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# **Assessment of the Mineral Potential of Public Lands Located within Proposed Solar Energy Zones in Colorado**

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July 2012





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## NOTATION

The following is a list of acronyms, abbreviations, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

### GENERAL ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
CBO	Congressional Budget Office
CDMG	Colorado Division of Minerals and Geology
CDRMS	Colorado Division of Reclamation, Mining and Safety
CDWR	Colorado Division of Water Resources
CGS	Colorado Geological Survey
DOI	U.S. Department of the Interior
FLPMA	Federal Land Policy and Management Act of 1976
FR	<i>Federal Register</i>
GIS	geographic information system
GWCSWG	GeoPowering the West Colorado State Working Group
IBLA	Interior Board of Land Appeals
INEEL	Idaho National Engineering and Environmental Laboratory
LR2000	Land and Mineral Legacy Rehost 2000 System
MRDS	Mineral Resources Data System
NWR	National Wildlife Refuge
PEIS	programmatic environmental impact statement
P.L.	Public Law
P.M.	Principal Meridian
RMP	Resource Management Plan
ROW	right-of-way
SEZ	solar energy zone
U.S.	United States
USC	<i>United States Code</i>
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

## UNITS OF MEASURE

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
ft	foot (feet)
km	kilometer(s)
km <sup>2</sup>	square kilometer(s)
kV	kilovolt(s)
m	meter(s)
mi	mile(s)

**ASSESSMENT OF THE MINERAL POTENTIAL OF PUBLIC LANDS  
LOCATED WITHIN PROPOSED SOLAR ENERGY ZONES  
IN COLORADO**

**LANDS INVOLVED**

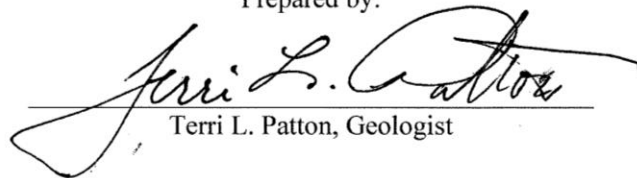
Antonito Southeast Solar Energy Zone  
Covering 9,729 acres of public land in Conejos County, Colorado  
T32N, R9E, sections 3, 4, 9 to 15, and 21 to 24  
T32N, R10E, sections 7 to 9, and 17 to 21  
New Mexico P.M.

De Tilla Gulch Solar Energy Zone  
Covering 1,064 acres of public land in Saguache County, Colorado  
T45N, R9E, sections 29 to 33  
New Mexico P.M.

Fourmile East Solar Energy Zone  
Covering 2,883 acres of public land in Alamosa County, Colorado  
T37N, R12E, sections 2 and 3  
T38N, R12E, sections 13, and 23 to 26, and 35  
New Mexico P.M.

Los Mogotes East Solar Energy Zone  
Covering 2,650 acres of public land in Conejos County, Colorado  
T34N, R8E, sections 1, 12, 13, 24, and 25  
New Mexico P.M.

Prepared by:

  
Terri L. Patton, Geologist

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## ASSESSMENT OF THE MINERAL POTENTIAL OF PUBLIC LANDS LOCATED WITHIN PROPOSED SOLAR ENERGY ZONES IN COLORADO

### SUMMARY

The report that follows presents an assessment of mineral resource potential of public lands located within four solar energy zones (SEZs) in south-central Colorado on behalf of the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM). The assessment was conducted in consultation with three BLM mineral specialists: Mr. Matt Shumaker, Chief Mineral Examiner (Division of Solid Minerals); Mr. Jason Powell, Geologist (Division of Solid Minerals); and Mr. John Morrone, Geologist (Colorado State Office). Mr. Jeff Holdren, Senior Realty Specialist (Division of Lands, Realty, and Cadastral Survey) prepared the legal descriptions for each of the SEZs.

The subject lands are located within four SEZs in the San Luis Valley, Colorado: Antonito Southeast (Conejos County), De Tilla Gulch (Saguache County), Fourmile East (Alamosa County), and Los Mogotes East (Conejos County). The mineral resource potential for each of these sites is summarized below.

#### S.1 ANTONITO SOUTHEAST SEZ

There are no documented occurrences of locatable mineral deposits within the Antonito Southeast SEZ. Most of the locatable minerals in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above a 300-ft (90-m) thick basalt unit at the northern edge of the Taos Plateau (within San Luis Basin), which is underlain by basin-fill sediments more than 1,000-ft (305-m) thick (based on boring logs). Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).<sup>1</sup>

The Antonito Southeast SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit, and alluvium above this unit is no more than 4 ft (1.2 m) thick (based on well logs). The site is a high-potential area for volcanic

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<sup>1</sup> Definitions of mineral potential are from the mineral potential classification system outlined in *BLM Manual 3031* (BLM 1985). Mineral potential ratings of low, moderate, or high are assigned where the geologic environment and inferred geologic processes indicate low, moderate, or high potential for accumulation of mineral resources. Levels of certainty are defined as follows: A = available data are *insufficient* to support or refute the occurrence of mineral resources; B = available data provide *indirect* evidence to support or refute the occurrence of mineral resources; C = available data provide *direct but quantitatively minimal* evidence to support or refute the occurrence of mineral resources; and D = available data provide *abundant direct and indirect* evidence to support or refute the occurrence of mineral resources.

material such as crushed stone or scoria (level of certainty D). There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley Resource Management Plan (RMP) describes the San Luis Basin as having a low potential for oil and gas development. The Colorado Geological Survey also rates state land tracts in the vicinity of the Antonito Southeast SEZ as having little or no potential for oil and gas occurrence. There are no active oil and gas leases within the site. A portion of the SEZ along the western boundary was leased at one time, but these leases were closed in 1985 and 1993. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara. There are no active or historical geothermal leases within the Antonito Southeast SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

## **S.2 DE TILLA GULCH SEZ**

There are no documented occurrences of locatable mineral deposits within the De Tilla Gulch SEZ. Most of the locatable mineral deposits in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur as epithermal vein deposits hosted by the Tertiary volcanic rocks associated with the Bonanza caldera (San Juan Volcanic Field). The SEZ sits above the Monte Vista graben (within San Luis Basin), where basin-fill sediments are estimated to be about 10,000-ft (30,400-m) deep. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The De Tilla Gulch SEZ is an area with high potential for sand and gravel (level of certainty D). The site is underlain by alluvial and basin-fill deposits, and past small-scale mining of sand and gravel within and around the site indicates that the future extraction of such resources within the SEZ is viable. There are no active free use permits or mineral materials contracts within the SEZ; however, three free use permits for sand and gravel were located along the northern site boundary. The pits have been intermittently active, but there has been no activity since 1992.

The BLM San Luis Valley RMP describes the basin as having a low potential for oil and gas development (although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca National Wildlife Refuge [NWR], about 10 mi [19 km] to the southeast [east of Highway 17]). There are no active or historical oil and gas leases within the site. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use. There are two hot springs spas

within 5 mi (8 km) of the De Tilla Gulch SEZ (to the northeast): Valley View Hot Springs and Mineral Hot Springs. There are no active or historical geothermal leases within the SEZ and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

### **S.3 FOURMILE EAST SEZ**

There are no documented occurrences of locatable mineral deposits within the Fourmile East SEZ. Most of the locatable mineral deposits in the region come from the Sangre de Cristo Mountains to the northeast. Deposits such as gold and silver occur in quartz veins in Precambrian gneissic tonalite and metadiorite. The SEZ sits above the Baca graben, the deepest part of the Alamosa Basin, where basin-fill sediments are estimated to be up to 19,000-ft (5,800-m) deep. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The Fourmile East SEZ is underlain by alluvial and basin-fill deposits and is, therefore, a high-potential area for sand and gravel deposits (level of certainty C). Past and ongoing small-scale mining of sand and gravel in the region indicates that the future extraction of such resources within the SEZ is viable. There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley RMP describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the Fourmile East SEZ as having little or no potential for oil and gas occurrence (although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 28 mi (45 km) to the north-northwest). There are no active oil or gas leases within the site. Eight oil and gas leases covered most of the site at one time, but these leases were closed in 1980s and 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located 10 mi (16 km) to the west of the Fourmile East SEZ (near Alamosa) and to the northwest (along Highway 17). There are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

### **S.4 LOS MOGOTES EAST SEZ**

There are no documented occurrences of locatable mineral deposits within the Los Mogotes East SEZ. Most of the locatable minerals in the region come from the Platoro-Summitville District, in the San Juan Mountains, to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with

the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above the Tertiary basalts of the Hinsdale Formation (along the eastern front of the San Juan Mountains) near the southwestern margin of the Alamosa Basin. Basin-fill sediments occur below the basalt and just beyond the eastern boundary of the SEZ. The thickness of these sediments below the SEZ is estimated to be about 2,400 ft (730 m). Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The Los Mogotes East SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit at or just below the surface (based on well logs). (Sand and gravel materials are deep beyond the eastern boundary of the site, which roughly coincides with the eastern extent of the basalt flow.) The site is a high-potential area for volcanic material such as crushed stone or scoria (level of certainty C). There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley RMP describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the Los Mogotes East SEZ as having little or no potential for oil and gas occurrence. There are no active oil or gas leases within the site. Six oil and gas leases covered the site at one time, but these leases were closed in the late 1980s and early 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara. There are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).



## 1 INTRODUCTION

### 1.1 PURPOSE OF REPORT

The purpose of this report is to assess the mineral resource potential of 16,326 acres (66.1 km<sup>2</sup>) of public lands within four SEZs in south–central Colorado, which the Secretary of the Interior may decide to withdraw from potentially conflicting uses through the issuance of a Public Land Order. If approved, the public lands within the SEZs would be withdrawn, subject to valid existing rights, from settlement, sale, location, or entry under the general land laws, including the mining laws, as follows:

- New mining claims could not be filed on the withdrawn lands; however, valid mining claims filed prior to the date the lands were segregated (i.e., withdrawal application notice was published in the *Federal Register*) would take precedence over future solar energy development ROW application filings.
- Lands could not be sold, exchanged, or otherwise disposed of during the term of the withdrawal.
- Withdrawn lands would remain open to mineral leasing, geothermal leasing, and mineral material laws; the BLM could elect to lease the oil, gas, coal, or geothermal steam resources or to sell common-variety mineral materials such as sand and gravel, if the authorized officer determined there would be no unacceptable impacts on future solar energy development.
- Withdrawn lands would remain open to right-of-way (ROW) authorizations and land leases or permits authorized under Section 302 of the Federal Land Policy and Management Act of 1976 (FLPMA).

The public lands are currently segregated under BLM’s Interim Temporary Final Rule, which was published on April 26, 2011, and is in effect until June 30, 2013 (Vol. 76, pp. 23198–23205 of the *Federal Register* [76 FR 23198–23205]).

### 1.2 LEGAL DESCRIPTION OF THE SUBJECT LANDS

There are four SEZs in Colorado: Antonito Southeast (Conejos County), De Tilla Gulch (Saguache County), Fourmile East (Alamosa County), and Los Mogotes East (Conejos County). The SEZs are located in the Saguache and La Jara Resource Areas. The locations of the SEZs are shown in Figure 1. Their full legal descriptions are provided in Appendix A.

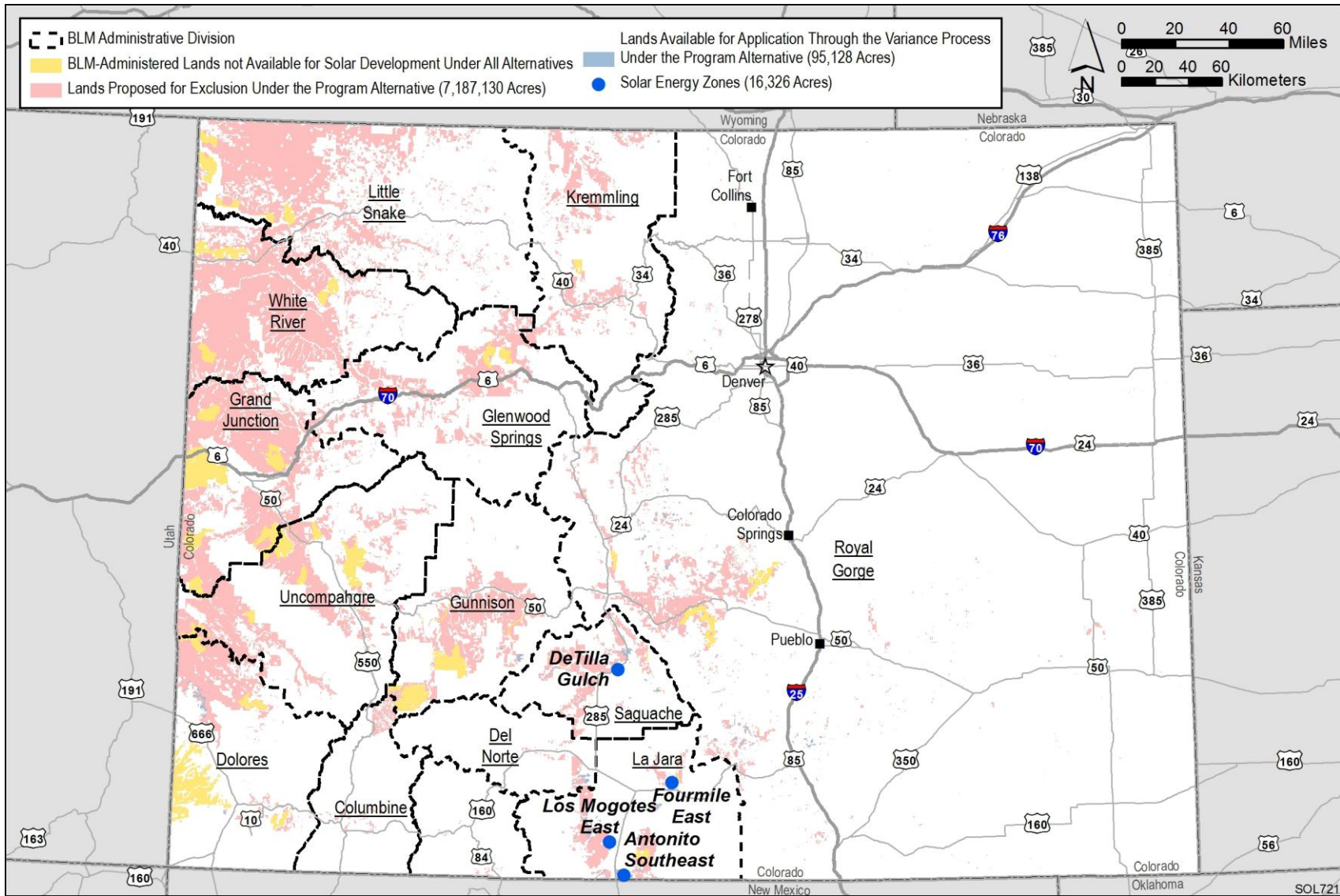


FIGURE 1 BLM-Administered Lands in Colorado Available for Application for Solar Energy Right-of-Way Authorization (SEZs are represented by blue dots)

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### 1.3 METHODOLOGY AND RESOURCES

The assessment presented in this report focuses on locatable (including those classified as strategic and critical), saleable, and leasable mineral resources within four SEZs in Colorado. The conclusions concerning mineral occurrence and development potential (and levels of certainty) follow the methodology outlined in *BLM Manual 3031* (BLM 1985) and are based on a review of topographic maps, geologic maps, mineral resource maps and reports, the scientific literature on the geology and mineral resources of Colorado, and consultation with BLM mineral specialists. No mapping or field sampling was conducted as part of this assessment.

Digital data for the geologic maps in Figures 3, 4, 6, 7, and 8 were obtained from the U.S. Geological Survey (USGS) (Stoeser et al. 2007). The dataset was digitized from previously published geologic maps ranging in scale from 1:100,000 to 1:1,000,000. Detailed map unit descriptions for this map are based on the published state geologic map by Scholle (2003). The data were corroborated by geologic maps prepared by Johnson (1969), Steven et al. (1974), Tweto (1979), and Thompson and Machette (1989). The large-scale, folded maps (Maps 1 through 4) provided in the back of this report show the public land survey system grid (township and range) and should be consulted to locate mines and other features discussed in the text. In addition, the Solar Programmatic Environmental Impact Statement (PEIS) Web site (<http://solareis.anl.gov/sez/index.cfm>) features mapped photographs of the SEZ.

The BLM's Legacy Rehost System (LR2000; BLM 2012) was queried on July 19 and 20, 2012, for information on active and historical (unpatented) mining claims and various leases and permits, including oil and gas leases, geothermal leases and land nominations, free use permits, and mineral materials contracts, issued on public lands within and around the SEZ. Another key BLM resource consulted was the San Luis Resource Area Resource Area RMP (BLM 1991).

Mines and mineral prospects and occurrences and their descriptions are those reported in the USGS Mineral Resource Data System (MRDS; USGS 2011a; Lipin 2000) and supplemented with information provided by Mr. John Morrone, a mineral specialist from the BLM Colorado State Office. The MRDS is a large database containing historical records of the USGS and the U.S. Bureau of Mines (which is now part of the USGS). These records are of variable quality and currency, so it is possible that some information will be found to be out of date (the revision and refinement of the database is an ongoing effort at the USGS). The mining activity map in Figure 5 was prepared from the MRDS and is intended to provide a general picture of the location and nature of mining activity in the vicinity of the SEZ. Refinements with regard to the status of particular mines are included in the text, as warranted, based on conversations with Mr. Morrone.

Geographic information system (GIS) data for mineralized areas in Colorado, based on Wilson (2003), were obtained from the USGS for the mining activity map. Mineralized areas encompass areas with mines, prospects, and/or mineralized occurrences that belong to one deposit type or a group of genetically related deposit types in a distinct geologic setting. They differ from mining districts in that they are based on geology and on the similarity of deposits and related commodities. Mineralized area designations do not include placer districts.

Information on active mining permits in Conejos, Saguache, and Alamosa Counties was obtained from the Colorado Division of Minerals and Geology (CDMG) and the Colorado Division of Reclamation, Mining and Safety (CDRMS). Coal and oil/gas statistics were obtained from reports prepared by the CGS. Also consulted were CGS open-file reports on the mineral and mineral fuel potential of state mineral lands within Conejos, Saguache, and Alamosa Counties (Keller and Wray 2001; Keller and Hemborg 2000). Well logs for wells drilled near the SEZs were obtained from the Colorado Division of Water Resources Web site (<http://www.dwr.state.co.us/WellPermitSearch/default.aspx>). There were no oil and gas well logs for Alamosa, Conejos, or Saguache Counties available on the Colorado Oil and Gas Information System Web site (maintained by the Colorado Oil and Gas Conservation Commission).

#### 1.4 LOCATABLE MINERALS

Under United States (U.S.) mining laws, minerals fall into three categories: locatable, leasable, and saleable. Because these categories were created by acts of Congress, they do not fall into simple economic or mineralogical divisions. Creating an exact and thorough list of locatable minerals (e.g., those subject to appropriation by locating mining claims) is therefore difficult. Metallic minerals (e.g., gold, silver, copper, mercury, aluminum, antimony, lithium, molybdenum, tungsten, uranium, vanadium, and rare earths) are considered to be locatable. Numerous uncommon varieties of nonmetallic minerals may also be locatable, depending on their chemical content, quality, uses, and characteristics, as well as associated economic and legal matters. These nonmetallic minerals could include barite, calcite, specialty clays, bentonite, diatomite, feldspar, some gemstones (e.g., opals and diamonds), gypsum, chemical-grade limestone, perlite, chemical-grade silica sand, specific types of stone, talc, zeolites, and specific and uncommon types of dolomite. The determination of the actual locatability of uncommon varieties of nonmetallic minerals and the validity of mining claims for them is complex and relies on Public Law (P.L.) 84-167 (*United States Code*, Title 30, Section 601 et seq. [30 USC 601 et seq.]) and applicable case law (e.g., *U.S. vs. Kenneth McClarty*, 17 Interior Board of Land Appeals [IBLA] 20, 1974 [81 Interior Department (I.D.) 472]) (Shumaker 2011).

In 2008, nonfuel raw mineral production in Colorado was valued at \$2.04 billion; there was no significant change in the state's nonfuel mineral production between 2008 and 2007, when production was up by 21.4% over that in 2006. The top nonfuel minerals were, by value of production, molybdenum ore and concentrates, construction sand and gravel, gold, portland cement, and crushed stone, which accounted for almost 99% of the state's total nonfuel mineral production value in 2008. The largest increases in production value in 2008 were in portland cement (which increased in production by 2.9% and production value by 4.3%). Although molybdenum production and gold production were down (by 4.5 and 11%, respectively), their production value increases offset these declines. Construction sand and gravel production was down by 21%. Most of the new claims filed in 2007 were for uranium resources, but they also included copper, gold, molybdenum, and silver. Uranium and vanadium exploration was strong in early 2008, but most projects ended by October with the economic recession. Colorado was first in the production of molybdenum and fourth in the production of gold among producing states in 2007 and 2008 (USGS 2010, 2011b).

## 1.5 STRATEGIC AND CRITICAL MINERALS

Table 1 lists the nonfuel strategic and critical nonfuel minerals that are imported by the United States for its National Defense Stockpile, as authorized by the Strategic and Critical Materials Stock Piling Act (50 USC 98 et seq.). Several of the minerals produced in Colorado are classified as strategic and critical minerals; these include antimony, bismuth, copper, tungsten, vanadium, and zinc.

**TABLE 1 Strategic and Critical Nonfuel Minerals**

Antimony	Copper	Platinum group
Asbestos	Diamonds (industrial)	Quartz crystals
Bauxite and alumina	Fluorspar	Rutile (titanium)
Beryllium	Graphite	Silicon
Bismuth	Iodine	Tantalum
Cadmium	Manganese	Thorium
Chromium	Mercury	Tin
Cobalt	Mica sheet	Tungsten
Columbian	Nickel	Vanadium
		Zinc

Source: CBO (1983).

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## 2 ANTONITO SOUTHEAST SEZ

### 2.1 SUMMARY AND CONCLUSIONS

This chapter assesses the mineral resource potential of 9,729 acres (39.4 km<sup>2</sup>) of public lands within an area known as the Antonito Southeast SEZ, located in Conejos County near the southern Colorado state boundary with New Mexico. The SEZ is about 34 mi (55 km) to the south of Alamosa; several smaller towns lie closer to the SEZ, with Antonito, Colorado, about 2 mi (3 km) to the northwest of the SEZ.

There are no documented occurrences of locatable mineral deposits within the Antonito Southeast SEZ. Most of the locatable minerals in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above a 300-ft (90-m) thick basalt unit at the northern edge of the Taos Plateau (within San Luis Basin), which is underlain by basin-fill sediments more than 1,000-ft (305-m) thick (based on boring logs). Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The Antonito Southeast SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit, and alluvium above this unit is no more than 4 ft (1.2 m) thick (based on well logs). The site is a high-potential area for volcanic material such as crushed stone or scoria (level of certainty D). There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley RMP describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence. There are no active oil and gas leases within the site. A portion of the SEZ along its western boundary was leased at one time, but these leases were closed in 1985 and 1993. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara. There are no active or historical geothermal leases within the Antonito Southeast SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

### 2.2 LANDS INVOLVED

The Antonito Southeast SEZ is located on BLM lands in the San Luis Valley Resource Area (La Jara Field Office), in Conejos County. The site lies within Township 32 north, Range 9

east (T32N, R9E), sections 3, 4, 9 to 15, and 21 to 24; and T32N, R10E, sections 7 to 9, and 17 to 21 (New Mexico Principal Meridian). Within this area, 17 acres (0.07 km<sup>2</sup>) of wetland and lake areas have been designated as non-development areas (BLM and DOE 2011). The SEZ and the non-development areas within it are shown on the location map in the back of this report (Map 1). The full legal description of the SEZ is provided in Appendix A.

## 2.3 LAND STATUS

According to the LR2000, accessed on July 19, 2012, there are no active or historical locatable mining claims within the Antonito Southeast SEZ (BLM 2012). The lands within the SEZ were first segregated from locatable mineral entry in June 2009, pending the outcome of the Draft Solar PEIS (BLM and DOE 2010). They are currently segregated under an Interim Temporary Final Rule, which is in effect until June 30, 2013 (76 FR 23198–23205).

There are no active free use permits or mineral materials contracts within the SEZ (BLM 2012). The site remains open for the disposal of saleable mineral materials.

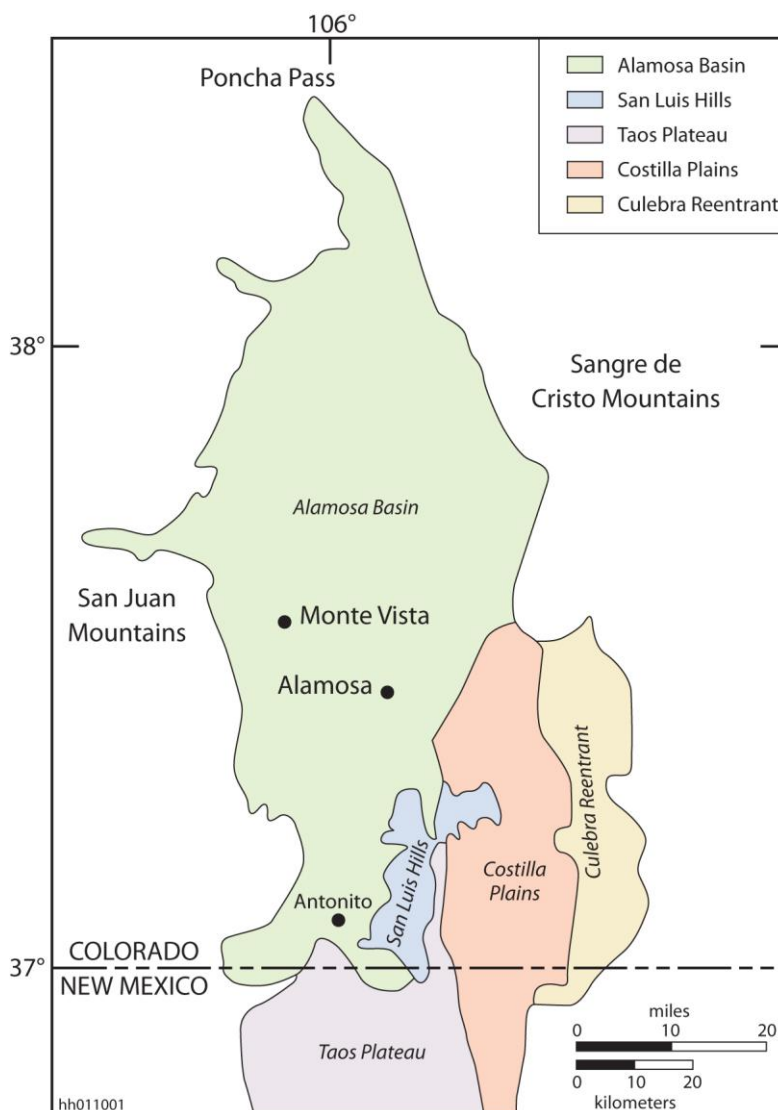
There are no active oil and gas leases within and around the SEZ; however, a portion of the site along its western boundary was leased for oil and gas in the past (three oil and gas leases overlapped the site in sections 4, 9, and 21 of T32N, R9E, but were closed in 1985 and 1993). There are no active or historical geothermal leases within the SEZ. The area remains open for discretionary leasing for oil and gas and other leasable minerals.

## 2.4 GEOLOGIC SETTING

The Antonito Southeast SEZ is located in the southern part of the San Luis Valley, an alluvial basin within the Southern Rocky Mountain physiographic province in south-central Colorado. The San Luis Valley is part of the San Luis Basin, an axial basin of the Rio Grande rift. The Rio Grande rift is a north-trending, tectonic feature that extends from south-central Colorado to northern Mexico. Basins in the rift zone generally follow the course of the Rio Grande and are bounded by normal faults that define the rift zone margins (Burroughs 1974, 1981; Emery 1979).

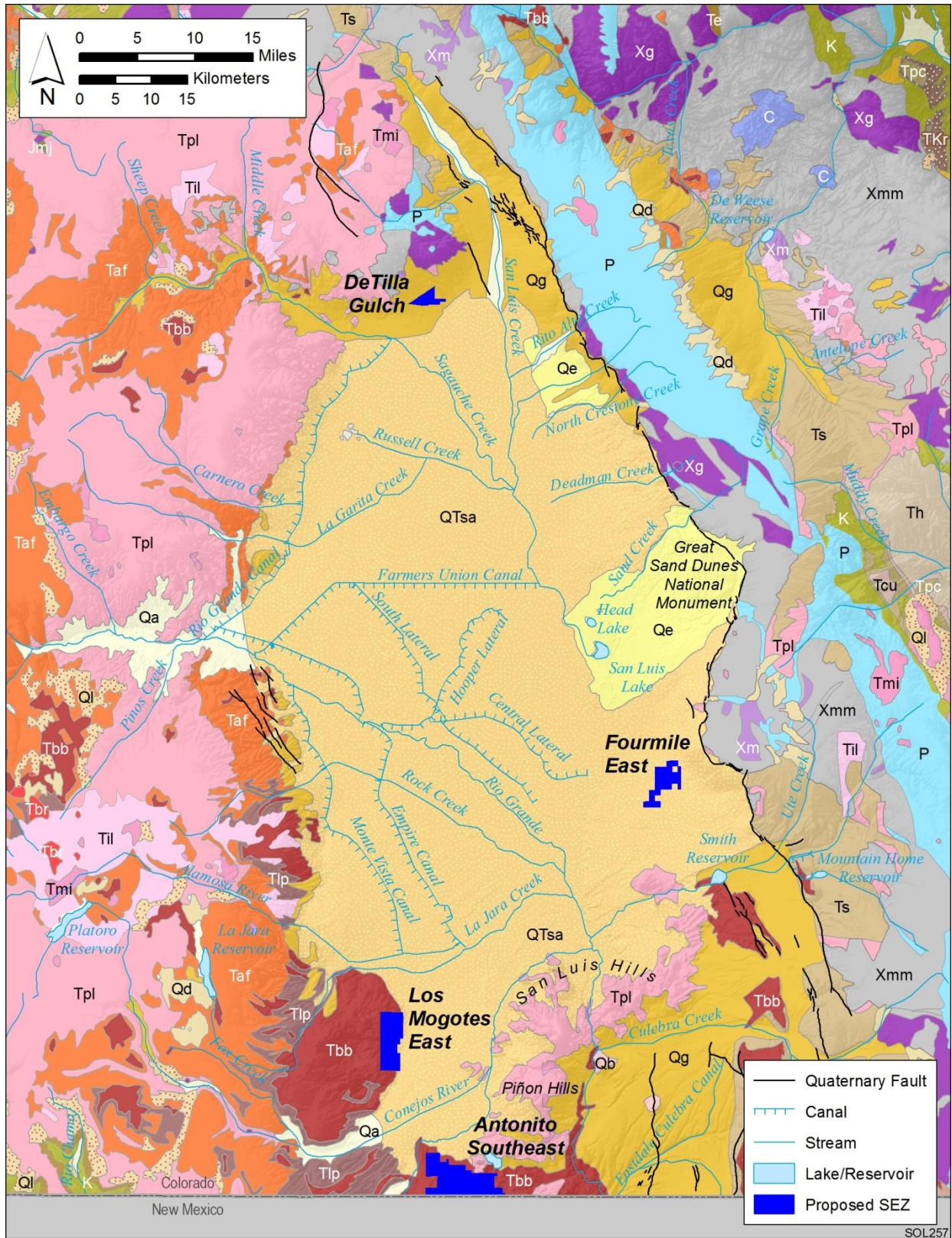
The San Luis Basin is an east-tilting half graben flanked by the San Juan Mountains to the west and the Sangre de Cristo Range to the east. It is generally divided into five physiographic subdivisions—the Alamosa Basin, the San Luis Hills, the Taos Plateau, the Costilla Plains, and the Culebra Reentrant (Figure 2). The Antonito Southeast SEZ sits at the northern edge of the Taos Plateau just south of the San Luis Hills, a series of northeast-trending basalt hills and mesas that form a physiographic, structural, and hydrological divide between the Alamosa Basin to the north and the Taos Plateau to the south. The Taos Plateau is characterized by numerous volcanic shields and cones that were active as recently as 2 million years ago (Burroughs 1974, 1981; Leonard and Watts 1989).





**FIGURE 2 Physiographic Subdivisions with the San Luis Basin (modified from Burroughs 1981)**

Exposed sediments in the San Luis Valley consist mainly of modern alluvial deposits and the fluvio-lacustrine clays and sands of the Quaternary-Tertiary Alamosa Formation (associated with an ancient lake that occupied the valley from the Pliocene to Pleistocene). Eolian deposits, such as those of the Great Sand Dunes National Monument, occur along the base of the Sangre de Cristo Mountains on the eastern side of the valley. The Rio Grande alluvial fan (at the base of the San Juan Mountains where the Rio Grande enters the valley) lies northwest of the town of Alamosa; it is one of the many fans that occur along the valley margins. The San Luis Hills, consisting of northeast-trending flat-topped mesas and irregular hills, are a prominent feature of the southern part of the valley. A good portion of southern San Luis Valley is covered by Tertiary basaltic lava flows of the Hinsdale and Servilleta Formations (Keller and Wray 2011). The geology of the San Luis Valley is shown in Figure 3.



**FIGURE 3** Geologic Map of the San Luis Valley and Vicinity (Sources: Stoesser et al. 2007; Tweto 1979)





FIGURE 3 (Cont.)

## 2.5 PHYSICAL FEATURES AND ACCESS

The Antonito Southeast SEZ is located about 7.5 mi (12 km) to the west of the Rio Grande. Its terrain is relatively flat with a gentle slope to the northeast. The land surface is dissected by intermittent streams that flow to the northeast. Elevations range from about 8,033 ft (2,448 m) near the southwestern corner to less than 7,775 ft (2,370 m) along the northeast-facing boundary. The highest point in the area is 8,229 ft (2,508 m) in the South Piñon Hills just north of the site's northern boundary.

The SEZ lies just to the north of the Colorado–Mexico border on the western side of the San Luis Valley. The overall character of the land within and around the site is rural and undeveloped. The SEZ contains only BLM-administered lands; however, two sections of state-owned land (in section 16 of T32N, R9E and section 16 of T32N, R10E) abut the site on either side. An operating perlite mill is located near the northwest corner of the SEZ. Access to the SEZ is from U.S. 285, which runs along the west side of the site.

## 2.6 SITE GEOLOGY

The geology of the Antonito Southeast SEZ is described based on the 1:500,000 scale geologic map by Tweto (1979) and the 1:250,000 scale geologic map by Johnson (1969) (Figure 4). The thicknesses of geologic units were inferred from a geologic cross section along a transect consisting of five 800-ft (244-m) deep wells drilled immediately to the west (sections 8 and 17 of T32N, R9E) and north (sections 21, 28, and 34 of T33N, R9E) of the SEZ, as described by Harmon (2009). The thicknesses of surface sediments are based on logs of water wells drilled at the site (CDWR 2012a). Descriptions of the Servilleta and Hinsdale Formations are based on Thompson and Machete (1989).

The Servilleta Formation (Pliocene), composed of basalts and interbedded gravels (map unit Tbb), covers most of the Taos Plateau near the Colorado–New Mexico border and is just below the surface (under a thin layer of alluvium) in the vicinity of the Antonito Southeast SEZ (well logs indicate alluvium is no more than about 4 ft [1.2 m] thick). In this area, the formation is about 420-ft (130-m) thick. The Servilleta Formation is composed of a series of thin tholeiitic basalt flows with small olivine phenocrysts, diktytaxitic texture, and local vesicle pipes and segregated veins. The formation is underlain by the intertongued sediments of the Santa Fe Group and Los Pinos Formations. The Santa Fe Group (late Oligocene to Pliocene) consists of buff to pinkish-orange clays with interbedded poorly to moderately sorted silty sands. The Los Pinos Formation (Oligocene to Pliocene) consists of eastward-thickening sandy gravels interbedded with volcanic rocks (tuffs and tuffaceous siltstones and conglomerates). The Los Pinos gravels are thought to represent coalescing alluvial fans that developed along the eastern flank of the San Juan Mountains during an earlier period of uplift and volcanism (Brister and Gries 1994; Burroughs 1981; Leonard and Watts 1989). The thickness of the Santa Fe Group and Los Pinos Formations in the vicinity of the Antonito Southeast SEZ is undetermined.

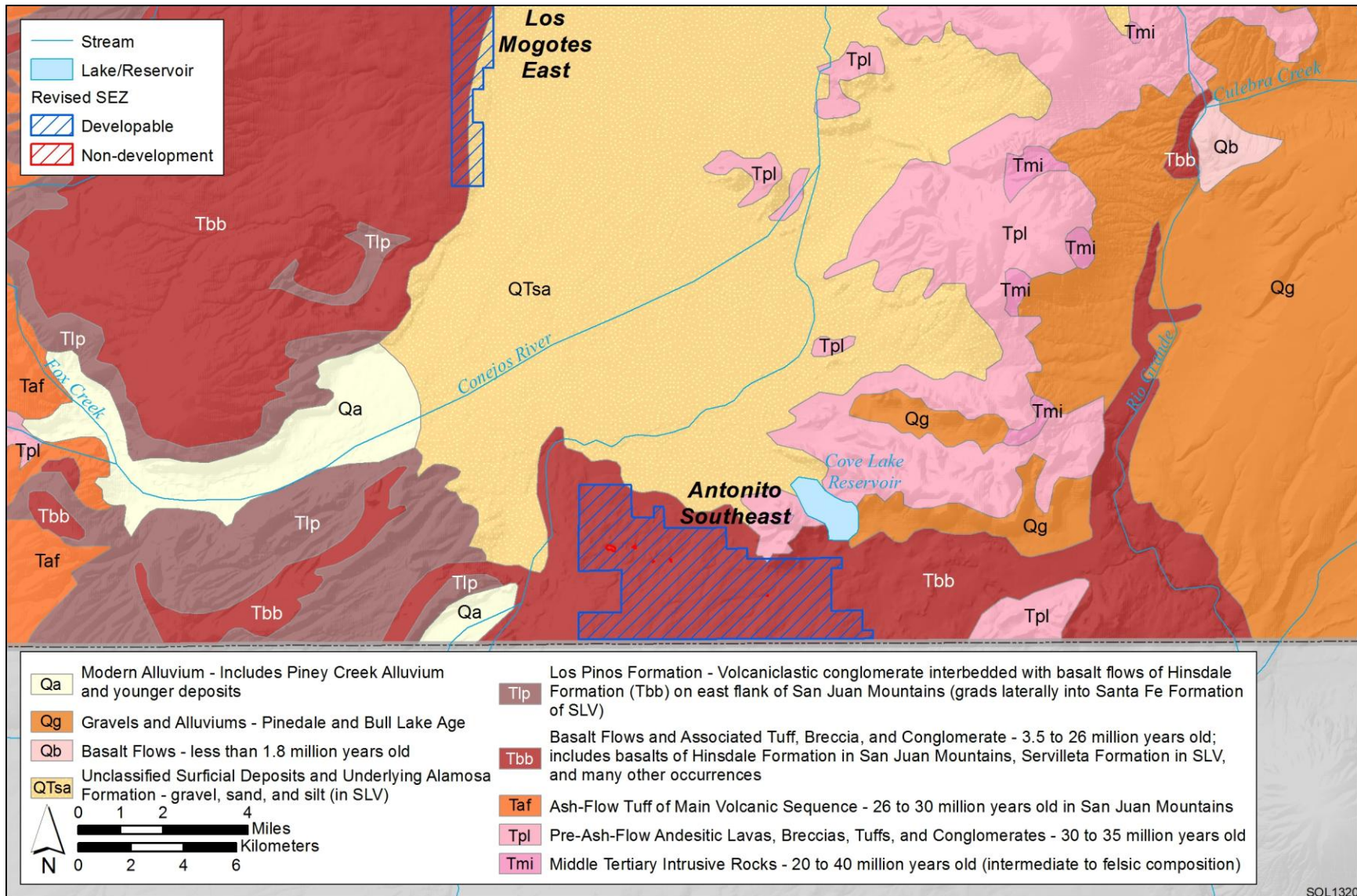


FIGURE 4 Geologic Map of the Antonito Southeast SEZ (Sources: Stoeser et al. 2007; Tweto 1979; Thompson and Machette 1989)

Surface water features at the site include Alta Lake, a shallow pond located in the western portion of the SEZ. The pond receives surface runoff from elevated areas to the south. The pond covers an area of about 2 acres (0.0040 km<sup>2</sup>). Ephemeral washes on the site are shallow and typically flow from southwest to northeast.

The San Luis Hills, to the northeast of the SEZ, are the exposed portion of an intrarift horst, capped by Hinsdale basalts (Miocene).<sup>2</sup> Intrusions of quartz monzonite and diorite are exposed about 5 mi (8 km) to the northeast of the San Luis Hills (Burroughs 1974; Thompson et al. 1991; Machete 2006; Harmon 2009).

## 2.7 MINERAL HISTORY

There has been no documented mining within the Antonito Southeast SEZ. Most of the mining activity in the region has been limited to small-scale mining of industrial (saleable) minerals, including sand and gravel, stone, and volcanic materials (pumice and scoria), in the basin, and the mining of locatable minerals in the San Juan Mountains to the northwest (USGS 2011a). The nearest mining activity is a scoria pit (Red Rock Mining), just to the northwest of the SEZ; three perlite expanding plants (Antonito Mill, Silbrico, and Johns-Manville) are also located to the northwest of the site (Patton 2009). An active bentonite (clay) mine is in operation a few miles to the east (in section 8 of T32N, R11E) (CDMG 2012a). The King Turquoise Mine produces turquoise near the San Luis Hills, about 13 mi (21 km) to the northeast in section 22 of T34N, R11E (Morrone 2011; see Map 1).

Currently, no mineral exploration or development work is being conducted within the SEZ. There have been no reports of recent exploration or development activities in Conejos County.

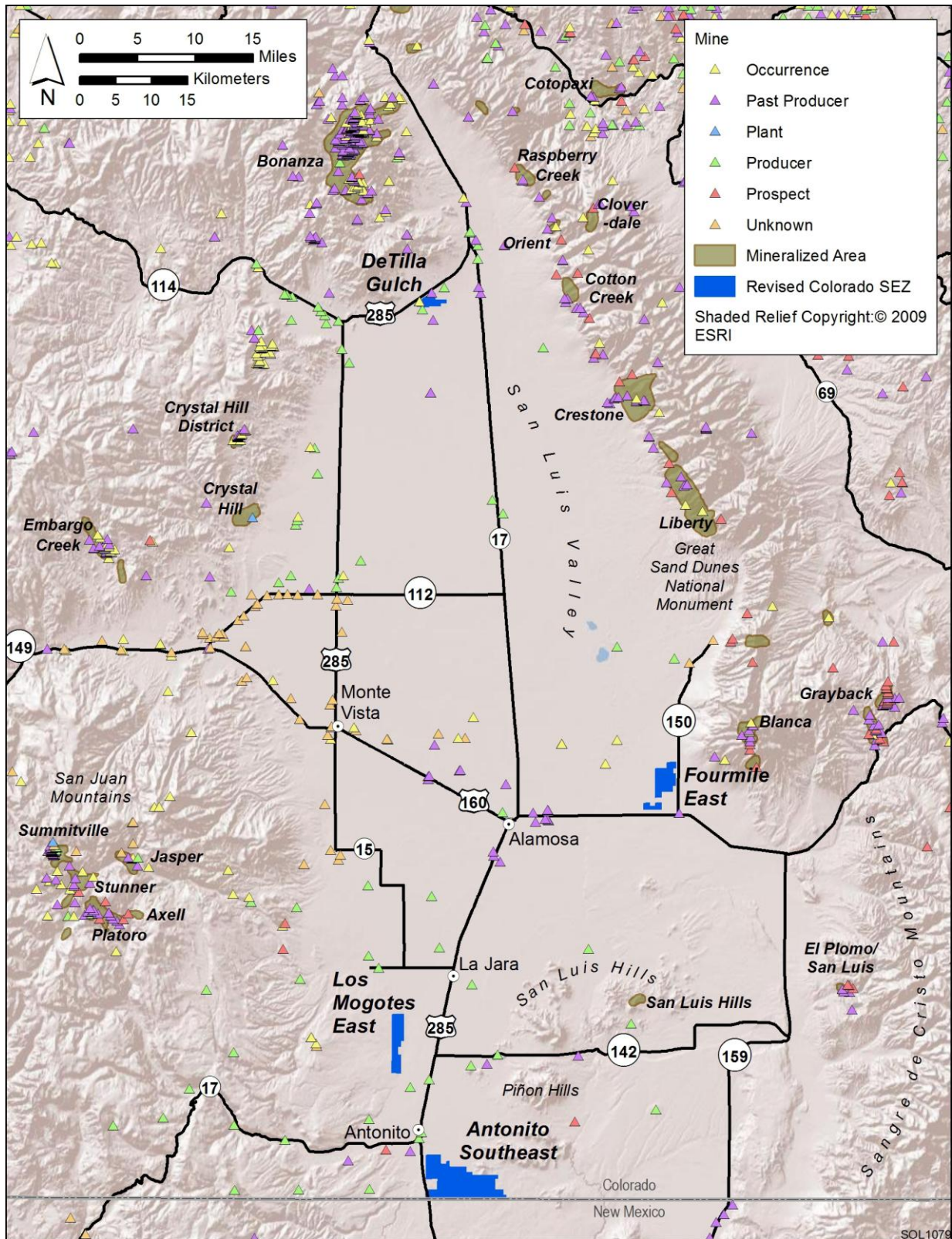
### 2.7.1 Locatable Minerals

There are no documented occurrences of locatable mineral deposits or prospects within the Antonito Southeast SEZ, and there is little or no potential for such deposits in the San Luis Valley (BLM 2012; Keller and Wray 2001). Most of the locatable minerals produced in the region come from the Platoro-Summitville District, in the San Juan Mountains, to the northwest (Figure 5). Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age (CGS 2011). Rift-related, brecciated fault zones along the east side of the valley (in Costilla County) host mineral deposits that were mined in the early 1900s; this area is currently being reclaimed (USGS 2011a; CGS 2011). These conditions are not likely to be present below the SEZ.

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<sup>2</sup> Geologic maps based on Tweto (1979) show exposures of pre-ash flow andesitic lavas (Tpl) with an estimated age of about 30 to 35 million years at the San Luis Hills (Figure 3); the description provided here is based on Thompson et al. (1991), which reported that the San Luis Hills are capped by the younger Hinsdale basalt (3.5 to 26 million years old).





**FIGURE 5** Map Showing Mineralized Areas, Mines, and Mineral Prospects in the San Luis Valley and Adjacent Areas (Sources: USGS 2011a; Wilson 2003)

Mines and mineral prospects in the vicinity of the SEZ are shown on the detailed map provided in the back of this report (Map 1). The nearest documented occurrences of locatable minerals (copper, lead, silver, gold, zinc, molybdenum, asbestos, and aluminum) are in the Tertiary volcanic and intrusive rocks of the San Juan Mountains about 37 mi (60 km) northwest of the site (USGS 2011a). Comparable units, if present beneath the Antonito Southeast SEZ, are buried by basalt and basin-fill sediments that together are more than 1,300 (400 m) thick.

The Summitville, Jasper, Stunner, Axell, and Platoro mineralized areas (Platoro-Summitville District) have produced gold, silver, copper, lead, zinc, antimony, tellurium, aluminum, and molybdenum. According to the USGS MRDS, active mines in the district (Summit District, Summitville Mine, and Decatur NE District) currently produce copper, lead, silver, gold, zinc, molybdenum, asbestos, and aluminum (alunite) (Bauer 1971; USGS 2011a). An underground turquoise mine (King Turquoise) is located on BLM public land southeast of the San Luis Hills (and northeast of Piñon Hills) about 13 mi (21 km) to the northeast of the SEZ (in section 22 of T34N, R11E) (Morrone 2011; USGS 2011a). The mine occurs within an extensive area of intermediate volcanic rocks that have undergone hydrothermal alteration; it is the largest turquoise mine in Colorado (Keller and Wray 2001).

The Antonito Southeast SEZ crosses none of the mineralized areas or historical mining districts listed above, and there has been no locatable mining activity within the site. Most of the locatable minerals in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above a 300-ft (90-m) thick basalt unit at the northern edge of the Taos Plateau (within San Luis Basin), which is underlain by basin-fill sediments more than 1,000-ft (305-m) thick (based on boring logs). Therefore, the potential for locatable minerals to occur within the Antonito Southeast SEZ is low (level of certainty B).

### **2.7.2 Saleable Mineral Materials**

Saleable mineral materials in the region include sand and gravel, aggregate, and scoria. Sand and gravel are the most common resources in the San Luis Valley, and large quantities of these resources occur throughout Conejos County; other types of volcanic rock (latite and andesite) have also been mined in the county. The shallow basalt in the region is considered by the CGS to be a viable source of crushed stone and riprap (Keller and Wray 2001).

The nearest mining activity is a scoria pit, just to the northwest of the SEZ (Patton 2009). There are several active sand and gravel producers to the west of the site, along the Colorado–New Mexico state line and in the Conejos River valley, and to the north near La Jara (Map 1). A scoria pit (Red Rock Mining) operates just to the northwest of the site (Patton 2009).

The Antonito Southeast SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit, and alluvium above this unit is no more than 4 ft (1.2 m) thick (based on well logs). The site is a high-potential area for volcanic material such as crushed stone or scoria (level of certainty D). According to the LR2000,



accessed on July 19, 2012, there are no free use permits or mineral materials contracts within the Antonito Southeast SEZ (BLM 2012).

### **2.7.3 Leasable Minerals**

There are no known coal resources within the immediate region of the Antonito Southeast SEZ (Keller and Wray 2001) and no history of coal production in Conejos County (most of the coal production occurs in northwest and west-central Colorado, with nearly half of the state's production coming from the Williams Fork Formation). The nearest coal fields are more than 60 mi (100 km) to the east and northeast in Las Animas and Huerfano Counties (Burnell et al. 2008; Kirschbaum and Biewick 2009). There are no exposed geologic formations containing coal resources in Conejos County (Keller and Wray 2001).

The BLM San Luis Valley RMP (BLM 1991) describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence (Keller and Wray 2001). There are no active oil and gas leases within the site. A portion of the SEZ along its western boundary (in sections 4, 9, and 21, T32N, R9E) was leased at one time, but these leases were closed in 1985 and 1993. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development (GWCSWG 2007; INEEL 2003). However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara, more than 16 mi (26 km) north of the site. According to the LR2000, accessed on July 19, 2012, there are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley (BLM 2012). The potential for development of geothermal energy within the SEZ is low (level of certainty B).

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### 3 DE TILLA GULCH SEZ

#### 3.1 SUMMARY AND CONCLUSIONS

This chapter assesses the mineral resource potential of 1,064 acres (4.3 km<sup>2</sup>) of public lands within an area known as the De Tilla Gulch SEZ, located in Saguache County in south-central Colorado, about 4 mi (6 km) to the south of Lund and 5 mi (8 km) to the east of Zane. Alamosa is located about 50 mi (80 km) to the south.

There are no documented occurrences of locatable mineral deposits within the De Tilla Gulch SEZ. Most of the locatable mineral deposits in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur as epithermal vein deposits hosted by the Tertiary volcanic rocks associated with the Bonanza caldera (San Juan Volcanic Field). The SEZ sits above the Monte Vista graben (within San Luis Basin), where basin-fill sediments are estimated to be about 10,000-ft (30,400-m) deep. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The De Tilla Gulch SEZ is an area with high potential for sand and gravel (level of certainty D). The site is underlain by alluvial and basin-fill deposits, and past small-scale mining of sand and gravel within and around the site indicates that the future extraction of such resources within the SEZ is viable. There are no active free use permits or mineral materials contracts within the SEZ; however, three free use permits for sand and gravel were located in along the northern site boundary. The pits have been intermittently active, but there has been no activity since 1992.

The BLM San Luis Valley RMP describes the basin as having a low potential for oil and gas development (although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 10 mi [19 km] to the southeast [east of Highway 17]). There are no active or historical oil and gas leases within the site. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use. There are two hot springs spas within 5 mi (8 km) of the De Tilla Gulch SEZ (to the northeast): Valley View Hot Springs and Mineral Hot Springs. There are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

#### 3.2 LANDS INVOLVED

The De Tilla Gulch SEZ is located on BLM lands in the San Luis Valley Resource Area (Saguache Field Office), in Saguache County. The site lies within T45N, R9E, sections 29 to 33

(New Mexico Principal Meridian). The SEZ is shown on the location map in the back of this report (Map 1). The full legal description of the SEZ is provided in Appendix A.

### 3.3 LAND STATUS

According to the LR2000, accessed on July 19, 2012, there are no active or historical locatable mining claims within the De Tilla Gulch SEZ; however, there are nine closed lode claims (closed in 1988) immediately south of the site in the south half of section 32 in T45N, R9E (BLM 2012). The lands within the SEZ were first segregated from locatable mineral entry in June 2009, pending the outcome of the Draft Solar PEIS (BLM and DOE 2010). They are currently segregated under an Interim Temporary Final Rule, which is in effect until June 30, 2013 (76 FR 23198–23205).

Although there are no active free use permits or mineral materials contracts within the SEZ, three free use permits for sand and gravel (to Saguache County) were located in section 29 of T45N, R9E, overlapping the SEZ in the southeast quadrant of the section (along the northern site boundary) (BLM 2012). The pits have been intermittently active, but there has been no activity since 1992. The site remains open for the disposal of saleable mineral materials.

There are no active or historical oil and gas or geothermal leases within or around the SEZ. The site remains open for discretionary mineral leasing for oil and gas and other leasable minerals.

### 3.4 GEOLOGIC SETTING

The De Tilla Gulch SEZ is located in the northern part of the San Luis Valley, an alluvial basin within the Southern Rocky Mountain physiographic province in south-central Colorado. The San Luis Valley is part of the San Luis Basin, an axial basin of the Rio Grande rift. The Rio Grande rift is a north-trending, tectonic feature that extends from south-central Colorado to northern Mexico. Basins in the rift zone generally follow the course of the Rio Grande and are bounded by normal faults that define the rift zone margins (Burroughs 1974, 1981; Emery 1979).

The San Luis Basin is an east-tilting half graben, flanked by the San Juan Mountains to the west and the Sangre de Cristo Range to the east. It is generally divided into five physiographic subdivisions—the Alamosa Basin, the San Luis Hills, the Taos Plateau, the Costilla Plains, and the Culebra Reentrant (Figure 2). The De Tilla Gulch SEZ is located at the northern end of the Alamosa Basin near Saguache. The Alamosa Basin is divided by a north-trending uplifted fault block (the Alamosa horst) that separates two down-dropped fault blocks (grabens): the Monte Vista graben to the west and the Baca graben to the east (Leonard and Watts 1989).

Exposed sediments in the San Luis Valley consist mainly of modern alluvial deposits and the fluviolacustrine clays and sands of the Quaternary-Tertiary Alamosa Formation (associated with an ancient lake that occupied the valley from the Pliocene to Pleistocene).

Eolian deposits, such as those of the Great Sand Dunes National Monument, occur along the base of the Sangre de Cristo Mountains on the eastern side of the valley. The Rio Grande alluvial fan (at the base of the San Juan Mountains where the Rio Grande enters the valley) lies northwest of the town of Alamosa. The San Luis Hills, consisting of northeast-trending flat-topped mesas and irregular hills, are a prominent feature of the southern part of the valley. A good portion of southern San Luis Valley is covered by Tertiary basaltic lava flows of the Hinsdale and Servilleta Formations (Keller and Wray 2011). The geology of the San Luis Valley is shown in Figure 3.

### 3.5 PHYSICAL FEATURES AND ACCESS

The De Tilla Gulch SEZ is located midway between Saguache and San Luis Creeks. Its terrain is relatively flat with a very gentle slope to the southeast. The land surface is dissected by a series of intermittent streams that flow to the southeast (De Tilla Gulch traverses the southwestern corner of the SEZ). Elevations range from about 7,775 ft (2,370 m) along its northern-most border to about 7,685 ft (2,342 m) at its southeastern-most corner.

The overall character of the SEZ and surrounding lands is rural and undeveloped. The SEZ is small, and signs of previous disturbances occur throughout the site, including county and informal roads, sand and gravel pits, transmission lines, and a windmill to provide livestock water. Access is by U.S. 285, which runs along the northwest side of the site.

### 3.6 SITE GEOLOGY

The geology of the De Tilla Gulch SEZ is described based on the 1:500,000 scale geologic map by Tweto (1979) and the 1:250,000 scale geologic maps by Tweto (1976) and Cappa and Wallace (2007) (Figure 6). The thicknesses of geologic units were inferred from a geologic cross section developed by Leonard and Watts (1989) along an east–west transect located about 20 mi (32 km) to the south of the SEZ.

The De Tilla Gulch SEZ likely sits above the Monte Vista graben, where basin-fill sediments are estimated to be about 10,000-ft (3,048-m) deep (Leonard and Watts 1989). The site is underlain by alluvial deposits of Quaternary age (map unit Qg). The deposits consist of lacustrine sediments (Bull Lake), fan alluvium, and glacial outwash gravel (Pleistocene) (Tweto 1979; Cappa and Wallace 2007).

The uppermost stratigraphic unit is the Alamosa Formation (Pliocene to Holocene), a fluviolacustrine formation consisting of a series of discontinuous blue clays interbedded with water-bearing sands that make up the unconfined and confined aquifers in the region. The Alamosa Formation is about 1,000-ft (305-m) thick above the Monte Vista graben. It thins to the west and is cut by channel-fill sands of various drainages in the valley. Underlying the Alamosa Formation are the alluvial sediments of the Los Pinos Formation. The Los Pinos Formation (Oligocene to Pliocene) consists of eastward-thickening sandy gravels interbedded with volcanic rocks (tuffs and tuffaceous siltstones and conglomerates). The Los Pinos gravels



are thought to represent coalescing alluvial fans that developed along the eastern flank of the San Juan Mountains during an earlier period of uplift and volcanism. Below the Los Pinos Formation are the older volcanic and volcanoclastic rocks and red-colored alluvial sediments of the Conejos and Vallejo Formations (Eocene to Oligocene). These units overlie a basement complex of Precambrian igneous and metamorphic rocks (Burroughs 1974, 1981; Leonard and Watts 1989; Molenaar 1988; Brister and Gries 1994).

There are no perennial surface water features within the SEZ. Several ephemeral drainages cross the site in the northwest to southeast direction.

### **3.7 MINERAL HISTORY**

There has been no documented mining within the De Tilla Gulch SEZ, other than for sand and gravel (under free use permits to Saguache County). Most of the mining activity in the region has been limited to small-scale mining of industrial (saleable) minerals, mainly sand and gravel, in the basin, and the mining of locatable minerals in the San Juan Mountains to the northwest (USGS 2011a). The nearest mining-related activity occurs within and around the SEZ where sand and gravel were produced from several small pits. There are several active sand and gravel producers to the northwest (along Route 285) and along Saguache Creek to the west. The Hall Turquoise Mine, a past producer of turquoise, is located about 12 mi (19 km) to the north in section 26 of T37N, R8E (see Map 2).

Currently, no mineral exploration or development work is being conducted within the De Tilla Gulch SEZ. The Hecla Mining Company (2011) reports that it is exploring historic mines (Bulldog and North Amethyst-Equity) in the Creede District for silver. (The Creede District is centered on a caldera in the central San Juan Mountains.) Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 10 mi (19 km) to the southeast (east of Highway 17) of the SEZ. There have been no other reports of recent exploration and development activities in Saguache County.

#### **3.7.1 Locatable Minerals**

There are documented occurrences of locatable mineral deposits or prospects within the De Tilla Gulch SEZ, and there is little or no potential for such deposits in the San Luis Valley (BLM 2012; Keller and Hemborg 2000). Most of the locatable mineral deposits in the region come from the Bonanza (Kerber Creek) District, in the San Juan Mountains to the northwest (Figure 5). Mineral deposits in this area occur as epithermal vein deposits hosted by the Tertiary volcanic rocks associated with the Bonanza caldera (San Juan Volcanic Field) (CGS 2011; Bauer 1971). Erosional products of these rocks likely occur at depths of about 4,000 ft (1,200 m) below the SEZ.

Mines and mineral prospects in the vicinity of the SEZ are shown on the detailed map provided in the back of this report (Map 2). The nearest documented occurrences of locatable

minerals (silver, lead, zinc, copper, and gold) are in the volcanic rocks of the San Juan Mountains to the northwest.

According to the USGS MRDS, turquoise was produced from the Hall Turquoise Mine, located about 12 mi (19 km) to the north of the SEZ, west of Villa Grove, in section 26 of T47N, R8E (see Map 2) (USGS 2011a). The mine is located in an intrusive gabbro in the Rawley Andesite of the Bananza volcanic complex. Originally mined for copper, the deposit was developed for turquoise in 1936. Turquoise occurs as veins and nodules within openings of felsite porphyry and as fracture fillings in gabbro. The mine closed in 2006 (Cappa and Wallace 2007).

Several mineralized areas lie across the valley to the east, along the western base of the Sangre de Cristo Mountains; from north to south they are Raspberry Creek, Cloverdale, Orient, Cotton Creek, and Crestone (Figure 5). Currently, there is no active mining in these areas. In the Raspberry Creek area, small quartz veins containing galena and chalcopyrite with traces of gold and silver occur in Precambrian rocks, mainly along the range crest. Several caved workings for silver and gold are located along the base of the range. In the Cloverdale area, the Oligocene Rito Alto stock crops out along the range crest; it was prospected for molybdenum in the early 1900s. Molybdenite, gold, silver, and tungsten occurrences are associated with quartz veins and a granitic dike within the stock (Johnson et al. 1984; USGS 2011a).

Iron ore (limonite, siderite with sparse barite, chalcopyrite, and gold) was produced in the 1930s from an oxidized replacement deposit in the Leadville Limestone, a sheared unit in close proximity to the Sangre de Cristo fault. The Orient Mine produced iron, manganese, copper, and graphite (USGS 2011a).

Mineralization in the Cotton Creek area (silver, gold, barite, and chalcopyrite) occurs throughout Precambrian gneiss and granite—along foliation planes in gneiss, in quartz veins, and in quartz-barite veins. The area was mined from the early 1900s to the 1960s and produced gold, silver, copper, lead, uranium, and vanadium. In the Crestone mineralization area, oxidized quartz veins in Precambrian quartz monzonite contain limonite and pyrite and were first worked by Spanish explorers in the late 1800s, but none of this production is recorded. Mining in the area took place until the Supreme Court granted all mineral rights in the region to the owners of the Baca Grant in 1904. Past mines produced gold, silver, copper, lead, and zinc (Johnson et al. 1984; USGS 2011a). There are no exposures of Precambrian rocks within or near the De Tilla Gulch SEZ; these rocks are estimated to occur at depths of 10,000 ft (3,050 m) or greater below the site (at the base of the Monte Vista graben).

The De Tilla Gulch SEZ crosses none of the mineralized areas or historical mining districts listed above, and there has been no hard rock or locatable mineral activity within the site. Most of the locatable mineral deposits in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur as epithermal vein deposits hosted by the Tertiary volcanic rocks associated with the Bonanza caldera (San Juan Volcanic Field). The SEZ sits above the Monte Vista graben (within San Luis Basin), where basin-fill sediments are estimated to be about 10,000-ft (3,040-m) deep. Therefore, the potential for locatable minerals to occur within the De Tilla Gulch SEZ is low (level of certainty B).



### 3.7.2 Saleable Mineral Materials

Saleable mineral materials in the region are mainly limited to sand and gravel, stone, pumice, and scoria (CDMG 2012b). Sand and gravel have been produced from several small pits within and around the SEZ (Map 2). There are also several active sand and gravel producers to the northwest (along Route 285; in T46N, R9E) and along Saguache Creek to the west (in T45N, R7E; and T44N, R7E). According to the LR2000, accessed on July 19, 2012, there currently are no free use permits or mineral materials contracts within the De Tilla Gulch SEZ. Sand and gravel were mined by Saguache County in the north part of the site until 1992 (overlapping the site in SE<sup>1</sup>/<sub>4</sub> of section 29 in T45N, R9E) (BLM 2012).

The De Tilla Gulch SEZ is an area with high potential for sand and gravel (level of certainty D). The site is underlain by alluvial and basin-fill deposits, and past small-scale mining of sand and gravel within and around the site indicates that the future extraction of such resources within the SEZ is viable. According to the LR2000, accessed on July 19, 2012, there are no active free use permits or mineral materials contracts within the SEZ. Three free use permits for sand and gravel (to Saguache County) were located in section 29 of T45N, R9E, overlapping the SEZ in the southeast quadrant of the section (along the northern site boundary). The pits have been intermittently active, but there has been no activity since 1992.

### 3.7.3 Leasable Minerals

There are no known coal resources within the immediate region of the De Tilla Gulch SEZ and no history of coal production in Saguache County (most of the coal production occurs in northwest and west-central Colorado, with nearly half of the state's production coming from the Williams Fork Formation). Coal-bearing units such as the Mesaverde Formation (Cretaceous) do not occur in Saguache County (Keller and Hemborg 2000). The nearest coal fields are more than 80 mi (130 km) to the west and northwest in Gunnison, Delta, and Montrose Counties (Burnell et al. 2008; Kirschbaum and Biewick 2009).

The BLM San Luis Valley RMP (BLM 1991) describes the basin as having a low potential for oil and gas development (although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 10 mi [19 km] to the southeast [east of Highway 17] [USFWS 2011a,b]). There are no active or historical oil and gas leases within the site. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development (INEEL 2003; Burroughs 1981). However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use. There are two hot springs spas within 5 mi (8 km) of the SEZ (to the northeast): Valley View Hot Springs and Mineral Hot Springs. According to the LR2000, accessed on July 19, 2012, there are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley (BLM 2012). The potential for development of geothermal energy within the SEZ is low (level of certainty B).

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## 4 FOURMILE EAST SEZ

### 4.1 SUMMARY AND CONCLUSIONS

This chapter assesses the mineral potential of 2,883 acres (11.7 km<sup>2</sup>) of public lands within an area known as the Fourmile East SEZ, located in Alamosa County in south-central Colorado, about 13 mi (21 km) to the east of Alamosa.

There are no documented occurrences of locatable mineral deposits within the Fourmile East SEZ. Most of the locatable mineral deposits in the region come from the Sangre de Cristo Mountains to the northeast. Deposits such as gold and silver occur in quartz veins in Precambrian gneissic tonalite and metadiorite. The SEZ sits above the Baca graben, the deepest part of the Alamosa Basin, where basin-fill sediments are estimated to be up to 19,000-ft (5,800-m) deep. Therefore, the potential for locatable minerals to occur within the Fourmile East SEZ is low (level of certainty B).

The Fourmile East SEZ is underlain by alluvial and basin-fill deposits and is, therefore, a high-potential area for sand and gravel deposits (level of certainty C). Past and ongoing small-scale mining of sand and gravel in the region indicates that the future extraction of such resources within the SEZ is viable. There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley RMP describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence (although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 28 mi [45 km] to the north-northwest). There are no active oil or gas leases within the site. Eight oil and gas leases covered most of the site at one time, but these leases were closed in 1980s and 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located 10 mi (16 km) to the west of the Fourmile East SEZ (near Alamosa) and to the northwest (along Highway 17). There are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

### 4.2 LANDS INVOLVED

The Fourmile East SEZ is located on BLM lands in the San Luis Valley Resource Area (La Jara Field Office), in Alamosa County. The site lies within T37N, R12E, sections 2 and 3; and T38N, R12E, sections 23 to 26 (New Mexico Principal Meridian). Within this area, 1 acre (0.004 km<sup>2</sup>) of wetlands has been designated as a non-development area (BLM and DOE 2011).

The SEZ and the non-development area within it are shown on the location map in the back of this report (Map 1). The full legal description of the SEZ is provided in Appendix A.

### 4.3 LAND STATUS

According to the LR2000, accessed on July 20, 2012, there are no active or historical locatable mining claims within the Fourmile East SEZ (BLM 2012). The lands within the SEZ were first segregated from locatable mineral entry in June 2009, pending the outcome of the Draft Solar PEIS (BLM and DOE 2010). They are currently segregated under an Interim Temporary Final Rule, which is in effect until June 30, 2013 (76 FR 23198–23205).

There are no active free use permits or mineral materials contracts within the SEZ (BLM 2012). The site remains open for the disposal of saleable mineral materials.

There are no active oil and gas leases within and around the SEZ; however, most of the site was leased for oil and gas in the past (eight oil and gas leases covered most of the site but were closed in 1980s and 1990s). There are no active or historical geothermal leases within the SEZ. The area remains open for discretionary leasing for oil and gas and other leasable minerals.

### 4.4 GEOLOGIC SETTING

The Fourmile East SEZ is located in the northern part of the San Luis Valley, an alluvial basin within the Southern Rocky Mountain physiographic province in south–central Colorado. The San Luis Valley is part of the San Luis Basin, an axial basin of the Rio Grande rift. The Rio Grande rift is a north-trending tectonic feature that extends from south–central Colorado to northern Mexico. Basins in the rift zone generally follow the course of the Rio Grande and are bounded by normal faults that define the rift zone margins (Burroughs 1974, 1981; Emery 1979).

The San Luis Basin is an east-tilting half graben, flanked by the San Juan Mountains to the west and the Sangre de Cristo Range to the east. It is generally divided into five physiographic subdivisions—the Alamosa Basin, the San Luis Hills, the Taos Plateau, the Costilla Plains, and the Culebra Reentrant (Figure 2). The Fourmile East SEZ is located along the eastern edge of the Alamosa Basin near the base of the Sangre de Cristo Range. The Alamosa Basin is divided by a north-trending uplifted fault block (the Alamosa horst) that separates two down-dropped fault blocks (grabens): the Monte Vista graben to the west and the Baca graben to the east (Leonard and Watts 1989).

Exposed sediments in the San Luis Valley consist mainly of modern alluvial deposits and the fluvio-lacustrine clays and sands of the Quaternary-Tertiary Alamosa Formation (associated with an ancient lake that occupied the valley from the Pliocene to Pleistocene). Eolian deposits, such as those of the Great Sand Dunes National Monument, occur along the base of the Sangre de Cristo Mountains on the eastern side of the valley. The Rio Grande alluvial fan (at the base of the San Juan Mountains where the Rio Grande enters the valley) lies northwest of the town of Alamosa. The San Luis Hills, consisting of northeast-trending flat-

topped mesas and irregular hills are a prominent feature of the southern part of the valley. A good portion of southern San Luis Valley is covered by Tertiary basaltic lava flows of the Hinsdale and Servilleta Formations (Keller and Wray 2011). The geology of the San Luis Valley is shown in Figure 3.

#### **4.5 PHYSICAL FEATURES AND ACCESS**

The Fourmile East SEZ is located in a topographic depression, known as the closed basin, about 10 mi (17 km) southeast of San Luis Lake. Its terrain is relatively flat with a very gentle slope to the west and northwest. Elevations range from about 7,640 ft (2,330 m) along the eastern boundary to about 7,580 ft (2,310 m) at the northwestern-most and southwestern-most corners.

The overall character of the SEZ is rural. The SEZ is located within an area of mixed land ownership and is surrounded mainly by private lands, but there are a number of BLM- and U.S. Forest Service- (USFS-) managed lands nearby. Access is from State Highway 150, which passes through the east side of the SEZ. Three country roads also provide access to portions of the site.

#### **4.6 SITE GEOLOGY**

The geology of the Fourmile East SEZ is described based on the 1:500,000 scale geologic map by Tweto (1979) (Figure 7). The thicknesses of geologic units were inferred from a geologic cross section developed by Leonards and Watts (1989) along an east–west transect located about 10 mi (16 km) to the north of the SEZ, near San Luis Lake.

The Fourmile East SEZ sits above the Baca graben, the deepest part of the Alamosa Basin, where basin-fill sediments are estimated to be up to 19,000-ft (5,800-m) deep (Leonard and Watts 1989). The uppermost stratigraphic unit, which is exposed in the vicinity of the SEZ, is the Alamosa Formation (Pliocene to Holocene), a fluviolacustrine formation consisting of a series of discontinuous blue clays interbedded with water-bearing sands that make up the unconfined and confined aquifers in the region (map unit QTsa). The Alamosa Formation is up to 2,050-ft (610-m) thick above the Baca graben. It thins to the west and is cut by channel-fill sands of various drainages in the valley. Underlying the Alamosa Formation are the interbedded buff to pink clays and silty sands of the Santa Fe Group (Miocene to Pliocene). These sediments are intertongued with the alluvial sediments of the Los Pinos Formation to the west and crop out near the eastern edge of the basin along the Northern Sangre de Cristo fault zone. The Los Pinos Formation (Oligocene to Pliocene) consists of eastward-thickening sandy gravels interbedded with volcanic rocks (tuffs and tuffaceous siltstones and conglomerates). Below the Santa Fe Formation are Tertiary and Cretaceous sedimentary rocks that predate the Vallejo Formation. These rocks overlie a basement complex of Precambrian igneous and metamorphic rocks (Brister and Gries 1994; Burroughs 1974, 1981; Leonard and Watts 1989; Molenaar 1988).

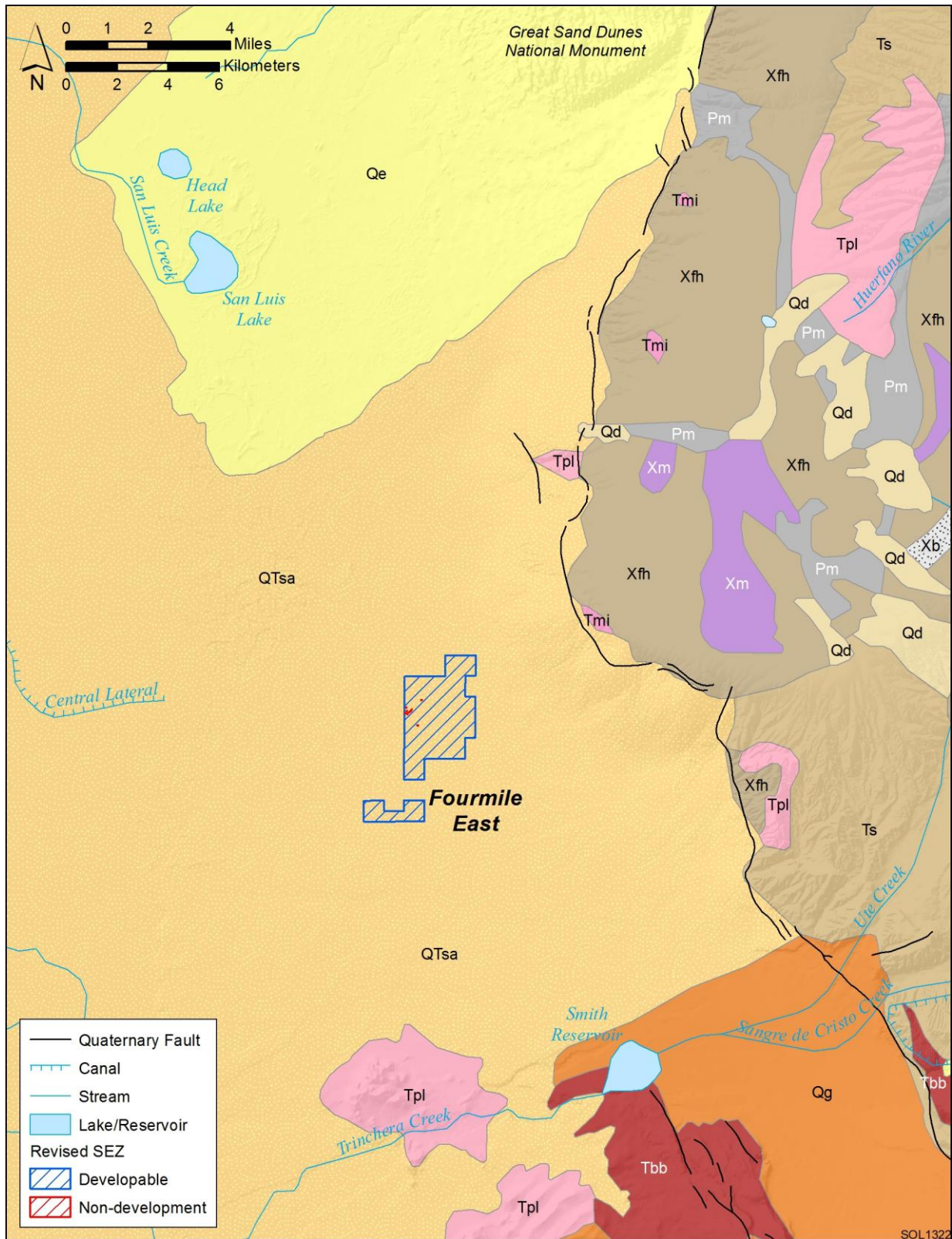
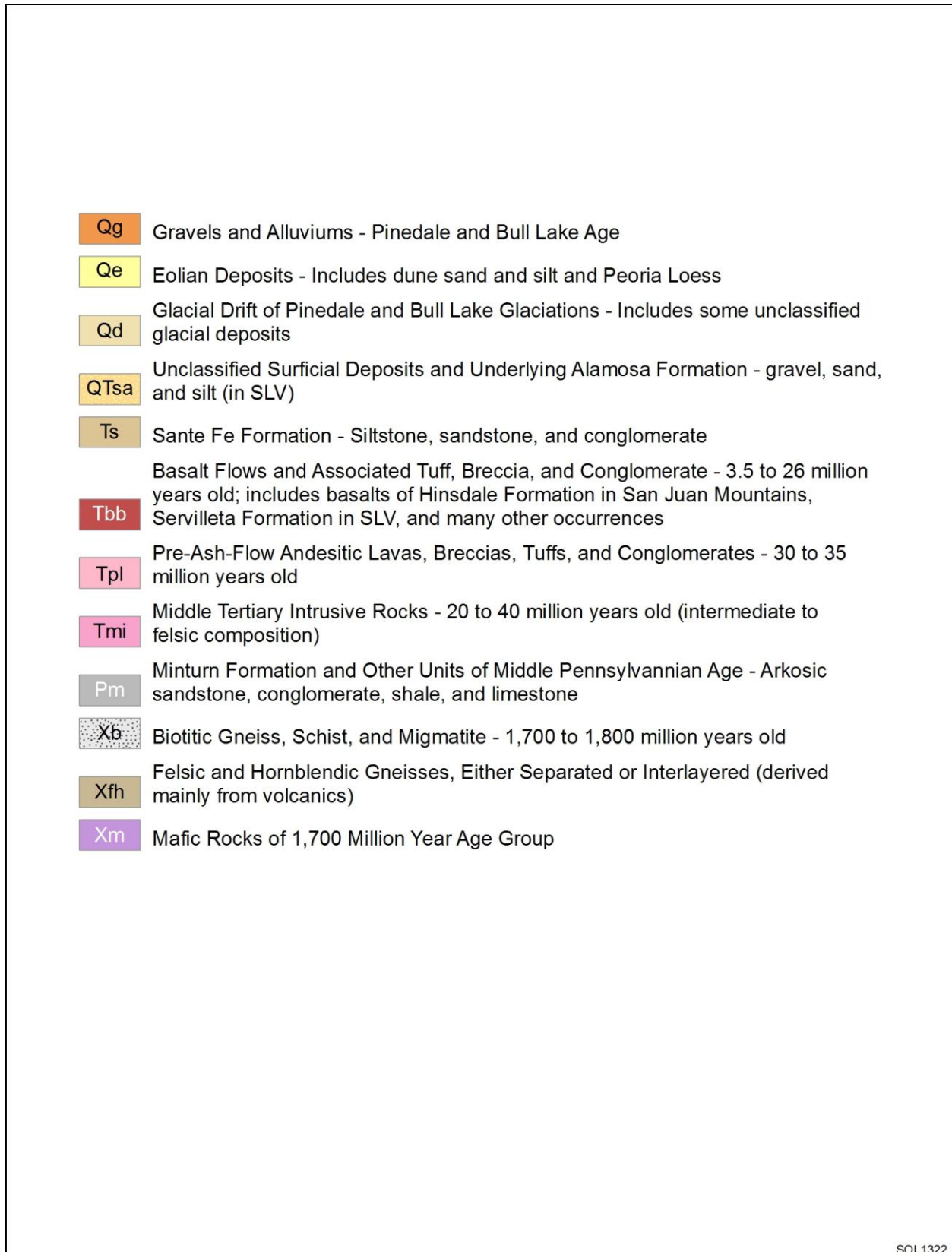


FIGURE 7 Geologic Map of the Fourmile East SEZ (Sources: Stoeser et al. 2007; Tweto 1979)



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FIGURE 7 (Cont.)



There are no perennial surface water features within the SEZ. Several ephemeral washes drain toward the site from the Sangre de Cristo Mountains to the east, but they end about 1 mi (1.6 km) east of the site.

## 4.7 MINERAL HISTORY

There has been no documented mining within the Fourmile East SEZ. Most of the mining activity in the region has been limited to small-scale mining of industrial (saleable) minerals, mainly sand and gravel, in the basin, and the mining of locatable minerals in the Sangre de Cristo Mountains to the east (USGS 2011a). The nearest mining activity is a small sand and gravel pit a few miles to the north of the SEZ (to the east of State Highway 150) (Patton 2009). According to the USGS MRDS, sodium (a leasable mineral) may have been produced to the north and northwest near the center of the closed basin at San Luis Lake in T40N, R12E (USGS 2011a; see Map 3); however, this was not confirmed by the author.

Currently, no mineral exploration or development work is being conducted within the SEZ. Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 28 mi (45 km) to the north–northwest of the SEZ. There have been no other reports of recent exploration or development activities in Alamosa County.

### 4.7.1 Locatable Minerals

There are no documented occurrences of locatable mineral deposits or prospects within the Fourmile East SEZ, and there is little or no potential for such deposits in the San Luis Valley (BLM 2012; Keller and Wray 2001). Most of the locatable mineral deposits in the region have come from the West Blanca District (Blanca Peak), in the Sangre de Cristo Mountains about 18 mi (29 km) to the northeast (Figure 5). Deposits of gold, silver, copper oxide, and scheelite are common in this area and occur in quartz veins in Precambrian gneissic tonalite and metadiorite (Johnson et al. 1984; Klein et al. 2008; USGS 2011a). There are no exposures of Precambrian rocks within or near the Fourmile East SEZ; these rocks are estimated to occur at depths of 12,000 ft (3,660 m) or greater below the site (at the base of the Baca graben). Rift-related, brecciated fault zones along the east side of the valley (in Costilla County) host mineral deposits that were mined in the early 1900s, but that area is currently being reclaimed (USGS 2011a; CGS 2011).

Mines and mineral prospects in the vicinity of the SEZ are shown on the detailed map provided in the back of this report (Map 3). The nearest documented occurrences of locatable minerals (copper, gold, silver, molybdenum, bismuth, lead, tungsten, antimony, and tellurium) are in the metamorphic rocks of the Sangre de Cristo Mountains, about 6 mi (10 km) to the northeast of the site (USGS 2011a). The area coincides with the West Blanca District where past mines (West Blanca, Blanca Mine, and Coronado Group) have produced copper, gold, silver, molybdenum, bismuth, lead, tungsten, antimony, and tellurium. There are currently no active mines in the area (USGS 2011a; Klein et al. 2008).



Past mines in the El Plomo/San Luis mineralized area (San Luis Mine and El Plomo Mine), about 22 mi (35 km) to the southeast, have produced gold, silver, copper, lead, molybdenum, and zinc (Bauer 1971; USGS 2011a).

The Fourmile East SEZ crosses none of the mineralized areas or historical mining districts listed above, and there has been no hard rock or locatable mineral activity within the site. Most of the locatable mineral deposits produced in the region have come from the Sangre de Cristo Mountains to the northeast. Deposits such as gold and silver occur in quartz veins in Precambrian gneissic tonalite and metadiorite. The SEZ sits above the Baca graben, the deepest part of the Alamosa Basin, where basin-fill sediments are estimated to be up to 19,000-ft (5,800-m) deep. Therefore, the potential for locatable minerals to occur within the Fourmile East SEZ is low (level of certainty B).

#### **4.7.2 Saleable Mineral Materials**

Saleable mineral materials in the region include sand and gravel, clay, sand, and peat. Sand and gravel are the most common resources in the San Luis Valley, and large quantities of these resources occur throughout Alamosa County. Sodium carbonate, sodium sulfate, and sodium chloride minerals occur in San Luis Lake, which is partially on state land; however, the deposits are small and are not economic to mine (Keller and Wray 2001). Most of the active mining permits near the Fourmile East SEZ are for sand and gravel mining and occur to the west and southwest of the SEZ in T37N, R10E and T38N, R10E; a peat mine is located a few miles to the southwest (in section 17 of T37N, R12E) (CDMG 2012c). There is a sand and gravel pit a few miles to the north of the SEZ (to the east of State Highway 150) (Patton 2009).

The Fourmile East SEZ is underlain by alluvial and basin-fill deposits and is, therefore, a high-potential area for sand and gravel deposits (level of certainty C). Past and ongoing small-scale mining of sand and gravel in the region indicates that the future extraction of such resources within the SEZ is viable. According to the LR2000, accessed on July 20, 2012, there currently are no free use permits or mineral materials contracts within the Fourmile East SEZ (BLM 2012).

#### **4.7.3 Leasable Minerals**

There are no known coal resources within the immediate region of the Fourmile East SEZ and no history of coal production in Alamosa County (most of the coal production occurs in northwest and west-central Colorado, with nearly half of the state's production coming from the Williams Fork Formation). The nearest coal fields are more than 100 mi (160 km) to the west and northwest in Gunnison, Delta, and Montrose Counties (Burnell et al. 2008; Kirschbaum and Biewick 2009).

The BLM San Luis Valley RMP (BLM 1991) describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence (Keller and Wray 2001)

(although Lexam Explorations, Inc., has proposed drilling two exploratory oil and gas wells in the Baca NWR, about 28 mi [45 km] to the north–northwest [USFWS 2011a,b]). There are no active oil or gas leases within the site. Eight oil and gas leases covered most of the site at one time, but these leases were closed in 1980s and 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development (GWCSWG 2007; INEEL 2003). However, most of the local geothermal resources are low-temperature springs in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located 10 mi (16 km) to the west of the SEZ (near Alamosa) and to the northwest (along Highway 17). According to the LR2000, accessed on July 20, 2012, there are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley (BLM 2012). The potential for development of geothermal energy within the SEZ is low (level of certainty B).

## 5 LOS MOGOTES EAST SEZ

### 5.1 SUMMARY AND CONCLUSIONS

This chapter assesses the mineral potential of 2,650 acres (10.7 km<sup>2</sup>) of public lands within an area known as the Los Mogotes East SEZ, located in Conejos County in south-central Colorado, about 3 mi (5 km) due west of Romeo. Alamosa is located about 22 mi (35 km) to the northeast.

There are no documented occurrences of locatable mineral deposits within the Los Mogotes East SEZ. Most of the locatable minerals in the region come from the Platoro-Summitville District, in the San Juan Mountains, to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above the Tertiary basalts of the Hinsdale Formation (along the eastern front of the San Juan Mountains) near the southwestern margin of the Alamosa Basin. Basin-fill sediments occur below the basalt and just beyond the eastern boundary of the SEZ. The thickness of these sediments below the SEZ is estimated to be about 2,400 ft (730 m). Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The Los Mogotes East SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit at or just below the surface (based on well logs). (Sand and gravel materials are deep beyond the eastern boundary of the site, which roughly coincides with the eastern extent of the basalt flow.) The site is a high-potential area for volcanic material such as crushed stone or scoria (level of certainty C). There are no free use permits or mineral materials contracts within the SEZ.

The BLM San Luis Valley RMP describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence. There are no active oil or gas leases within the site. Six oil and gas leases covered the site at one time, but these leases were closed in the late 1980s and early 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development. However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara. There are no active or historical geothermal leases within the Los Mogotes SEZ, and there are no nominated lands for geothermal sale in San Luis Valley. The potential for development of geothermal energy within the SEZ is low (level of certainty B).

## 5.2 LANDS INVOLVED

The Los Mogotes East SEZ is located on BLM lands in the San Luis Valley Resource Area (La Jara Field Office), in Conejos County. The site lies within T32N, R8E, sections 1, 12, 13, 24, and 25 (New Mexico Principal Meridian). The SEZ is shown on the location map in the back of this report (Map 4). The full legal description of the SEZ is provided in Appendix A.

## 5.3 LAND STATUS

According to the LR2000, accessed on July 20, 2012, there are no active or historical locatable mining claims within the Los Mogotes East SEZ (BLM 2012). The lands within the SEZ were first segregated from locatable mineral entry in June 2009, pending the outcome of the Draft Solar PEIS (BLM and DOE 2010). They are currently segregated under an Interim Temporary Final Rule, which is in effect until June 30, 2013 (76 FR 23198–23205).

There are no free use permits or mineral materials contracts within the SEZ (BLM 2012). The site remains open for the disposal of saleable mineral materials.

There are no active oil and gas leases within and around the SEZ; however, all of the site was leased for oil and gas in the past (six oil and gas leases covered the site but were closed in the late 1980s and early 1990s). There are no active or historical geothermal leases within the SEZ. The area remains open for discretionary leasing for oil and gas and other leasable minerals.

## 5.4 GEOLOGIC SETTING

The Los Mogotes East SEZ is located in the southern part of the San Luis Valley, an alluvial basin within the Southern Rocky Mountain physiographic province in south-central Colorado. The San Luis Valley is part of the San Luis Basin, an axial basin of the Rio Grande rift. The Rio Grande rift is a north-trending, tectonic feature that extends from south-central Colorado to northern Mexico. Basins in the rift zone generally follow the course of the Rio Grande and are bounded by normal faults that define the rift zone margins (Burroughs 1974, 1981; Emery 1979).

The San Luis Basin is an east-tilting half graben flanked by the San Juan Mountains to the west and the Sangre de Cristo Range to the east. It is generally divided into five physiographic subdivisions—the Alamosa Basin, the San Luis Hills, the Taos Plateau, the Costilla Plains, and the Culebra Reentrant (Figure 2). The Los Mogotes East SEZ sits above the Tertiary basalts of the Hinsdale Formation (along the eastern front of the San Juan Mountains) near the southwestern margin of the Alamosa Basin. The basalts of the Hinsdale Formation (Miocene) are associated with early rifting in the valley (about 27 million years ago) and covered ash-flow tuffs of the San Juan volcanic field along the western margin of the valley before the volcanic field was uplifted and eroded (Brister and Gries 1994). Basin-fill sediments occur below the basalt and just beyond the eastern border of the SEZ, thickening to the east.

Exposed sediments in the San Luis Valley consist mainly of modern alluvial deposits and the fluviolacustrine clays and sands of the Quaternary-Tertiary Alamosa Formation. Eolian deposits, such as those of the Great Sand Dunes National Monument, occur along the base of the Sangre de Cristo Mountains on the eastern side of the valley. The Rio Grande alluvial fan (at the base of the San Juan Mountains where the Rio Grande enters the valley) lies northwest of the town of Alamosa. The San Luis Hills, consisting of northeast-trending flat-topped mesas and irregular hills, are a prominent feature of the southern part of the valley. A good portion of southern San Luis Valley is covered by Tertiary basaltic lava flows of the Hinsdale and Servilleta Formations (Keller and Wray 2011). The geology of the San Luis Valley is shown in Figure 3.

## 5.5 PHYSICAL FEATURES AND ACCESS

The Los Mogotes East SEZ is about 17 mi (27 km) west of the Rio Grande. Its terrain is relatively flat with a gentle slope to the east. An unnamed drainage feature and its tributaries run from west to east across the southern portion of the site (sections 13, 14, and 25); the drainage discharges to an irrigation ditch (Romero Ditch) that serves croplands to the east. Elevations range from about 7,920 ft (2,414 m) at the site's southwestern corner to 7,710 ft (2,350 m) along its eastern boundary.

The overall character of the SEZ is rural and undeveloped. Access to the SEZ is via three county roads from U.S. 285.

## 5.6 SITE GEOLOGY

The geology of the Los Mogotes East SEZ is described based on the 1:500,000 scale geologic map by Tweto (1979) and the 1:250,000 scale geologic map by Steven et al. (1974) (Figure 8). The thicknesses of geologic units were inferred from a geologic cross section along a southeast–northwest transect, described by Thompson et al. (1991), that crosses the northern part of the SEZ. The thicknesses of surface sediments are based on logs of water wells drilled at the site (CDWR 2012b).

The SEZ sits above the Tertiary basalts of the Hinsdale Formation (along the eastern front of the San Juan Mountains) near the southwestern margin of the Alamosa Basin (well logs indicate that basalt is at or just below the surface). The basalts of the Hinsdale Formation (Miocene) are associated with early rifting in the valley (about 27 million years ago) and covered ash-flow tuffs of the San Juan volcanic field along the western margin of the valley before the volcanic field was uplifted and eroded (Brister and Gries 1994). Basin-fill sediments occur below the basalt and just beyond the eastern border of the SEZ, thickening to the east. The thickness of basin-fill sediments below the Los Mogotes East SEZ is estimated to be about 2,400 ft (730 m). At this depth, sediments overlie volcanic tuffs erupted during the waning stages of caldera-related magmatism in the San Juan volcanic field (Thompson et al. 1991).

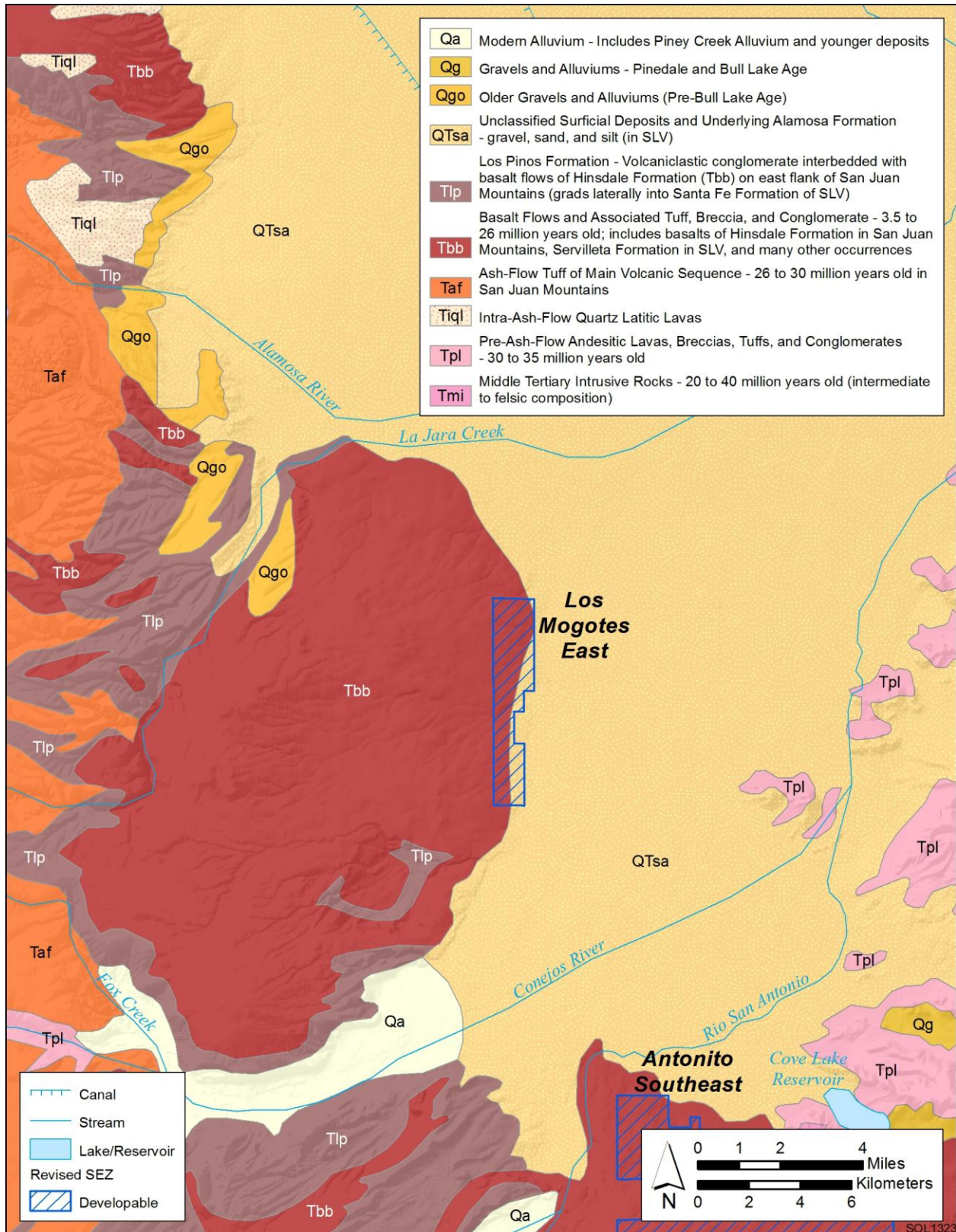


FIGURE 8 Geologic Map of the Los Mogotes East SEZ (Sources: Stoesser et al. 2007; Tweto 1979)

There are no perennial surface water features within the SEZ. Several ephemeral washes drain across the site from the San Juan Mountains to the west.

## 5.7 MINERAL HISTORY

There has been no documented mining within the Los Mogotes East SEZ. Activity in the immediate area has been limited to small-scale mining of industrial (saleable) minerals, including sand, gravel, and crushed stone, in the basin, and the mining of locatable minerals in the San Juan Mountains to the northwest (USGS 2011a). The nearest mining activity is a small sand and gravel pit just to the east of the SEZ (between the site and U.S. 285); other sand and gravel pits occur within a few miles to the southeast and east-southeast (Patton 2009). An active bentonite (clay) mine is in operation a few miles to the east (in section 8 of T32N, R11E) (CDMG 2012a). The King Turquoise Mine produces turquoise near the San Luis Hills, about 15 mi (24 km) to the east in section 22 of T34N, R11E (Morrone 2011; see Map 4).

Currently, no mineral exploration or development work is being conducted within the SEZ. There have been no reports of recent exploration or development activities in Conejos County.

### 5.7.1 Locatable Minerals

There are no documented occurrences of locatable mineral deposits or prospects within the Los Mogotes East SEZ, and there is little potential for such deposits in the San Luis Valley (BLM 2012; Keller and Wray 2001). Most of the locatable mineral deposits produced in the region come from the Platoro-Summitville District, in the San Juan Mountains, to the northwest (Figure 5). Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age (CGS 2011). Rift-related, brecciated fault zones along the east side of the valley (in Costilla County) host mineral deposits that were mined in the early 1900s; this area is currently being reclaimed (USGS 2011a; CGS 2011).

Mines and mineral prospects in the vicinity of the SEZ are shown on the detailed map provided in the back of this report (Map 4). The nearest documented occurrences of locatable minerals (copper, lead, silver, gold, zinc, molybdenum, asbestos, and aluminum) are in the Tertiary volcanic and intrusive rocks of the San Juan Mountains about 26 mi (42 km) to the northwest. These rocks (mainly tuffs) occur at depths greater than 2,000 ft (610 m) below the SEZ.

The Summitville, Jasper, Stunner, Axell, and Platoro mineralized areas (Platoro-Summitville District) have produced gold, silver, copper, lead, zinc, antimony, tellurium, aluminum, and molybdenum. According to the USGS MRDS, active mines in the district (Summit District, Summitville Mine, and Decatur NE District) currently produce copper, lead, silver, gold, zinc, molybdenum, asbestos, and aluminum (alunite). An underground turquoise mine (King Turquoise) is located on BLM public land southeast of the San Luis Hills (and



northeast of Piñon Hills), about 15 mi (24 km) to the east of the SEZ (in section 22 of T34N, R11E) (Morrone 2011; USGS 2011a). The mine occurs within an extensive area of intermediate volcanic rocks that have undergone hydrothermal alteration; it is the largest turquoise mine in Colorado (Keller and Wray 2001).

The Los Mogotes East SEZ crosses none of the mineralized areas or historical mining districts listed above, and there has been no hard rock or locatable mineral activity within the site. Most of the locatable minerals in the region come from the San Juan Mountains to the northwest. Mineral deposits in this area occur in veins, fracture zones, and breccias in quartz latite porphyry intrusives associated with the Summitville and Platoro calderas (San Juan Volcanic Field), resurgent volcanic centers of Tertiary age. The SEZ sits above the Tertiary basalts of the Hinsdale Formation (along the eastern front of the San Juan Mountains) near the southwestern margin of the Alamosa Basin. Basin-fill sediments occur below the basalt and just beyond the eastern boundary of the SEZ, thickening to the east. The thickness of these sediments below the Los Mogotes East SEZ is estimated to be about 2,400 ft (730 m). Therefore, the potential for locatable minerals to occur within the Los Mogotes East SEZ is low (level of certainty B).

### **5.7.2 Saleable Mineral Materials**

Saleable mineral materials in the region include sand, gravel, and scoria. Sand and gravel are the most common resources in the San Luis Valley, and large quantities of these resources occur throughout Conejos County; other types of volcanic rock (latite and andesite) have also been mined in the county. The shallow basalt in the region is considered by the CGS to be a viable source of crushed stone and riprap (Keller and Wray 2001).

The nearest mining activity is a small sand and gravel pit just to the east of the SEZ (between the site and U.S. 285); other sand and gravel pits occur within a few miles to the southeast and east-southeast (Patton 2009). There are also several active sand and gravel producers to the west, along the Colorado–New Mexico state line and in the Conejos River valley, and to the north near La Jara (CDMG 2012a).

The Los Mogotes East SEZ is an area with low potential for sand and gravel (level of certainty C). The site is underlain by a shallow basalt unit at or just below the surface (based on well logs). (Sand and gravel materials are deep beyond the eastern boundary of the site, which roughly coincides with the eastern extent of the basalt flow.) The site is a high-potential area for volcanic material, such as crushed stone or scoria (level of certainty C). According to the LR2000, accessed on July 20, 2012, there are no free use permits or mineral materials contracts within the Los Mogotes East SEZ (BLM 2012).

### **5.7.3 Leasable Minerals**

There are no known coal resources within the immediate region of the Los Mogotes East SEZ and no history of coal production in Conejos County (most of the coal production occurs in



northwest and west–central Colorado, with nearly half of the state’s production coming from the Williams Fork Formation). Coal-bearing units such as the Mesaverde Formation (Cretaceous) do not occur in Conejos County (Keller and Wray 2001). The nearest coal fields (which are not currently being mined) are more than 60 mi (100 km) to the east and northeast in Las Animas and Huerfano Counties (Burnell et al. 2008).

The BLM San Luis Valley RMP (BLM 1991) describes the San Luis Basin as having a low potential for oil and gas development. The CGS also rates state land tracts in the vicinity of the SEZ as having little or no potential for oil and gas occurrence (Keller and Wray 2001). There are no active oil or gas leases within the site. Six oil and gas leases covered the site at one time, but these leases were closed in the late 1980s and early 1990s. The potential for oil and gas development within the SEZ is low (level of certainty B).

The San Luis Basin is considered prospectively valuable for geothermal energy development (GWCSWG 2007; INEEL 2003). However, most of the local geothermal resources are low-temperature springs and wells in the range of 20 to 50°C (68 to 122°F), suitable for direct use, and are located to the north of La Jara (which is about 6 mi [10 km] northeast of the site). According to the LR2000, accessed on July 19, 2012, there are no active or historical geothermal leases within the SEZ, and there are no nominated lands for geothermal sale in San Luis Valley (BLM 2012). The potential for development of geothermal energy within the Los Mogotes East SEZ is low (level of certainty B).

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## 7 LIST OF PREPARERS

Table 2 lists the BLM management team members and technical reviewers for this assessment. Table 3 lists the names, education, and expertise of the report preparers.

**TABLE 2 BLM Management Team and Mineral Specialists Consulted**

Name	Office/Title
Linda Resseguie	Minerals and Realty Management Directorate, Realty Specialist
Shannon Stewart	Renewable Resources and Planning Directorate, Senior Planning and Environmental Analyst
Jeff Holdren	Division of Lands, Realty and Cadastral Survey, Senior Realty Specialist
Matt Shumaker	Division of Solid Minerals, Chief Mineral Examiner
Jason Powell	Division of Solid Minerals, Geologist
John Morrone	Colorado State Office, Geologist

**TABLE 3 Report Preparers**

Name	Education/Expertise	Contribution
Linda Graf	Desktop publishing specialist; 41 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Heidi Hartmann	M.S., Environmental Toxicology and Epidemiology; 25 years of experience in environmental assessment, exposure and risk analysis, and environmental impact assessment.	Solar PEIS Project Manager
Irene Hogstrom	M.A. Geography and Environmental Studies; B.L.A., Landscape Architecture; 23 years of experience in landscape architecture, including design, regional planning, and ecological restoration.	LR2000 queries
Patricia Hollopeter	B.A., Religion; M.A., Philosophy; 27 years of experience in technical editing and environmental assessment document production.	Editor
James E. May	M.S., Water Resources Management, B.A., Zoology; 34 years of experience in natural resources management; 8 years of consulting experience in resource management, land use planning, and NEPA compliance.	Lands and realty; and mineral review
Greg McGovern	M.S., B.S., Geology (Hydrogeology); 23 years of experience in environmental site assessment and contaminant fate and transport studies.	Site specific geology
Mary R. Moniger	B.A., English; 35 years of experience in editing and writing.	Lead editor
Michele Nelson	Graphic designer; 35 years of experience in graphical design and technical illustration	Report cover design and foldout map layout
Terri L. Patton	M.S., B.S., Geology (Igneous Petrology and Mineral Chemistry); 24 years of experience in environmental research and assessment.	Lead author; geology and mineral assessment
Kurt Picel	Ph.D., Environmental Health Sciences; 33 years of experience in environmental health analysis and 18 years in environmental assessment.	Environmental analysis and review
Lorenza Salinas	Desktop publishing specialist; 30 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production



**TABLE 3 (Cont.)**

Name	Education/Expertise	Contribution
Barbara Simmons	B.A., Technical Writing; E.L.S. certification by the Board of Editors in the Life Sciences; Fellow, Society for Technical Communication; 45 years of experience in technical editing and publications management.	Editor
Karen P. Smith	M.S., B.A., Geology; B.S., Anthropology; more than 23 years of experience in energy and environmental regulatory and policy analysis.	Solar PEIS Program Manager
Emily A. Zvolanek	B.A., Environmental Science; 4 years of experience in GIS mapping.	GIS mapping

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**APPENDIX A:**  
**LEGAL DESCRIPTIONS OF COLORADO SOLAR ENERGY ZONES**

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**APPENDIX A:****LEGAL DESCRIPTIONS OF COLORADO SOLAR ENERGY ZONES**

This appendix presents the legal descriptions for the four proposed SEZs in Colorado.

New Mexico Principal Meridian

**Antonito Southeast SEZ**

T. 32 N., R. 9 E.,  
 sec. 3, lot 4, SW<sup>1</sup>/<sub>4</sub>NW<sup>1</sup>/<sub>4</sub>, W<sup>1</sup>/<sub>2</sub>SW<sup>1</sup>/<sub>4</sub>, SE<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub>, SW<sup>1</sup>/<sub>4</sub>SE<sup>1</sup>/<sub>4</sub>, and E<sup>1</sup>/<sub>2</sub>SE<sup>1</sup>/<sub>4</sub>;  
 secs. 4, 9, 10, and 11;  
 sec. 12, W<sup>1</sup>/<sub>2</sub> and SE<sup>1</sup>/<sub>4</sub>;  
 secs. 13, 14, and 15;  
 sec. 21, lots 1 to 4, inclusive, and N<sup>1</sup>/<sub>2</sub>;  
 sec. 22, lots 1 to 4, inclusive, and N<sup>1</sup>/<sub>2</sub>;  
 sec. 23, lots 1 to 4, inclusive, and N<sup>1</sup>/<sub>2</sub>;  
 sec. 24, lots 1 to 4, inclusive, and N<sup>1</sup>/<sub>2</sub>.

T. 32 N., R. 10 E.,  
 sec. 7, lot 4, SE<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub>, and S<sup>1</sup>/<sub>2</sub>SE<sup>1</sup>/<sub>4</sub>;  
 sec. 8, S<sup>1</sup>/<sub>2</sub>S<sup>1</sup>/<sub>2</sub>;  
 sec. 9, SW<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub>;  
 secs. 17 and 18;  
 sec. 19, lots 1 to 6, inclusive, NE<sup>1</sup>/<sub>4</sub>, and E<sup>1</sup>/<sub>2</sub>NW<sup>1</sup>/<sub>4</sub>;  
 sec. 20, lots 1 to 4, inclusive, and N<sup>1</sup>/<sub>2</sub>;  
 sec. 21, lots 1 to 4, inclusive, W<sup>1</sup>/<sub>2</sub>NE<sup>1</sup>/<sub>4</sub>, and NW<sup>1</sup>/<sub>4</sub>.

The areas described above aggregate approximately 9,729 acres (39.4 km<sup>2</sup>).

**De Tilla Gulch SEZ**

T. 45 N., R. 9 E.,  
 sec. 29, that portion of the S<sup>1</sup>/<sub>2</sub> lying one-quarter mile southeasterly and parallel to the centerline of Highway 285;  
 sec. 30, that portion of the SE<sup>1</sup>/<sub>4</sub>SE<sup>1</sup>/<sub>4</sub> lying one-quarter mile southeasterly and parallel to the centerline of Highway 285;  
 sec. 31, those portions of the NE<sup>1</sup>/<sub>4</sub> and the SE<sup>1</sup>/<sub>4</sub>NW<sup>1</sup>/<sub>4</sub> lying one-quarter mile southeasterly and parallel to the centerline of Highway 285; and those portions of the NE<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub> and the N<sup>1</sup>/<sub>2</sub>SE<sup>1</sup>/<sub>4</sub> lying one-quarter mile north of and parallel to the centerline of the Old Spanish National Historic Trail as mapped by the National Park Service;  
 sec. 32, N<sup>1</sup>/<sub>2</sub>, and that portion of the N<sup>1</sup>/<sub>2</sub>SW<sup>1</sup>/<sub>4</sub>, lying one-quarter mile north of and parallel to the centerline of the Old Spanish National Historic Trail as mapped by the National Park Service;

sec. 33, N $\frac{1}{2}$ NE $\frac{1}{4}$  and NW $\frac{1}{4}$ .

The areas described above aggregate approximately 1,064 acres (4.3 km<sup>2</sup>).

### **Fourmile East SEZ**

T. 37 N., R. 12 E.,  
sec. 2, lots 3 and 4, and S $\frac{1}{2}$ NW $\frac{1}{4}$ ;  
sec. 3, lots 3 and 4, and S $\frac{1}{2}$ N $\frac{1}{2}$ .

T. 38 N., R. 12 E.,  
sec. 13, SW $\frac{1}{4}$  and W $\frac{1}{2}$ SE $\frac{1}{4}$ ;  
sec. 23;  
sec. 24, W $\frac{1}{2}$  and W $\frac{1}{2}$ SE $\frac{1}{4}$ ;  
sec. 25, W $\frac{1}{2}$ NE $\frac{1}{4}$  and W $\frac{1}{2}$ ;  
sec. 26;  
sec. 35, NW $\frac{1}{4}$ .

The areas described above aggregate approximately 2,883 acres (11.7 km<sup>2</sup>).

### **Los Mogotes East SEZ**

T. 34 N., R. 8 E.,  
sec. 1;  
sec. 12;  
sec. 13, NE $\frac{1}{4}$ NE $\frac{1}{4}$ , W $\frac{1}{2}$ NE $\frac{1}{4}$ , W $\frac{1}{2}$ , and NW $\frac{1}{4}$ SE $\frac{1}{4}$ ;  
sec. 24, W $\frac{1}{2}$  and W $\frac{1}{2}$ SE $\frac{1}{4}$ ;  
sec. 25, W $\frac{1}{2}$  and W $\frac{1}{2}$ E $\frac{1}{2}$ .

The areas described above aggregate approximately 2,650 acres (10.7 km<sup>2</sup>).