



**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

1		
2		
3	BIA	Bureau of Indian Affairs
4	BLM	US Department of the Interior, Bureau of Land Management
5	BOR	US Department of the Interior, Bureau of Reclamation
6		
7	CCD	Carson City District
8	CDFW	California Department of Fish and Wildlife
9	CFR	Code of Federal Regulations
10		
11	DOE	Department of Energy
12	DOI	United States Department of the Interior
13		
14	EA	environmental assessment
15	EIS	environmental impact statement
16		
17	FLPMA	Federal Land Policy and Management Act of 1976
18		
19	GIS	geographic information system
20		
21	MOU	memorandum of understanding
22		
23	NBMG	Nevada Bureau of Mines and Geology
24	NEPA	National Environmental Policy Act of 1969
25	NOI	notice of intent
26	NURE	National Uranium Resource Evaluation
27		
28	REE	rare earth element
29	RMP	resource management plan
30	ROD	record of decision
31		
32	USFWS	US Fish and Wildlife Service
33	USFS	US Forest Service
34	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 Cordilleran 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 volcanoclastic 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

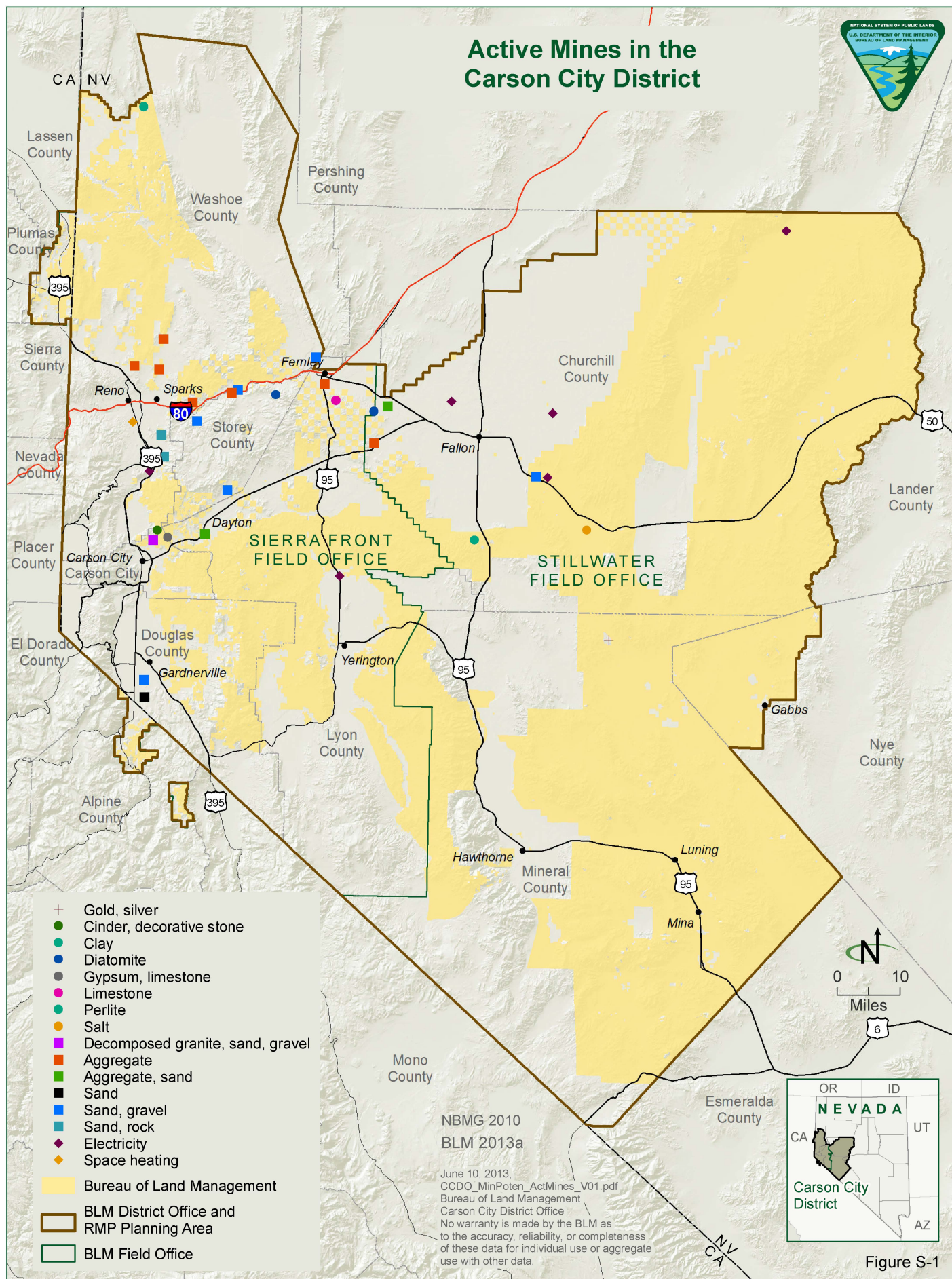


Figure S-1

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,

1 tungsten, iron, and uranium. Examples of industrial minerals are gypsum, barite,
2 diatomaceous earth, and fluorspar.

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

7 **Saleable**

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

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SECTION I

INTRODUCTION

I.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.

I.2 LANDS INVOLVED AND RECORD DATA

The CCD planning area (**Figure I-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).

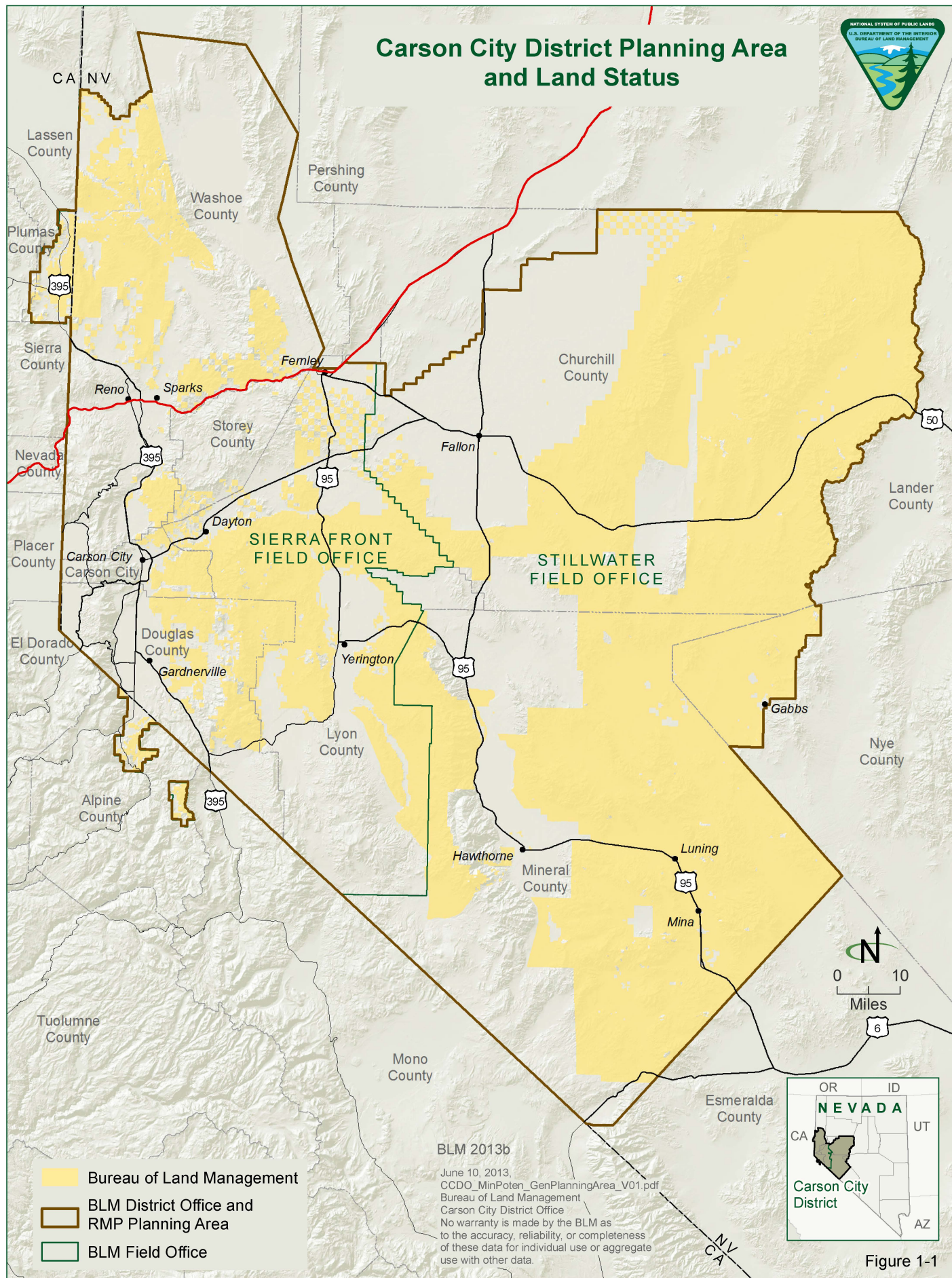


Figure 1-1

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 I-1**, Status of Lands within the Planning Area, lists the land ownership or administration lands within each of the planning area counties.

I.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 I-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

¹Water represents lakes and ponds.²Includes 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 Mississippian to Early Permian chert, argillite, shale, greenstone, and minor siltstone, sandstone, conglomerate and limestone. Most of this Golconda Allochthon is in north-central Nevada, but remnants are represented in the Pumpnickel 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 Cordilleran 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 rhyodacite 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 volcanoclastic 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 volcanoclastic 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 volcanoclastic 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 volcanoclastic during the Early Jurassic than the Paradise Terrane, 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 magnetism 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.

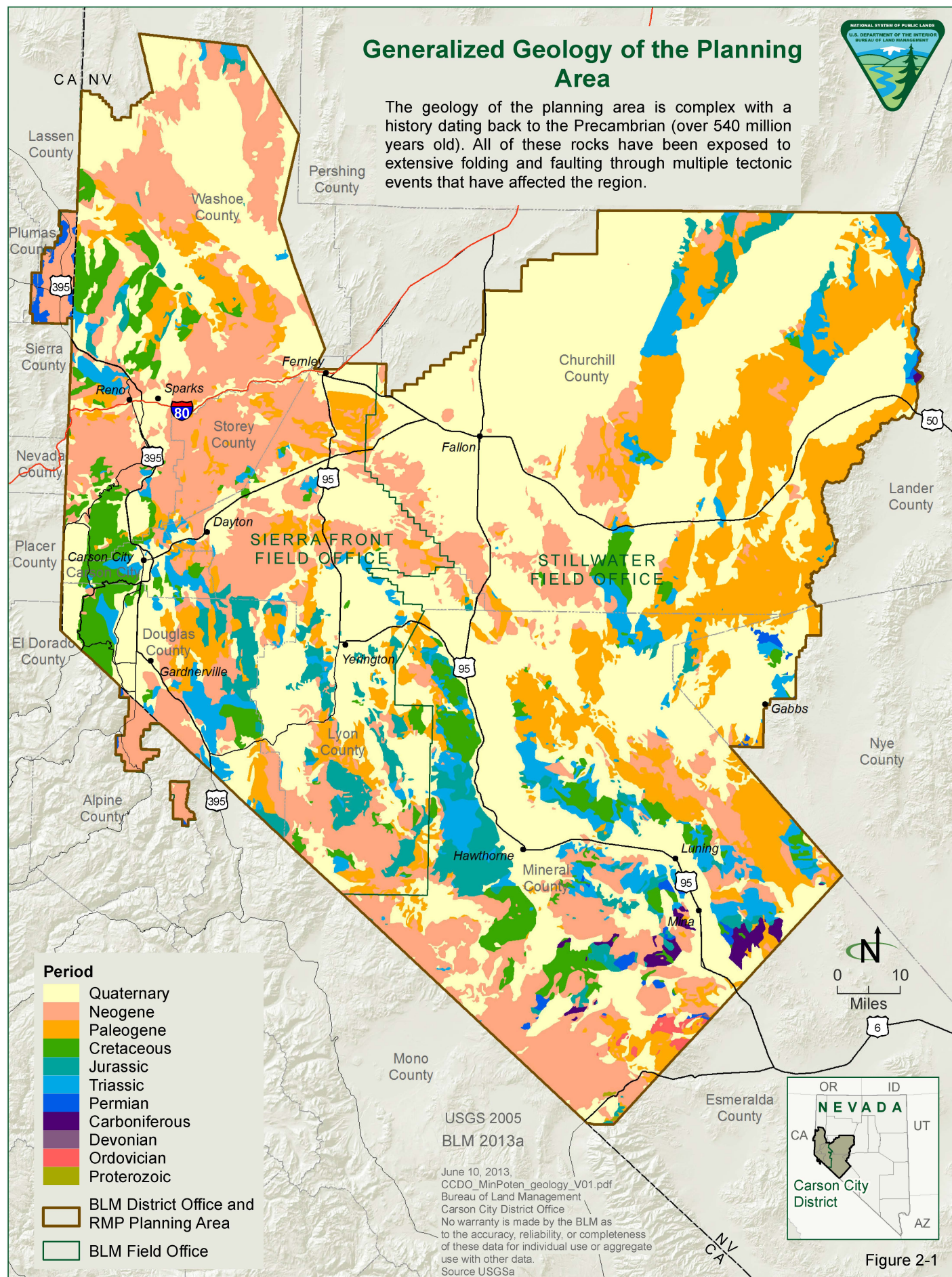


Table 2-1
Lithologic Units within the Planning Area

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 units of 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 units 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 Fonglomerate (Permian?) in Humboldt County	Rhyolite; andesite; clastic; basalt
TRPd	Early Permian to Early Triassic	Conglomerate, sandstone, shale, 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 Allochthon. 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

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

12 Mihalasky (2004) used ratios of potassium (K) to sodium (Na) and barium (Ba)
13 to sodium, from data obtained during the NURE program, as an indicator of
14 gold-silver mineralization. In the Great Basin, these ratios tend to increase in
15 rocks that have been altered by hydrothermal or geothermal fluid circulation,
16 which is associated with precipitation of metals. In volcanic rock-hosted gold
17 and silver mineralization, the ratios should increase as barium and potassium are
18 introduced and sodium is removed (the sodium is removed by being dissolved in
19 hydrothermal fluids). These same conditions are also associated with
20 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, pyrophyllite, 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/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

¹Most 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-I, 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

1 groundwater to circulate to depths for warming before being circulated back to
2 the surface (BLM 2012). The planning area has abundant geothermal resources,
3 including thermal springs, where warm or hot water comes to surface naturally,
4 and thermal wells, which must be drilled, developed, and sometimes pumped.

5 The 2008 Geothermal Programmatic EIS identified the entire state of Nevada as
6 having potential for geothermal resources. Up to 75 percent of all geothermal
7 leases on federal land in the US are in Nevada (BLM 2011). The EIS stated that
8 as of 2008, there were 45,991,073 acres of BLM-administered lands and
9 6,221,008 acres of National Forest Service-administered lands with geothermal
10 potential within Nevada. All of the BLM-administered lands within the CCD
11 were identified as having geothermal potential (BLM 2008). Of those lands with
12 geothermal resources, approximately 4.8 million BLM-administered acres with
13 geothermal potential are in the planning area (BLM 2008). Of those, 45,392
14 acres are closed to geothermal leasing due to key scenic, wildlife, recreation,
15 and historic areas (BLM 2013).

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

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

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

35 From January 1990 to February 20, 2013, 204 permit applications have been
36 received; this includes notices of intent for exploration, exploration drilling
37 plans, geothermal drilling permits, sundry notices for facilities changes at existing
38 exploration and production facilities, and geothermal power plant development
39 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.

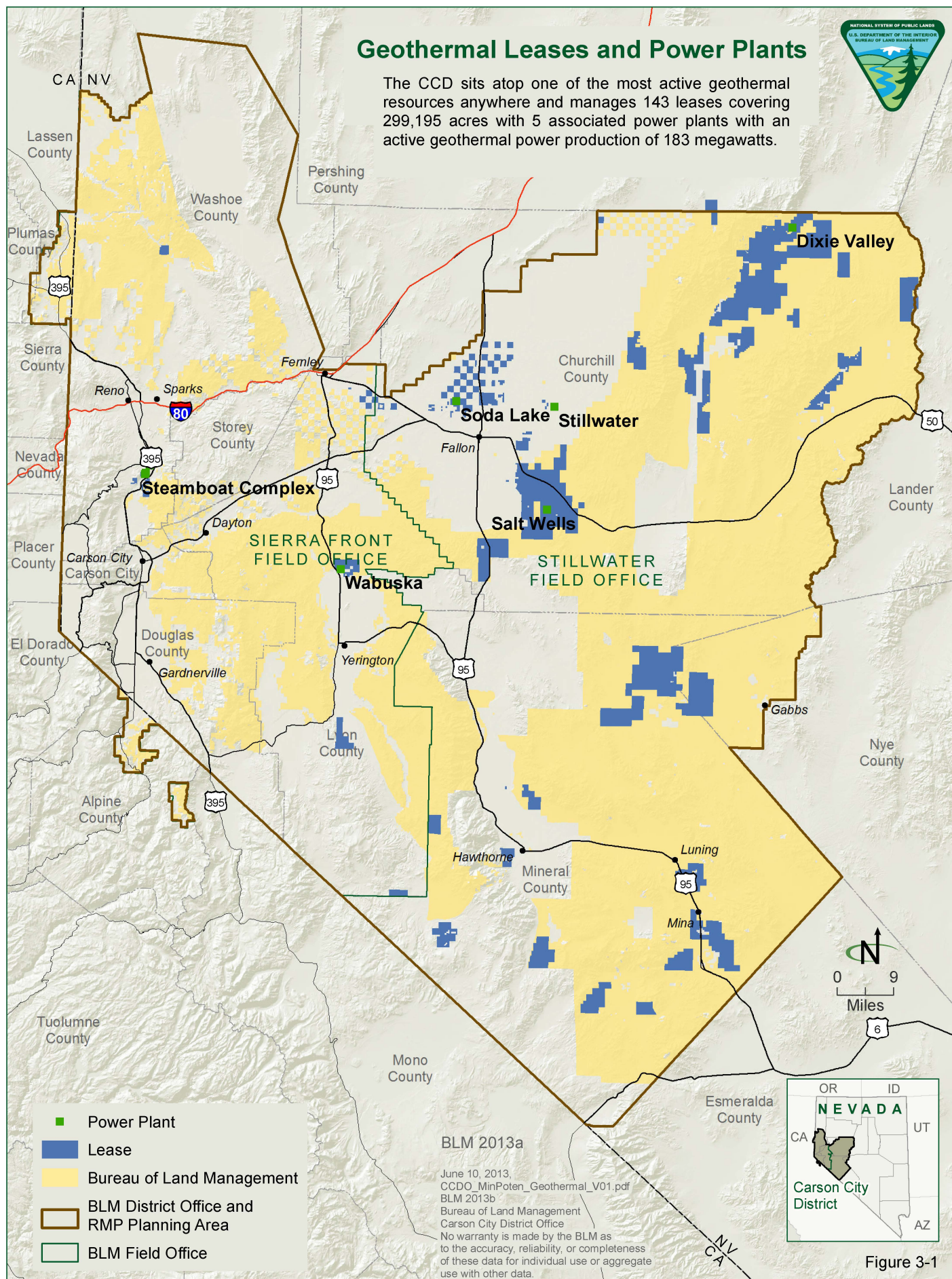


Table 3-2
Geothermal Power Plants in the CCD

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

1

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

2

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

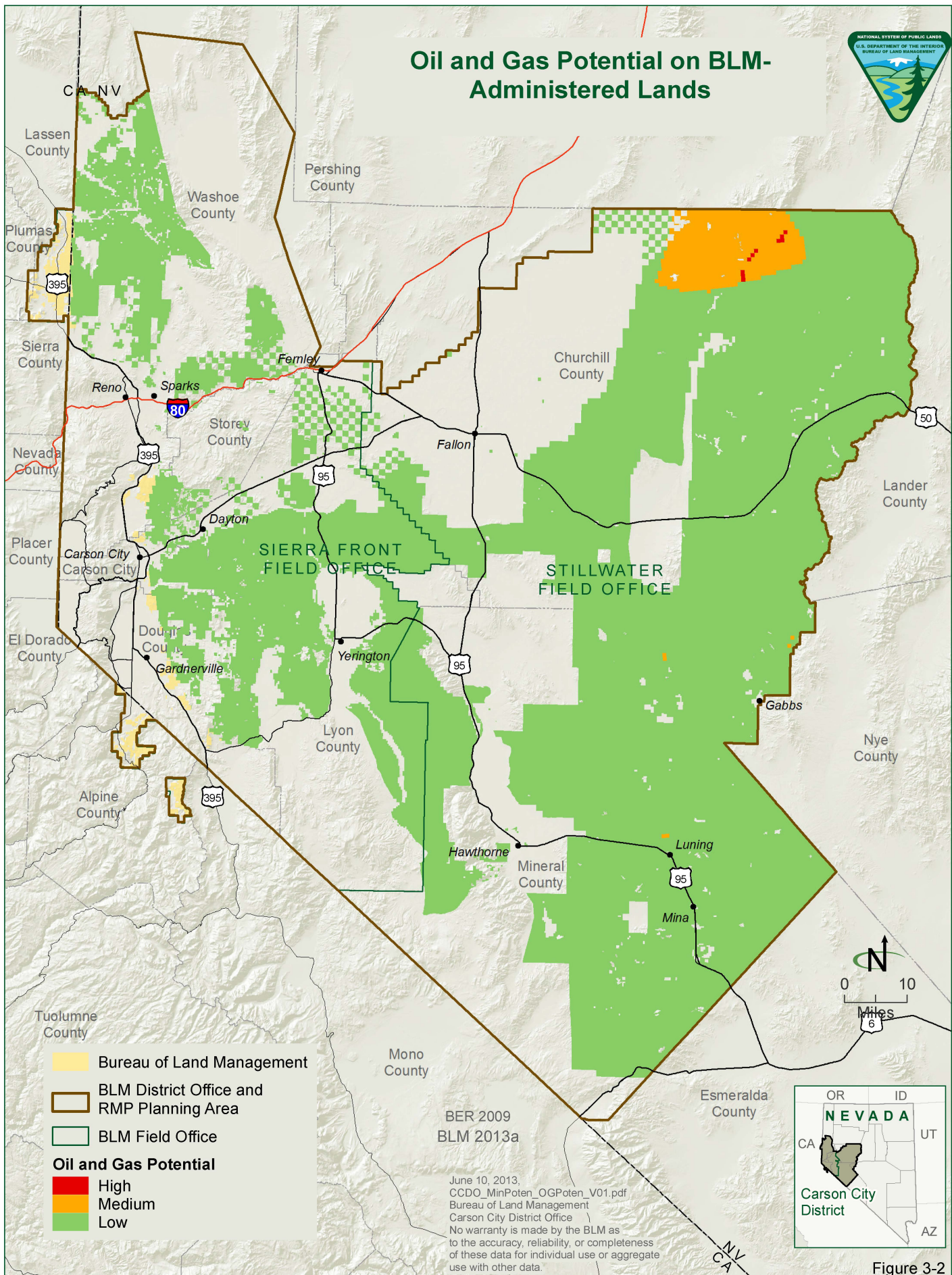


Figure 3-2

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.

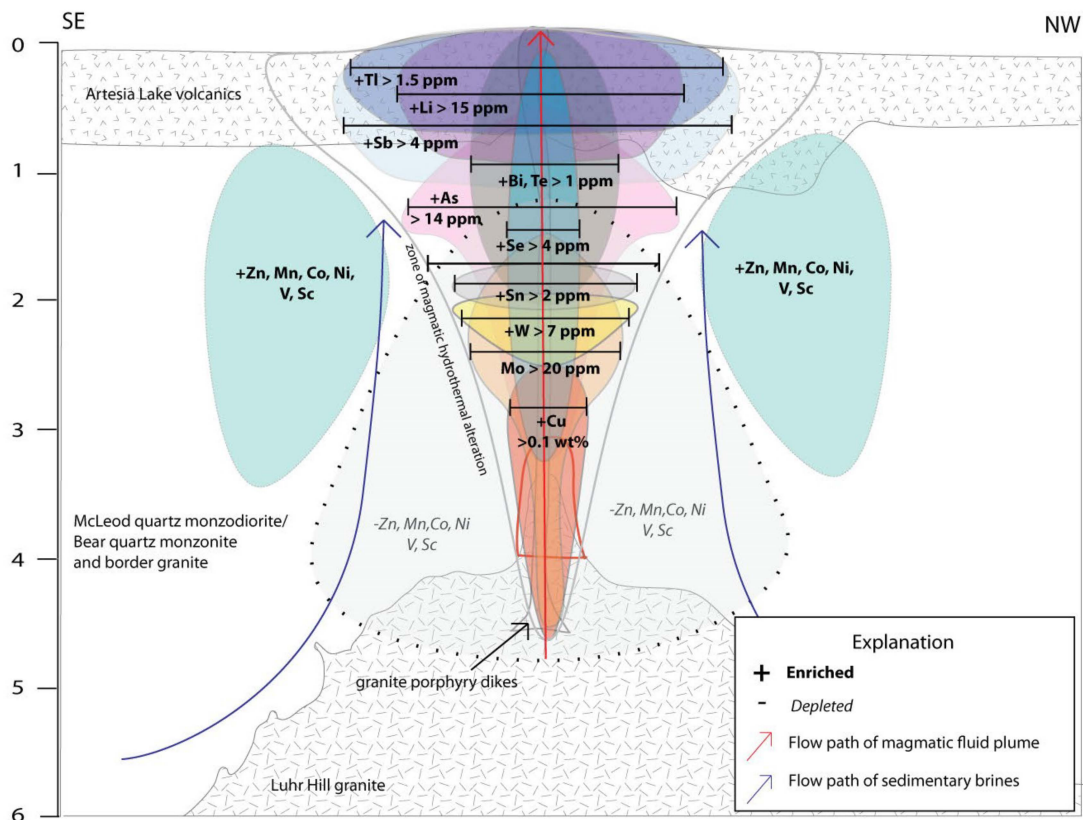


Figure 3.16. Summary figure showing distribution of trace elements as measured in rock chemistry on a cartoon cross-section through the Ann-Mason porphyry copper deposit. Colored shapes represent the spatial extent of trace element anomalies (Table 3.2). The red arrow indicates the path of the magmatic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

1 of the Wassuk Range along both sides of the Lyon-Mineral county line. The
2 district is known for several highly productive copper deposits; these are the
3 Ludwig, Anna Mason, MacArthur, Lyon, Bear, Lagomarsino, Walker River, and
4 Pumpkin Hollow Deposits, as well as the Bluestone, Mason Valley, Douglas, and
5 Yerington Mines (Tingley 1990, 1998).

6 Copper was first mined in 1865 when bluestone (a copper sulfate) was mined
7 from oxidized outcrops of the Ludwig copper deposit for reduction works on
8 the Comstock Lode. Mining for copper metal began in 1883, with production
9 from the Douglas District totaling \$272,000 between 1883 and 1891. The
10 Yerington Mine, operated by Anaconda Corporation, produced 89 million tons
11 of copper in 25 years of production between 1950 and 1978, when depressed
12 world copper prices brought the mine to a close. Exploration continued in the
13 area in the 1970s, particularly in Pumpkin Hollow, east of Yerington, where
14 several deposits of copper-iron skarn mineralization have been noted (Tingley
15 1990).

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

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

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

39 The highest grade copper ore is associated with potassic alteration at
40 approximately a two- to four-kilometer paleodepth within the Jurassic intrusive
41 complex (Einaudi 1994). The copper is most abundant in low-sulfur quartz-
42 sulfide veinlets. At greater depths within the sequence, sodic-calcic alteration

1 was superimposed on the earlier potassic assemblage during the evolution of
2 the depositional sequence.

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

13 The primary ore mineral of these deposits is chalcopyrite associated with pyrite.
14 Secondary ore minerals include chalcantite, brochantite, azurite, chrysocolla,
15 chalcocite, copper pitch (melanconite), and some native copper (Tingley 1990,
16 1998). The skarn is typically composed of variable amounts of pyroxene, garnet,
17 and epidote, with quartz and calcite.

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

21 **Gold and Silver**

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

27 The planning area contains well-known historical gold and silver mining districts,
28 including the Comstock District in Storey County, Jessup in Churchill County,
29 Talapoosa in Lyon County, and Borealis and Santa Fe in Mineral County (Tingley
30 1998). Most of the historical gold production in the CCD is from lode deposits,
31 and most of the most easily accessible lode deposits have probably been
32 identified and extracted.

33 Lode deposits, in which metals are precipitated from hydrothermal fluids that
34 have invaded fractured rocks associated with plutonic intrusive bodies, are an
35 important type of mineral occurrence. However, they represent just one end of
36 a continuum of types of metallic mineral deposits associated with Tertiary
37 magmatism in the CCD. Most of the lode deposits were discovered and
38 exploited from the 1850s to the early 1900s and accounted for almost all the
39 precious metal production during that period. Far larger quantities of these
40 metals are present in finer and more distributed deposits or in deposits that are
41 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	10,11,13,14,15,16,2 3,24	14.22
NVN 085212	QUATERRA ALASKA INC	11/20/2009	MACARTHUR PIT	14N 14N	24E 25E	24,25,26 19,30	43.34

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

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

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

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

16 As of 2011, the Denton-Rawhide Mine in Mineral County (now formally the
17 Buckskin Mine) is the only gold and silver mine operating in the planning area
18 (Driesner and Coyner 2011). This mine is in its final phases of production and
19 has been a residual leach-pad operation since 2004 (Pacific Rim Mining Corp.
20 2010). In 2010, the mine reportedly produced 20,159 ounces of gold and
21 342,382 ounces of silver (Driesner and Coyner 2011).

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

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

35 Long before plate tectonics offered an explanation of what they observed,
36 geologists identified numerous spatial trends in the occurrences of various
37 mineral assemblages, especially those that included gold and silver as a significant
38 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 8N 9N 9N	34E 35E 34E 35E	1, 3 & 24 6 36 31	400
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 4N	35E 35E	3,4 25,26,27,32,33,34,35	600
NVN 069458	BARRICK MINING CO.	3/10/1992	CALVADA FLAT	8N 9N	35E 35E	4,5 28,32,33	260
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 19N	24E 24E	2,3,10,11 34	120
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 21N	40E 40E	6 31	9.32
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-Tonopah 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.

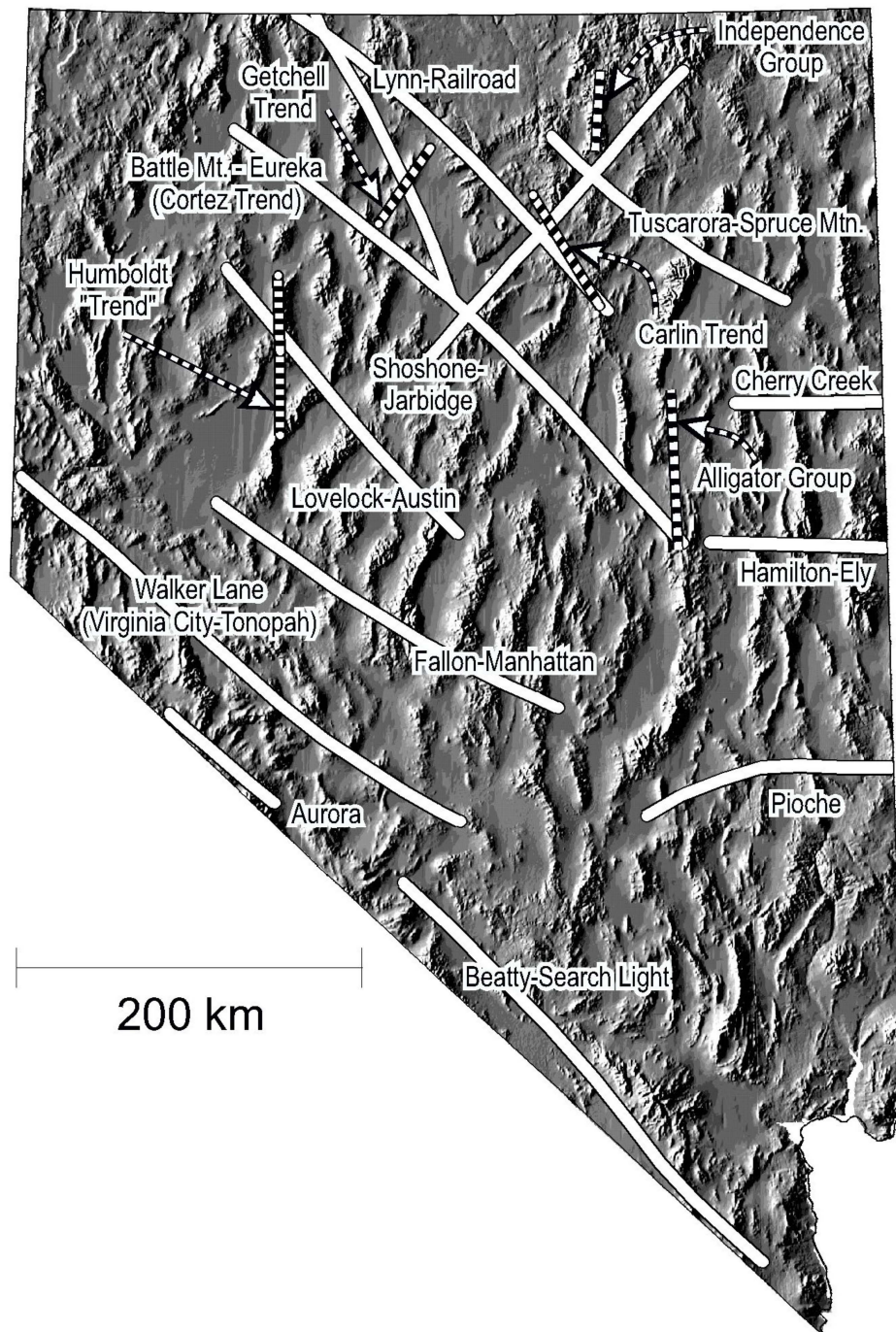
The Aurora Belt is marked by hot spring and Comstock-vein deposits that contain gold and silver. It extends southeast from the Borealis and Aurora Districts along the California-Nevada border. The Virginia City-Tonopah Belt (which is sometimes equated with the Walker Lane) is 350 kilometers long and 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,

1 east of Yerington, explored by US Steel. The reserves in the Wassuk Range
2 have been estimated at between one-half to one billion tons, averaging 40
3 percent or more iron (USGS and NBM 1964). The ore was reportedly
4 associated with high-grade sulfide copper.

5 **Lead**

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

10 Lead is widely present throughout the CCD and is present in at least 52
11 historical mining districts. However, lead and zinc appear to be more abundant
12 in the sedimentary rock-hosted deposits on the east side of Nevada than in the
13 volcanic rock-hosted deposits on the west; here antimony, iron, and mercury
14 are more abundant (USGS and NBM 1964). Production of over one million
15 pounds is noted from six districts in Mineral County and southern Churchill
16 County and of up to one million pounds in many other districts (Horton et al.
17 1962a). Lead was widely used in the past in paint and gasoline, but its uses have
18 been greatly curtailed due to toxicity concerns. Among the most important
19 current uses is in batteries.

20 **Magnesium Compounds**

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

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

35 **Manganese**

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

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

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

12 **Mercury**

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

17 Mercury has a number of unique and useful properties, and because it has no
18 ready substitutes, it has generally been considered a strategic mineral during
19 times of national emergency. Historically, mercury was used to concentrate gold
20 from ore, and most of the early interest in mercury prospecting in Nevada is
21 probably associated with this use. Commercial demand for mercury in the mid-
22 1960s triggered a resurgence in mining. However, most mercury production in
23 the US is from the central Coastal Ranges of California (USGS 1966).

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

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

40 Cinnabar was also discovered in the historical Castle Peak District (Storey
41 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 disulfide) 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-foot 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 Candelaria, 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

1 contain rare earths. Recent interest in rare earths has centered on lithium,
2 based on demand for its use in batteries.

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

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

12 In one of the few active mining operations in the US, lithium is currently
13 produced from subsurface brines pumped to the surface and evaporated on the
14 Clayton Valley playa, near the Silver Peak District in Esmeralda County (NMBG
15 2011). This method was pioneered there but is now used elsewhere, including
16 in Chile, which accounts for a significant amount of world production.

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

28 ***Titanium***

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

35 The principal titanium ore minerals are rutile and ilmenite, which are found in
36 lode deposits and secondary deposits in sedimentary rocks. Most commercial
37 titanium lode deposits consist of ilmenite associated with magnetite or hematite,
38 found in intrusive rocks or adjacent metamorphic rocks. Scattered titanium-
39 bearing pegmatites are found near Hungry Valley, west of the Virginia Range in
40 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

1 recorded production of uranium minerals. Mining districts that have recorded
2 ore descriptions and exploration are the State Line area, Freds Mountain area,
3 the Washington District, and the Marietta District. Districts that have recorded
4 production are the Pyramid District and the Stateline Peak area (Tingley 1990,
5 1998).

6 Uranium mineralization was discovered in the historical Pyramid District in
7 1954, resulting in large numbers of claims being staked. Only small-scale
8 production of uranium occurred; production was intermittent between 1956
9 and 1969. Uranium mineralization occurs principally in ash-flow tuffs, but also in
10 high-angle, generally northeast-trending fault zones, which are commonly
11 localized along diabase dikes intrusive to the Hartford Hill Rhyolite. Uranium
12 minerals of this deposit include autunite, sabugalite, uranospinite,
13 phosphuranylite, and uraniferous opal, chalcedony, and hematite (Tingley 1990).

14 Uranium mineralization in the Stateline Peak area was discovered in 1954 on the
15 west flank of the Peterson Mountain, located in the California portion of the
16 CCD. The area was extensively prospected for uranium, and in 1955 and 1956
17 400 tons of uranium ore with grades exceeding 0.2 percent uranium were
18 produced. Production was concentrated at the Buckhorn Claims in California.
19 After 1957, uranium production ceased, and activity focused on assessment
20 work and minor exploration. The uranium mineralization occurred in two
21 principal zones within rhyolite tuffs of the Tertiary Hartford Hill Rhyolite, and
22 the uranium minerals included gummite, autunite, and uranophane (Tingley
23 1990).

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

27 **Vanadium** is noted in the Chalk Mountain District, but ore deposits, time of
28 discovery, and production amounts are not recorded or further noted (Tingley
29 1998, 1990). Most of the vanadium produced in the US is from deposits in
30 uranium-bearing sandstone in the Four Corners area. Vanadium occurrence, but
31 no production, is noted in one prospect in eastern Alpine County. Most
32 production in California is in the Mojave Desert province (USGS 1966).

33 **Zinc**

34 Like lead, zinc is frequently found in association with gold, silver, and especially
35 copper and is extracted mainly as a byproduct of these other mining operations.
36 The principal ore mineral is sphalerite (zinc sulfide), which is typically found in
37 hydrothermal ore bodies. Zinc is noted in 14 of the historical mining districts in
38 the CCD, with production of up to one million pounds reported in five districts
39 in Mineral and Storey Counties (Horton et al. 1962b). Most of the zinc
40 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 20N	25E 25E	3,4 32,33	45
NVN 086260	NV CEMENT CO	3/1/2011	NV CEMENT CO	20N	24E	28	25.9

1

Table 3-8
Diatomite Mines in the Planning Area

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

Source: Driesner and Coyner 2011

2

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

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

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

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

23 **Fluorspar**

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

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

Pyrophyllite

Pyrophyllite is an aluminum silicate present in the historical Buckskin District. Pyrophyllite is often present in hydrothermal veins or in bedded deposits in schistose rocks and can be a variety of colors (Mindat.org 2013). Ore bodies where pyrophyllite 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 Candelaria 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.

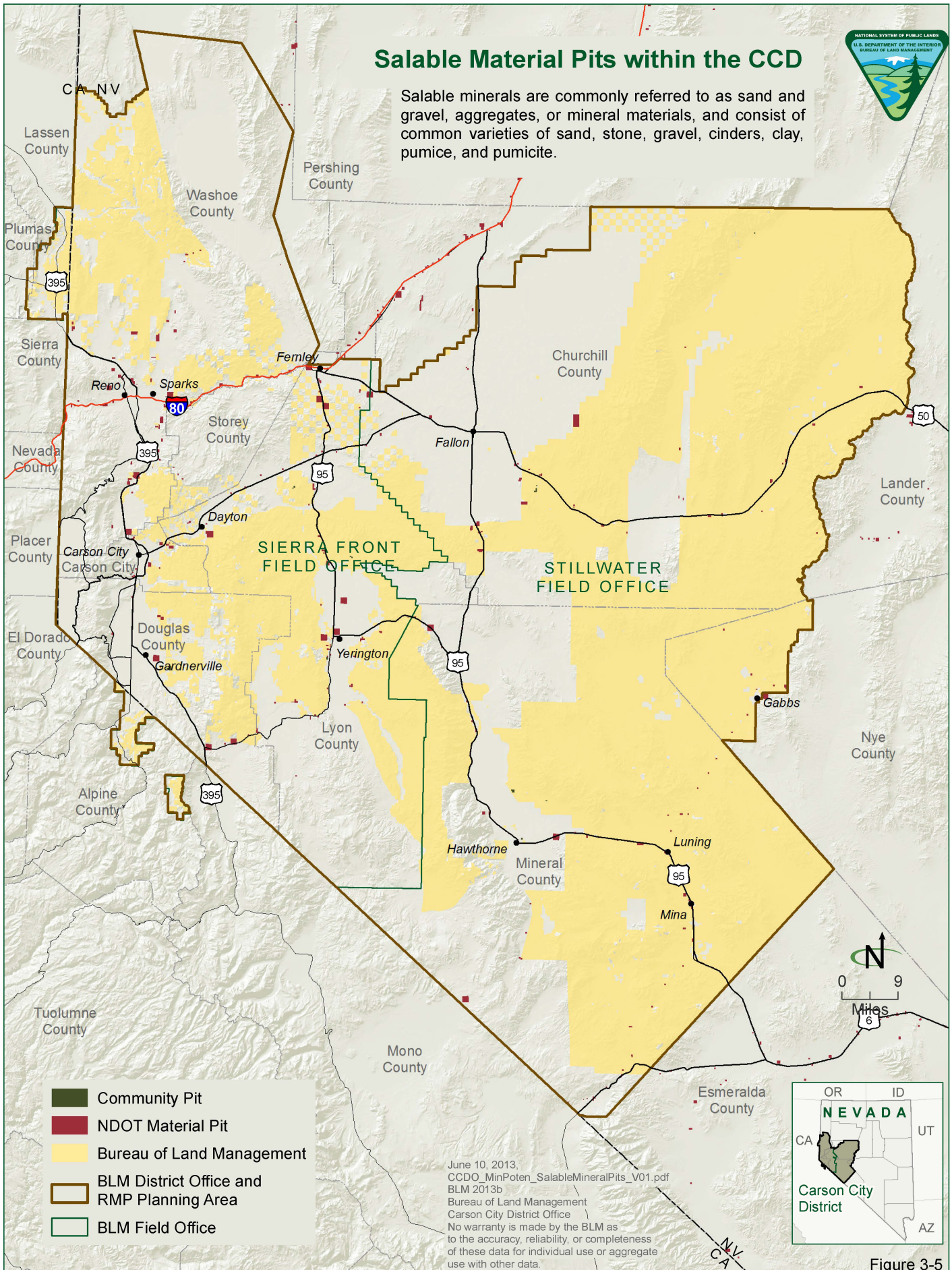


Figure 3-5

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	28E	24	24.5
NVN 075839	NOBLE PERLITE	4/2/2002	NOBLE PERLITE	16N	29E	19	
				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	30E	24,25	65.5
				18N	31E	18,19	

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

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

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

5 The Defense Logistics Agency is responsible for stewardship of 28 strategic
6 materials commodities that are stockpiled at various locations (USGS 2013).
7 Among the mineral materials managed by the agency are chromium, the rare
8 earths germanium, lithium, niobium, and tantalum, silica (crystalline quartz), and
9 tin. No deposits containing significant quantities of these materials have been
10 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

- 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.

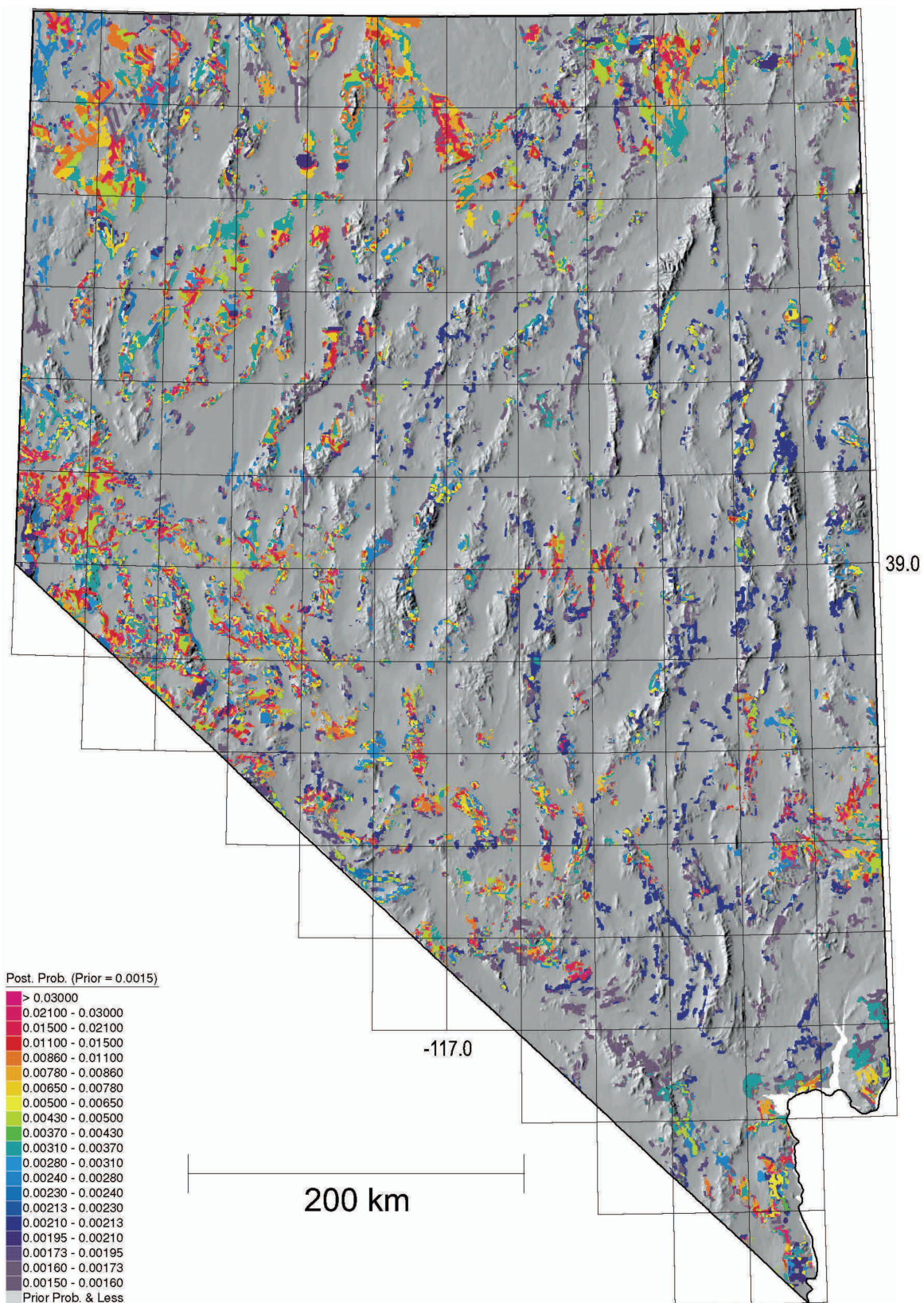
The modeling results showing predicted posterior probabilities of favorable areas for volcanic and sediment rock-hosted gold and silver are presented on **Figure 4-2**, Volcanic Hosted Gold and Silver Deposits, and **Figure 4-3**, Sedimentary Rock Hosted Gold and Silver Deposits. Favorable areas are 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

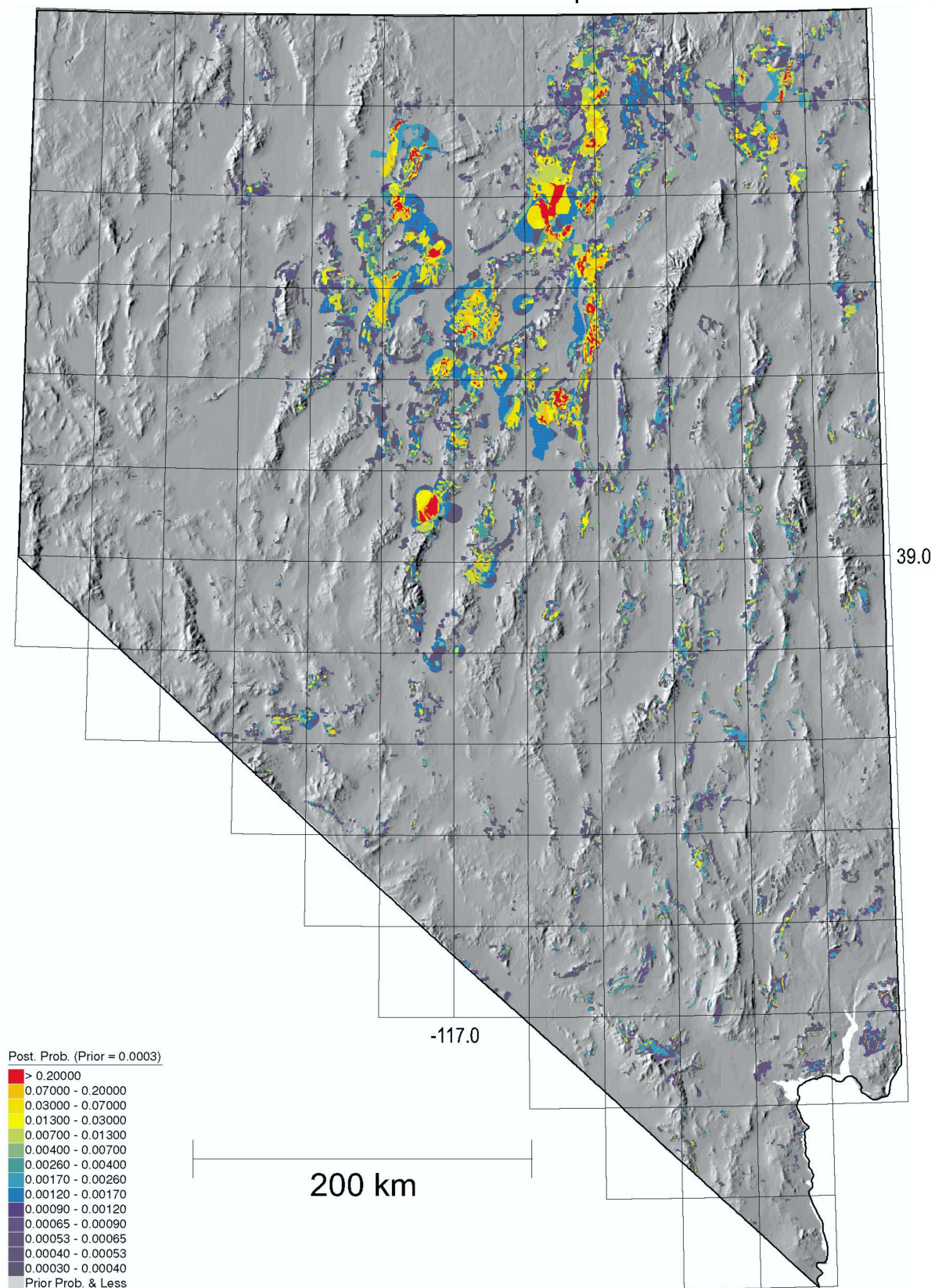
Areas of Volcanic Rock Hosted Gold and Silver Deposits



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



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 (Filippelli 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 [$^{\circ}\text{C}$], or 98.6 Fahrenheit [$^{\circ}\text{F}$]) and hot heat-flow wells ($>100^{\circ}\text{C}/\text{km}$ or 212°F); Edwards Creek Valley has hot wells only. In addition, these areas have warm wells ($20\text{-}37^{\circ}\text{C}$, $68\text{-}98.6^{\circ}\text{F}$) and warm heat-flow wells ($20\text{-}100^{\circ}\text{C}/\text{km}$, $68\text{-}212^{\circ}\text{F}$; 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 1/10th 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 (Tingley 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

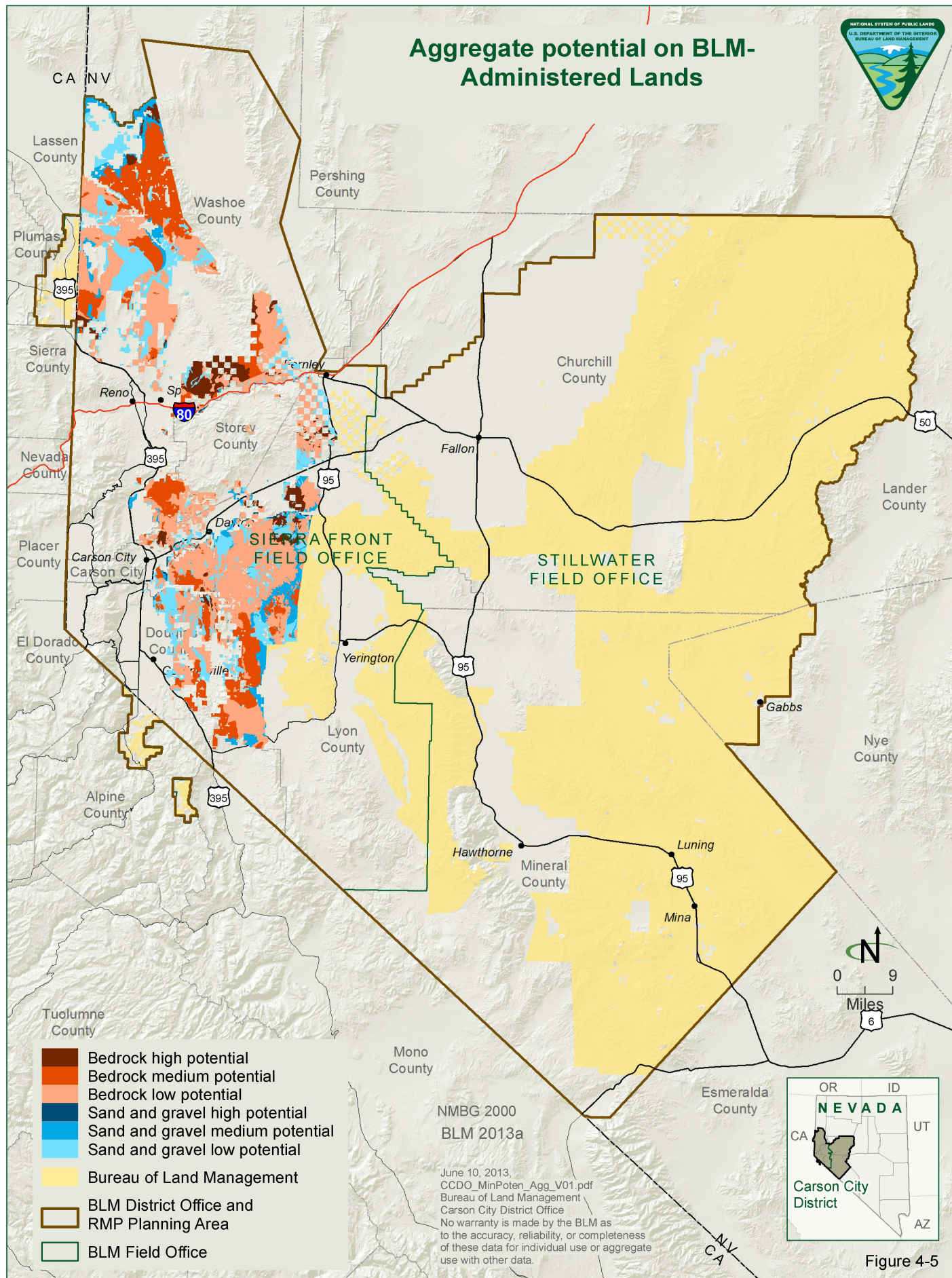


Figure 4-5

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		District	Remarks
		Potential	Certainty		
				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 volcanics
	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 alteration 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

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2

BLM MANUAL #303 I

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

1 activities exceed the casual use threshold, they may be categorically excluded
2 from National Environmental Policy Act (NEPA), or require additional analysis
3 under NEPA.

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

17 Upon completion of exploration activities focused on temperature gradient
18 wells, and the confirmation of a sufficient temperature anomaly, one or more
19 exploration wells could be drilled in order to test the prospect. These drill
20 holes may be several hundred to several thousand feet deep, and are typically
21 2,000 to 4,000 feet deep. A Geothermal Drilling Permit (GDP) must be
22 approved for each well drilled. Each well pad with associated facilities would
23 disturb an area of about 350 feet by 350 feet, or approximately 3 acres. In many
24 cases a new road could be constructed into the site, creating additional
25 disturbance. One or more GDPs will typically be analyzed in an EA.

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

37 Development of production capabilities could include the construction of a
38 geothermal electric generating plant, direct use facilities (such as green houses
39 or dehydration plants), or a combination of the two. Other facilities that would
40 be constructed include pipelines, at least one electric transmission line, and
41 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.

1 Until actual geothermal exploration and development begin, it is difficult to
2 quantify the resource potential and possible future intensified production
3 measures necessary to develop the resources.

4 **OIL AND GAS (REASONABLE FORESEEABLE DEVELOPMENT)**

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

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

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