originally formed several thousand years ago when inland lakes were common in Nevada. Other sources of sand and gravel are widespread alluvial fan deposits. While these sources provide much of the borrow materials and

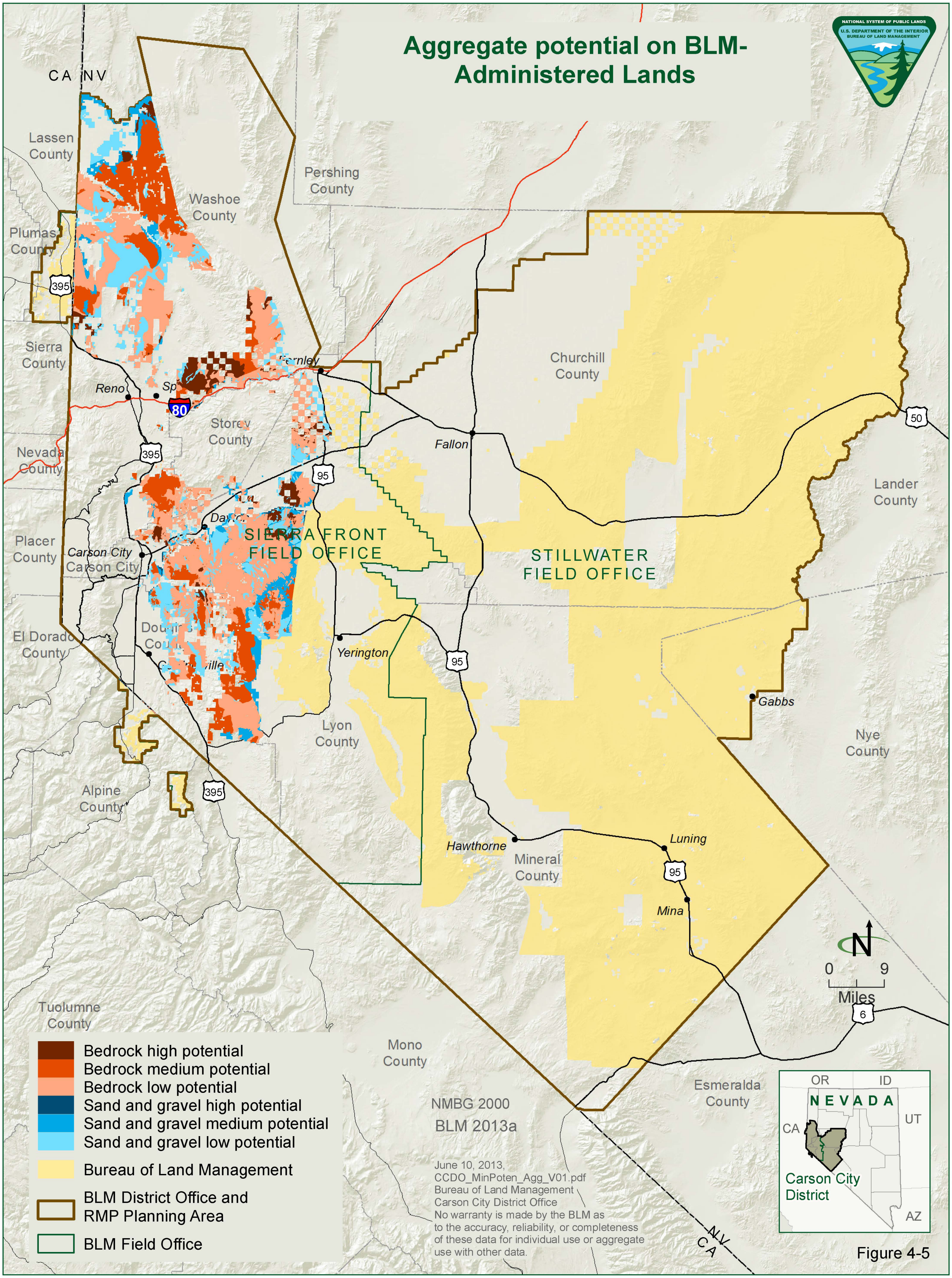

Aggregate potential on BLM-Administered Lands
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CA NV
Lassen County
Plumas County
Sierra County
Nevada County
Placer County
El Dorado County
Alpine County
Tuolumne County
Mono County
Washoe County
Pershing County
Storey County
Churchill County
Lander County
Lyon County
Mineral County
Nye County
Esmeralda County
Carson City
Reno
Fernley
Fallon
Yerington
Gabbs
Hawthorne
Luning
Mina
SIERRA FRONT FIELD OFFICE
STILLWATER FIELD OFFICE
395
80
95
50
6
N
0 9
Miles
Bedrock high potential
Bedrock medium potential
Bedrock low potential
Sand and gravel high potential
Sand and gravel medium potential
Sand and gravel low potential
Bureau of Land Management
BLM District Office and RMP Planning Area
BLM Field Office
NMBG 2000
BLM 2013a
June 10, 2013,
CCDO_MinPoten_Agg_V01.pdf
Bureau of Land Management
Carson City District Office
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
NV
CA
OR
ID
NEVADA
UT
AZ
Carson City District

Figure 4-5

aggregate base, they are generally not used as a source for high-quality concrete or asphalt aggregate. Sand and gravel deposits generally occur in relatively flat and low-lying portions of the study area, land that is in most cases the most desirable for construction. For this reason, urbanization takes place most rapidly in areas with sand and gravel potential, and such areas tend to be preferentially removed from consideration as an aggregate resource (NBMG 2000).

### 4.3.2 Clay

The one permitted clay operation, the NCC Limestone Quarry and Mill, is in the planning area in Lyon County near Fernley. This mine is a specialty stone operation as well, mining limestone along with unspecified clay (NDOM 2011). Production levels of the clay are not reported, but due to the history of the mine (dating to 1998), production is expected to continue.

The most significant clay production came from the bentonite clay deposits in the historical Churchill District in Lyon County (1-2 thousand tons/year) and the only currently permitted clay operation, NCC Limestone Quarry and Mill in Lyon County near Fernley. The Mineral Potential Classification Rating (Table 4-1) for clay deposits in the planning area is M-D due to the past production levels, documented locations of deposits, and recent mineral exploration programs.

### 4.3.3 Pumice and Cinder

Pumice and cinder are pyroclastic materials that form after a volcanic eruption due to lava cooling rapidly above ground, forming the extrusive igneous rocks. As the lava cools, gas bubbles escape the forming rock leaving air pockets with results in the highly vesicular texture and commonly low weight. There is one active plan of operation for pumice and cinder in the planning area, but current or historical production levels are not recorded. The Mineral Potential Classification Rating **(Table 4-1)** for pumice and pumicite within the planning area is M-D, based on localized deposits and low production levels.

## 4.4 STRATEGIC MINERALS

This assessment provides a comprehensive evaluation for all minerals that have a reasonable possibility of occurring within the planning area. Any minerals that are not specifically mentioned and evaluated are considered to have no potential to occur, based on a lack of identification anywhere within the planning area.

The Mineral Potential Classification System as defined in BLM Manual #3031 is outlined below.

**Table 4-1**
**Summary of Commodity Potential of the CCD**

| Type | Commodity | Mineral Potential | | District | Remarks |
|---|---|---|---|---|---|
| | | Potential | Certainty | | |
| **LEASABLE** | | | | | |
| | Geothermal | H | D | NA | The planning area has abundant geothermal resources, including thermal springs where warm or hot water comes to surface naturally, and thermal wells which must be drilled and developed. |
| | Oil/gas | L | C | NA | Oil exploration in the planning area has generally been limited to the Carson Desert north and west of Salt Wells Lake and the area surrounding Fallon. Oil discoveries in western Nevada have been limited to a few reported shows identified during drilling, usually in dry holes. |
| | Potash and Sodium | H | D | Rand, Dixie Marsh, Sand Springs Marsh, Sheephead, Rhodes Marsh, Double Springs Marsh, Carson Sink, Teels Marsh, Wabuska Marsh, Soda Lake District | Exploration activities and mining has been limited. There is minimal interest in developing these resources in the CCD. |
| | Coal | L | C | Eldorado District; | Inferior to Lignite |
| **SALABLE** | | | | | |
| | Sand/gravel/aggregate | H | D | NA | Aggregates are widely available throughout the planning area. They are often mined from alluvial-covered areas along the lower flanks of mountain ranges and from alluvial deposits near the Truckee, Walker, and Carson Rivers |
| | Pumice/pumicite | M | D | Carson City Mining District | Production has occurred in the Cinderlite area in Carson City County, Pumco area in Mineral County, the Naturalite area in Storey County, and the CB (Rilite) and Sierra Aggregates in Washoe County. |
| | Clay | M | D | Rhodes Marsh, Pilot Mountains, Silver Star, Fitting, Desert Mountains, Churchill, Sheephead, Sand | Exploration activities and mining has been limited. There is minimal interest in developing these resources in the CCD. |

**Table 4-1**
**Summary of Commodity Potential of the CCD**

| Type | Commodity | Mineral Potential | | District | Remarks |
|---|---|---|---|---|---|
| | | Potential | Certainty | | |
| | | | | Pass District, and Lodi District. | |
| **LOCATABLE Metals** | | | | | |
| | Gold (lode) | H | D | Refer to Figure 4-2, 4-3 | Gold and silver potential and certainty, per Mihalasky (2004) and Wallace et al. (2001) |
| | Gold (placer) | H | D | None identified within planning area | Relatively minor. Associated with existing streams and paleo channels near lode deposits, |
| | Silver | H | D | Multiple districts | per Mihalasky (2004) and Wallace et al. (2001) |
| | Copper | H | D | Mainly in Walker Lane; Stillwater range | Porphyry Cu and related Cu skarn |
| | Molybdenum | M | D | Copper Mtn., Mineral County, | Porphyry Cu-Mo; porphyry Mo |
| | Iron | H | D | Yerington; north Stillwater Range (White Cloud, Copper Kettle, Corral Canyon, Mineral Basin[?]) | Yerington deposits associated with porphyry Cu; Stillwater Range deposits also associated with Cu, Au |
| | Lead/zinc | H | D | many | Associated with plutons, polymetallic vein deposits; secondary mineral associated with porphyry-Cu |
| | Mercury | M | D | Pilot Mtns. | Associated with pluton intrusions, porphyry-Cu; alteration and replacement by cinnabar; secondary mineral; small deposits, uneconomical to mine |
| | Tungsten | H | D | Gardnerville and Topaz Lake, in Douglas County; Nevada Sheelite, Silver Dyke Mines, Black Jack Mine in Mineral County; Victory Mine near Gabbs in Nye County; Tungsten Flat, Cowboy Mine in Lyon County; Peavine Mining District in Washoe County, Tungsten Mountain Mine, North and South Sand Springs Range, | Associated with pluton intrusions; contact deposits of scheelite in tactite, which consists mainly of garnet, epidote, and diopside, with abundant pyrite, some chalcopyrite, molybdenite |

**Table 4-1**
**Summary of Commodity Potential of the CCD**

| Type | Commodity | Mineral Potential: Potential | Mineral Potential: Certainty | District | Remarks |
|---|---|---|---|---|---|
| | | | | and two other mines in Churchill County | |
| | Antimony | M | D | Potosi Mine in the Candelaria District was 4th largest producer in Nevada; smaller deposits elsewhere, | Associated with porphyry Cu |
| | Uranium | L | D | mainly in Washoe County west of Pyramid Lake, and smaller deposits throughout Mineral County. | Widely distributed, in veins in small quantities in felsic volcanic tuffs and flows; well explored in 1950s |
| | Vanadium | L | C | Churchill and Mineral Counties | Small deposits of vanadium with uranium |
| | Beryllium | L | C | No significant quantities | Minor occurrence in pegmatites |
| | Cobalt/Nickel | L | C | No significant quantities | Minor occurrence |
| | Manganese | L | C | No significant quantities | No significant known deposits reported in planning area. |
| | Titanium/Zirconium | M | C | No ore deposits reported in Nevada | Subcommercial amounts of ilmenite and rutile in placer deposits may be present. |
| | Gemstones | H | D | Candelaria, Pilot Mountains | Most production is from small vein deposits associated with intrusive bodies in Middle Paleozoic rocks in southeast Mineral County. |
| **LOCATABLE Industrial** | | | | | |
| | Magnesium compounds | H | D | Gabbs | Magnesite and brucite current major production |
| | Thorium/rare earths (lithium) | M | B | Salt Wells (brine) | Lithium brines could be present elsewhere, but the area has not been thoroughly explored. |
| | Barite | H | D | Mineral County | Eagleville, Crystal, Little Summit, Noquez deposits recent operations |
| | Fluorspar | H | D | Churchill, Mineral Counties; Nye County prospective | Revenue and Dixie (Churchill County); Baxter area, Spardome, Fluorspar King (Mineral County) recent operations |
| | Gypsum/anhydrite | H | C | Lyon, Mineral Counties | Mount House, Ludwig (Lyon County); Regan (Mineral County) recent operations. |

**Table 4-1**
**Summary of Commodity Potential of the CCD**

| Type | Commodity | Mineral Potential | | District | Remarks |
|---|---|---|---|---|---|
| | | Potential | Certainty | | |
| | Carbonate minerals | H | D | Lyon, Washoe Counties | Nevada Cement (current major operation); Double Check, Rivermott, Marble Bluff (Washoe County, recent) |
| | Diatomite | H | D | Churchill, Storey Counties | Nightingale, Desert Peak, Black Butte, Russell Spit (Churchill County), Celatom, Chalk Hills (Storey County), recent operations |
| | Kyanite/refractories | L | C | Gillis Range, Mineral County; Bodie Creek Mine, southwest Mineral County; Desert Mountains in western Churchill County | Small quantities with sporadic occurrence, primarily andalusite, associated with alteration of Triassic volcaniclastics |
| | Mica/feldspar | L | C | No significant occurrence in the planning area | Sheet mica not reported in the planning area |
| | Silica | L | C | Steamboat Springs, Washoe County | Localized occurrence, small quantities, low quality/purity |
| | Talc | L | C | No significant occurrence in the planning area | Produced in Esmeralda County from alternation near thrust faults of granitic rock over dolomite |
| | Perlite | L | C | Sheephead (Washoe County) | Localized occurrence, small quantities |

Mineral potential based on BLM Mineral Potential Classification System, Manual #3031

# BLM MANUAL #3031

## Mineral Potential Classification System

LEVEL OF POTENTIAL

O. The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.

L. The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.

M. The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

H. The geologic environment, the inferred geologic processes, the reported mineral occurrences and or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

ND. Minerals potential not determined due to lack of useful data. This does not require a level of certainty qualifier.

LEVEL OF CERTAINTY

A. The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C. The available data provide direct but quantitatively minimal evidence to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

For determination of No Potential use O/D. This class shall be seldom used, and when used it should be for a specific commodity only.

As used in this report, potential refers to "… potential for the presence (occurrence) of a concentration of one or more energy and/or mineral resources. It does not refer to or imply potential for development and/or extraction of the mineral resource(s). It does not imply that the potential concentration is or may be economic, that is, could be extracted profitably."

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# SECTION 5
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# Appendix A

## Reasonable Foreseeable Development Scenario for Fluid Minerals

# Appendix A
# Reasonable Foreseeable Development Scenario for Fluid Minerals

## Introduction

The following Reasonably Foreseeable Development Scenario (RFD) has been prepared in support of the United States (US) Department of the Interior, Bureau of Land Management (BLM) Carson City District (CCD) Resource Management Plan (RMP) and Environmental Impact Statement (EIS). The RFD identifies the lands that are likely most suitable for the development of fluid mineral resources, including geothermal and oil and gas resources, and estimates the electrical energy generating capacity or production of those lands should they be developed.

Developing an RFD requires a series of assumptions about future development; these assumptions include evolution of technologies, energy policy, economic growth, and the cost of energy in the future, among others. Uncertainties due to assumptions are amplified when dealing with unproven and yet-to-be commercialized technologies. For the purpose of this RFD, only known, proven, and currently used technologies were considered in the estimations provided.

## Purpose of This Report

The purpose of this report is to identify the potential for development and potential location of fluid minerals on lands administered by the BLM within the CCD planning area. The planning area encompasses 4.8 million acres of BLM-administered land in 11 counties within 2 states (Washoe, Storey, Carson City, Douglas, Lyon, Churchill, Mineral, and Nye counties within Nevada, and Alpine, Plumas, and Lassen counties within California).

An RFD is a forecast or estimate of activity that is likely to occur. The goal is to give scope or scale to the potential consequences of new activities and their associated impacts on the environment. The RFD is not meant to predict actual activities but to be a basis for quantifying environmental effects from a range of development scenarios.

The RFD projection is based on knowledge of past use, the capability of the resource for additional development, local and regional economic trends, and the needs of the public. The data presented in an RFD is deliberately general for ease in assessment. Specific locations of surface-disturbing activities, such as roads or well developments, are not indicated. The period covered by this RFD is 20 years.

## Geothermal Reasonable Foreseeable Development

As stated in the Mineral Potential Report, the CCD sits atop one of the most active geothermal resources anywhere. The BLM manages 148 geothermal leases covering approximately 299,195 acres, with 5 associated power plants and an active geothermal power production of 183 megawatts (MW), as of February 2013. These power plants are in Steamboat Hills near Reno; Dixie Valley northeast of Fallon; and Soda Lake, Stillwater, and Salt Wells near Fallon. In addition, the Wabuska facility is on private land within the planning area.

In addition, two power plants are under construction on BLM-administered lands in the planning area: The Wild Rose Power Plant in Gabbs Valley will produce 15 to 35 MW, and the Patua Power Plant near Fernley will produce 60 MW. Another three areas with active exploration projects for proposed future energy production are Southern Gabbs Valley, Northern Edwards Creek Valley, and the Hazen area.

The act of leasing land for geothermal development does not affect the environment, but lease issuance confers the future right to develop geothermal resources, subject to applicable regulations and lease stipulations. An RFD discloses future potential direct and indirect impacts that could occur once the lands are leased. This evaluation does not replace the requirement that BLM conduct a site-specific environmental assessment (EA) at the exploration, development, and production stages, in order to comply with the NEPA. Geothermal development can be broken down into three generally sequential phases: exploration, development and production, and reclamation and abandonment.

The exploration phase includes all activities necessary to explore for geothermal resources, including geologic, geochemical, and geophysical surveys; drilling temperature gradient wells; and drilling exploration wells. Most activities at this stage are proposed to the BLM via a Notice of Intent to Conduct Geothermal Resource Exploration Operations. Geologic, geochemical, and geophysical surveys typically involve analyzing the surface geology, collecting water data and samples from hot springs, and collection of geophysical data by various methods. Cross-country travel could occur in order to complete the surveys and this work typically covers a broad surface area. Typically, these surveys cause minimal surface disturbance and are often considered casual use. If the proposed activities exceed the casual use threshold, they may be categorically excluded from National Environmental Policy Act (NEPA), or require additional analysis under NEPA.

Based on the analysis of the data gathered from the geologic, geochemical, and geophysical surveys, inference can be made as to where higher temperature gradients could occur. The higher temperature gradients are then confirmed by drilling temperature gradient (TG) wells. These wells are usually less than six inches in diameter and are drilled to depths of several hundred to several thousand feet. Well drilling occurs in association with road and well pad construction. Well pads are about 0.1 acres (55 feet by 80 feet) in size and may be established without removing existing vegetation. Wells are typically drilled next to existing roads, but new road may need to be built in order to get an accurate extent of the temperature anomaly. Temperature gradient studies may be categorically excluded from NEPA. When greater levels of disturbance are necessary (for example, road building), preparation of an EA may be appropriate.

Upon completion of exploration activities focused on temperature gradient wells, and the confirmation of a sufficient temperature anomaly, one or more exploration wells could be drilled in order to test the prospect. These drill holes may be several hundred to several thousand feet deep, and are typically 2,000 to 4,000 feet deep. A Geothermal Drilling Permit (GDP) must be approved for each well drilled. Each well pad with associated facilities would disturb an area of about 350 feet by 350 feet, or approximately 3 acres. In many cases a new road could be constructed into the site, creating additional disturbance. One or more GDPs will typically be analyzed in an EA.

If the exploration activities have produced results that strongly indicate the presence of a heat reservoir capable of commercial production, then developments of the field will ensue. This is the stage where most of the ground disturbing activities will occur. Development and utilization proposals require NEPA analysis, often at the EA level. In certain circumstances, an EIS might be required. The production limits of a field are determined by drilling of production and injection wells, which often results in more surface disturbance to construct additional roads and well pads. In the early development stages, the status of any given well may be uncertain due to limited knowledge of the details of the reservoir. Once there is confidence about the setting and geometry of the reservoir, development of production facilities will begin

Development of production capabilities could include the construction of a geothermal electric generating plant, direct use facilities (such as green houses or dehydration plants), or a combination of the two. Other facilities that would be constructed include pipelines, at least one electric transmission line, and administrative facilities such as offices, a warehouse, and maintenance facilities. If the development is for direct use, the generating facilities would be replaced by greenhouses, dehydration plants, and possibly cooling ponds.

The reclamation and abandonment, or close-out, stage involves abandonment when exploration is unsuccessful or after production ceases. This includes the following discrete operations: surface equipment removal, cementing and capping drill holes and wells, and surface rehabilitation. All surface disturbances must be reclaimed to BLM standards. Reclamation includes removing all facilities, re-grading and re-contouring all surface disturbances to blend with the surrounding topography, and re-establishment of a desirable variety of vegetation.

## Quantitative Reasonably Foreseeable Development Scenario

Until actual geothermal exploration and development begins, 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 levels of intensities of such development.

Several models were assumed which describe the major processes and actions involved in the various stages of lease implementation. These models serve as the baseline against which to analyze impacts on the existing environment.

## General Assumptions

There are currently 148 geothermal leases covering approximately 299,195 acres, with 5 associated power plants and an active geothermal power production of 183 megawatts as of February 2013. The plants range from 13.2 MW to 67 MW). The number of leases has declined from 193 leases at the end of 2012.

The RFD 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 5 15-MW geothermal power plants. The 15-megawatt power plant is used as a typical size to estimate the amount of disturbance that could be involved for the RFD. These calculations are meant to be used as an indicator of the impacts involved, not as a cap or bound on the size of any geothermal power plant development. 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 in **Table A-1**, Geothermal Exploration Drilling Disturbance, which lists the maximum degree of anticipated surface disturbance expected during this phase.

**Table A-1**
**Geothermal Exploration Drilling Disturbance**

| Activity | Acres of Disturbance (Acres) | Unit per Lease | Total Acres Disturbed per Lease | Total Acres Disturbed with Two Leases Explored Per Year |
|---|---|---|---|---|
| Exploration Roads | 1 acre/mile | 3 0.5-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** |

If we assume that as many as three temperature gradient 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 0.5 mile in length, would disturb an additional 1.5 acres. Therefore, the total disturbance per lease is approximately 4.5 acres (**Table A-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. Components from successful exploration programs can be used through the development process, frequently using the existing surface disturbances for some of the development activities. There may be numerous leases on which exploration drilling takes place; however, it is unlikely that they would not all be drilled 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, 6 holes would be drilled per year. If we further assume that unsuccessful exploration holes are reclaimed within a 2-year period, then there would never be more than 12 drill pads disturbed at any one time. **Table A-1** summarizes anticipated individual and cumulative impacts for the exploration drilling.

### Development

The following describes the construction activities required to develop 5 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 reinjection.

Since development is likely to occur in about 5-MW increments over a period of several years, the degree of surface disturbance at any given time is less than that presented in **Table A-2**, Surface Disturbance from Construction of a Geothermal Power Facility. Mitigation and enhancement would have occurred in some portions of the lease before additional portions of the lease are developed.

**Table A-2**
**Surface Disturbance from Construction of a Geothermal Power Facility**

| Facility or Feature | Facilities 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)

Up to 6 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 3 pipelines would disturb approximately 5 acres and each of 5 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 A-2**). Again, not all power plants would be constructed at the same time, and construction would likely be staged in 5-MW increments.

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.

## OIL AND GAS (REASONABLE FORESEEABLE DEVELOPMENT)

Limited drilling and exploration for oil and gas resources have taken place in the planning area since the early 1900s in Washoe, Lyon, Churchill, and Mineral counties. The CCD currently manages less than 30 oil and gas leases in Churchill, Nye, and Mineral Counties (BLM 2011). There is a limited amount of exploration on these leases, and no production has occurred in association with any of these leases.

Oil exploration in the planning area has generally been limited to the Carson Desert north and west of Salt Wells Lake and the area surrounding Fallon. Oil discoveries in western Nevada have been limited to a few reported shows identified during drilling, usually in dry holes. The Nevada Bureau of Mines and Geology identified this area as favorable for oil and gas (Garside et al. 1988). Most of the area identified as favorable, including most of the Carson Sink, is not within the decision area. Therefore, there is no reason to believe that oil and gas would production would be foreseeable within the CCD during the 20 year planning period.

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