





NEVADA TEST AND TRAINING RANGE (NTTR)
Land Withdrawal Application Packages/
Case File and Legislative EIS

ENERGY AND MINERAL RESOURCE ASSESSMENT UPDATE NEVADA TEST AND TRAINING RANGE CLARK, NYE, AND LINCOLN COUNTIES, NEVADA

FINAL
April 2017

ENERGY AND MINERAL RESOURCE ASSESSMENT UPDATE

Nevada Test and Training Range
Clark, Nye, and Lincoln Counties, Nevada



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April 2017

EXECUTIVE SUMMARY

Introduction

This energy and mineral resource assessment supports Legislative Environmental Impact Statement (LEIS) for the land withdrawal extension and potential expansion at the Nevada Test and Training Range (NTTR), Nellis Air Force Base, in Clark, Nye, and Lincoln Counties, Nevada. In addition to the extension of the currently withdrawn lands in the NTTR, this Energy and Mineral Resource Assessment addresses additional lands that are proposed for withdrawal from public use (the expansion areas).

The expansion areas are intended to meet US Air Force's needs to increase combat operations testing and training capability, enhance irregular warfare testing and training capability, and increase NTTR operations security and safety. Several alternatives for expansion were identified by the USAF. This assessment addresses Alternative 3, which would withdraw additional land from public use to expand the boundaries of the NTTR. Alternative 3 includes the following areas:

- Alternative 3A: the EC South area
- Alternative 3B: the 64C/D and 65D area and the Administrative Incorporation Area
- Alternative 3C: the Alamo area

The NTTR and proposed expansion areas are shown on Figure ES.1.

This assessment had two objectives:

- To update the energy and mineral resource assessment of the existing NTTR
- To complete an energy and mineral resource assessment of the expansion areas

Three previous Energy and Mineral Resource Assessments have been completed on the NTTR and the Desert National Wildlife Refuge (DNWR): the 1993 Assessment, which included the East DNWR; the 1998 Assessment, which included the North and South Ranges of the NTTR and portions of the DNWR; and the 2014 Assessment, which updated the 1993 Assessment of the East DNWR. Previous assessment areas are shown on Figure ES.2. The 1993 and 2014 Assessments included portions of the expansion areas, including the Indian Springs Parcel in the 64C/D and 65D area, and the Alamo area.

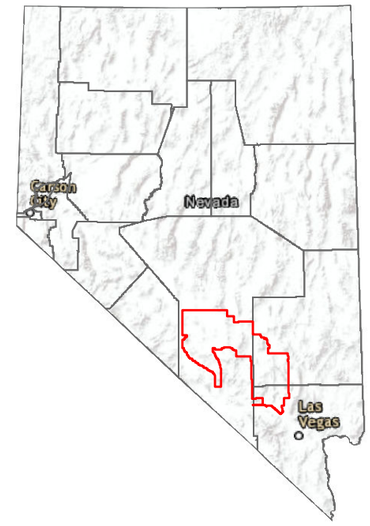
The primary assumption of this assessment is that the data presented in the previous assessments are valid and do not require duplication. Therefore, data collection was limited primarily to the proposed expansion areas and sites of interest identified in previous assessments. Field investigation methods identical to those used in previous assessments were adopted to ensure that data from the previous and current assessments could be integrated in a comprehensive assessment.

FIGURE ES.1
STUDY AREA

LEGEND

STUDY AREA

- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION
- INDIAN SPRINGS PARCEL



16 8 0 16
Kilometers

NTTR NORTH RANGE

NEVADA TEST AND TRAINING RANGE

NTTR SOUTH RANGE AND DESERT NATIONAL WILDLIFE REFUGE

Indian Springs Parcel

Nye

Clark

Lincoln

Alamo

Beatty

NEVADA

CALIFORNIA

266

267

374

95

375

318

93

373

160

156

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REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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SOURCES: ESRI, USGS, NOAA

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PROJECT
NEVADA TEST AND TRAINING RANGE
MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	ES.1

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TITLE

FIGURE ES.2
PREVIOUS ENERGY AND MINERAL RESOURCE ASSESSMENT STUDY AREAS

LEGEND

PREVIOUS STUDY AREA

- 1993 MINERAL ENERGY AND RESOURCE ASSESSMENT AND 2014 UPDATED ASSESSMENT
- 1998 MINERAL AND ENERGY RESOURCE ASSESSMENT

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

NTTR NORTH RANGE

North/South Range Boundary

NTTR SOUTH RANGE AND DESERT NATIONAL WILDLIFE REFUGE

EAST SECTION DESERT NATIONAL WILDLIFE REFUGE

Beatty

Alamo

Indian Springs

Nye County

Nevada Test and Training Range

Nellis Air Force Range

Nellis Air Force Base

Creech Air Force Base

Nellis Air Force Base Complex

Desert National Wildlife Refuge

Tonopah Test Range

Tonopah Test Range Airport

Nellis Auxiliary Airfield

Las Vegas

North Las Vegas

Jean

Sloan

Primm

Stateline

Pahrump

Death Valley Junction

Furnace Creek

Stovepipe Wells

Scotty's Castle

Saratoga Springs

Lathrop Wells

Amargosa Valley

Crystal Springs

Beatty Junction

Lida Junction

Oasis

Lida

Gold Point

Silver Peak

Esmeralda County

Nye County

Lincoln County

Clark County

Inyo County

Mono County

Tecopa Hot Springs

Tecopa

Shoshone

Death Valley National Park

Amargosa Desert

Amargosa Range

Bare Mountain

Specter Range

Pahrump Valley

Stonewall Mountain

Stonewall Flat

Sarcobatus Flat

Oasis Valley

Lida Valley

Gold Point Hills

Silver Peak Range

Silver Peak Marsh

Clayton Valley

Fish Lake Valley

Deep Springs Valley

Saline Valley

Eureka Valley

Panamint Valley

Panamint Range

Owlshead Mountains

Kingston Range

Resting Spring Range

Nopah Range

Salsberry Peak

Spring Mountains

Sheep Range

Desert Range

Las Vegas Range

Las Vegas Valley

Las Vegas Wash

Lake Mead National Recreation Area

Lake Mead

Lake Mohave

Lake Las Vegas

Lake Tonopah

Lake Meadow

Lake Manly

Lake Dunn

Lake Elsinore

Lake Cahuilla

Lake Tecopa

Lake Amargosa

Lake Manix

Lake Mojave

Lake Mojave Basin

Lake Mojave Valley

Lake Mojave Wash

Lake Mojave Flat

Lake Mojave Mountains

Lake Mojave Range

The comprehensive assessment includes advances in geologic understanding of selected deposits, changes in metal or commodity demand, and technological advances since the previous assessments.

The Mineral Potential Classification System used in this assessment is as defined in BLM Manual 3031 (BLM, 1985). In the classification system, mineral potential ranges from no potential to high potential with the certainty level that mineral potential does or does not exist ranging from highly uncertain (A) to highly certain (D).

Metallic Mineral Resources

The geochemical evaluation for metallic mineral resources followed the general structure of the 1998 Assessment and was conducted on two scales: the mining district scale, and the regional scale. All mining districts and prospect areas evaluated in the current and previous assessments are shown on Figure ES.3. The district scale evaluation was based on detailed field observations and geochemical data from samples collected from mineralized outcrops and pertains only to the expansion areas and sites of interest within the NTTR. The regional scale evaluation was based on a statistical analysis of geochemical data from previous and current field investigations.

This evaluation differed from the 1998 Assessment in two ways:

- In addition to a single-element anomaly evaluation, multivariate principal component analysis (PCA) was conducted to identify multi-element groups and assess metallic mineral potential
- Metallic resource potential was assessed for specific deposit types, rather than by individual commodity

The geochemical evaluation data from the previous and current assessments were combined into a single database. The database used for the PCA included analytical results from more than 2,400 samples. Additionally, an ArcGIS geodatabase was created, which integrated the geochemical database and pertinent geospatial information, including: the location of inferred buried plutons, geological, geophysical (gravity and magnetic), and structural data.

The results of this mineral resource assessment are, for the most part, consistent with the previous assessments. The district scale evaluation presented in the previous assessments remains essentially unchanged. Potential metallic mineral resource areas of interest are located primarily in the North Range of the NTTR in known mining districts. The 1998 Assessment reported potential sites of interest that could be worthy of exploratory drilling, with limited additional sampling and detailed geologic mapping. To date, no economically viable precious metal deposits have been identified in the study area.

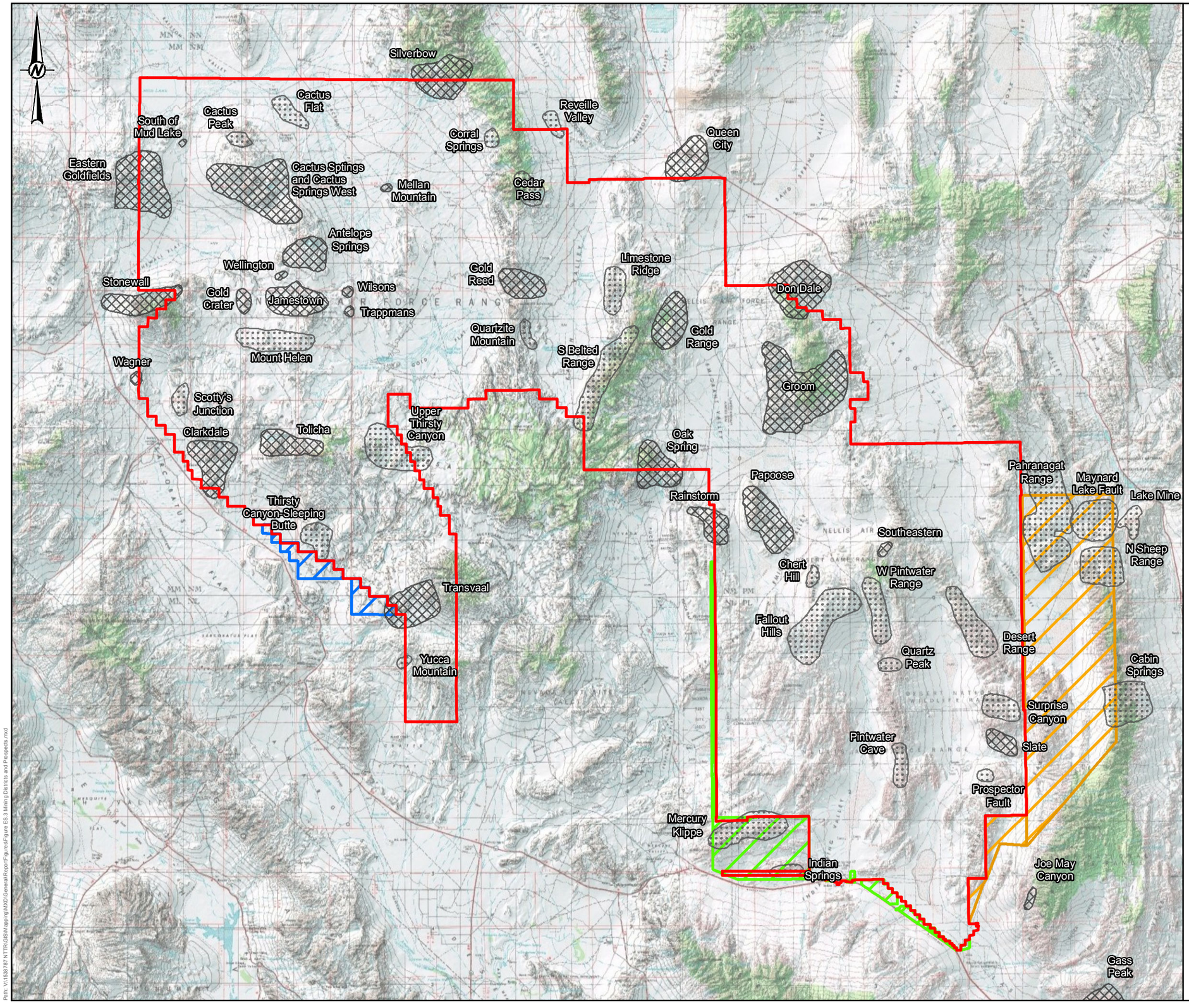


FIGURE ES.3
MINING DISTRICTS AND PROSPECT AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

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The current study focused on the identification of potential porphyry, epithermal, Carlin-type gold and regionally dolomitized carbonate replacement deposits. Based on the deposit-type assessment conducted for this study, base metal anomalies in the Cactus Springs West, Cactus Springs, Gold Crater, and Jamestown districts in the North Range appear to be associated with epithermal mineralization with possible links to copper/molybdenum porphyry mineralization at depth. The potential for porphyry mineralization at depth is supported by high porphyry mineralization factor scores, base metal geochemical anomalies in silt and float chip samples, high copper to zinc ratios in mineralized area samples, and interpreted/inferred granitoid plutons at depth. Moderate potential for porphyry mineralization was also indicated in the Gold Crater, Wagner and Tolicha mining districts in the North Range, and in the Papoose and Southeastern mining districts in the South Range.

A high potential for epithermal mineralization was identified in the Cactus Springs/Cactus Springs West (certainty level C), and the Silverbow and Wilsons mining districts (certainty level B). Moderate potential for epithermal systems (certainty level C) was identified in the Antelope Springs Mining District.

The single element and multivariate analyses identified high potential, certainty level B, for epithermal mineralization in the southern Belted Range prospect, an area that was not identified in previous assessments. High potential for epithermal mineralization, certainty level B, was also identified in the EC South area near the Transvaal mining district, and in the Papoose Mining District in the South Range.

A moderate potential for Carlin-type gold deposits (CTGD) was identified in the Southeastern Mining District in the South Range (certainty level B), in the 64CD/65D expansion area (certainty level B), and in the Alamo expansion area near Cabin Springs (certainty level C).

In the South Range, the potential for regionally dolomitized carbonate replacement deposits was indicated in the Southeastern Mining District, in Yellow Jacket Canyon, and in the Alamo area. Yellow Jacket Canyon is not in a known mining district, and was not previously identified. It was classified as having moderate potential, certainty level B, for regionally dolomitized carbonate base metal replacement deposits. To date, no economically viable base metal deposits have been identified in the study area.

Energy Resources

Geothermal

The study area is in the Great Basin, where the potential for geothermal resources is high relative to most of the contiguous US, but in an area of low heat flow relative to the Great Basin. As such, there is less potential for geothermal resources capable of power generation in the study area than other parts of the Great Basin. Several locations near the study area have low temperature thermal waters with direct uses (in pools and spas).

The geothermal resource assessment consisted of two parts: a review of previous assessments and field investigations of identified sites of interest. The review included compiling and analyzing the following datasets: geochemical and physical water parameters, faults and lineaments, strain rate, and temperature gradient to identify sites for field investigation. The field investigation recorded observations concerning the structural setting, recent fault activity, and presence or absence of hot-spring-related geologic materials (travertine, sinter, etc.).

The NTTR has relatively low potential for high temperature geothermal resources. The heat flow and strain rate within the NTTR are low compared to the rest of the Great Basin. No recent silicic intrusive bodies have been identified in the NTTR which would provide a shallow magmatic source of heat flow. The potential for deep stratigraphic geothermal systems in the carbonate basement rocks of the South Range is also considered low due to the relatively low heat flow in this part of the Great Basin.

The 1998 Assessment determined the potential for moderate- and high-temperature geothermal systems to be low, certainty level C, within the existing boundaries of the NTTR. Data compilations and regional studies published after the 1998 Assessment, along with the current field investigation, suggest no change to the geothermal resource potential of the NTTR is warranted.

The EC South area is considered to have moderate potential, certainty level B, for low temperature geothermal systems capable of direct-use applications. This assessment was based on the presence of the Beatty area geothermal cluster, and an existing direct use at the Bailey Hicks Hot Spring. The potential for high temperature geothermal resources in the EC South area is considered low, certainty level C.

The 64C/D and 65D area is underlain by Paleozoic sedimentary rocks with a relatively low heat gradient. The potential for high-temperature geothermal resources in the area is considered low, certainty level C. There is a low potential, certainty level B, for low temperature geothermal resources for direct use.

The Alamo area was updated in the 2014 Assessment; no change in geothermal potential resulted from this assessment. There is low potential for high-temperature geothermal systems, certainty level C, within the East DNWR and the Alamo area. There are a few occurrences of low temperature thermal waters near the Alamo area. As such, there is a low potential, certainty level B, for direct-use low-temperature geothermal resources

Oil and Gas

The NTTR and the DNWR were closed to mineral exploration in 1940 and 1936, respectively; these closures pre-date the majority of oil and gas exploration in Nevada. In previous assessments and in regional studies, the potential for oil and gas resources in the study area has been characterized as low. The primary Great Basin petroleum sources rocks are the shales of the Mississippian Chainman Formation (FM) and

Pilot FM. These organic-rich shales that are hydrocarbon source rocks elsewhere in the Great Basin are not known to occur in the study area, or do not occur in significant thickness. There is some potential for organic-rich shales in the Tikaboo Valley and Pahranagat Range areas, where both Chainman FM and Pilot FM shale facies may occur, and potential source rocks have not been heated to overmaturity. The potential for oil and gas resources in the Tikaboo/Pahranagat area is moderate, certainty level B. Elsewhere in the NTTR, the potential for oil and gas resources is low. Activities outside the scope of a mineral and energy resource assessment would be required to better define the potential for oil and gas resources in the Tikaboo/Pahranagat area.

The EC South area is dominated by Cenozoic ash-flow tuffs and other volcanic products. Mississippian carbonate rocks were not identified in the field investigation, nor were they mentioned in the literature. For this reason, EC South is considered to have low potential, certainty level C, for oil and gas resources.

The 64C/D and 65D area contains lithologies that have been identified as source rocks in other areas of the Great Basin; however, due to local metamorphism those rocks are not considered potential hosts. Samples were collected from several extensive carbonate units; however, none contained high levels of organic carbon. For these reasons, the 64C/D and 65D area is considered to have low potential, certainty level B, for oil and gas resources.

No change to the potential for the Alamo area (low, certainty level C) is warranted because no new site-specific information has been developed since the previous assessment.

Coal

Nevada, in general, is not known to contain economically viable coal deposits. No coal occurrences have been identified within the study area. This potential for coal in NTTR or the East DNWR remains low, certainty level D. The EC South area is considered to have low potential, certainty level D, as the geological environment is not suitable for coal formation, and no evidence of coal was observed in the field. The 64C/D and 65D area is considered to have low potential, certainty level D, as no coal was observed in the field. No change to the assessment for Alamo area is warranted as no new information was developed.

Uranium

In the previous and current assessments, uranium concentrations indicative of a significant occurrence were not identified in the study area. There are a number of geologic settings in the study area that are conducive to uranium deposits. The study area remains under-explored relative to uranium resources.

No change to the potential for uranium resources presented in the previous assessments is warranted. The 1993 Assessment assigned a low potential, certainty level D, for uranium resources in the East DNWR.

The 1998 Assessment assigned a low potential, certainty level B, to portions of the NTTR containing volcanic rocks and adjacent basins, and a low potential, certainty level C, to non-volcanic terranes.

The EC South area is considered to have low potential, certainty level B, because of the predominance of Cenozoic volcanic rocks.

Industrial Minerals

Industrial minerals and commodities that are potentially abundant in the study area include construction aggregate from both sand and gravel deposits and quarry sources. The value of on-range aggregate resources is limited under current conditions due to the distance to markets and associated transportation costs.

Cement limestone has a moderate potential to occur in the South Range and in the 64C/D and 65D area. However, there appear to be adequate resources for construction aggregate and cement manufacture in existing off-range sources for the foreseeable future.

Clays suitable for industrial uses are likely to be common in the North Range, where Cenozoic volcanic rocks predominate. Tertiary sedimentary rocks are not well explored within the study area. Tertiary lacustrine basins covered by younger volcanic rocks and quaternary alluvium have the potential to host valuable evaporite and clay deposits. Additional detailed geologic mapping and subsurface exploration would be required to define this potential.

Lithium was found in all study area playa sediments sampled in previous assessments. Comparison of study area playas to Clayton Valley, where lithium is currently recovered from brine, suggests less favorable conditions for lithium concentration in the study area. Further definition of the potential for exploitable lithium concentrations would require drilling and groundwater sampling.

Recommendations

Access to the NTTR and portions of the expansion areas was restricted for on-site field investigations. The 1998 Assessment presented an extensive list of recommendations for further geologic study. These recommendations included additional sampling, detailed geologic mapping in the select mining districts, and others sites where the potential for Carlin-type gold deposits has been inferred, geophysical studies and subsurface exploration. Further definition of energy and mineral resources would also require access for field investigations.

Much research has been conducted on blind geothermal resources; those where surface expressions of geothermal activity are lacking. The structural settings associated with blind geothermal systems can be identified on geologic maps or through field reconnaissance; however, field temperature probe surveys and

drilling would be required to confirm geothermal potential. These tasks are outside the scope of a mineral and energy resource assessment.

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Appendix A: Proposed Withdrawal and Renewal Area Legal Descriptions
Appendix B: Active Mining Claims
Appendix C: Geochemical Analytical Results
Appendix D: Geochemical Evaluation Data

List of Acronyms and Abbreviations

AIHA-LAP	American Industrial Hygiene Association - Laboratory Accreditation Program
AAS	Atomic Absorption Spectroscopy
Ag	Silver
ALS	ALS Global
amsl	above mean sea level
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
Au	Gold
BLM	Bureau of Land Management
˚C	degrees Celsius
CAI	conodont color alteration index
CaO	Calcium oxide
CFR	Code of Federal Regulations
CTGDs	Carlin-type gold deposits
Cu	Copper
DCM	DCM Science Laboratory Inc.
DNWR	Desert National Wildlife Refuge
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
Fe_2O_3	Ferric (iron) oxide
FM	Formation
Ga	billion years before present, giga annum
GIS	Geographical Information System
gpm	gallons per minute
GPS	global positioning system
GSC	geochemical sampling for lithologic characterization
Ha	hectare
Hg	Mercury
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
ICP-MS	Inductively coupled plasma mass spectroscopy
IEC	International Electrotechnical Commission
INAA	instrumental neutron activation analysis
ISO	International Organization for Standardization
K_2O	Potassium oxide
kg	kilogram
km	kilometer
km^2	square kilometer
lbs	Pounds
Leidos	Leidos, Inc.
LEIS	Legislative Environmental Impact Statement
LOI	Loss on ignition
LVSZ	Las Vegas Shear Zone
m	Meter
Ma	million years before present, mega-annum
MA	mineralized area
MLWA	Military Lands Withdrawal Act of 1999
mm	Millimeter
Mo	Molybdenum
mW/m^2	milliwats per square meter
Na_2O	Sodium oxide
NAFB	Nellis Air Force Base
NBMG	Nevada Bureau of Mines and Geology
NEPA	National Environmental Policy Act of 1969

NNSS	Nevada National Security Site (formerly the Nevada Test Site)
NTTR	Nevada Test and Training Range
NURE	National Uranium Resource Evaluation
oz	ounce
P_2O_5	Phosphorus pentoxide
Pb	Lead
PCA	principal component analysis
ppb	parts per billion
ppm	parts per million
QA/QC	Quality assurance and quality control
REE	rare earth elements
ROCK-EVAL	petroleum source rock analysis
SMU	Southern Methodist University
SNVF	Southwestern Nevada Volcanic Field
TCFZ	Thirsty Canyon Fault Zone
TOC	Total Organic Carbon
U_3O_8	Triuranium octoxide
UDH	Ultra-Deep Hydrocarbon
uS/cm	microSiemens per centimeter
USAF	United States Air Force
USC	United States Code
USEIA	US Energy Information Administration
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
W	Tungsten
WL	Walker Lane
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence
Zn	Zinc

1.0 INTRODUCTION

1.1 Purpose

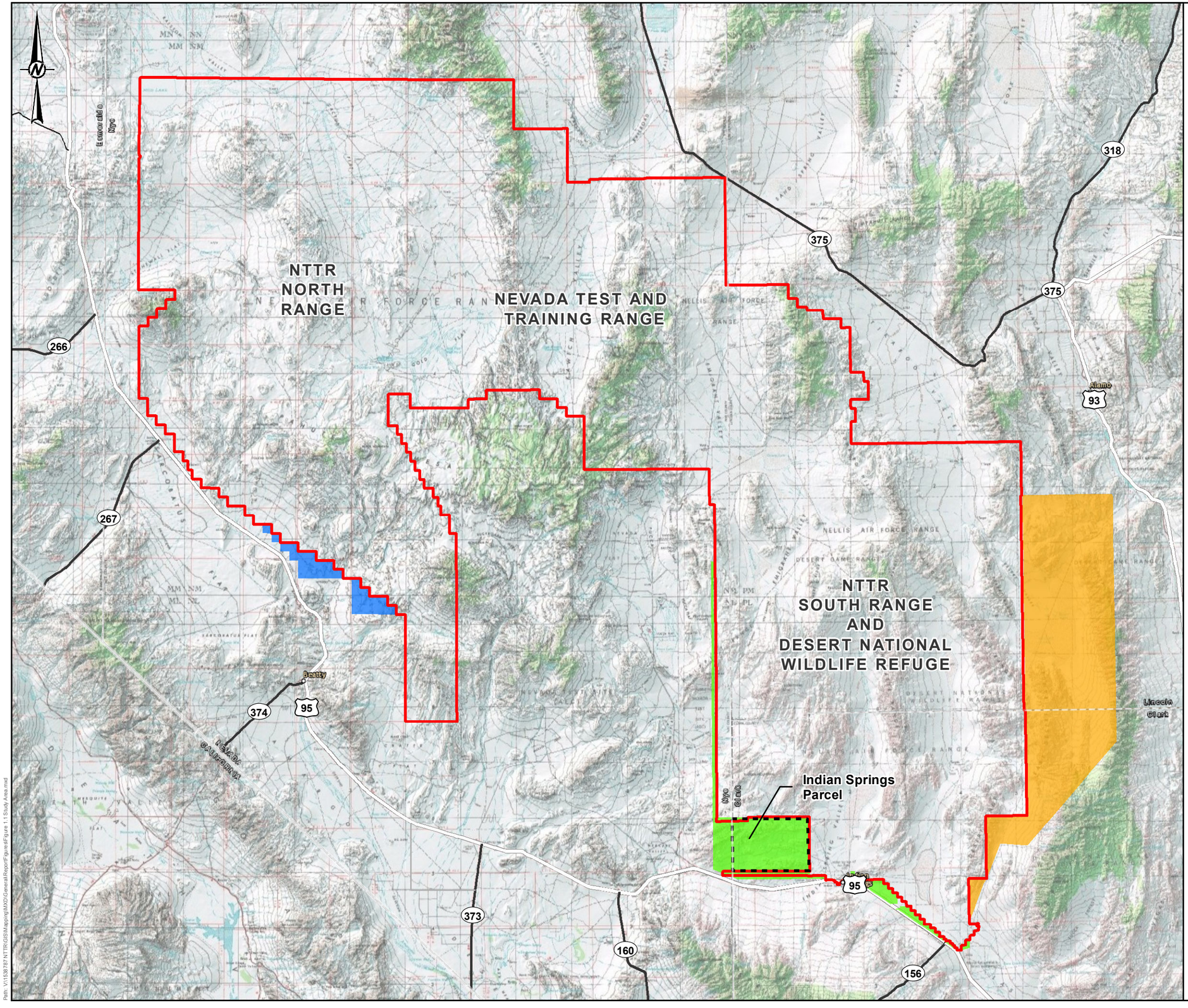
This energy and mineral resource assessment supports the Legislative Environmental Impact Statement (LEIS) for the land withdrawal extension and potential expansion at the Nevada Test and Training Range (NTTR), Nellis Air Force Base (NAFB), in Clark, Nye, and Lincoln counties, Nevada. The NTTR is part of the US Air Force's (USAF's) Major Range and Test Facility Base enterprise and currently encompasses an area of approximately 2.9 million acres (1.174 million hectares [Ha]) of land, 5,000 square nautical miles (17,200 square kilometers [km^2]) of airspace that is restricted from civilian air traffic, and another 7,000 square nautical miles (24,000 km^2) of Military Operations Area, which is shared with civilian aircraft. The 12,000-square-nautical mile (41,200 km^2) range provides a realistic arena for operational testing and training to improve combat readiness. A wide variety of live munitions can be employed on targets on the NTTR. The study area is shown on Figure 1.1.

The NTTR consists of federal land that has been withdrawn from public use and reserved for military training and operations through the *Military Lands Withdrawal Act of 1999*, Public Law 106-65 (MLWA). The current withdrawal will expire in November 2021 unless Congress enacts legislation to extend it. In accordance with Section 3016 of the MLWA, the USAF has notified Congress of a continuing military need for the NTTR withdrawal and intends to submit a legislative proposal through the Department of the Interior (DOI) to extend the withdrawal period. The *National Environmental Policy Act of 1969*, 42 United States Code (USC) Sections 4321-4370h (NEPA) requires agencies to include a LEIS with any proposal for legislation significantly affecting the quality of the human environment.

The USAF is considering expansion of the NTTR through acquisition of contiguous properties to expand operations and increase operational security. The USAF is developing the documentation required to support the Application Package, Case File, and legislative language to successfully accomplish the NTTR land withdrawal by November 2021. To maintain critical test and training capabilities at the NTTR, the USAF must complete all required studies in compliance with NEPA, the *Engle Act, Federal Land Policy and Management Act*, the MLWA, and Land Withdrawals regulations set forth in Title 43 Code of Federal Regulations (CFR) Part 2300. The analyses and results of this assessment are needed to comply with NEPA and Land Withdrawal regulations, and to support submittal of an application to Bureau of Land Management (BLM), a provision of a Case File to the DOI, and development of draft legislation for Congressional approval of the withdrawal in accordance with applicable rules and regulations.

As part of the LEIS process, the USAF proposed four action alternatives for the land withdrawal extension and expansion for the NTTR. These action alternatives are pre-decisional from a NEPA perspective. The action alternatives are as follows:

FIGURE 1.1
STUDY AREA



LEGEND

STUDY AREA

- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION
- INDIAN SPRINGS PARCEL



16 8 0 16
Kilometers

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REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED
SOURCES: ESRI, USGS, NOAA

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PROJECT
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MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 1.1 Study Area.mxd

- Alternative 1 – Extend Existing Land Withdrawal and Management of the NTTR (North and South Ranges) – Status Quo
- Alternative 2 – Extend Existing Land Withdrawal and Provide Ready Access in the North and South Ranges
- Alternative 3 – Expand Withdrawal of Public Lands for the NTTR
- Alternative 4 – Establish the Period of Withdrawal

Nevada Bureau of Mines and Geology (NBMG) personnel completed an energy and mineral assessment of the lands within the existing boundaries of the NTTR subject to the withdrawal extension (Tingley and others, 1998), as well as two assessments of the eastern section of the Desert National Wildlife Refuge (East DNWR) (Tingley and others, 1993, Muntean and others, 2014). Portions of the DNWR that are within the South Range of the NTTR and were included in the 1998 Assessment.

The primary, underlying assumption used in developing this current assessment was that the previous energy and mineral assessments do not require duplication as they relate to the existing boundaries of the North and South Ranges of the NTTR and the DNWR. The energy and mineral potential of all proposed expansion areas were assessed and results integrated into an area-wide energy and mineral resource assessment update of the NTTR. This comprehensive assessment addresses advances in geologic understanding of selected deposits, changes in metal or commodity demand, and technological advances since the previous assessments.

1.2 Report Organization

This report is organized as follows:

- Purpose and introduction to the study area (Section 1.0)
- Summary of previous assessments (Section 2.0)
- Current assessment methods of investigation (Section 3.0)
- Field investigation results (Section 4.0)
- Comprehensive energy and mineral resource potential assessment (Sections 5.0 through 10.0)

This report uses the International System of Units unless indicated otherwise.

1.3 Study Area

Figure 1.1 illustrates the study area considered in this energy and mineral resource assessment. Figure 1.2 illustrates primary land management responsibility of the study area. The study area includes the North and South ranges of the NTTR that were previously withdrawn and are being considered for extension (Alternatives 1 and 2) and the public lands now proposed for withdrawal to expand the operational area of the NTTR (Alternative 3).

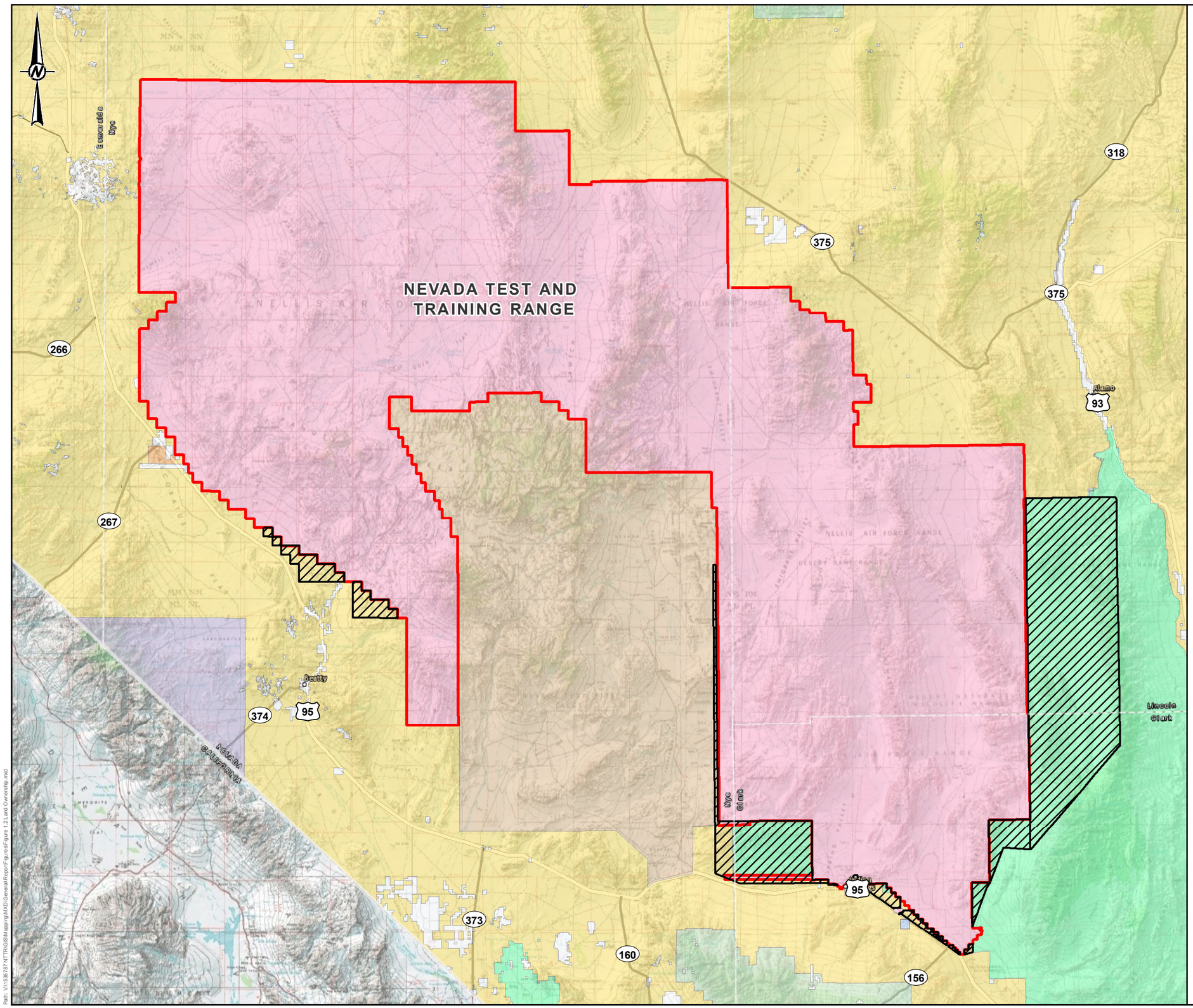


FIGURE 1.2
STUDY AREA PRIMARY LAND MANAGEMENT RESPONSIBILITY

LEGEND

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- PROPOSED EXPANSION AREA

LAND MANAGEMENT AGENCY
- BUREAU OF INDIAN AFFAIRS
- BUREAU OF LAND MANAGEMENT
- DEPARTMENT OF DEFENSE
- DEPARTMENT OF ENERGY
- FISH AND WILDLIFE SERVICE
- NATIONAL PARK SERVICE
- NEVADA STATE
- PRIVATE
- US FOREST SERVICE

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM 2015, USDA FARM SERVICE AGENCY (FSA). IMAGE TAKEN 5-27-2015.
LAND OWNERSHIP: SURFACE MANAGEMENT AGENCY (SMA) DATASET, BUREAU OF LAND MANAGEMENT NEVADA. PUBLISHED 3-10-2016.

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The DNWR lies partially within the boundaries of the South Range of the NTTR. The expansion areas are primarily along the south boundaries of the North and South ranges and adjacent to the east boundary of the South Range within the East DNWR.

Alternative 3 addresses the USAF's needs to increase Major Combat Operations test/training capability, enhance Irregular Warfare test/training capability, and increase NTTR operation security and safety. Alternative 3 would withdraw land from public use to expand the boundaries of the NTTR, and includes three basic areas:

- **Alternative 3A – the EC (Electric Combat) South area:** It increases the NTTR by approximately 18,000 acres (7,000 Ha) along the south boundary of the North Range, located to the north and northeast of Beatty, Nevada.
- **Alternative 3B – Enhanced Operation Security and Safety; the 64C/D and 65D Area and Administrative Incorporation:** The NTTR would be increased by approximately 57,000 acres (23,000 Ha) along the southeastern boundary of the South Range, consisting of the following two areas:
  - **The 64C/D and 65D area:** Approximately 50,000 acres (20,000 Ha) along the southern border of the South Range would be withdrawn, as well as 6,000 acres (2,518 Ha) that are parallel to the existing South Range's southern boundary and Highway 95. The 64C/D and 65/D area includes the Indian Springs Parcel.
  - **Administrative Incorporation:** Approximately 1,000 acres (400 Ha) that were analyzed but not included in the legal land description of the 1999 land withdrawal.
- **Alternative 3C – the Alamo area:** It increases the NTTR area by approximately 227,000 acres (91,890 Ha) of the East DNWR to correspond with potential weapons safety footprints associated with South Range target areas

These lands are collectively referred to as the expansion areas. Legal descriptions of the expansion areas are in Appendix A. Portions of the proposed expansion areas were not subject to previous assessments. Expansion areas not previously evaluated include:

- The EC South 3A area
- Lands to the south and west of the Indian Springs Parcel in the 64C/D and 65D area.

The Indian Springs Parcel in the 64C/D and 65D area and the Alamo area were evaluated in the 1993 and 2014 assessments (Figure 1.1).

1.4 Requirements for Energy and Mineral Resource Assessments

The requirements of an energy and mineral resource assessment on lands administered by the BLM are defined in BLM Manuals 3031 (BLM, 1985) and 3060 (BLM, 1994). The BLM requirements also apply to lands under the jurisdiction of the United States Fish and Wildlife Service (USFWS). Some changes to the BLM reporting format were made due to the complexities of the withdrawal status and the study area. The study area includes previously withdrawn lands and some of the expansion areas that have been previously investigated through the previously completed energy and mineral resource assessments (Tingley and

others, 1993, 1998; Muntean and others, 2014). The results of previous assessments are incorporated in this assessment.

The Mineral Potential Classification System used in this assessment is as defined in BLM Manual 3031 (BLM, 1985):

- Level of Potential
  - O = No Potential: The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral or energy resources.
  - L = Low potential: The geologic environment and inferred geologic processes indicate a low potential for accumulation of mineral resources.
  - M = Moderate potential: The geologic environment, the inferred geologic processes, and the reported mineral or energy occurrences or valid geochemical/geophysical anomaly indicate moderate potential for the accumulation of mineral resources.
  - H = High potential: The geologic environment, inferred geologic processes, the reported mineral or energy occurrences and/or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for the accumulation of mineral or energy resources. The “known mines and deposits” do not have to be in the area that is being classified, but have to be within the same type of geologic environment.
  - ND = Potential not determined: Mineral and energy resource potential not determined due to a lack of useful data. This notation does not require a level-of-certainty qualifier.
- Level of certainty
  - A = The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral or energy resources within the respective area.
  - B = The available data provide indirect evidence to support or refute the possible existence of mineral or energy resources.
  - C = The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral or energy resources.
  - D = The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral and energy resources.

The mineral potential classification system is shown in tabular form in Table 1.1.

Table 1.1: Mineral Potential Classification System

Increasing Potential >>	ND Unknown Potential	H/B High Potential	H/C High Potential	H/D High Potential	O/D No Potential [1]
		M/B Moderate Potential	M/C Moderate Potential	M/D Moderate Potential	
		L/B Low Potential	L/C Low Potential	L/D Low Potential	
	Increasing Certainty >>				

Notes:
Source - Based on BLM Manual 3031 (1985), Illustration 3
1 - Not commonly used and only in special circumstances

The Mineral Potential Classification System addresses the potential for the presence or occurrence of a mineral concentration. The classification system does not require an estimate of the economic significance or the commercial viability of the concentration. It should be noted that the BLM uses the shortened term "mineral potential" to include both mineral and energy resource potential.

1.5 Physiographic Setting

The study area's major physiographic features are shown on Figure 1.3. The study area is in the southern part of the Great Basin sub-province of the Basin and Range physiographic province. The Great Basin forms the widest segment of the vast Basin and Range province, which extends approximately 1,553 miles (2,500 kilometers [km]) north to south, from the Pacific Northwest of the US to central Mexico, and east to west, from the Colorado Plateau to the Sierra Nevada Mountains. The Great Basin sub-province occupies a 375- by 375-mile (600- by 600-km) tract, which predominantly lies within the state of Nevada. Within the study area, this region is characterized by generally north-trending mountain ranges separated by alluvial valleys.

Thirteen named mountain ranges and one mesa are partially or fully within the existing NTTR boundaries (Figure 1.3). Alternative 3C, the Alamo area, in the East DNWR, includes one other named mountain range, the Sheep Range. Elevation across the study area varies from a low of 908 meters (m) above mean seal level (amsl) along the southeast boundary to a high of 2,886 m amsl on Bald Mountain in the Groom Range. The higher mountains are generally located east and northeast of Pahute Mesa. Pahute Mesa, a volcanic plateau in the southwestern portion of the North Range, is the most laterally extensive geomorphic feature on the NTTR. The mesa varies from 30 to 40 km wide. Its high point is Tolicha Peak at 2,150 m amsl. The primary mountain ranges northeast of Pahute Mesa are the Kawich, Belted, and Groom ranges. Minor mountain ranges north of Pahute Mesa include the Stonewall and Cactus ranges.

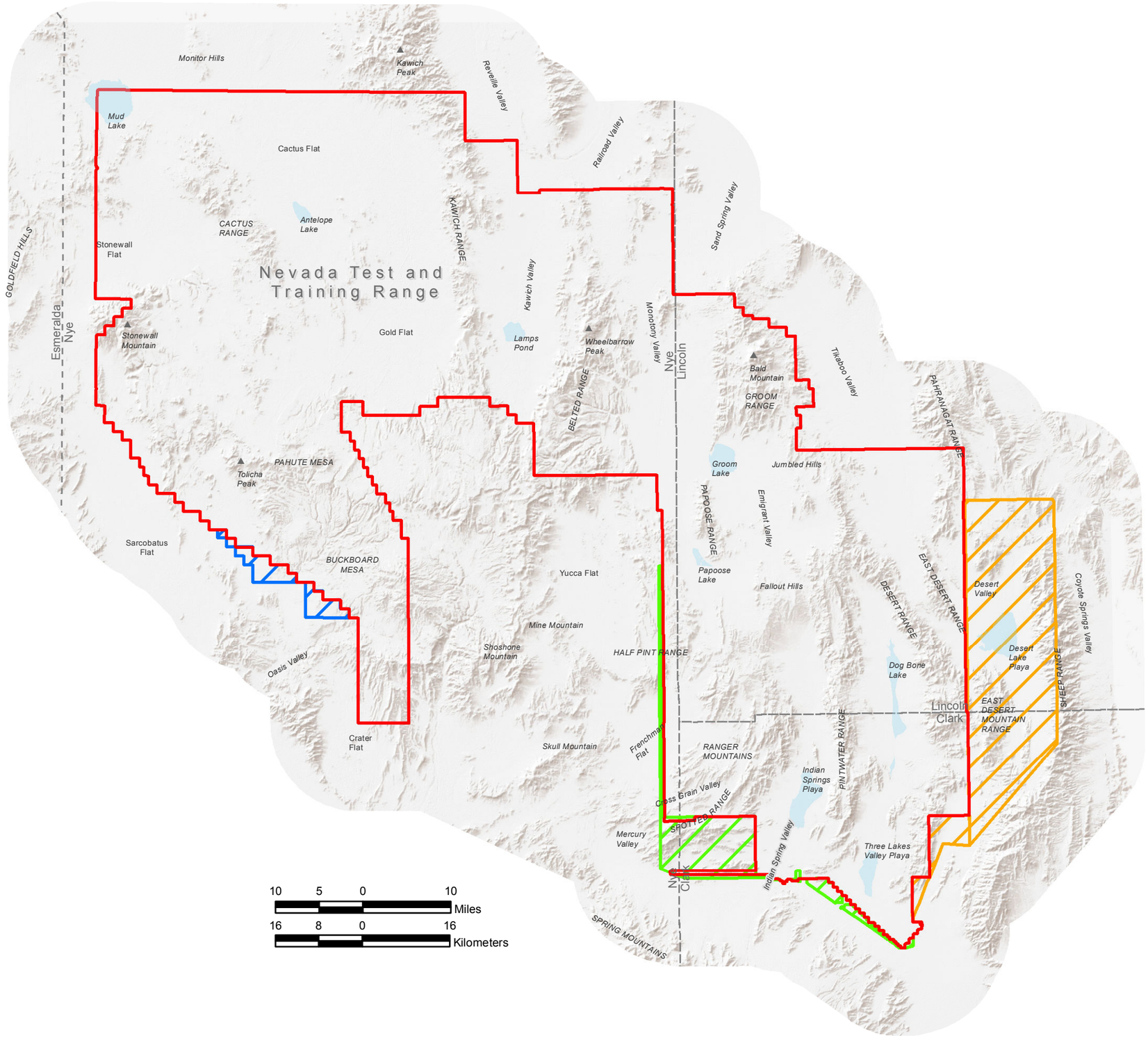


FIGURE 1.3
STUDY AREA PHYSIOGRAPHIC MAP

LEGEND

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION



NOTES

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REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 1.3 Physiographic Map.mxd

The primary mountains to the southeast of Pahute Mesa are the Spotted, Pintwater, and Desert ranges. Besides the aforementioned Bald Mountain, notable peaks include Wheelbarrow Peak in the Belted Range (2,586 m amsl) and Kawich Peak in the Kawich Range (2,865 m amsl). In the South Range, the higher peaks in the Spotted, Pintwater, and Desert ranges are generally less than 2,000 m amsl, with the exception of one unnamed peak in the Desert Range at 2,119 m amsl. Mountain ranges in the Alamo area are generally higher than 2,000 m amsl, with the East Desert Range at 2,152 m amsl, and a portion of the Sheep Range at 2,488 m amsl.

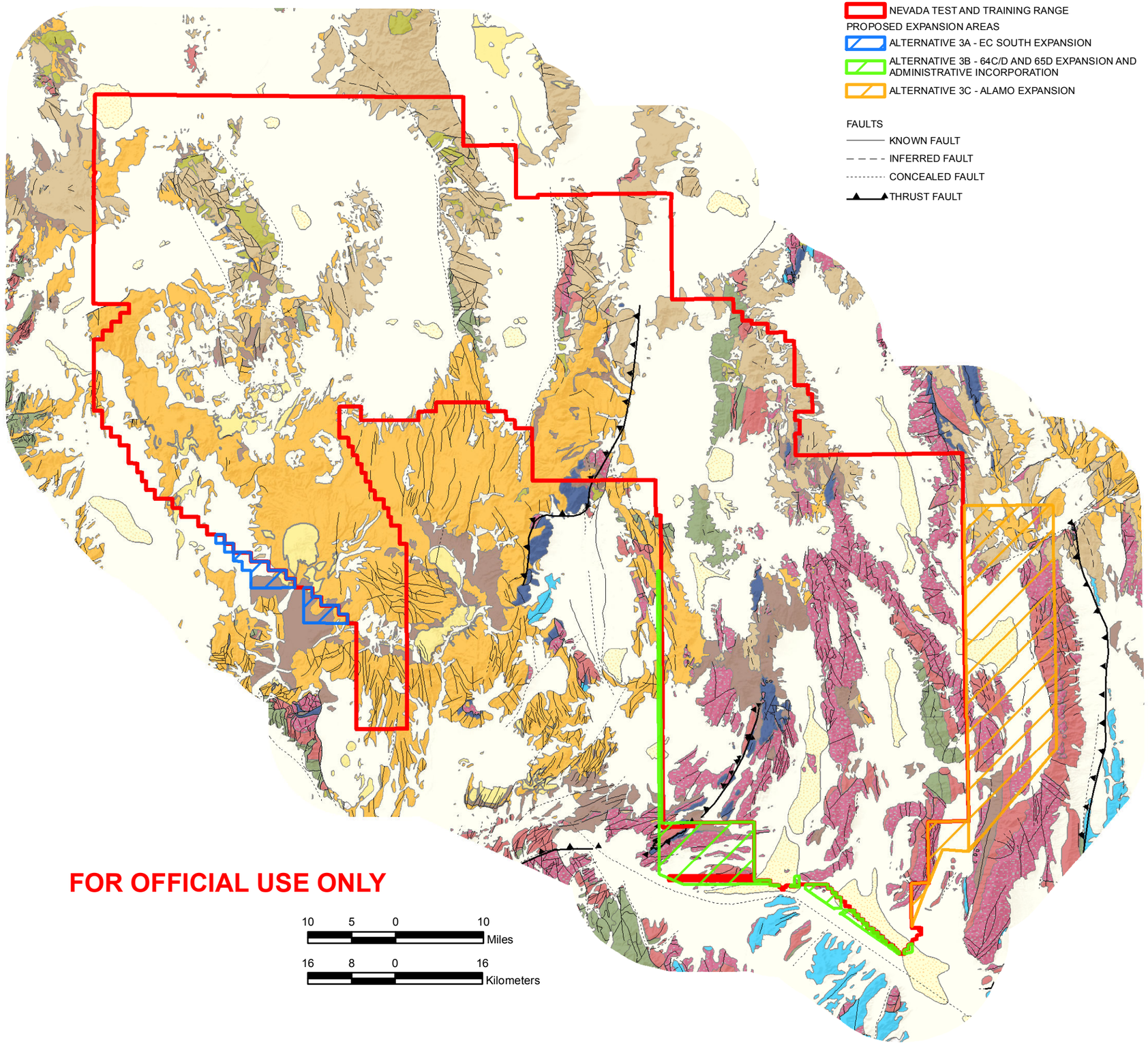
Most of the Great Basin, as the name reflects, is an area of internal drainage. That is, the surface runoff does not report to rivers that eventually report to the ocean. Instead, water is captured in basins and only discharges to groundwater or to the atmosphere via evaporation. Within the NTTR, there are two exceptions. A small part on the southeastern corner of the NTTR that reports to the Las Vegas Wash, and in the northeastern section of the Alamo area, where the boundary crosses to the east side of the Sheep Mountains, the drainages flow into the Coyote Springs Valley and Pahranagat Wash, which discharge to Lake Mead.

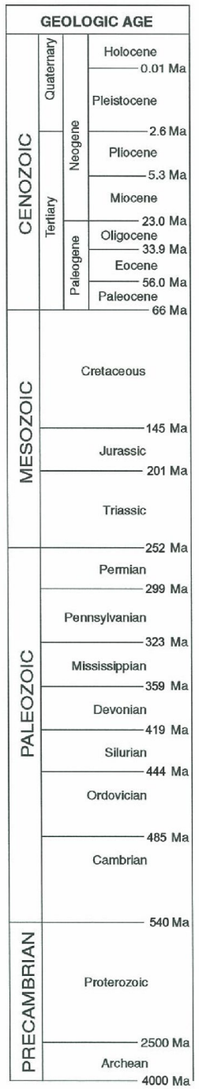
The majority of surface water runoff within the study area reports to eight primary playa lakes within, or mostly within, the NTTR boundary (Figure 1.3). These include: Mud Lake, Antelope Lake, and Lambs Pond in the North Range of the NTTR, and Groom Lake, Papoose Lake, Three Lakes Valley Playa, Dog Bone Lake and the Indian Springs Playa in the South Range. The Alamo area has one playa, the Desert Lake Playa. Though the lakes have seasonal surface water, none of the lakes have permanent surface water. Drainages from the Stonewall Mountains and Pahute Mesa flow west and southwest, off the NTTR, into the Sarcobatus Flat and Amargosa Desert. Drainages from the higher mountains in the central and eastern parts of the NTTR flow into closed valleys with playa lakes. These include Cactus Flat, Gold Flat, Kawich Valley, Monotany Valley, Emigrant Valley, Indian Springs Valley, and Three Lakes Valley (Tingley and others, 1998).

1.6 Geologic Setting

A generalized geologic map of the study area is shown in Figure 1.4. The NTTR and East DNWR are in the southern portion of the Great Basin geologic province, a sub-province of the Basin and Range that is defined by internally drained basins. Outcrops in the North Range are composed primarily of volcanic rocks of late Cenozoic age. Outcrops in the South Range and the East DNWR are composed largely of Paleozoic sedimentary rocks. Rocks of the NTTR and the East DNWR were deformed by folding and thrusting during the Mesozoic and by normal and strike-slip faulting during the Cenozoic. Figure 1.5 illustrates major structural features of the study area. The following discussion of the regional geologic and structural setting is organized chronologically.

FIGURE 1.4
GENERALIZED GEOLOGIC MAP OF THE NTTR AND VICINITY





GEOLOGY

Quaternary alluvial deposits
Includes minor amounts of sand dunes, landslides, colluvium, and talus.

Quaternary playa deposits

Tertiary and Quaternary Basalt Flows and Related Rocks
Mostly younger than 17 Ma.

Miocene - Silicic Volcanic
Minor andesite.

Oligocene - Early Miocene - Silicic Volcanics
Lesser amounts of andesite or basalt.

Late Tertiary (?) and Cretaceous sedimentary rocks
Includes older pre-volcanic coarse fluvial units and mainly mid-Miocene and younger bedded and nonwelded tuff and tuffaceous sedimentary rocks (including caldera moat fill).

Tertiary and Mesozoic silicic and intermediate intrusive rocks
Includes plutonic, subvolcanic, and volcanic units.

Pennsylvanian and Permian marine shelf carbonate and siliciclastic rocks
Includes Bird Springs Formation and Tippipah Limestone.

Upper Devonian and Mississipian marine limestone, shale, and conglomerate
Carbonate shelf and silliciclastic foredeep basin deposits. Includes Chainman Shale, Monte Cristo Limestone, and Eleana Formation.

Ordovician to Devonian miogeoclinal rocks of the carbonate shelf
Includes Pogonip Group, Simonson and Sevy Dolomites, Guilmette Formation, Ely Springs Dolomite, Eureka Quartzite, and Laketown Dolomite.

Cambrian to Lower Ordovician continental-margin carbonate platform deposits
Mainly carbonate rocks and minor shale. Includes Nopah, Bonanza King, and Carrara Formations, and Dunderberg Shale.

Late Proterozoic and Lower Cambrian terrigenous detrital sequence; shallow marine quartzite with lesser siltstone, argillite, and phyllite
Includes Sterling and Zabriskie Quartzites, Wood Canyon and Johnnie Formations. Also includes an area in the Trappman Hills of mostly weakly foliated, coarse-grained granite of unknown age with inclusions and small pendants of schists.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
GEOLOGY: CRAFFORD, E., GEOLOGIC MAP OF NEVADA, U.S. GEOLOGICAL SURVEY DATA SERIES 249. A DIGITAL CONODONT DATABASE OF NEVADA. PUBLISHED 2007.

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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 1.4 Generalized Geologic Map of the NTTR and Vicinity.mxd

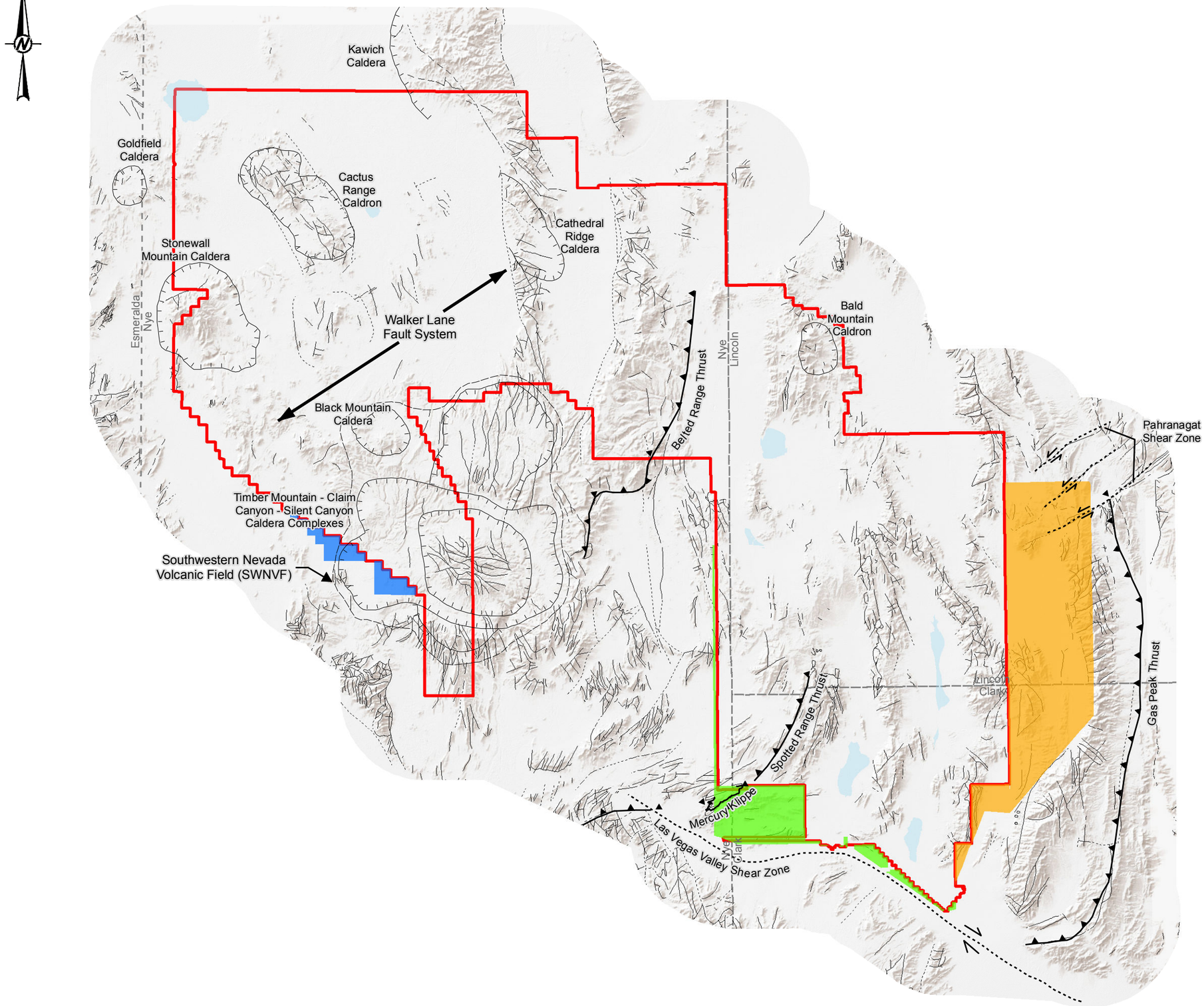


FIGURE 1.5
TECTONIC MAP OF THE NTTR AND VICINITY

LEGEND

- CALDERA BOUNDARY
- THRUST FAULT
- FAULT

STUDY

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
MAJOR GEOLOGIC STRUCTURES:TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
FAULTS: CRAFFORD, E. GEOLOGIC MAP OF NEVADA. U.S. GEOLOGICAL SURVEY DATA SERIES 249, 2007.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787 NTTR\GIS\Mapping\MXD\GeneralReport\Figure#Figure 1.5 Tectonic Map.mxd

1.6.1 Precambrian

The Precambrian in the study area is characterized by the accretion of continental crust followed by rifting, and subsequent deposition along a passive continental shelf. Descriptions of the tectonic setting, structures, the lithology, and stratigraphy are presented below.

1.6.1.1 Precambrian Tectonics and Structures

The Precambrian basement rocks in the study area consist of continental crust of the Proterozoic Mojave Province (Mueller and others, 2011). The Mojave Province was accreted along the southern fringe of Laurentia 2.5 to 1.6 billion years ago (Ga) from a postulated subduction zone southeast of the Great Basin province. The location of the transition from the Proterozoic Mojave province to the more mature Archean crust is not well defined in the central Great Basin due to the extensive cover of younger materials. This suture zone may extend into the northern portion of the study area where the basement rocks may consist of mixed Proterozoic and Archean terrains.

Although the vast majority of Precambrian basement rocks and accompanying structures in the study area are covered by younger sedimentary and volcanic rocks, they likely have a strong influence on later tectonism and ore-bearing igneous activity in the study area (Sims and others, 2005). There are two main sets of structures that resulted from Proterozoic rifting that have had continued influence on tectogenesis and metallogenesis. These structures abruptly formed after consolidation of the protocontinent (1.76 to 1.70 Ga), and probably represent initial lithospheric fragmentation that eventually led to continental separation in the latest Proterozoic time, that is, the postulated breakup of Rodinia. The two fracture systems are generally northwest-striking transcurrent faults, formed by continent-scale transpressional deformation, and northeast-striking ductile shears (Sims and others, 2005). The rifting resulted in the formation of a passive continental margin that delineated the Cordilleran miogeocline, along which passive margin sedimentation continued until Mid- to Late-Devonian time (Dickenson, 2006).

1.6.1.2 Precambrian Lithology and Stratigraphy

With the exception of the gneiss and schist of the Trappman Hills, exposures of crystalline Precambrian basement rocks do not occur in the NTTR (Ekren and others, 1971). Isotopic dating has not been performed on the crystalline rocks of the Trappman Hills, but given their location in the North Range, these rocks may belong to the Proterozoic Mojave province or are Archean in age. The central and southern portions of the study area are thought to have Mojave province basement rocks. Basement rocks from the Archean craton are typically more mature continental-type rocks (higher in silica). The Proterozoic Mojave province is typically composed of a mixture of more juvenile accreted terrains, such as submarine volcanic arc deposits (i.e., metamorphosed greywackes), and mature continental crust (i.e., granitic plutons).

Rifting during the Neoproterozoic resulted in the formation of basins and eventually a passive margin in which shallow marine siliciclastic rocks were deposited in a miogeoclinal belt (shelf province) of the

858 geocline. These Neoproterozoic rocks, which include the Johnnie Formation (FM), are found in the southern
859 areas of the NTTR and constitute the oldest sedimentary rocks in the study area. Deposition of these
860 formations extended into the Early Cambrian.

861 ### *1.6.2 Paleozoic*

862 The Paleozoic in the study area is summarized by thick depositional accumulations along a passive
863 continental margin, followed by tectonic activity that mainly affected areas north of the NTTR, followed by
864 a return to a passive continental margin environment.

865 #### 1.6.2.1 Paleozoic Tectonics and Structures

866 The Antler Orogeny was the first and only Paleozoic-age tectonic event to affect the study area and vicinity.
867 The Antler Orogeny marks the change from a passive to active continental margin along the west coast of
868 North America. All of the structures associated with the Late Devonian-Early Mississippian Antler Orogeny,
869 including the Roberts Mountain thrust/allochthon, the primary Antler structure, are north of the NTTR. The
870 Antler Orogeny resulted in the formation of a broad highland from southwestern to northern Nevada. The
871 NTTR is east of this broad highland, in the foreland basin. Although no thrust faults of Antler age have been
872 identified in the study area, the effects of the orogeny are evident in the NTTR as a marked change from
873 carbonate deposits to clastic deposits (Workman and others, 2002).

874 #### 1.6.2.2 Paleozoic Lithology and Stratigraphy

875 The southern portion of the study area is dominated by thick sequences of predominantly Paleozoic
876 carbonate rocks deposited along a passive continental margin (Figure 1.4). After the Middle Cambrian, a
877 carbonate shelf developed and thousands of meters of marine carbonate rocks and minor shale were
878 deposited (Guth and others, 1988). Deposition continued relatively uninterrupted during the Early Paleozoic
879 until the end of the Devonian, when the Late Devonian/Early Mississippian Antler Orogeny resulted in the
880 formation of a broad highland from southwestern to northern Nevada. Siliciclastic sediments were shed
881 east from the Antler highland, a north striking belt, into a foreland basin (Stewart, 1980). In the NTTR, the
882 Antler foreland basin deposits are represented by the Pilot Shale, the Chainman Shale, and the Eleana FM.
883 By Pennsylvanian time, deposition of carbonate rocks was reestablished and continued through the end of
884 the Paleozoic era.

885 ### *1.6.3 Mesozoic*

886 The Mesozoic in the study area was marked with the continued deposition of carbonate rocks. Active
887 contractual deformation due to eastward convergence along the western margin of North America started
888 effecting the study area during the Mesozoic, but the timing is poorly constrained. This tectonism resulted
889 in thrust faulting, folding, and the eventual emplacement of plutons.

1.6.3.1 Mesozoic Tectonic Features

The western margin of North America underwent near-continuous eastward convergence from the Early Mesozoic to the end of the Oligocene (Engebretson and others, 1985). Mesozoic structures were the earliest found on the NTTR. All of these structures are a result of compressional tectonism associated with the Cordilleran fold and thrust belt. Three orogenic belts related to the continued active continental margin west of NTTR have been identified. These orogenic belts include: the Death Valley thrust belt (Snow, 1992), Sevier orogenic belt (Armstrong, 1968; Fleck, 1970), and the Central Nevada thrust belt (Taylor and others, 1993). All of the Mesozoic structures on the NTTR are a result of one orogenic event, the Death Valley thrust belt (Workman and others, 2002); although the Gass Peak thrust, which is related to the Sevier orogeny, is hypothesized to underlie the East DNWR (Guth, 1990).

The Belted and Spotted range thrust faults (Figure 1.5) are the two most prominent Mesozoic structures in the study area (Cole and Cashman, 1999). The Belted Range thrust fault is exposed in the eastern portion of the North Range and has a stratigraphic throw of 7 km. It juxtaposes rocks of the Late Proterozoic age over Mississippian rocks. The Spotted Range thrust fault, and its' associated Mercury Klippe are exposed in the South Range of the NTTR and in the Alternative 3B 64C/D and 65D area. The structure clearly indicates south-southeast movement of the hanging wall (Cole and Cashman, 1999). The Spotted Range thrust fault juxtaposes Cambrian rocks in the upper plate against Devonian and Mississippian rocks in the lower plate. Most of the folding of Paleozoic rocks in the study area is a result of Mesozoic compressional tectonics. Mesozoic structures are not exposed in most of the North Range of the NTTR because of thick Cenozoic-age cover.

1.6.3.2 Mesozoic Lithology and Stratigraphy

The Mesozoic lithology and stratigraphy of the NTTR recorded the change from a passive to active continental margin. Rocks of the Triassic and Jurassic Periods are not exposed in the NTTR. It is not clear if formations from this time were eroded away due to uplift and erosion or they were simply not deposited (Barker, 1994). The Cretaceous was a time of magmatic activity and high heat flow (Cornwall, 1972; Frizzell and others, 1990). This activity likely enhanced uplift and erosion (Barker, 1994). A regional unconformity between the middle Mesozoic to middle Cenozoic suggests little topographic relief was present during this time (Vandervoort and Schmitt, 1990). Nonmarine fluvial conglomerates and sandstones were deposited during the Late Cretaceous and Early Tertiary. These units are exposed in the Fallout Hills/Buried Hills/northern Spotted Range region (Figure 1.3). Granitic plutonism was widespread in western Nevada and California due to an extensive magmatic arc along the western continental margin. Exposures of granitic plutons are relatively rare in the study area, although they may be concealed by younger rocks. Most of the plutons on the NTTR are thought to be Cretaceous in age.

The location of exposed Cretaceous plutons (or thought to be Cretaceous age) on the NTTR include:

- Oak Springs region of the southern Belted Range
- Southern Kawich Range
- South of Urania Peak in the Cactus Range

1.6.4 Cenozoic

The earliest Cenozoic in the study area was relatively tranquil with no magmatic activity and low topographic relief. The magmatic arc affecting the study area during the Cretaceous migrated eastward, leaving the study area a highland shedding sediment to the east. During the Oligocene, the volcanic arc migrated back (westward) into the study area, renewing magmatic activity. The predominantly siliceous volcanism and profound extensional tectonism continued from Late Oligocene into the Neogene. Minor basaltic volcanic activity continued into the Holocene. Extensional tectonism, though minor in comparison to Oligocene and Neogene time, is still occurring.

1.6.4.1 Cenozoic Tectonic Features

A Cenozoic regime of extensional tectonism created the Great Basin as an internally drained tract of mountainous topography broken by sediment-filled valleys (Dickenson, 2006). In the study area, two successive phases of extensional deformation related to different geodynamic settings can be distinguished. The phases include the development of low angle detachment faults (e.g., metamorphic core complexes) and basin-and-range extensional tectonism.

1.6.4.1.1 Detachment Faults

The development of detachment faults is interpreted to be a result of crustal extension during the Early to Middle Tertiary from rising asthenosphere and re-steepening of the subducting Farrallon slab along western North America (Burchfiel and others, 1992; Christiansen and Yeats, 1992; Lipman, 1992). In the Great Basin, detachment faulting typically occurred in the wake of extensional siliceous volcanism that swept southward from Eocene time in Idaho to Oligocene time in Nevada. The Fluorspar Canyon-Bullfrog Hills detachment fault system, in the Bare Mountains near Beatty, is much younger, at approximately 20 million years before present (Ma), and is likely related to super-extension linked to dextral strike-slip along en echelon, subparallel strands of the Walker Lane (WL) fault system (Dickenson, 2006). Normal faulting related to this detachment system propagated into the southwestern edge of the North Range of the NTTR, into the Transvaal Hills region (Fridrich and others, 1999), and the EC South area (Figure 1.5). Additionally, the Sheep Range detachment fault system (Miocene age) is inferred to accommodate east-to-west extension in the South Range of the NTTR and the East DNWR (Guth, 1990). This detachment fault system may have reactivated the upper decollement of the Gass Peak thrust. Extensional faults associated with the Sheep Range detachment fault system are typically downdropped to the west. Additional detachment faults may have accommodated extensional tectonism in the study area, but they have yet to be recognized.

1.6.4.1.2 Basin-and-Range Tectonism

Classic basin-and-range deformation is typified by block faulting. The Basin and Range province was initiated in early Miocene time (approximately 17.5 Ma) after the San Andreas transform system was established in California as the boundary between the Pacific and North American lithospheric plates (Dickenson, 1997). Before that time, the two regional plates were shielded by oceanic microplates. In the Southern Great Basin, early phases of extension are believed to have been episodic (Best and Christiansen, 1991). High angle basin-and-range normal faulting in the study area began between 17 and 14 Ma (Ekren, 1968). Two major pulses of normal faulting and tilting took place at approximately 12.7 and 7.6 Ma in the area to the southeast, south, southwest, and west of the Timber Mountain caldera complex (Figure 1.5) (Carr and others, 1988; Carr, 1990; Noble and others, 1991; Minor and others, 1993; Sawyer and others, 1994). Normal faults of late Quaternary age are known to exist on the NTTR (Frizzell and others, 1990), indicating that extensional tectonism is still affecting the region.

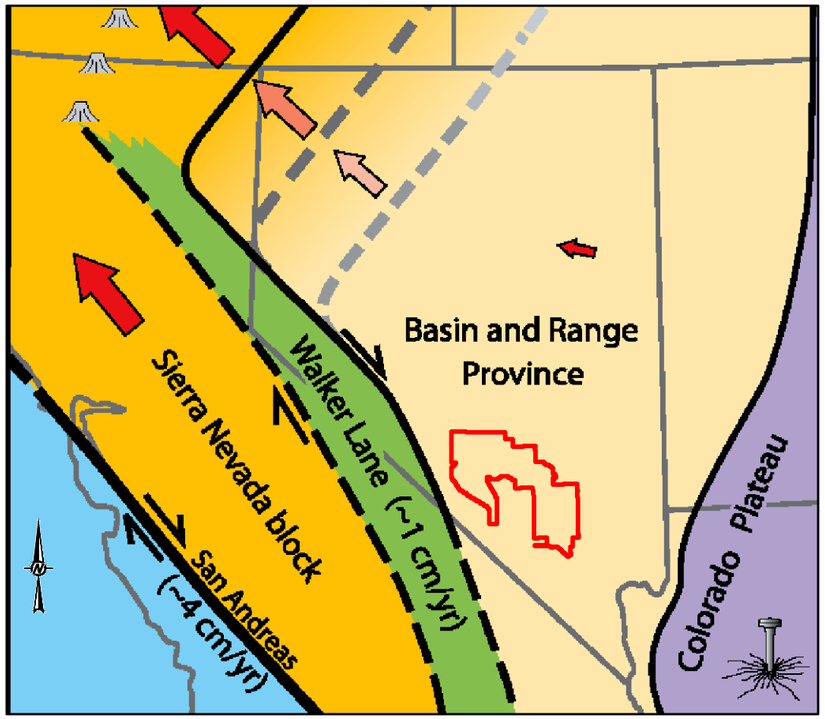
In addition to the classic basin-and-range block faulting, major strike-slip faulting associated with basin--and-range tectonism are present in the study area. The majority of the strike-slip faulting is thought to be related to the development of the WL fault system (Figure 1.6), an incipient dextral transform fault system along the evolving Pacific–North American plate boundary (Faulds and Henry, 2008). The WL fault system is a 700-km-long, northwest to north-northwest trending belt of valleys and ranges along the Nevada-California border that is dominated by strike-slip faults (Stewart, 1988; Stewart and Crowell, 1992). Deformation associated with the WL fault system extends from the Sierra Nevada into the study area to the Kawich Range (Figure 1.5). Global positioning system (GPS) geodetic strain rates currently indicate up to approximately 10 millimeters (mm) per year of dextral movement across the WL fault system (Kreemer and others, 2012) near the study area. The spatial and temporal evolution of the WL fault system is closely linked to major plate boundary events along the San Andreas Fault system. Unlike the San Andreas Fault, which is transpressional, the WL fault system consists of transtensional faults (see Figure 1.6).

The first major deformational event along the WL fault zone occurred approximately 13 Ma, along the Las Vegas Shear Zone (LVSZ) (Figure 1.5). This shear zone developed parallel to plate motions and east of where the San Andreas system initially organized into a through-going structure. The LVSZ accommodated approximately 60 km of dextral slip from approximately 13 to 6 Ma. According to Barnes and others (1982), dextral displacement along the LVSZ caused the north-to-south oriented mountain ranges (i.e., Sheep and Spotted ranges) near the LVSZ to rotate clockwise. An alternate interpretation to the clockwise rotation of these ranges is provided by Cole and Cashman (1999), who believe that the clockwise rotation is a remnant of the original orientation of thrust-sheet emplacement during Mesozoic age compressional tectonics.

FIGURE 1.6
GENERALIZED BLOCK MODEL OF TRANSTENSION AND TRANSPRESSION STRIKE-SLIP FAULT

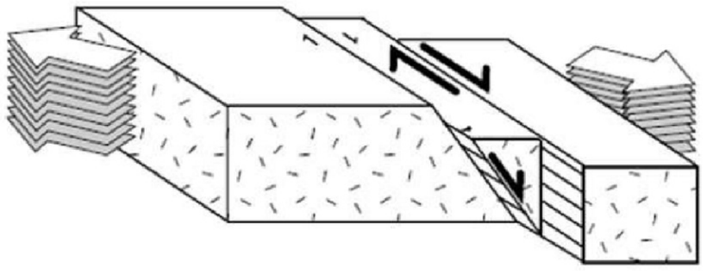
LEGEND

NEVADA TEST AND TRAINING RANGE

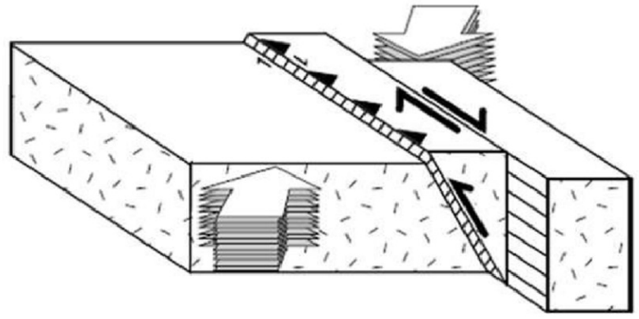


GENERALIZED CARTOON OF WALKER LANE FROM (FAULDS AND HENRY, 2008).

TRANSTENSION - WALKER LANE



TRANSPRESSION - SAN ANDREAS



THE OBLIQUE COMPONENT OF DISPLACEMENT ALONG THE TRANSTENSIONAL AND TRANSPRESSIONAL STRIKE-SLIP SYSTEMS OF THE WALKER LANE AND SAN ANDREAS FAULT SYSTEM, RESPECTIVELY, IS COMMONLY TAKEN UP LOCALLY ON NORMAL AND OBLIQUE DIP-SLIP FAULTS WHICH TRENDS PARALLEL TO THE MAIN ZONES OF SHEAR (WESNOUSKY, 2005).

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COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 1.6 Strike and Slip System.mxd

Changes in plate motion between 11 and 6 Ma resulted in the formation of dextral shear in the WL fault zone and a cessation of strike-slip movement along the LVSZ. Overall, the WL fault zone is slowly fragmenting the western margin of North America and transferring large slices of the continent to the Pacific plate.

Another prominent Cenozoic structure, the Pahranagat shear zone, cuts east-west across the northern portion of the South Range (Figure 1.5). This shear zone is approximately 20 to 25 km wide and is composed of three major sinistral strike-slip faults. More typical Cenozoic high angle normal faults are truncated by this shear zone, which has accumulated up to 40 km of offset since 14 to 18 Ma (Hudson and others, 1998). The Pahranagat shear zone is believed to act as a transfer/accommodation zone, providing a kinematic connection between the Wasatch fault zone and the WL fault zone (Kreemer and others, 2010).

1.6.4.2 Cenozoic Lithology and Stratigraphy

In the North Range, the pre-Cenozoic sedimentary and metamorphic rocks are unconformably overlain by volcanic and subvolcanic rocks of Tertiary age. These rocks are part of a broad zone of middle Tertiary volcanic rocks that extend across the Cordillera from Mexico's Sierra Madre Occidental to Oregon (Best and others, 2013). The vast majority of the volcanic rocks in the study area are rhyolitic ash-flow tuffs of Oligocene and Miocene age. These volcanic tuffs make up nearly all of the exposed bedrock in the North Range (Figure 1.4). Cenozoic volcanic rocks are present in only a few locations in the South Range and in the East DNWR.

The Oligocene-Miocene ash-flow tuffs comprise regionally extensive sheet-shaped deposits, tens to hundreds of meters thick, which cover areas more than 100 km from their vent areas. For the most part, the ash-flow tuffs lie unconformably on Late Proterozoic and early Paleozoic marine sedimentary rocks. In some locations, the volcanic rocks lie on clastic rocks of probable Late Cretaceous to early Tertiary age (Ekren and others, 1971; Stewart, 1980).

Two general groups of volcanic rocks are recognized: 1) an older, late Oligocene/early Miocene sequence of ash-flow tuffs and related lavas from volcanic centers within and to the north of the NTTR (Ekren and others, 1971; Best and others, 1989), and 2) a younger sequence of middle and late Miocene ash-flow tuffs and lavas from volcanic centers of the Southwestern Nevada Volcanic Field (SNVF). The SNVF extends from Stonewall Mountain on the north to Yucca Mountain on the south (Sawyer and others, 1994). It includes the Timber Mountain Caldera Complex, Black Mountain caldera, and the Silent Canyon Caldera Complex. The Timber Mountain Caldera Complex includes the Thirsty Canyon, Claim Canyon, Ammonia Tanks, and Rainier Mesa calderas (Figure 1.5).

The older, Oligocene/early Miocene units are the predominant volcanic units in the North Range of the NTTR. The Monotony Tuff (27.8 Ma) is the oldest extensive ash-flow tuff. Other regionally extensive ash-

flow tuffs include, from older to younger, the tuffs of Antelope Springs (27.7 Ma), the Shingle Pass Tuff (25.4 Ma), the Pahranagat FM (22.6 Ma), and the Fraction Tuff, which correlates with the 18.3 Ma intracaldera tuff of Cathedral Ridge caldera (Ekren and others, 1971).

The younger, middle to late Miocene SNVF units in the southern part of the North Range overlie pre-Cenozoic rocks and, in some places, the Oligocene/early Miocene volcanic units. The SNVF is a classic example of a silicic multicaldera volcanic field with more than six major calderas formed between approximately 15 and 7.5 Ma. The major units of this volcanic series were erupted between 15 and 10 Ma from overlapping and nested calderas in the Timber Mountain region. Volcanic units originating from the Timber Mountain region include, from oldest to youngest, the Belted Range Group, the tuff of the Tolicha Peak, the Paintbrush Group, and the Timber Mountain Group (Byers and others, 1976; Noble and others, 1991; Sawyer and others, 1994). Peak volcanism in the SNVF occurred during eruption of the Paintbrush and Timber Mountain Groups, when over 4,500 cubic kilometers of predominantly volcanic ash was erupted in two episodes. The center of volcanism switched from the Timber Mountain region to the Black Mountain and Stonewall Mountain regions between 9.5 and 7.5 Ma. The major volcanic units erupted from this new volcanic center include the Thirsty Canyon Group and the Stonewall Flat Tuff (Noble and others, 1991; Sawyer and others, 1994).

In addition to the extensive ash-flow deposits in the North Range of the NTTR, relatively minor amounts of rhyolitic, andesitic, and basaltic lavas, and intracaldera sedimentary units are present. The caldera volcanism was episodic with widespread ash-flow sheets erupted within 100- to 300 thousand year time spans, and pre- and post-caldera lavas erupted within 100 to 300 thousand years of the associated ash flows. Volcanism in the SNVF coincided with peak Great Basin extensional deformation in the Miocene; however, there was less extensional deformation in the SNVF than elsewhere in WL fault zone (Sawyer and others, 1994).

Lacustrine and fluvial units were deposited in shallow basins produced by the middle to late Tertiary extension. These sedimentary rocks included bedded tuffs, lacustrine limestones and shales, and volcanic sandstone (Figure 1.3). These units outcrop in several areas with the larger deposits found in the Spotted Range, Pintwater Range, and the Desert Range (Guth and others, 1988; Barnes and others, 1982).

Quaternary units in the NTTR occur over approximately one-half of the land surface (Figure 1.4). These units consist predominantly of alluvium and colluvium, as well as minor eolian, lacustrine (playa lakes), and streambed deposits.

1.7 Active Mining Claims

The BLM LR2000 database contains one mining claim within the proposed expansion areas (Appendix B). The previously withdrawn NTTR and East DNWR have been closed to mineral location and the mineral

rights were acquired by NAFB and the USFWS. The EC South area, portions of the 64C/D and 65D area, and the Administrative Incorporation area are administered by the BLM and are currently open to mineral location.

2.0 PREVIOUS ASSESSMENTS

In 1993, NBMG personnel (Tingley and others, 1993) completed the *Energy and Mineral Resource Assessment of the Desert National Wildlife Refuge, Eastern Section* (the 1993 Assessment). The East DNWR does not overlap the existing NTTR boundaries; however, the 1993 Assessment did include the Alamo area and portions of the 64C/D and 65D area (Figure 2.1).

In 1997, the NBMG and TRC Mariah Associates published the *Mineral and Energy Resource Assessment of the Nellis Air Force Range, U.S. Air Force Combat Command, Clark, Lincoln and Nye Counties, Nevada*. This report was later released by the NBMG as Open-File Report 98-1 (Tingley and others, 1998 [the 1998 Assessment]). The report included the North and South ranges of the NTTR and those portions of the DNWR within the existing boundaries of the South Range (Figure 2.1).

Both the 1993 and 1998 assessments evaluated the following:

- Background concentrations for metals of interest
- Remote sensing imagery and geophysical data to guide the field investigation and understand subsurface conditions
- Stream sediment samples to explore widespread and remote areas of anomalous metal concentrations
- Mineralized outcrops, altered rocks, and mine dump samples collected from known mining districts
- Sources of anomalies
- Precious and base metal mineral potential
- Oil, gas, geothermal resources, leasable commodities, and industrial minerals

In 2014 the NBMG issued *An Updated Mineral and Energy Resource Assessment of the Desert National Wildlife Range, Clark and Lincoln Counties, Nevada* (Muntean and others, 2014) (the 2014 Assessment), which included the East DNWR (Figure 2.1). Portions of the 64C/D and 65D area were also evaluated with the East DNWR in the 1993 and 2014 Assessments.

The 2014 Assessment was an update of the 1993 Assessment, and included the following:

- Reanalysis of selected mineralized area (MA) samples collected during the 1993 Assessment
- Collection of additional samples from selected sites
- Review of the potential for Carlin-type gold deposits (CTGDs)
- Consideration of the potential for buried porphyry deposits within the East DNWR
- Re-evaluation of geothermal resources based on the current understanding of their occurrence
- Additional consideration of lithium due to its current importance in industry
- A review of the availability of industrial minerals in southern Nevada and the impacts of the continued withdrawal of industrial materials within the boundaries of the DNWR

TITLE

FIGURE 2.1
PREVIOUS ENERGY AND MINERAL RESOURCE ASSESSMENT STUDY AREAS

LEGEND

PREVIOUS STUDY AREA

- 1993 MINERAL ENERGY AND RESOURCE ASSESSMENT AND 2014 UPDATED ASSESSMENT
- 1998 MINERAL AND ENERGY RESOURCE ASSESSMENT

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

NTTR NORTH RANGE

North/South Range Boundary

NTTR SOUTH RANGE AND DESERT NATIONAL WILDLIFE REFUGE

EAST SECTION DESERT NATIONAL WILDLIFE REFUGE

Alamo

Beatty

Indian Springs

Nye County

Nevada Test Site

Nellis Air Force Range

Nellis Air Force Base

Creech AFB

Las Vegas

Jean

Primm

93

95

15

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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SOURCES: ESRI, USGS, NOAA

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PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 2.1 Previous Assessment Study Areas.mxd

2.1 Description of Previous Assessments

2.1.1 Remote Sensing and Geophysical Evaluation

In the 1993 and 1998 assessments, the NBMG evaluated Landsat imagery to assist in defining sites for stream sediment and MA sampling. For the 2014 Assessment of the East DNWR, Landsat imagery was supplemented with Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery.

The geophysical evaluation utilized existing gravity and magnetic data. All assessments have relied on the same raw gravity and magnetic data; however, the 1998 and 2014 Assessments were able to take advantage of updated analyses of the gravity and magnetic data performed for state-wide mineral resource assessments (Singer, 1996).

2.1.2 Geochemical Sampling

NBMG personnel conducted thorough geochemical sampling in the East DNWR in 1993 (Tingley and others, 1993) and in the NTTR in 1998 (Tingley and others, 1998). In 2014, NBMG personnel collected additional samples in the East DNWR (Muntean and others, 2014) as part of the update of the 1993 Assessment. All three assessments collected the same types of samples:

- Unaltered and unmineralized geochemical/lithological characterization (GSC) samples analyzed to determine background metal concentrations.
- Stream sediment samples, consisting of active channel silt samples (silt samples) and float chip samples used for reconnaissance.
- MA samples to evaluate mineral deposits, prospects, and mineralized structures.

2.1.2.1 Geochemical Sampling for Lithologic Characterization (GSC) Sampling

In 1993, NBMG personnel collected 101 GSC samples from unaltered and unmineralized outcrops in the East DNWR and portions of the 64C/D and 65D area to determine background metal concentrations and to identify anomalous concentrations. In 1993, GSC samples were analyzed for 56 major and trace elements. In 1998, NBMG personnel collected 220 GSC samples from the NTTR and analyzed them for 48 major and trace elements. These samples were subdivided by location to analyze background metal concentrations within the Paleozoic sedimentary rocks that are predominant in the South Range, and the Cenozoic volcanic rocks that predominate in the North Range. Figure 2.2 illustrates the distribution of GSC samples collected from the East DNWR and the NTTR for the 1993 and 1998 Assessments. Additional GSC sampling was not conducted for the 2014 Assessment.

2.1.2.2 Stream Sediment: Silt and Float Chip Sampling

NBMG personnel collected stream sediment samples from 216 locations within the East DNWR for the1993 Assessment, and from 380 locations within the NTTR for the 1998 Assessment.

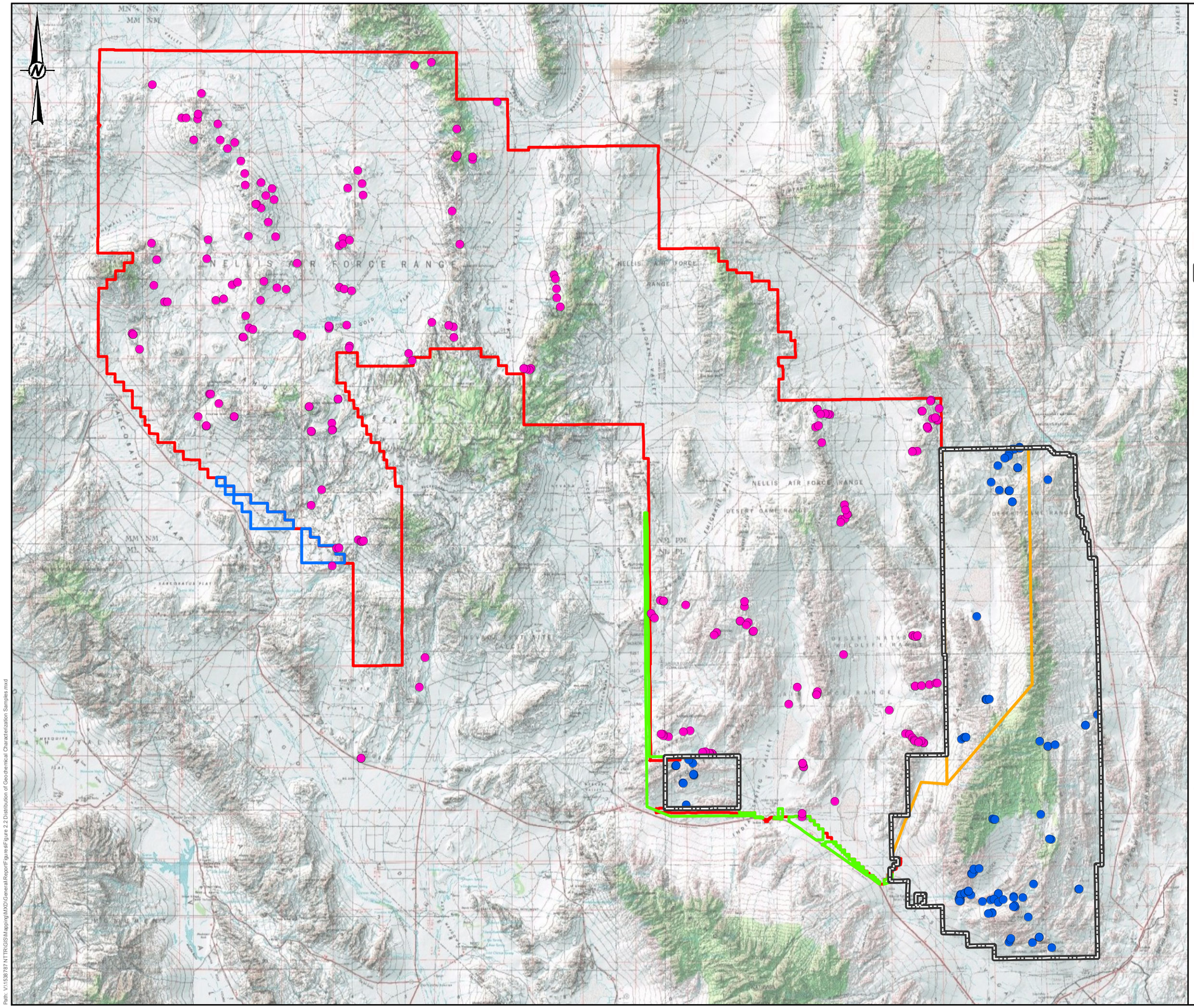


FIGURE 2.2
LOCATION OF GEOCHEMICAL CHARACTERIZATION (GSC) SAMPLES COLLECTED BY NBMG FOR THE 1993 AND 1998 MINERAL RESOURCE ASSESSMENTS

LEGEND

GEOCHEMICAL CHARACTERIZATION SAMPLES
- 1993
- 1998

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- 1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: \\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\Figure#\Figure 2.2 Distribution of Geochemical Characterization Samples.mxd

Samples were collected for initial reconnaissance and to evaluate geologic features identified by remote sensing studies. At most locations, a fine sediment (silt) sample was collected from the active portion of each stream channel and a separate sample of mineralized rock fragments (float chips) was collected nearby. Limonite-stained fractures, altered, and mineralized rocks were preferentially collected as float chip samples. Figure 2.3 illustrates the distribution of silt and float chip samples collected for the 1993 and 1998 Assessments. No additional silt and float chip sampling was conducted for the 2014 Assessment.

2.1.2.3 Mineralized Area (MA) Sampling

MA samples were collected from prospects, mine sites, and altered and mineralized outcrops throughout the NTTR and East DNWR. These were described as “high grade” samples in the 1993, 1998, and 2014 Assessments. The distribution of MA samples is shown on Figure 2.4.

For the 1993 Assessment of the East DNWR, NBMG personnel collected 70 MA samples, which were analyzed for 48 elements by inductively coupled plasma mass spectroscopy (ICP-MS) and instrumental neutron activation analysis (INAA). For the updated 2014 Assessment of the East DNWR, NBMG personnel collected an additional 58 MA samples that were analyzed for 52 elements, and reanalyzed the pulps from 66 MA samples collected during the 1993 Assessment.

For the 1998 Assessment, NBMG personnel visited all known mining districts in the NTTR, identified ore deposits and mineralized prospects within the existing boundaries of the NTTR, and collected 800 MA samples that were analyzed for 48 elements by ICP, INAA, and x-ray fluorescence (XRF).

2.2 Summary of Findings

This section summarizes the results of the evaluation of identified ore deposits, mineralized prospects, known mining districts, identified industrial minerals, and energy resources within the existing NTTR boundaries and and the East DNWR as presented in 1993, 1998, and 2014 Assessments (Tingley and others, 1993, 1998; Muntean and others, 2014). This assessments updates the previous assessments to include advances in geologic understanding of selected deposit occurrences, changes in metal or commodity demand, and technological advances (Section 5.0).

2.2.1 Mining History and Production

Figure 2.5 shows the known mining districts within and near the existing boundaries of the NTTR and the East DNWR. Mining activity in the NTTR and East DNWR post-dates the discovery of the Comstock Lode in Virginia City in 1859. Following the discovery of the Comstock Lode, mineral exploration began in and around the study area. Within the existing NTTR, discoveries were made in the Groom Mining District in 1864 and the Southeastern Mining District in 1870 (Figure 2.5).

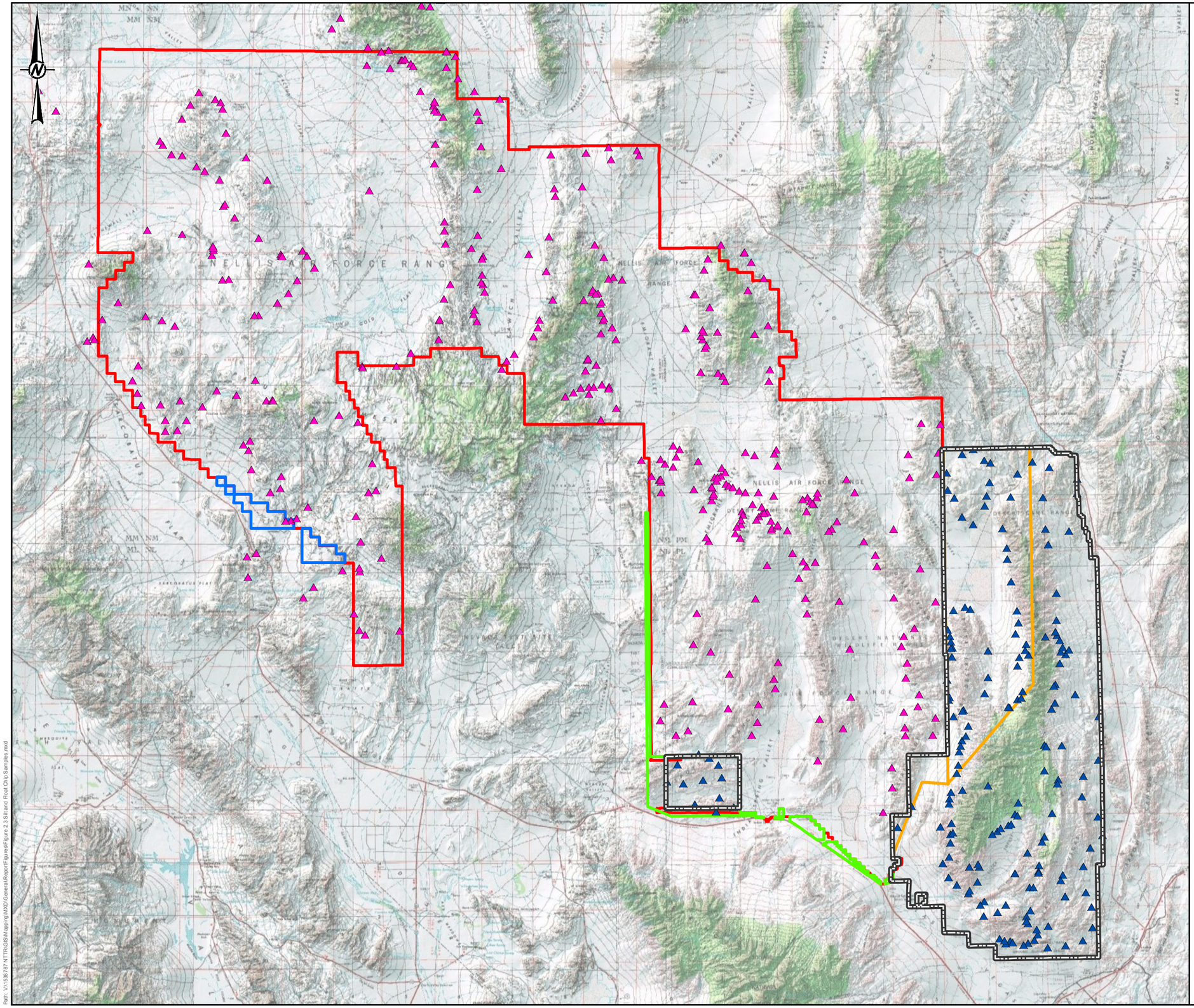


FIGURE 2.3
LOCATION OF SILT AND FLOAT CHIP SAMPLES COLLECTED BY NBMG FOR THE 1993 AND 1998 MINERAL RESOURCE ASSESSMENTS

LEGEND

SILT AND FLOAT CHIP
- 1993
- 1998

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- 1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED WITHDRAWAL AREAS
- ALTERNATIVE 3A - EC SOUTH WITHDRAWAL
- ALTERNATIVE 3B - 64C/D AND 65D WITHDRAWAL AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO WITHDRAWAL

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 2.3 Silt and Float Chip Samples.mxd

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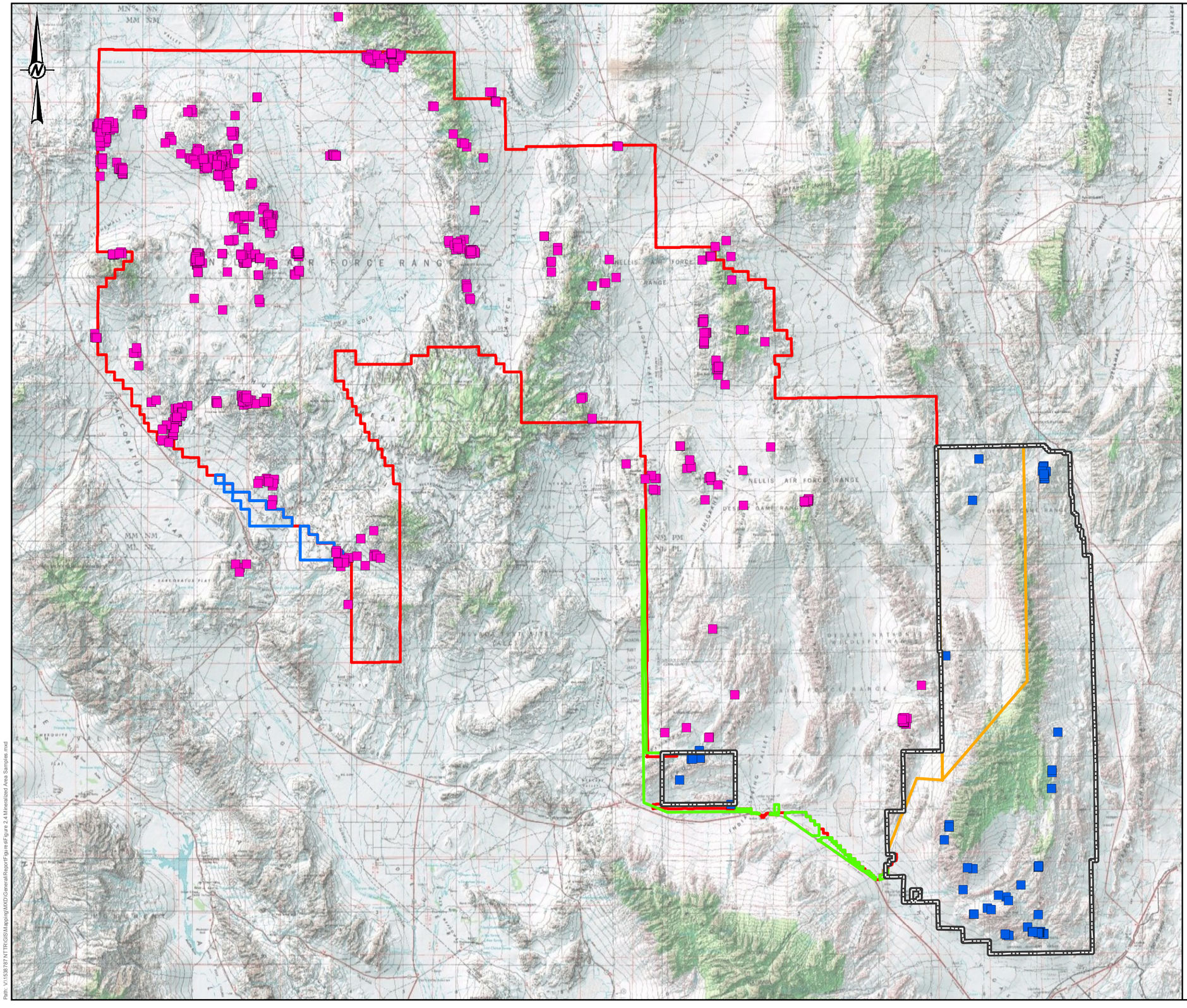


FIGURE 2.4
LOCATION OF MINERALIZED AREA SAMPLES COLLECTED FOR THE 1993, 1998, AND 2014 MINERAL RESOURCE ASSESSMENTS

LEGEND

MINERALIZED AREA SAMPLES
- 1993
- 1998
- 2014

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- 1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

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PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0

Path: V:\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\Figure 2.4 Mineralized Area Samples.mxd

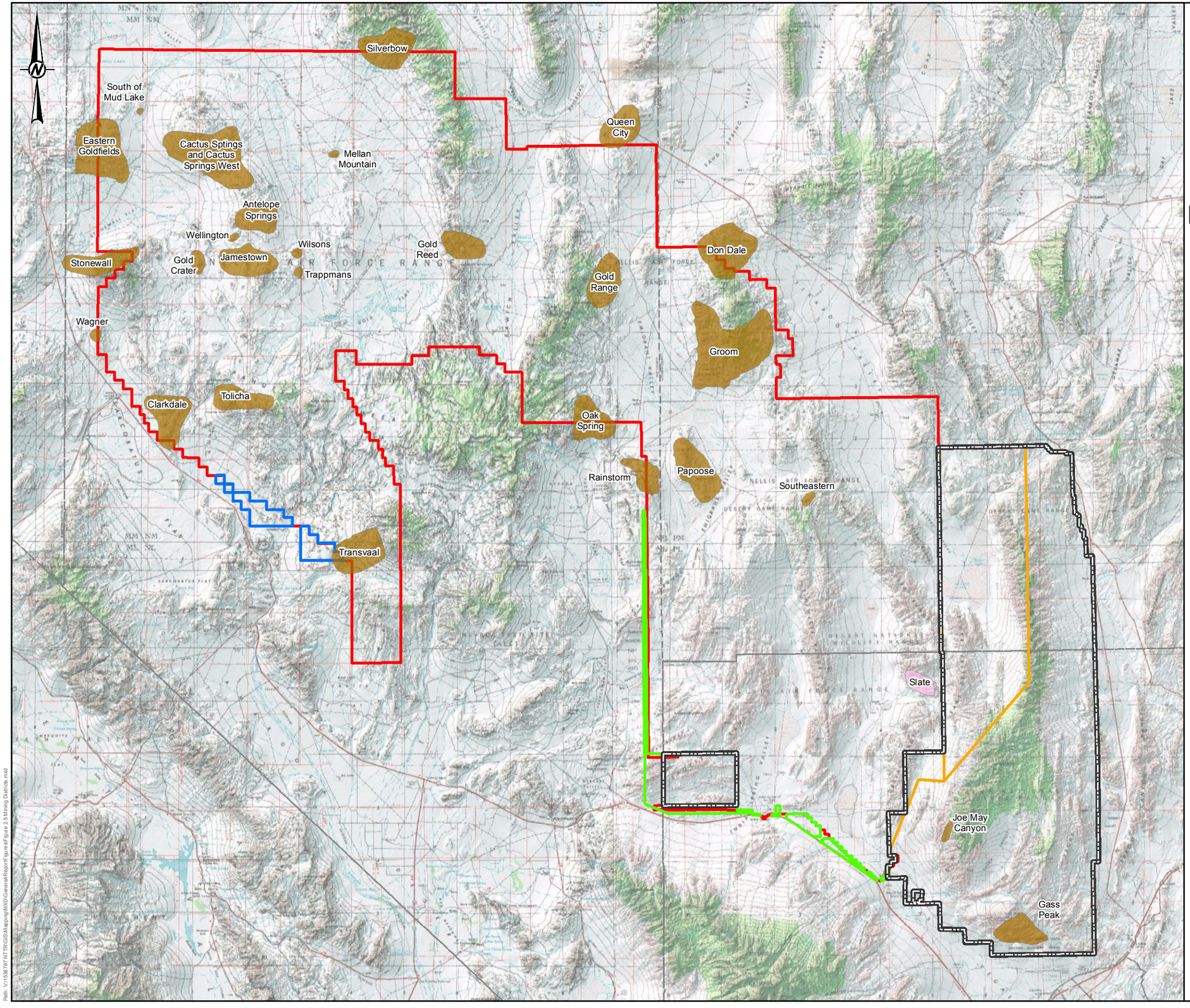


FIGURE 2.5
MINING DISTRICTS IN THE NTTR AND EAST DNWR

LEGEND

MINING DISTRICTS

- METALLIC
- NONMETALLIC

STUDY AREA

- NEVADA TEST AND TRAINING RANGE
- 1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM 2015, USDA FARM SERVICE AGENCY (FSA). IMAGE TAKEN 5-27-2015.
MINING DISTRICTS: MINING DISTRICTS OF NEVADA, NEVADA BUREAU OF MINES AND GEOLOGY. PROVIDED BY GAME AND WILDLIFE, 2016.

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	2.5

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Path: V:\1538787 NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 2.5 Mining Districts .mxd

Silver discoveries in Tonopah in 1900, and gold discoveries at Goldfield in 1902, stimulated additional mineral exploration within the North Range of the NTTR. By 1942, the majority of the NTTR was closed to mineral location. Mining in the Groom Mining District continued sporadically until 1956.

Table 2.1 is a summary of production records for mining districts within the existing NTTR boundaries, from the 1998 Assessment (Tingley and others, 1998). Few records exist prior to 1908. Metals produced in the NTTR in recorded quantities were gold, silver, copper, lead, and zinc. The majority of mineral production was from mines in the North Range of the NTTR. The Groom Mining District was the largest producer in the North Range and accounted for approximately 90 percent of the ore mined and the metals produced. Lead was the dominant metal produced in the Groom Mining District and in the existing NTTR, 10.4 million and 10.7 million pounds, respectively. Available mining production records are incomplete; however, the value of recorded historical production from mines in the NTTR between 1906 and 1956 was approximately $18 million (US), based on 2016 metal prices. Less mine production occurred in the South Range, at the Papoose, Rainstorm, and Southeastern mining districts, which accounted for approximately $300,000 of the recorded mine production value from the existing NTTR.

Within the East DNWR, the only recorded mining production occurred at the June Bug Mine in the Gass Peak Mining District, where lead-zinc ore was mined in 1916 and 1917. Metallic mineral prospects and deposits within the East DNWR lie primarily along the Gass Peak thrust fault.

Table 2.1: Historical Production Records for Mining Districts in the NTTR between 1906 and 1956

Mining District	Ore (tons)	Gold (oz)	Silver (oz)	Copper (lbs)	Lead (lbs)	Zinc (lbs)
Antelope Springs	328	157	54,024	275	454	NA
Cactus Springs	200	15	3,147	NA	NA	NA
Clarkdale	316	160	398	NA	NA	NA
Gold Crater	188	82	2,722	NA	4,500	NA
Gold Reed	335	217	475	NA	NA	NA
Groom	34,484	45	145,279	72,421	10,425,430	39,100
Jamestown	1	4	NA	NA	NA	NA
Mellan	20	3	2	NA	NA	NA
Oak Springs	26	10	667	3,832	NA	NA
Papoose	458	1	3,029	400	301,673	NA
Rainstorm [1]	39	5	918	128	42,74 1	NA
Silverbow [1]	3,524	1,346	95,976	NA	NA	NA
Southeastern	31	NA	352	1,400	NA	NA
Stonewall [1]	38	16	1,165	NA	NA	NA
Tolicha	991	1,345	2,409	NA	NA	NA
Trappmans	1	1	130	NA	NA	NA
Wilsons	15	NA	527	105	993	NA
Total	**40,995**	**3,407**	**311,220**	**78,561**	**10,778,491**	**39,100**

Notes:
Source - Tingley and others, 1998
1 - Some production may have come from mines outside NTTR
ton = short tons, oz = ounces, lbs = pounds

2.2.2 Metallic Mineral Deposits in the NTTR

The 1998 Assessment (Tingley and others, 1998), identified the following deposit types and prospects within the existing boundaries of the NTTR:

- Epithermal precious metals (Eastern Goldfield, Antelope Springs, Cactus Springs, Gold Reed, Mellan Mountain, Jamestown, Silverbow, Stonewall, Gold Crater, Clarkdale, Tolicha, Gold Range, Wellington, and Wilsons mining districts)
- Carlin-type (sediment-hosted) gold (Don Dale Mining District and the Limestone Ridge area)
- Epithermal manganese (south of Mud Lake Mining District)
- Hot springs mercury (Transvaal and Gold Reed mining districts)
- Polymetallic veins (Southeastern, Rainstorm, and Papoose mining districts)
- Polymetallic replacement (Groom Mining District)
- Porphyry copper–molybdenum prospects (Cactus Range)

The potential for undiscovered deposits is addressed in Section 5.0 for the existing boundaries of the NTTR and the proposed expansion areas.

2.2.2.1 Base and Precious Metals in Known Mining Districts in the NTTR

Table 2.2 and Table 2.3 summarize precious and base metal deposit potential, respectively, within known mining districts and prospects within the existing boundaries of the NTTR. The tables were developed for the 1998 Assessment and are organized by district or prospect. Inclusion in Table 2.2 and Table 2.3 is based on the presence of mines and/or prospects, mineralized geologic structures, stratigraphy, mineral zoning, alteration, rock chemistry, and geochemical anomalies. The mineral potential at each location is ranked according to BLM guidance (1985) (Table 1.1).

Figure 2.6 illustrates the areas of precious metal potential in known mining districts and prospect areas in the NTTR. The areas shown on Figure 2.6 correspond to the districts or prospects listed in Table 2.2. Similarly, Figure 2.7 shows areas with low to high potential for base metal deposits that are listed in Table 2.3.

1222 **Table 2.2: Potential for Precious Metal Deposits in the NTTR**

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Basis of Identification
Antelope Springs	1	Ag, Au disseminated	Low	B	Defined by alteration, rock chemistry
	2	Ag, Au vein	Moderate	D	Defined by mines and surface sampling
	3	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
	4	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
	5	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
	6	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
	7	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
Cactus Flat	1	Ag, Au	Low	C	Defined by prospects, alteration, rock chemistry
	2	Ag, Au	Low	C	Defined by prospects, alteration, rock chemistry
Cactus Peak	1	Ag, Au	Moderate	B	Defined by color anomaly, rock alteration
Cactus Springs	1	Ag, Au	Moderate	B	Defined by color anomaly, rock alteration
	2	Ag, Au	Moderate	B	Defined by color anomaly, rock alteration
	3	Ag, Au	Moderate	C	Defined by mines, prospects, alteration, rock chemistry
	4	Ag, Au veins	High	C	Defined by mines, prospects, alteration, rock chemistry
	5	Ag, Au	Moderate	C	Defined by mines, prospects, alteration, rock chemistry
	6	Ag, Au	Moderate	B	Defined by prospects, alteration, rock chemistry
Cactus Springs West	1	Ag, Au	Moderate	B	Defined by rock alteration, rock chemistry
	2	Ag, Au	Moderate	B	Defined by mines, prospects, alteration, rock chemistry
	3	Ag, Au	Moderate	B	Defined by mines, prospects, alteration, rock chemistry
Cedar Pass	1	Ag, Au	Moderate	B	Defined by prospects, color anomaly, alteration, rock chemistry

1223

Table 2.2: Potential for Precious Metal Deposits in the NTTR (continued)

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Basis of Identification
Central Tolicha	1	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
Clarkdale	1	Ag, Au	Moderate	B	Defined by alteration, rock chemistry
	2	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
	3	Ag, Au	Moderate	C	Defined by mines, prospects, alteration, rock chemistry
Corral Spring	1	Ag, Au	Moderate	B	Defined by prospects, alteration, rock chemistry
Don Dale	1	Ag, Au	Moderate	C	Defined by prospects, rock chemistry
	2	Au	Moderate	B	Defined by stratigraphy, rock chemistry
Eastern Goldfield	1	Ag, Au	Moderate	B	Defined by mines, prospects, alteration, rock chemistry
	2	Ag, Au	Moderate	B	Defined by mines, prospects, alteration, rock chemistry
	3	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
Gold Crater	1	Ag, Au	High	B	Defined by alteration, rock alteration
	2	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
Gold Crater-Jamestown	1	Ag, Au	Moderate	B	Defined by color anomaly, alteration
Gold Reed	1	Ag, Au	Moderate	C	Defined by prospects, color anomaly, alteration, rock chemistry
	2	Ag, Au	Moderate	B	Defined by prospects, color anomaly, alteration, rock chemistry
	3	Ag, Au	High	C	Defined by prospects, color anomaly, alteration, rock chemistry
Gold Range	1	Ag, Au	Moderate	B	Defined by prospects, alteration, rock chemistry
	2	Ag, Au	Moderate	C	Defined by prospects, alteration, rock chemistry
	3	Ag, Au	Moderate	C	Defined by prospects, alteration, rock chemistry

1226 **Table 2.2: Potential for Precious Metal Deposits in the NTTR (continued)**

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Basis of Identification
Groom	1	Ag, Au	Moderate	C	Defined by mines, prospects, structure, rock chemistry
Jamestown	1	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
	2	Ag, Au	High	C	Defined by mines, prospects, alteration, rock chemistry
Limestone Ridge	1	Au	Moderate	B	Defined by stratigraphy, alteration, rock chemistry
Mellan Mountain	1	Au, Ag	High	C	Defined by mines, prospects, alteration, rock chemistry
Northeast of Scotty's Junction	1	Au, Ag	Moderate	B	Defined by prospects, color anomaly, rock chemistry
	2	Au, Ag	Moderate	B	Defined by prospects, color anomaly, rock chemistry
Papoose	1	Au	Moderate	B	Defined by prospects, stratigraphy, alteration, rock chemistry
Quartz Mountain	1	Au, Ag	High	C	Defined by mines, prospects, alteration, rock chemistry
Quartzite Mountain	1	Au, Ag	Low	C	Defined by prospects, alteration, rock chemistry
Queen City	1	Au, Ag	Low	C	Defined by color anomaly, alteration, rock chemistry
Reveille Valley	1	Ag, Au	Moderate	B	Defined by color anomaly, alteration
South and West of Mount Helen	1	Ag, Au	Moderate	B	Defined by color anomaly, alteration, rock chemistry
	2	Ag, Au	Moderate	B	Defined by color anomaly, alteration, rock chemistry
	3	Ag, Au	Moderate	B	Defined by color anomaly, alteration, rock chemistry
Silverbow	1	Ag, Au	Moderate	C	Defined by mines, prospects, alteration, rock chemistry
	2	Ag, Au	High	C	Defined by structure, alteration, rock chemistry
South of Mud Lake	1	Ag	Low	C	Defined by mines, prospects, alteration, rock chemistry
	2	Ag	Moderate	B	Defined by mines, prospects, alteration, rock chemistry

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Table 2.2: Potential for Precious Metal Deposits in the NTTR (continued)

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Comments
Stonewall	1	Ag, Au	High	C	Defined by prospects, alteration, rock chemistry
	2	Ag, Au	Moderate	B	Defined by geology, mines, prospects
Thirsty Canyon-Sleeping Butte	1	Ag, Au	Low	B	Defined by alteration, rock chemistry
Tolicha	1	Ag, Au	Moderate	B	Defined by color anomaly, alteration, rock chemistry
Transvaal	1	Ag, Au	Low	B	Defined by alteration, rock chemistry
Trappmans	1	Ag, Au	Moderate	C	Defined by mines, prospects, alteration
Wellington	1	Ag, Au	Moderate	C	Defined by prospects, alteration, rock chemistry
Wilsons	1	Ag, Au	High	C	Defined by rock structure, color anomaly, alteration, rock chemistry

Notes:
Source - Modified from Tingley and others, 1998
1 - Resource potential and certainty classification are as defined in BLM Manual 3031 (1985)
Ag = silver, Au = gold

Table 2.3: Potential for Base Metal Deposits in the NTTR

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Basis of Identification
Cactus Range Central	1	Cu, Mo, Au	Moderate	B	Multiple porphyritic intrusions; propylitic, argillic, acid-sulfate alteration
Cactus Springs	1	Pb, Ag, Zn	Moderate	B	Defined by stratigraphy, alteration, rock chemistry
Cactus Springs West	1	Cu, Mo,	Moderate	C	Defined by mines, prospects, alteration, rock chemistry
	2	Turquoise (Cu)	High	C	Defined by mines, prospects, alteration, rock chemistry
Cedar Pass	1	Mo	Moderate	B	Defined by prospects, color anomaly, alteration, rock chemistry
Gold Crater-Jamestown	1	Cu, Mo	Moderate	B	Defined by alteration, mineral zoning
Gold Reed	1	Cu	Moderate	B	Defined by prospects, color anomaly, alteration, rock chemistry
	2	Cu	Moderate	B	Defined by prospects, color anomaly, alteration, rock chemistry
	3	Hg	Low	C	Defined by prospects, color anomaly, alteration, rock chemistry
Groom	1	Pb, Ag, Zn	High	C	Defined by mines, prospects, structure, rock chemistry
Northeast of Scotty's Junction	1	Cu, Mo	Moderate	B	Defined by alteration, rock chemistry
	2	Cu, Mo	Moderate	B	Defined by alteration, rock chemistry
Oak Spring	1	W	Moderate	B	Defined by stratigraphy, rock chemistry
	2	Pb, Ag	Moderate	B	Defined by prospects, rock chemistry
Papoose	1	Pb, Ag	High	C	Defined by mines, prospects, rock chemistry
	2	Pb, Ag	Low	B	Defined by mines, prospects, rock chemistry
Prospector Fault	1	Cu, Pb, Ag, Zn	Moderate	B	Defined by prospects, rock structure, rock chemistry
Rainstorm	1	Pb, Ag (replacement)	Moderate	B	Defined by mines, prospects, stratigraphy, rock chemistry
	2	Pb, Ag (vein)	Moderate	C	Defined by mines, prospects, stratigraphy, rock chemistry

Table 2.3: Potential for Base Metal Deposits in the NTTR (continued)

Mining District or Prospect Area	Area	Mineral Resource	Resource Potential [1]	Certainty Level [1]	Basis of Identification
Southeastern	1	Pb, Cu, Ag (replacement)	High	B	Defined by mines, prospects, stratigraphy, rock chemistry
	1	Pb, Cu, Ag (vein)	High	C	Defined by mines, prospects, stratigraphy, rock chemistry
Transvaal	1	Hg	Moderate	C	Defined by prospects, alteration, rock chemistry
Wagner	1	Cu	Low	C	Defined by geologic relationships

Notes:
Source - Modified from Tingley and others, 1998
1 - Resource potential and certainty classification are as defined in BLM Manual 3031 (1985)
Pb = lead; Mo = molybdenum; Cu = copper; Hg = mercury; W = tungsten; Zn = zinc

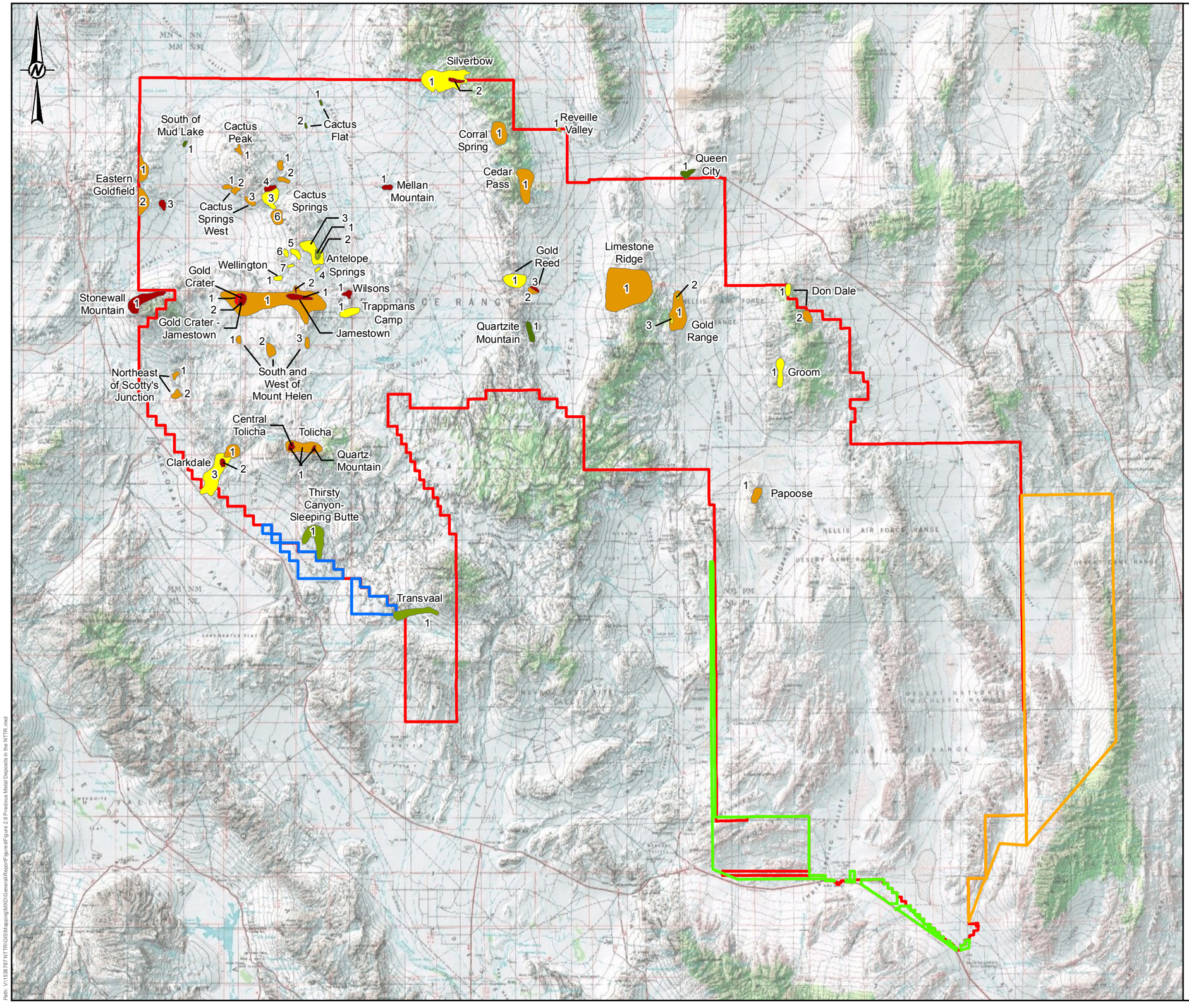


FIGURE 2.6
PRECIOUS METAL POTENTIAL IN MINING DISTRICTS AND PROSPECT AREAS WITHIN THE NTTR

LEGEND

POTENTIAL PRECIOUS METAL DEPOSITS

- HIGH POTENTIAL/CERTAINTY LEVEL C
- HIGH POTENTIAL/CERTAINTY LEVEL B
- MODERATE POTENTIAL/CERTAINTY LEVEL B
- MODERATE POTENTIAL/CERTAINTY LEVEL C
- MODERATE POTENTIAL/CERTAINTY LEVEL D
- LOW POTENTIAL/CERTAINTY LEVEL B
- LOW POTENTIAL/CERTAINTY LEVEL C

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	2.6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureFigure 2.6 Precious Metal Deposits in the NTTR.mxd

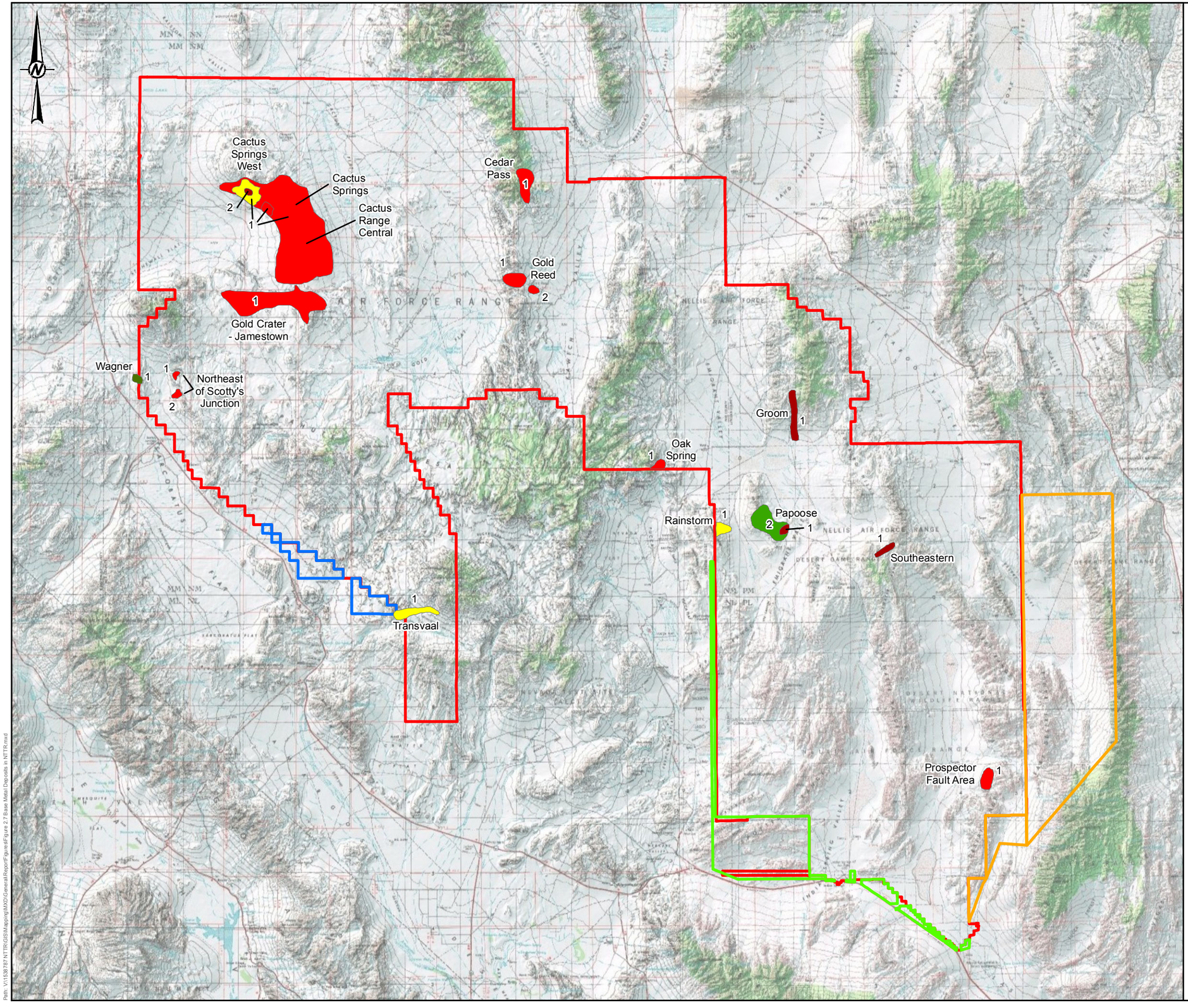


FIGURE 2.7
BASE METAL POTENTIAL IN MINING DISTRICTS AND PROSPECT AREAS WITHIN THE NTTR

LEGEND

POTENTIAL FOR BASE METAL DEPOSITS

- HIGH POTENTIAL/CERTAINTY LEVEL C
- MODERATE POTENTIAL/CERTAINTY LEVEL B
- MODERATE POTENTIAL/CERTAINTY LEVEL C
- LOW POTENTIAL/CERTAINTY LEVEL B
- LOW POTENTIAL/CERTAINTY LEVEL C

STUDY

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSIONL AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	2.7

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 2.7 Base Metal Deposits in NTTR.mxd

2.2.3 Industrial Minerals in the NTTR

Industrial minerals with moderate to high potential to occur within the NTTR include clay, construction aggregate (quarried and alluvial sources), cement limestone, volcanic cinders, and zeolites. Exposures of limestone and dolomite potentially suitable for lime and cement manufacture are extensive in the South Range of the NTTR. Mineral potential maps illustrating the distribution of these resources in the NTTR are included in Section 10.0, which includes an updated area-wide assessment of industrial mineral potential.

2.2.4 Energy Resources in the NTTR

2.2.4.1 Uranium in the NTTR

No economically significant uranium deposits are known to occur in Nevada mining districts and in the NTTR (Tingley and others, 1998). Areas underlain by Cenozoic volcanic rocks and adjacent sedimentary basins were classified as having a low potential, certainty level B, for uranium deposits. The potential is lower in areas underlain by Paleozoic rocks, such as those in the South Range of the NTTR. No commercially viable or economically significant uranium deposits were identified in the NTTR.

2.2.4.2 Oil and Gas in the NTTR

No petroleum wells are known to occur in the NTTR and no hydrocarbon shows from water wells, mineral exploration drill holes, or outcrops have been identified. With the exception of rocks in the Tikaboo Valley and Pahranagat Range area, source rocks in the NTTR are generally overmature for the generation of petroleum. Section 6.0 contains an updated, area-wide description of oil and gas potential and figures showing potential oil and gas resources.

2.2.4.3 Coal in the NTTR

The occurrence of coal resources in Nevada is limited. There are no known occurrences in the NTTR and the stratigraphy is considered unfavorable for coal deposits (Tingley and others, 1998).

2.2.4.4 Geothermal Resources in the NTTR

No exploitable geothermal resources were identified in the 1998 Assessment of the NTTR. Since the 1998 Assessment, there have been advances in identifying structurally controlled, blind, geothermal resources, those with no obvious surface expression. An update of the 1998 Assessment of geothermal resources within the NTTR and the expansion areas is contained in Section 9.0.

2.2.4.5 Lithium in the NTTR

Samples were collected from all NTTR playa sediments for the 1998 Assessment. Lithium was detected at all playa sampling locations; however, Tingley and others (1998) concluded that there were no economically significant lithium deposits within the NTTR. There has been recent interest in the Mud Lake area, which

straddles the northwest corner of the North Range (Figure 1.3). Because of its current importance in industry, potential lithium resources are addressed in more detail in Section 10.0.

2.2.5 Metallic Mineral Resources in the East DNWR

As noted above, there are few metal mining districts located in the East DNWR. The 1993 Assessment identified no economically significant metallic mineral deposits in the East DNWR and a low potential for base and precious metal deposits in general. No changes in metallic mineral deposit potential were made for the 2014 Assessment of the East DNWR.

2.2.5.1 Base Metals in the East DNWR

Geochemical sampling and data analyses conducted for the 1993 and 2014 Assessments identified several areas with the potential for locatable base and precious metals. These areas are listed in Table 2.4 and ranked according to the mineral classification criteria from the BLM (1985). In general, highest potential for base metal deposits occurs in the Gass Peak Mining District. Less potential for base metals occurs along the Gass Peak thrust fault and in the Lake Mine area. Figure 2.8 shows the distribution of base metal potential in the East DNWR and a portion of the 64C/D and 65D area. Most of the identified potential is outside the limits of the current study area.

Table 2.4: Potential for Locatable Base and Precious Metals in the East DNWR from the 2014 Assessment

Deposit Type	Location	Resource Potential [1]	Level of Certainty [1]	Basis
Zinc-lead-copper-silver	June Bug Mine and Sampson Juniper Claims [2]	High	D	Mapped mines, stream sediment anomalies, and dolomitization
Zinc-lead-copper-silver	North June Bug [2]	High	C	Extension of the June Bug Mine, stream sediment anomalies, and dolomitization
Zinc-lead-copper-silver	South Las Vegas Range	Low	C	Spatial association with mineralization at the June Bug Mine
Zinc-lead-copper-silver	Gass Peak Thrust Mining District	Low	C	Fault controlled base metal occurrences on the trace of the thrust
Zinc-lead-copper-silver	Joe May Canyon Mining District	Low	C	Stream sediment anomalies and prospects
Zinc-lead-copper-silver	Southeast 64C/D and 65D area	Low	C	Stream sediment anomalies

Table 2.4: Potential for Locatable Base and Precious Metals in the East DNWR from the 2014 Assessment (continued)

Deposit Type	Location	Resource Potential [1]	Level of Certainty [1]	Basis
Carlin-type gold	Lake Mine area	Low	C	Limonite staining, silicification and As-Hg-Sb-Tl geochemical association
Carlin-type gold	Central Sheep Range	Low	C	Arsenic anomaly and favorable host rocks
Carlin-type gold	North 64C/D and 65D area	Low	C	Arsenic in silt and float chip samples

Notes:
Source - Tingley and others, 1993; Muntean and others, 2014
1 - Resource potential and certainty classification as defined in BLM Manual 3031 (1985)
2 - June Bug Mine and Sampson Juniper Claims are within the Gass Peak Mining District

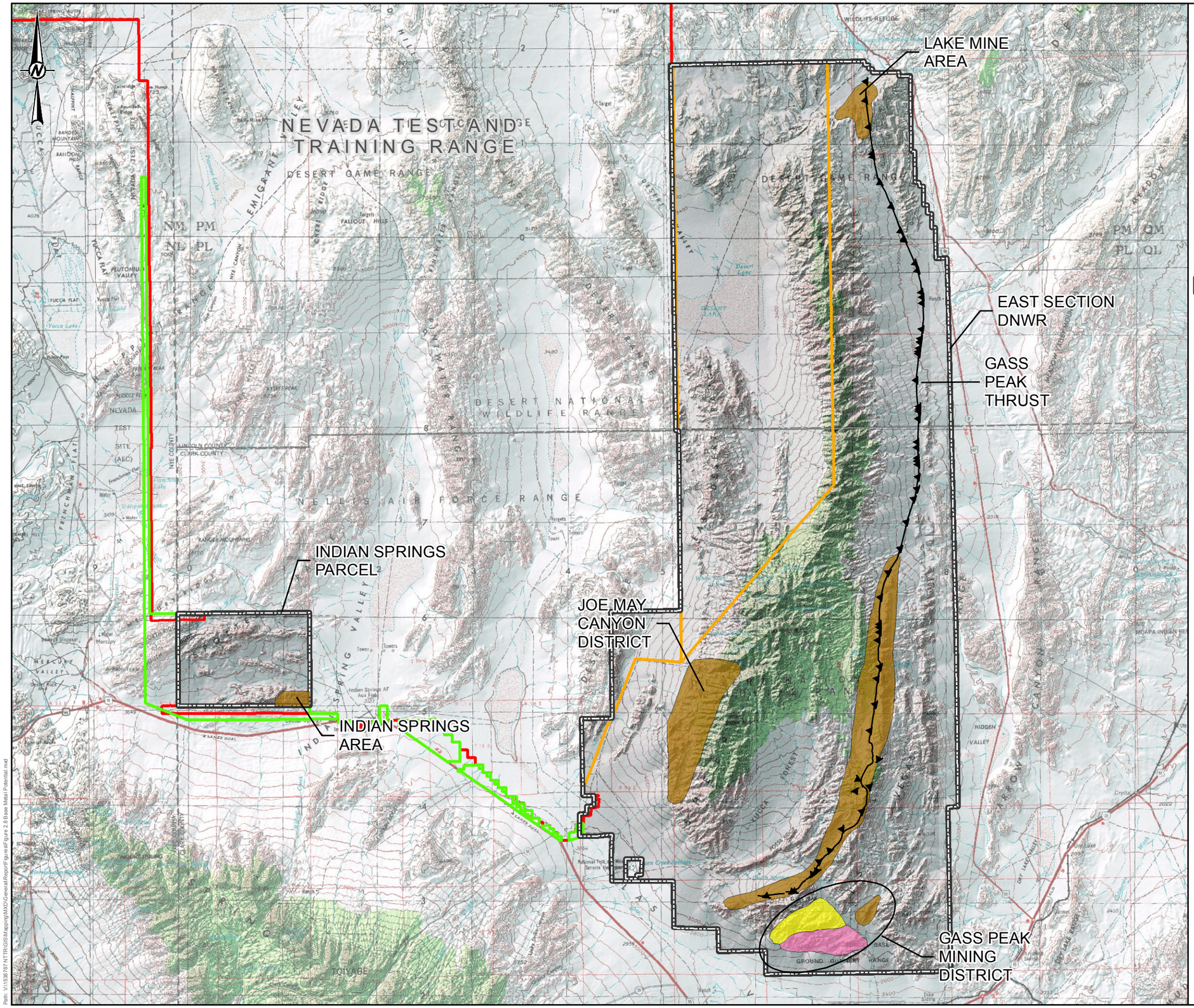


FIGURE 2.8
POTENTIAL FOR BASE METAL DEPOSITS IN THE EAST DNWR AND INDIAN SPRINGS PARCEL

LEGEND

GASS PEAK THRUST

POTENTIAL FOR BASE METAL DEPOSITS

- HIGH POTENTIAL/CERTAINTY LEVEL D
- HIGH POTENTIAL/CERTAINTY LEVEL C
- LOW POTENTIAL/CERTAINTY LEVEL C

STUDY

- NEVADA TEST AND TRAINING RANGE
- 1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED EXPANSION

- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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5 2.5 0 5 Miles

8 4 0 8 Kilometers

NOTES

SOURCE:
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

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Path: V:\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 2.8 Base Metal Potential.mxd

2.2.5.2 Precious Metals in the East DNWR

The 1993 and 2014 Assessments identified three zones where the combination of geochemistry, alteration, and stratigraphy indicate potential for sediment-hosted CTGDs. Figure 2.9 illustrates the potential for CTGDs in the East DNWR.

In the Lake Mine area, a zone exhibiting clay alteration, limonite staining, and silicification (jasperoid) was identified in Cambrian to Ordovician sedimentary rocks exposed in a window through unaltered Tertiary ash-flow tuffs (Muntean and others, 2014). The alteration predated the 27.57-Ma Monotony tuff, the oldest of the tuff units present, and the observed brecciation of the Paleozoic rocks may be associated with the Gass Peak thrust fault. These relationships suggest that the age of alteration may be 42 to 34 Ma, during which the majority of the CTGDs in Nevada formed (Muntean and others, 2011). The style of alteration observed is considered to be consistent with CTGDs (Muntean and others, 2014).

The zone in the Lake Mine area is associated with anomalously high arsenic concentrations measured in several MA rock samples, and the highest gold concentration recorded in the East DNWR (44 parts per billion [ppb]); however, the mean gold concentration in 34 rock samples collected in the Lake Mine area was less than the method detection limit of 5 ppb. As such, the Lake Mine area was considered to have a low potential, certainty level C, for CTGDs.

An area of anomalously high arsenic concentration, the highest arsenic concentration measured in the previous assessments, was identified in in the central Sheep Range in the Cabin Springs area. In this area, rocks of the Ordovician Pogonip Group and Cambrian Notch Peak FM occur in the Gass Peak allochthon. These rocks are reported to host the ore at the Long Canyon gold deposit in Elko County, Nevada. Limonite float chip samples, collected below the Ordovician-Cambrian contact, had high arsenic, and low silver and base metal concentrations. All gold concentrations were less than the 5-ppb method detection limit. ASTER maps prepared for the 2014 Assessment indicated clays and goethite (limonite) along the contact; however, a zone of alteration on a scale consistent with CTGD was not identified. A low potential for CTGDs, certainty level C, was assigned to the central Sheep Range.

Anomalously high arsenic in rock and float chip samples collected for the 1993 Assessment from the north portion of the 64C/D and 65D area were associated with limonitic jasperoid breccias and gossan in northeast trending faults cutting Mississippian carbonate rocks. The highest gold concentration in samples from the area was 5 ppb (the method detection limit). This area was also assigned a low potential, certainty level C, for CTGDs.

2.2.6 Industrial Minerals and Commodities in the East DNWR

Potential industrial minerals identified during previous assessments in the East DNWR include sand and gravel, dolomite, cement limestone, and high calcium limestone.

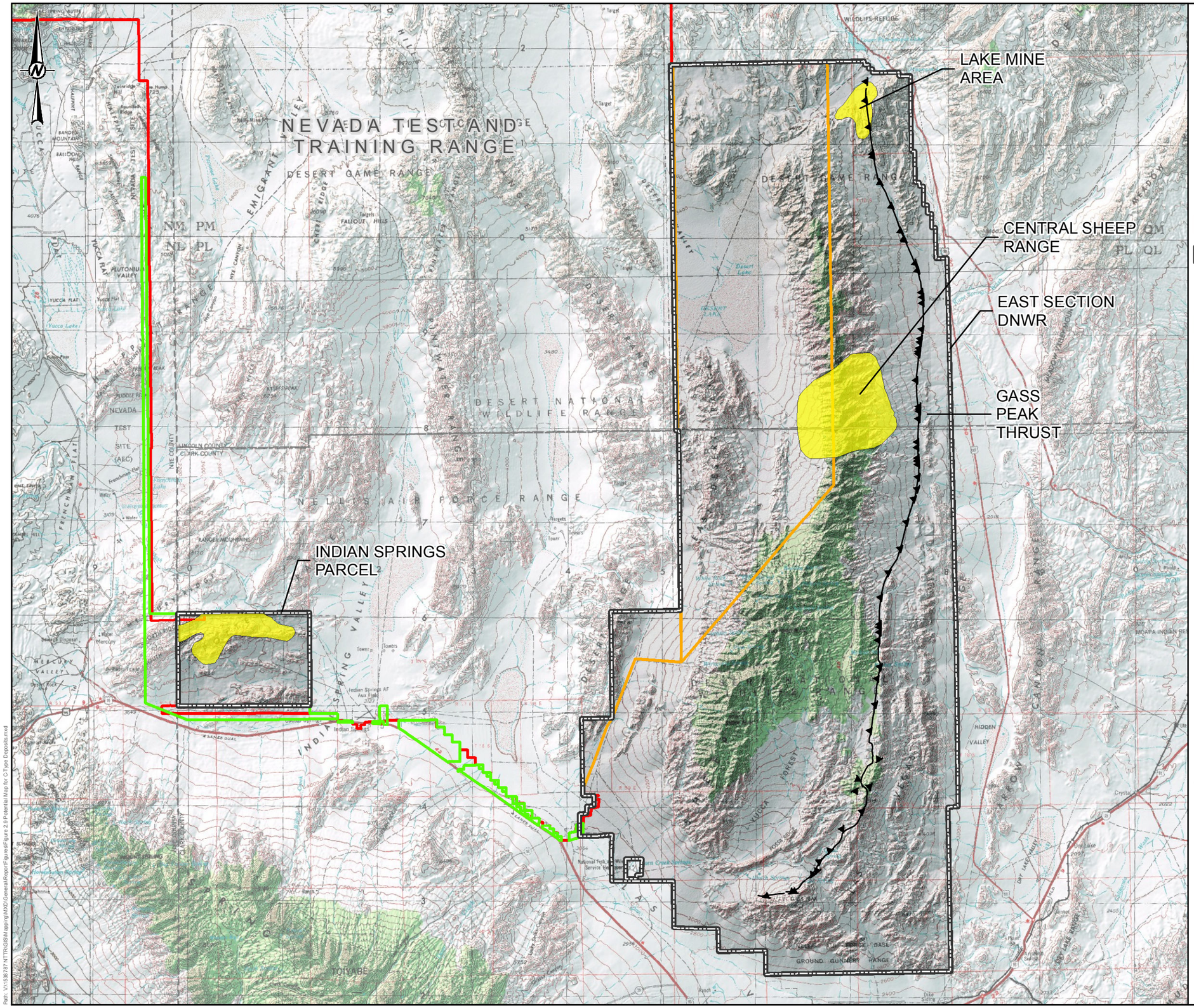


FIGURE 2.9
POTENTIAL FOR CARLIN GOLD DEPOSITS IN THE EAST DNWR AND INDIAN SPRINGS PARCEL

LEGEND

GASS PEAK THRUST

POTENTIAL FOR CARLIN-TYPE GOLD DEPOSITS

LOW POTENTIAL/CERTAINTY LEVEL C

STUDY AREA

NEVADA TEST AND TRAINING RANGE

1993 AND 2014 MINERAL AND ENERGY RESOURCE ASSESSMENT STUDY AREA

PROPOSED EXPANSION AREAS

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

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5 2.5 0 5 Miles

8 4 0 8 Kilometers

NOTES

SOURCE:
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureF\Figure 2.9 Potential Map for C-Type Deposits.mxd

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These materials were evaluated in the 1993 and 2014 Assessments. Industrial mineral potentials are summarized below. Figures and a more detailed description are included in Section 10.0.

Potential sand and gravel resources were found to be abundant within the East DNWR and the 64C/D and 65D area. The highest potential, certainty level C, is in coarse Quaternary alluvium adjacent to carbonate rock highlands, and where volcanic rocks of the Horse Springs FM lie within source areas. Moderate potential for sand and gravel deposits, certainty level B, exists in areas of coarse Quaternary cover derived from volcanic source rocks.

The potential for high calcium limestone, cement limestone, and dolomite is high, certainty level C, in the East DNWR. Potential for high calcium lime is greater in areas where the Guilmette FM occurs (Tingley and others, 1993). The Guilmette FM outcrops in the southern Sheep Range, the southern end of the Desert Range, and inside the 64C/D and 65D area.

The potential for cement limestone is high where the Guilmette FM, Mississippian limestone, and Bird Springs FM occur, while dolomite has high potential where the Nopah FM occurs (Tingley and others, 1993). High potential for cement limestone and dolomite is common within the East DNWR and the 64C/D and 65D area.

2.2.7 Energy Resources within the East DNWR

2.2.7.1 Uranium in the East DNWR

At the Sampson Claims at the Sampson Juniper prospect in the East DNWR, an oxidized vein exhibited radioactivity at approximately 30 times background levels (Tingley and others, 1993). This was not considered indicative of an economically significant deposit. It was concluded that uranium minerals in the East DNWR occur in small amounts and do not represent a commercially viable resource.

2.2.7.2 Oil and Gas in the East DNWR

A low potential and certainty level C was assigned to the East DNWR for oil and gas resources (Muntean and others, 2014). Conditions are unfavorable for source rock hydrocarbon preservation within the East DNWR and there is a lack of the petroleum source rocks that are known hydrocarbon-producers elsewhere in the eastern Great Basin.

2.2.7.3 Coal in the East DNWR

Coal resources in Nevada are limited. There are no known coal occurrences in the East DNWR and the stratigraphy is considered unfavorable for coal deposits (Tingley and others, 1993).

2.2.7.4 Geothermal Resources in the East DNWR

The 1993 and 2014 Assessments assigned a low potential, certainty level C, for geothermal resources in the East DNWR. Structural settings potentially conducive to blind geothermal systems were identified, but it was concluded that water temperatures are probably too low to generate electricity. Geothermal waters capable of greenhouse or building heating may exist.

2.2.7.5 Lithium in the East DNWR

Anomalously high lithium concentrations were detected in surface and near surface silt samples collected from the Desert Lake Playa for the 2014 Assessment, but the occurrence of a viable lithium deposit was assigned a low potential, certainty level C. Due to its current importance in industry, lithium is addressed in more detail in Section 10.0.

2.2.8 Geothermal Resources

2.2.8.1 1993 Geothermal Resource Assessment of the DNWR

The 1993 Assessment of the East DNWR noted that the sources of geothermal heat in the East DNWR were believed to be entirely related to the increase in temperature with depth (the geothermal gradient), and that there were no known igneous rocks in the area young enough (less than approximately 2 Ma) to supply heat. Any geothermal potential was considered to be related to deep stratigraphic reservoirs. The highest temperatures reported from deep carbonate aquifers in the vicinity of the East DNWR were 64 ºC from a drill hole on the Nevada National Security Site (formerly the Nevada Test Site [NNSS]), 58 ºC from an exploratory oil well drilled near Las Vegas, and 35 ºC from a carbonate aquifer test well in Coyote Valley (Tingley and others, 1993).

2.2.8.2 2014 Updated Geothermal Resource Assessment of the East DNWR

In the 2014 Assessment of the East DNWR (Muntean and others, 2014), the geothermal resource potential was re-evaluated in light of recent research that showed that many geothermal systems in the Great Basin were blind (i.e., not associated with hot springs, fumaroles, or recognizable surface expressions), and were associated with specific fault and structural settings. The 2014 Assessment evaluated the potential for blind, structurally controlled geothermal systems, as well as deep stratigraphic reservoirs, in the DNWR.

In the 2014 Assessment, 25 sites with structural settings considered favorable for structurally controlled geothermal systems were ranked based on recent fault activity and slip and dilation tendency analyses. Selected sites were then investigated. Muntean and others (2014) reviewed well temperatures, geochemistry, and subsurface data, and found no structurally controlled geothermal resources in the East DNWR. Identification of blind geothermal systems was determined to require detailed site investigation methods that are outside the scope of a mineral and energy resource assessment; however, regional

relationships indicate relatively low potential for structurally controlled geothermal systems in the East DNWR relative to others areas of the Great Basin.

The data also indicated low potential for deep stratigraphic aquifer resources. Muntean and others (2014) concluded that if geothermal systems did exist within the DNWR, they would likely not be hot enough for electricity generation.

Muntean and others (2014) concluded that available information indicated that the potential for moderate and high temperature geothermal resources (those that can be used for applications such as generating electricity, food drying, etc.) was low, certainty level C, in the East DNWR. A potential for direct use applications such as heating buildings was identified. It was also concluded that the relatively low temperature of carbonate aquifer waters, its considerable depth below the surface, and distance from population centers made the geothermal resources not economically viable at that time, and for the foreseeable future. Low temperature geothermal resources in the East DNWR were considered to have a low potential, certainty level C. The level of uncertainty is in part due to a lack of subsurface exploration in the East DNWR.

2.2.8.3 1998 Geothermal Resource Assessment of the NTTR

Several low temperature geothermal wells and springs were identified in and near the NTTR. They are shown on Figure 2.10 and their recorded temperatures are listed in Table 2.5.

Table 2.5: Summary of Spring and Well Water Temperatures in and Near the NTTR and Vicinity

Location	Temperature (°C)	Comments
Beatty	47.2	Bailey Hicks-Burrell Hot Spring, 7 km south of the NTTR
Indian Springs	26	South of the town of Indian Springs and the Indian Springs Parcel, approx. 1 km south of the NTTR
Hiko	32	Approximately 35 km north of the East DNWR
Stinking Spring	27.8	On the North Range's north boundary
Cedar Spring	25	South end of the Kawich Range, inside the North Range
Sand Spring Valley	28.3	Near Hiko, west of the Pahranagat Range
Ash Creek Spring	22	Inside the South Range
Climax Seep	41.5	Inside the NNSS
Sarcobatus Flat	22	Wells located southwest of the existing NTTR boundary

Notes:
Source - Tingley and others, 1998
°C = degrees Celsius

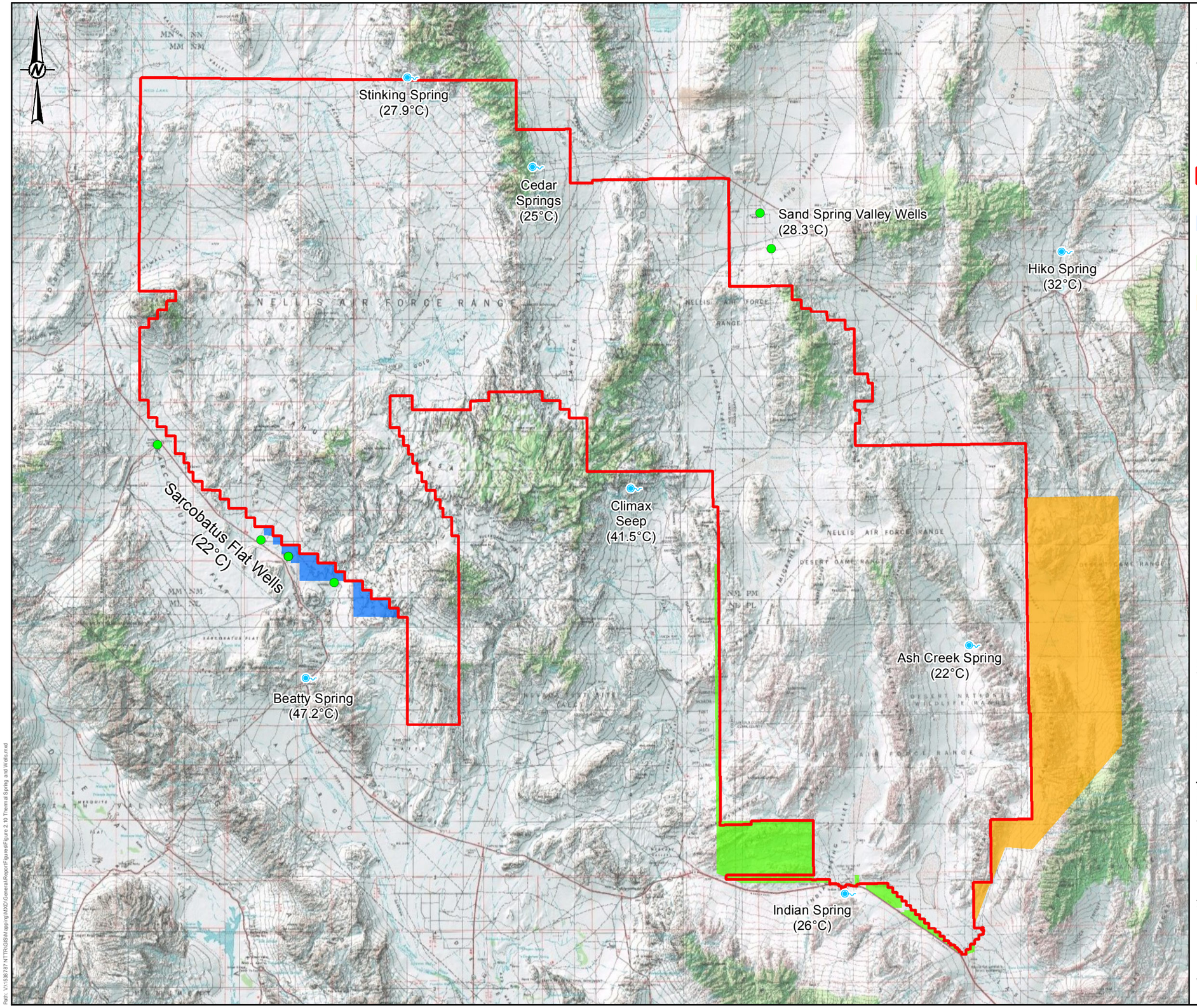


FIGURE 2.10
THERMAL SPRING AND WELLS IDENTIFIED IN THE NTTR

LEGEND

- SPRING
- WATER WELL

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

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Path: V:\1538787 NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 2.10 Thermal Spring and Wells.mxd

Near-surface water temperatures may be impacted by climatic conditions; however, the reported temperatures indicate that the thermal springs and seeps in and near the NTTR are too low temperature for most uses. The Bailey Hicks-Burrell Hot Spring, which supports a spa, is an exception.

Subsurface water temperatures can be estimated using chemical geothermometers, which are based on the temperature-dependent solubility of silica and temperature-dependent exchange reactions of certain dissolved constituents (e.g., silica dioxide, calcium, sodium, potassium, magnesium) in groundwater (Fournier, 1981). Several geothermometer databases were evaluated for local springs and well water in the 1998 Assessment (Tingley and others, 1998), including 113 samples collected from near the NTTR. The results of the analyses indicated that only 4 percent of the local well and spring samples could be associated with source waters at between 100 ºC to 150 ºC.

Based on available thermal gradient data from Pahute Mesa and the NNSS, Tingley and others (1998) concluded that water temperatures at accessible depths in the NTTR were likely too low for any geothermal uses. Temperatures from 55 ºC to 70 ºC were predicted in areas of local groundwater upwelling. Igneous-related high temperature resources were considered unlikely in the NTTR. The probable deep drilling required to exploit potential geothermal waters made them economically unfeasible at the time of the 1998 Assessment, and for the foreseeable future. For water at temperatures of 70 ºC or less, the only practical uses were considered to be for building heating, agriculture (greenhouse, soil heating), or aquaculture (fish farming, etc.). Drilling to 1 km for such water was not considered to be economically feasible. Thus, the NTTR was determined to have less potential for high-temperature geothermal resources than most areas in Nevada.

3.0 CURRENT ASSESSMENT METHODS OF INVESTIGATION

This assessment evaluates the mineral and energy resource potential of the proposed expansion areas and updates the previous mineral and energy assessments of the existing NTTR boundaries and East DNWR. In general, the approach for this assessment of the expansion areas was modeled after the 1993, 1998, and 2014 Assessments for consistency (Tingley and others, 1993, 1998; Muntean and others, 2014). The field investigation was conducted in accordance with the survey protocols employed in the previous assessments. The analysis of mineral resources used for the previous assessments was also used for this assessment.

3.1 Access Considerations

3.1.1 NTTR

The NTTR is administered by the USAF and the current NTTR lands have been withdrawn from public use since 1959 and closed to mineral and energy exploration since the initial establishment of the range in 1940. Portions of the DNWR lie inside the South Range and are jointly administered by the USAF and the USFWS.

The USAF recognizes the NTTR as its preeminent range for test and evaluation, tactics development, and advanced combat training of military personnel. There are additional non-Department of Defense training uses. Significant infrastructure has been developed within the NTTR, including targets, emitters, aircraft landing strips, and installations to monitor performance. Access to the range is currently restricted by NAFB because of the potential to interrupt planned training activities and operations that are considered vital to military preparedness. In the 1998 Assessment, NBMG personnel had less restricted access to the range to conduct field investigations. Field investigations for this assessment were restricted to non-operational areas and times. This reduced the amount of time available for on-ground observation and sampling. Field investigations within the North and South ranges were limited to selected areas of interest identified in the previous assessments, where access was granted.

3.1.2 Alternative 3A – the EC South Area

The EC South area is currently BLM administered land outside the existing NTTR boundaries, but within controlled airspace. Access to this area was unrestricted for this field investigation, although coordination with NAFB security was required.

3.1.3 Alternative 3B (64C/D and 65D) and 3C (Alamo) Areas

The 64C/D and 65D and Alamo areas are in NTTR-controlled air space. Portions of these expansion areas lie within the East DNWR and are jointly administered by the USAF and the USFWS. This includes the majority of the 64C/D and 65D area. A portion of the 64C/D and 65D area, specifically the western portion of the Indian Springs Parcel, lies outside the DNWR and NTTR and is currently administered by the BLM

(Figure 1.2). The Administrative Incorporation area, adjacent to the South Range's southern boundary, is also currently administered by the BLM.

Access to the 64C/D and 65D area for field investigations was coordinated with the USAF and USFWS. Access was approved by the USAF, subject to scheduled training activities. The USAF also required a NTTR safety and security escort to the DNWR via NTTR land. Access to the DNWR was further restricted because of few maintained roads and its rugged and remote terrain.

The USFWS denied access for a field investigation inside the Alamo area, because the area was previously included in the 2014 Assessment. As such, the current assessment relies on previously completed work in the Alamo area.

3.2 Field Investigation

Field investigations were undertaken in the expansion areas and in selected portions of the NTTR. The objective of field investigations in the expansion areas were to collect samples for geochemical analysis and observations for geochemistry modeling, both to be used to define mineral and energy resource potential. Field investigations in selected portions of the NTTR (referred to hereafter as field checks) sought to investigate previously identified areas of mineral potential, especially related to CTGDs. Field checks additionally gathered field observations to evaluate geothermal energy potential.

3.2.1 Expansion Area Field Investigation

3.2.1.1 Alternative 3A – the EC South Area

The EC South area is on the southern boundary of the North Range. It contains a portion of the Transvaal Mining District, the only known mining district within the expansion areas (Figure 2.5). Geochemical samples were collected during three separate site visits in February, April, and October 2016.

3.2.1.2 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Areas

The 64C/D and 65D area and the Administrative Incorporation area were investigated during three separate site visits in February, March, and April 2016. The 64C/D and 65D area includes a westward extension of the Indian Springs Parcel adjacent to the NNSS, and land between the South Range boundary and US Highway 95. The majority of the 64C/D and 65D area was evaluated in both the 1993 and 2014 Assessments. However, the 64C/D and 65D area was revisited as part of the current assessment to investigate previously identified metal anomalies and to collect additional GSC samples. Field investigation was also conducted west of Indian Springs Parcel to the NNSS boundary, an area not subject to previous assessments. No mining districts are known in these areas.

3.2.1.3 Alternative 3C – the Alamo Area

The Alamo area lies along the eastern boundary of the South Range, within the East DNWR. The mineral and energy resource potential of the area was evaluated in the comprehensive 1993 and 2014 Assessments. The current assessment for the Alamo area focused on evaluating previously collected data and published regional studies.

3.2.2 NTTR Field Checks

Field checks were conducted in the following sites within the existing NTTR boundaries:

- Limestone Ridge (geochemical anomaly and potential CTGDs)
- The Don Dale Mining District (geochemical anomaly and potential CTGDs)
- Stonewall Mountain (potential geothermal resource site)
- Cedar Springs (potential geothermal resource site)
- White Sage Gap (potential geothermal resource site)

These sites were checked in September 2016. Results of the field checks to investigate CTGDs are reported in Section 4.0. The field checks to investigate potential geothermal resources is included in Section 9.0.

3.3 Geodatabase Development

United States Geological Survey (USGS) 7.5-minute topographic maps and aerial photographs for the expansion areas were assembled and uploaded to a geographical information system (GIS) geodatabase. NBMG, USGS, BLM, and other related data sources were searched for geologic maps and information on existing mines, prospects, claims, leases, mining districts, historical mining production records, regional and local geology, and other information pertinent to this assessment. Landsat and ASTER satellite imagery, gravity data, and aeromagnetic survey data were compiled for the expansion areas.

These data were used to identify sites for field investigation. Mines and prospects in the expansion areas were identified using topographic maps, aerial photographs, and published reports. These mines and prospects were targeted for inspection and sample collection. Topographic maps were used to define watershed boundaries and select sites for silt and float chip sample collection.

3.4 Geophysical Evaluation

Gravity and magnetic data used for the current assessment were obtained from compilations by Hittleman and others (1994). Bouguer gravity and magnetic anomaly maps were developed for the expansion areas and for selected field check sites. Gravity and magnetic data for the expansion areas were evaluated to assist in the assessment of geology and geochemistry.

The geophysical evaluation focused on the potential for undiscovered metallic mineral deposits at minable depth, beneath the cover of Cenozoic volcanic and sedimentary rocks, and in the pre-Tertiary bedrock. The evaluation also relied on a 1996 state-wide mineral resource study conducted jointly by NBMG and the USGS (Singer, 1996). The state-wide study utilized gravity data from Saltus (1988a and 1988b) that was recorded at 71,000 irregularly spaced gravity measurement stations, and aeromagnetic survey data collected by the Department of Energy (DOE) as part of the National Uranium Resource Evaluation (NURE). Discussions of geophysical methods applied to mineral resource potential determinations are in Sections 4.0 and 5.0.

3.5 Landsat and ASTER Imagery

Landsat imagery obtained from the USGS and National Oceanic and Atmospheric Administration, and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data were evaluated for expansion areas. The ASTER images were evaluated to identify zones of alteration, and individual and grouped alteration minerals, in the 2014 Assessment (Muntean and others, 2014).

This assessment applied remote sensing analysis only to the EC South area. New satellite imagery covering the EC South areas was obtained and processed using the techniques described by Cramer (2014) and presented in the 2014 Assessment of the DNWR. This process consisted of the following elements:

- Radiance to reflectance conversion
- Atmospheric correction
- Creation of true and false color images applying specific band selections and band ratios
- Principal component or decorrelation stretches
- Supervised and unsupervised classifications
- Masking of areas not contributing to the analysis

In the 2014 Assessment, mineral potential maps developed by Cramer (2014) were used to identify calcite, dolomite, clays, silica, and iron oxide in ASTER images to identify common alteration minerals. The spectral library developed by Cramer (2014) was obtained for this assessment; however, the mineral potential mapping conducted by Cramer as presented in the 2014 Assessment could not be duplicated.

In the 2014 Assessment, it was noted that the updated evaluation of satellite imagery and the use of the more recently available ASTER imagery was of limited benefit in identifying zones of alteration and mineralization in the East DNWR. The identifiable features were typically related to lithology and did not cross lithological contacts. As such, the images were most useful in identifying geological contacts and structures.

Image-based remote sensing methods are most useful in covering large, remote areas with limited access, where collecting field data is not feasible. Remote sensing imagery studies were conducted in all previous assessments of the NTTR and the East DNWR. Areas not previously included in the remote sensing imagery studies were the EC South area and portions of the 64C/D and 65D area. In general, these areas were more accessible for field investigations than those in the interior of the NTTR and DNWR. Therefore, the primary methods of field investigation for the expansion areas were observations, sample collection and geochemical analyses.

3.6 Geochemical Analysis

Four types of samples were collected for geochemical analysis. Geochemical analysis was performed according to the sample material. The sample collection procedures and analyses presented below are similar to those used in the 1998 and 2014 Assessments (Tingley and others, 1998; Muntean and others, 2014) and are intended to provide consistent data for the expansion areas. Geochemical data were incorporated into a combined geochemical database for the area-wide geochemical analysis presented in Section 5.0.

3.6.1 GSC Samples

The term geochemical sampling for characterization (GSC) was used by NBMG in all previous assessments and is used herein for continuity. The purpose of GSC sampling and analysis was to determine background metal concentrations and identify anomalous metal concentrations that indicate the potential for a metallic mineral deposit. Based on the comprehensive GSC sampling and analysis conducted for the 1993 and 1998 Assessments, this assessment focused primarily on collecting and analyzing MA, silt, and float chip samples. The determination of background metal concentrations in the current assessment was supported by data developed in the 1993, 1998, and 2014 Assessments. NBMG divided the study area into regions dominated by Cenozoic volcanic rocks and Paleozoic sedimentary rocks, and evaluated background metal concentrations for each environment. The Cenozoic volcanic rock and Paleozoic sedimentary rock terrains evaluated by NBMG extend into the expansion areas.

Where GSC samples were collected, representative unaltered and unmineralized rock samples were collected from outcrops within that expansion area. These rock samples were used to evaluate potential petroleum source rocks and to evaluate carbonate unit suitability for industrial uses.

GSC samples were collected as follows:

- Two to 5 kilograms (kg) of material from the rock unit of interest was placed in olefin sample bags and assigned a unique sample identification (ID) number.
- A sample tag book was used to record and assign sample ID. Preprinted sample ID labels are included in the sample tag book with a tear-off sample tag. The tear-off tag was placed

inside the sample bag and the outside of the sample bag was labeled with the sample ID, and type (GSC or MA).

- The location of the sample site was marked on the relevant USGS 7.5-minute quadrangle.
- The GPS coordinates were recorded.
- A photograph of the sample site was taken with the sample ID visible.
- A representative hand sample was collected for future reference and/or preparation of thin sections.
- A written description of the sampled rock unit was recorded in a bound field notebook.
- Other pertinent information concerning the location and characteristics of the rock unit and outcrop were recorded in a bound field notebook.

3.6.2 Mineralized Area (MA) Samples

The purpose of sampling mineralized and altered materials was to investigate the occurrence of metals of interest, identify anomalous metal concentrations, and identify areas of mineral potential. Rock samples were collected from documented mining areas and prospects and from outcrops where alteration and mineralization were observed in the field. These samples were collected from waste rock dumps, safely accessible mine workings, prospect pits, mineralized outcrops, and geologic structures.

MA samples were collected following the same procedures described for GCS samples, in Section 3.6.1, above.

3.6.3 Stream Sediment Samples

Stream sediment samples were collected from strategic locations for reconnaissance and to evaluate metal occurrences on a broader, but sub-regional basis. The stream sediment sampling included collection of both active stream channel silt samples (silt samples) and mineralized float chip fragments, similar to the procedure used in the 1993 and 1998 Assessments. Sampling sites were preselected based on the evaluation of topographic maps, aerial photographs, and geological information, and an evaluation of previously sampled areas and associated geochemical data.

3.6.3.1 Silt Samples

Silt samples were collected from within the most active portion of stream channels and were composited over a reach length of up to 61 m. The following sampling procedures were followed at each silt sampling site:

- Samples were passed through a No. 10 sieve into a pan and the fraction passing through the sieve was retained.
- Approximately 1 kg of sample was placed in self-sealable plastic bags and assigned a unique sample ID.
- A sample tag book was used to record and assign sample ID. Preprinted sample ID labels are included in the sample tag book with a tear-off sample tag. The tear-off tag was placed

inside the sample bag and the outside of the sample bag was labeled with the sample ID and type.

- The location of the sample was recorded on the appropriate USGS 7.5-minute quadrangle.
- The GPS coordinates were recorded.
- A photograph of the sample site was taken with the sample ID visible.
- A description of the channel geomorphology were recorded in a bound field book.

Written data were recorded on both preprinted forms and in a bound field notebook.

3.6.3.2 Float Chip Samples

Float chip samples consist of altered and mineralized rock fragments collected within stream channels at and near each silt sampling site. The following sampling procedures were followed at each float chip sampling site:

- Up to 2 kg of altered and/or mineralized rock chips were placed in cloth or olefin bags and a unique sample ID was assigned.
- A sample tag book was used to record and assign sample ID. Preprinted sample ID labels are included in the sample tag book with a tear-off sample tag. The tear-off tag was placed inside the sample bag and the outside of the sample bag was labeled with the sample ID and type.
- The location of the sample was recorded on the appropriate USGS 7.5-minute quadrangle.
- The GPS coordinates were recorded in the bound field notebook.
- A photograph of the sample site was taken with the sample ID visible.
- A written description of the materials that occur in the stream channel was recorded in the bound field notebook, including the dominant lithologies and types of mineralization and alteration observed.

3.6.4 Sample Analysis

The laboratory analyses for the current assessment were consistent with the 1998 and 2014 Assessments. Data from the field investigation and GSC evaluation are contained in Appendix C. A complete list of laboratory analytical methods, results, and detection limits is included in Appendix C.1.

ALS Global (ALS), located in Reno, Nevada, was used as the geochemical testing laboratory for the 2014 Assessment and was used for the current assessment. Analytes and ALS method designations are described for each sample type below.

GSC, MA, and float chip samples were subjected to a four-acid digestion and the following analyses:

- 48-element inductively coupled plasma atomic emission spectroscopy (ICP–AES) and inductively coupled plasma mass spectroscopy (ICP-MS) (ALS Laboratory Method ME-561M)
- Rare earths by ICP–AES/ICP-MS (ALS Laboratory Method ME-561R)

- Platinum, Palladium, and Iridium by fire assay (ALS Laboratory Method PGM-NAA26)
- Gold by Fire Assay (ALS Laboratory Method Au-AA23)
- Mercury by cold vapor Atomic Absorption Spectroscopy (AAS) (ALS Laboratory Method Hg-CV41)

In addition, GSC samples were subjected to the following:

- Whole rock analysis by XRF for major oxides plus loss on ignition (LOI) (ALS Laboratory Method ME-ICP06)
- Carbonate carbon (ALS Method C-GAS05) and non-carbonate carbon (ALS Method C-IR17) were evaluated in selected carbonate rock samples

Silt samples were subjected to the following:

- Aqua regia digestion and a 53-element analysis by ICP–AES/ICP-MS (ALS Laboratory Method ME-541L)
- Due to the poor gold detection capability of Method ME-541L, active channel silt samples were also subjected to gold analysis by fire assay (ALS Method Au-AA23)

ALS tabulated assay data are presented in Appendix C.1

GSC and MA samples were subjected to X-Ray Diffraction (XRD) for mineralogical analysis. Splits of sample pulps prepared by ALS were submitted to DCM Science Laboratory Inc. (DCM) in Wheatridge, Colorado, for analysis by XRD. Tabulated XRD results and DCM laboratory reports are presented in Appendix C.2.

3.7 Laboratory Quality Assurance (QA) and Quality Control (QC)

3.7.1 ALS Global

Laboratory quality assurance and quality control (QA/QC) data for ALS are contained in Appendix C.3. ALS is a major analytical laboratory serving the mining industry globally. ALS is certified by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), and adheres to a robust quality management system, which includes participation in external “round robin” proficiency tests, yearly internal audits, and external audits performed by ISO.

ALS included standards, blanks, and duplicates as part of its internal QA/QC program. In total ALS tested 18 certified standards for whole rock and individual element analysis. The reported normal frequency of ALS QA/QC testing was as follows:

- ICP-MS/ICP-AES- two standards, one duplicate, and one blank for every 40 samples
- Fire Assay- two standards, one duplicate, and one blank for every 84 samples
- XRF- two standards, three duplicates, and one blank for every 39 samples

The range of acceptable values for each standard was reported along with assay values. Blanks, which are composed entirely of silica dioxide (SiO_2) were run on all of the analytical techniques and the results were reported. Additionally, ten samples were selected by ALS to be run as duplicates for all the analytical methods. Samples were delivered to ALS in two shipments. The first sample shipment consisted of 103 samples sent in May 2016, and the second sample shipment consisted of 23 samples sent in September 2016. The results from the ALS internal quality control (QC) program are presented in Appendices C.3a and C.3b for samples delivered in May and September, 2016, respectively.

3.7.2 May Samples

The laboratory ran over 1,000 QC tests while analyzing the May 2016 samples. All the duplicate and blank analyses from these samples were within the laboratory's statistically derived upper and lower bounds. On seven occasions, constituents included in the laboratory standards were outside of the upper and lower bounds. The laboratory bounds represent ±1 standard deviation of the data set for a given laboratory control standard constituent. Assuming the results are normally distributed, approximately 68 percent of the results should fall within the upper and lower bounds assigned by the laboratory. Increasing the bounds to 2 standard deviations should capture 95 percent of the sample results and 3 standard deviations should capture 99 percent of the sample results. Standards with constituents outside the upper or lower bounds, and the number of times they were out of range, were as follows: three for mercury, two for palladium, and one for rubidium and zirconium. With the exception of two of the mercury results, all of the results were within the bounds at ±2 standard deviations. This statistical evaluation indicates that laboratory data for these constituents are accurate and useful for their intended purpose. Additionally, two of the mercury results from the ICP method were outside the bounds of 3 standard deviations, but within the laboratory bounds for the lower concentration mercury standard (OREAS-45b, with mercury lower and upper limits of 0.028 to 0.052 ppm, respectively). This suggests that the ICP mercury results are not reliable. However, the mercury results from the ICP analysis were not used for this assessment. Instead, mercury assays from the cold vapor AAS were used for this evaluation, as this method is more accurate because mercury is not lost to volatilization.

3.7.3 September Samples

The laboratory ran approximately 500 QC tests while analyzing the September 2016 samples. All the blank analyses from these samples were within the statistical bounds; however, standards were outside of the bounds three times and duplicate samples were outside of the bounds ten times. The constituents exceeding the bounds for the standard samples include phosphorus, yttrium, and organic carbon. All these constituents had results skewed higher than the 1-standard-deviation upper bound reported by the laboratory; however, expanding the upper bound for phosphorus by two standard deviations and by 3 standard deviations for yttrium and organic carbon brings all the constituents within the bounds. The constituents exceeding the bounds for the duplicate samples include copper, lithium, dysprosium, erbium,

and terbium. As with the standard samples, expanding the bounds 2 to 3 standard deviations brings all the constituents with the bounds. Because the results are within 3 standard deviations, they are considered usable for their intended purpose.

3.7.4 USGS Standard QA

As an additional QA check on ALS precision and accuracy, two USGS certified standards: QLO-1a and DGPM-1 were submitted with the May samples. Standard DGPM-1 was a disseminated gold standard, whereas QLO-1a was prepared from unmineralized rock and is a quartz latite whole rock standard. One standard of DGPM-1 and four standards of QLO-1a were randomly included with the May samples. The results from the assays of the standards were compared to the reference values provided by the USGS, and to one other, to evaluate consistency. The QA analysis results are contained in Appendices C.3c and C.3d.

The results for the quartz latite standard (QLO-1a) were outside of the upper or lower bounds for 8 of the 24 constituents tested. As with the ALS laboratory standards, the bounds for the USGS standards represent 1 standard deviation. Of the eight out-of-range constituents, one overestimated the concentration and the remaining seven underestimated the concentration. When using 2 standard deviations to set the bounds, all of the results are within range, indicating that the data is usable for its intended purpose. The disseminated gold ore standard (DGPM-1) was within the 1 standard deviation bound for all gold results. Arsenic and antimony were also evaluated using this standard. When comparing to a 1 standard deviation bound, the results indicate four arsenic concentrations were overestimated and two antimony concentrations were underestimated. Comparing to a 2 standard deviation bound indicates that all of the data were within the bounds with exception of the antimony analysis performed with ICP-MS on the aqua regia digestant.

3.7.5 DCM Science

No project-specific QA/QC procedures were used for XRD analyses. DCM is accredited by the National Voluntary Laboratory Accreditation Program and the American Industrial Hygiene Association Laboratory Accreditation Program (AIHA-LAP). DCM's XRD capabilities are accredited as part of its AIHA-LAP certification.

3.8 Geochemical Data Incorporated from Previous Studies

The following geochemical data from previously completed studies were incorporated in the GIS geodatabase for the current assessment:

- GSC sample geochemical data from the 1993 Assessment of the East DNWR and 1998 Assessment of the NTTR
- MA, silt, and float chip geochemical data from the 1998 Assessment of the NTTR, and the 1993 and 2014 Assessments of the East DNWR

These data were obtained through a combination of GIS data packages available via the NBMG publications website, through character recognition scanning of tabular data in the appendices of the 1993, 1998, and 2014 Assessment reports, and the GIS database from the 2014 Assessment provided by the USFWS.

As noted above, limited additional GSC sampling was conducted for the current assessment. The determination of background geochemical values for metals of interest in the current assessment is based on the data developed by NBMG for the 1993, 1998, and 2014 Assessments, which included the analysis of 321 unmineralized samples collected throughout the NTTR and East DNWR. As noted above, the geologic environments characterized in the GSC sampling conducted by NBMG extend into the expansion areas.

4.0 FIELD INVESTIGATION RESULTS

4.1 Alternative 3A – the EC South Area

4.1.1 Geologic Setting

The EC South area is part of the Oasis Valley and the Transvaal Hills, on the western edge of the Southwestern Nevada Volcanic Field (SNVF) (Figure 1.4). To the east are the overlapping Rainer Mesa and Ammonia Tanks calderas, which together comprise the Timber Mountain Caldera Complex (Figure 1.5). Oasis Mountain and the Hogback are on the western border. To the north is the fringe of the Thirsty Mountain Shield Volcano. Much of the EC South area is in the center of Oasis Valley and is covered by Quaternary and Tertiary alluvium. Volcanic rocks outcrop in the east on the Rainer Mesa/Ammonia Tanks caldera margins and, to the north, along the Thirsty Mountain Shield Volcano (Figure 1.5, Figure 4.1, and Figure 4.2). The geology of the EC South area is shown on Figure 4.1. Figure 4.2 contains the geologic unit legend for Figure 4.1. Figure 4.3 shows the geology of the Transvaal Hills area and the geochemical samples collection sites, discussed below.

4.1.2 Stratigraphy

The middle Miocene SNVF is a classic example of a multi-caldera silicic volcanic field. The ash-flow tuffs that erupted from these calderas once covered an area of more than 11,000 km^2 (Christiansen and others, 1977). Rocks erupted from at least three SNVF calderas are exposed in the EC South area, including tuffs and lavas from Rainier Mesa, Ammonia Tanks, and Black Mountain calderas (Figure 4.1 and Figure 4.2). Noble and others (1991) divided volcanism in the SNVF into three periods:

- 15.2 to 12.7 Ma: main stage
- 11.6 to 9 Ma: Timber Mountain stage
- 9 to 7 Ma: late stage

The majority of the exposed rocks in the EC South area are products of the Timber Mountain stage. The volcanism of the SNVF is characterized by a rhyolite-basalt association, with few examples of intermediate composition rocks present. The rhyolite-basalt association is linked spatially and temporally in the western US to widespread extension accommodated by normal faulting after periods of crustal thickening and heating (Christiansen and others, 1977).

The dominant bedrock units exposed in the EC South area are regionally extensive ash-flow tuff sheets erupted from the overlapping Rainier Mesa and Ammonia Tanks calderas during the Timber Mountain stage of the SNVF. These units include: Rainer Mesa Tuff (Tmr), Ammonia Tanks Tuff (Tma), Tuff of Cut-off Road (Tmc), and Beatty Wash FM (Tvw) (Figure 4.1 and Figure 4.2). Rainier Mesa and Ammonia Tanks tuff are the most voluminous and extensive tuffs present in the EC South area. Generally, these units dip gently to the west, away from their eruptive center, into the half graben that formed Oasis Valley.

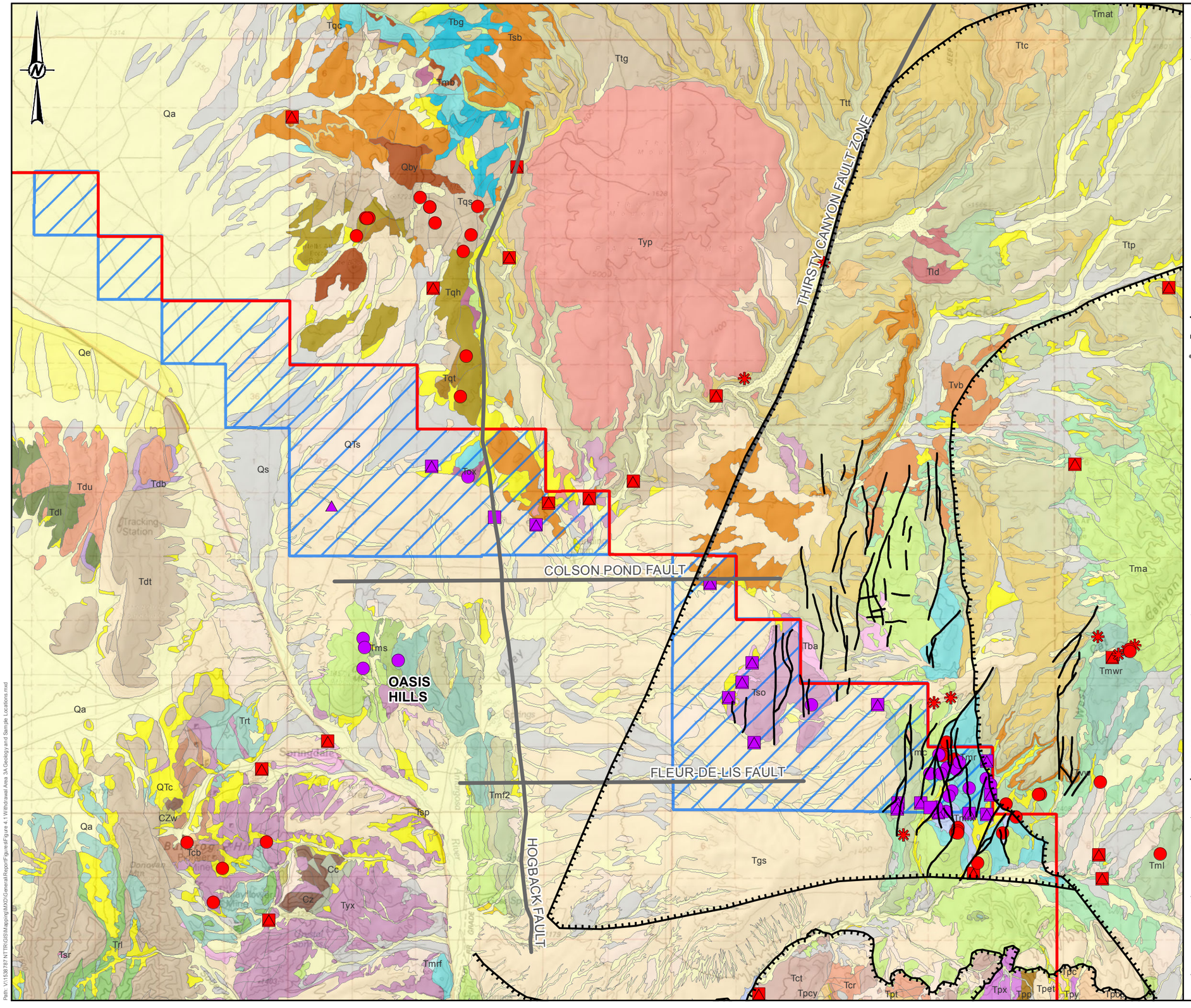


FIGURE 4.1
ALTERNATIVE 3A GEOLOGY AND SAMPLE LOCATIONS

LEGEND

2016 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1998 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA
- SILT SAMPLE

GEOLOGIC STRUCTURES
- MINOR NORMAL FAULT
- CALDERA MARGIN
- FAULT/LINEAMENT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION

FOR OFFICIAL USE ONLY

1 0.5 0 1 Miles

1.6 0.8 0 1.6 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998.

FRIDRICH, C; MINOR, S; SLATE, J; RYDER, P. GEOLOGIC MAP OF OASIS VALLEY SPRING-DISCHARGE AREA AND VICINITY, NYE COUNTY, NEVADA. USGS, 2007.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED
SOURCES: ESRI, DELORME, USGS, NPS
SOURCES: ESRI, USGS, NOAA

CLIENT
LEIDOS, INC.

PROJECT
NEVADA TEST AND TRAINING RANGE
MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787 NTTR\GIS\Mapping\MXD\GeneralReport\FiguresFigure 4-1 Withdrawal Area 3A Geology and Sample Locations.mxd

FIGURE 4.2
ALTERNATIVE 3A GEOLOGIC MAP LEGEND

GEOLOGIC UNITS

- QA - YOUNG ALLUVIAL DEPOSITS (HOLOCENE)
- QE - EOLIAN SAND DEPOSITS (QUATERNARY)
- QS - MIDDLE ALLUVIAL DEPOSITS (PLEISTOCENE)
- QTC - COLLUVIUM (HOLOCENE, PLEISTOCENE, AND PLIOCENE)
- QTS - OLD ALLUVIAL DEPOSITS (EARLY PLEISTOCENE AND PLIOCENE)
- TYP - BASALT OF THE THIRSTY MOUNTAIN SHIELD VOLCANO (PLIOCENE)
- TGS - OLDER GRAVELS (LOWER PLIOCENE AND MIOCENE)
- TBA - YOUNGER BEDDED TUFFS (MIOCENE)
- TSB - BASALTS GENERALLY OF THIRSTY CANYON AGE (MIOCENE)
- TTT - TRAIL RIDGE TUFF OF THIRSTY CANYON GROUP (MIOCENE)
- TTP - PAHUTE MESA TUFF OF THIRSTY CANYON GROUP (MIOCENE)
- TSO - RHYOLITE OF OASIS VALLEY (MIOCENE)
- TVW - BEATTY WASH FORMATION (MIOCENE)
- TYX - YOUNGER LANDSLIDE BRECCIAS (MIOCENE)
- TMC - TUFF OF CUTOFF ROAD OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMF2 - UPPER TUFF OF FLEUR-DE-LIS RANCH OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMWR - LAVAS OF FLEUR-DE-LIS RANCH AND OF WEST CAT CANYON OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMF1 - LOWER TUFF OF FLEUR-DE-LIS RANCH OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TML - RHYOLITE OF COFFER'S WELL OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMA - AMMONIA TANKS TUFF OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMR - RAINIER MESA TUFF OF TIMBER MOUNTAIN GROUP (MIOCENE)
- TMS - LAKE SEDIMENTS OF OASIS MOUNTAIN (MIOCENE)
- TMRX - BRECCIAS ASSOCIATED WITH TIMBER MOUNTAIN TUFFS (MIOCENE)

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NOTES

SOURCE:
FRIDRICH, C; MINOR, S; SLATE, J; RYDER, P. GEOLOGIC MAP OF OASIS VALLEY SPRING-DISCHARGE AREA AND VICINITY, NYE COUNTY, NEVADA. USGS, 2007.

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**4.2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 4.2 Withdrawal Area 3A Geology and Sample Locations - Map Units.mxd

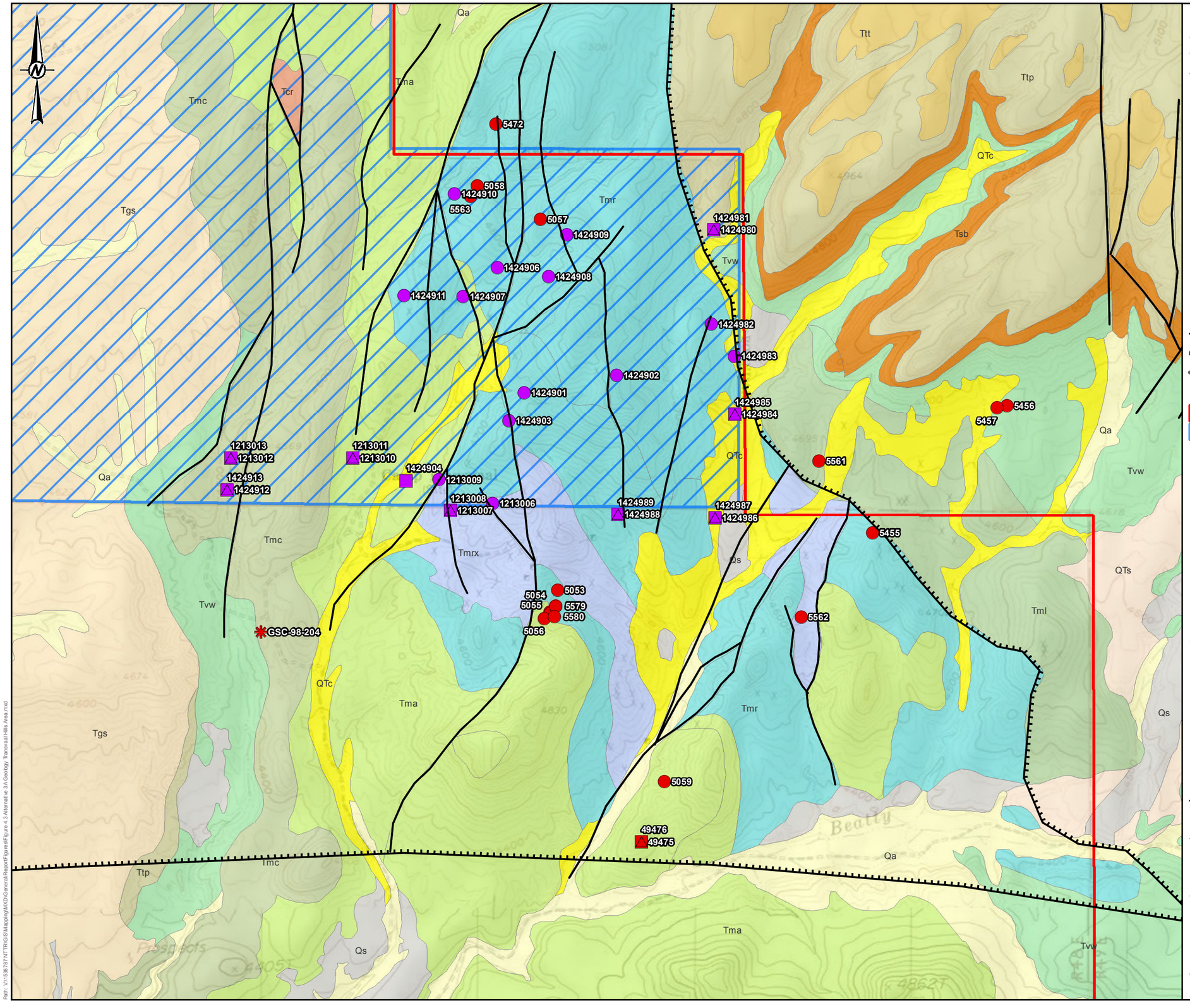


FIGURE 4.3
ALTERNATIVE 3A GEOLOGY TRANSVAAL HILLS AREA GEOLOGY, STRUCTURE, AND SAMPLE LOCATIONS

LEGEND

2016 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1998 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA
- SILT SAMPLE

GEOLOGIC
- MINOR NORMAL
- CALDERA MARGIN
- FAULT/LINEAMENT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION

FOR OFFICIAL USE ONLY

1,000 500 0 1,000 Feet

300 150 0 300 Meters

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998.

FRIDRICH, C; MINOR, S; SLATE, J; RYDER, P. GEOLOGIC MAP OF OASIS VALLEY SPRING-DISCHARGE AREA AND VICINITY, NYE COUNTY, NEVADA. USGS, 2007.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED
SOURCES: ESRI, DELORME, USGS, NPS
SOURCES: ESRI, USGS, NOAA

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**4.3**

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 4.3 Alternative 3A Geology Transvaal Hills Area.mxd

The Rainier Mesa Tuff is the oldest tuff unit exposed in the EC South area (Figure 4.1 and Figure 4.2). It is a rhyolitic, crystal-rich, welded ash-flow tuff which was deposited 11.6 Ma during the collapse of the Rainer Mesa caldera (Sawyer and others, 1994). It is quartz-rich and locally exhibits strong eutaxitic texture. Within the EC South area, the Rainer Mesa Tuff has a maximum exposed thickness of at least 250 m. The Ammonia Tanks Tuff is stratigraphically higher than the Rainer Mesa Tuff. It was erupted from the Ammonia Tanks caldera 11.45 Ma (Sawyer and others, 1994). It is a rhyolitic, crystal-rich, welded ash-flow tuff with variable eutaxitic texture and common lithic fragments. The Tuff of Cut-off Road is a poorly to incipiently welded rhyolitic ash-flow tuff and is stratigraphically higher than Ammonia Tanks Tuff. The Beatty Wash FM is a sequence of non-welded rhyolitic tuffs related to at least two separate eruptive events.

Rhyolite of Oasis Valley (Tso) is a rhyolite dome emplaced approximately 9.9 Ma during an interval when caldera activity was transitioning from the Rainier Mesa and Ammonia Tanks calderas to the Black Mountain caldera.

The tuffs of the Thirsty Mountain Group include Pahute Mesa Tuff (Ttp) and Trail Ridge Tuff (Ttt) (Figure 4.1 and Figure 4.2). These tuffs are the products of the collapse of the Black Mountain caldera, which occurred between 9.15 and 9.43 Ma. Black Mountain caldera is north of the EC South area and the exposures found within the EC South area represent some of the most distal exposures of this eruptive event (Figure 1.5). These exposed units are variably welded, rhyolitic ash-flow tuffs that are sub-horizontal and overlie both the tuffs of the Timber Mountain Group and basalts (Tsb) related to Black Mountain caldera (Figure 4.1 and Figure 4.2).

Throughout the EC South area, tuffs are interfingered with rhyolite and basalt lavas, as well as tephras from cinder cones (Figure 4.1 and Figure 4.2). Alluvial and lake sediments, and landslide breccia deposits, are also present. The SNVF sequence is overlain by alluvium containing minor amounts of upper Miocene to Quaternary basalts and small-volume tuffs in major washes. The EC South area contains no outcrops of the pre-SNVF basement rocks. However, according to Burchfiel (1964), the Cenozoic sequence is unconformably underlain by a sequence of latest Proterozoic to late Paleozoic sedimentary rocks consisting of limestone, dolomite, argillite, and quartzite. This miogeoclinal sequence is approximately 11 km thick in the NNSS region (Burchfiel, 1964).

4.1.3 Structure

In Nevada, structural controls are recognized as playing an important role in metallogenesis (Muntean and others, 2007). Figure 4.4 illustrates the major structures in and near the EC South area, where both regional and local structures interplay. Regionally, the EC South area is at the nexus of extensional and translational tectonic provinces. On the local scale, numerous features are related to caldera development and collapse.

FIGURE 4.4
ALTERNATIVE 3A GEOLOGIC STRUCTURE

GEOLOGIC STRUCTURES

- CALDERA MARGIN
- FAULT/LINEAMENT
- MINOR NORMAL FAULT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION

HOGBACK FAULT
THIRSTY CANYON FAULT ZONE
AMMONIA TANKS TOPOGRAPHIC WALL
COLSON POND FAULT
RAINIER MESA RING FEATURE
FLEUR-DE-LIS FAULT
RAINIER MESA RING FRACTURE ZONE
RAINIER MESA TOPOGRAPHIC WALL
PAHUTE MESA
OASIS VALLEY
Nellis Air Force Range
Tracking Station
Landing Strip
Springdale
Oasis Valley Springs
Antelope Springs
Goss Springs
Crystal Springs
Hot Springs
Butlfrog Hills
Pioneer Mine
Mayflower Mine
Donovan Mtn
Picnic Area
Rocket
Beatty Wash
Well
Thirsty Mountain
Oasis Mtn
Spotted Range
Sober-up Grade
Cat Canyon
West

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1 0.5 0 1 Miles

1.6 0.8 0 1.6 Kilometers

NOTES

SOURCE:
FRIDRICH, C; MINOR, S; MANKINEN, E. GEOLOGIC EVALUATION OF THE OASIS VALLEY BASIN, NYE COUNTY, NEVADA USGS, 1999. OPEN-FILE REPORT 99-533-A.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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SOURCES: ESRI, DELORME, USGS, NPS
SOURCES: ESRI, USGS, NOAA

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1538787	---	---	**4.4**

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Path: \\1538787 NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 4.4 Withdrawal Area 3A geologic structures.mxd

There are also features whose origins are unclear, but are postulated to be related to development of detachment faults (see discussion below regarding the Colson Pond fault and the Fluer-de-Lis fault) (Fridrich and others, 2007).

As discussed in Section 1.5, the Basin and Range province is typified by extension accommodated by block faulting along north-to-south trending normal faults. In the EC South area, extension likely initiated prior to the eruption of the Timber Mountain caldera; however, the majority of extension post-dates caldera activity (Christiansen and others, 1977). An example of basin-and-range faulting in the EC South area is the Hogback fault, a half graben that bounds Oasis Valley on the west (Figure 4.4). Based on stratigraphic relationships, Fridrich and others (1999) reported that movement along the Hogback fault was initiated before the deposition of the 11.6-Ma Rainier Mesa Tuff and ceased approximately 9.5 Ma.

The WL is a broad zone of dextral transtension accommodated by en echelon, non-continuous, northwest trending strike-slip faults (Figure 1.6). The WL separates the Sierra Nevada Mountains from the Basin and Range province, and connects to the LVSZ through the western edge of the SNVF. Although no distinct structure has been identified that passes from the WL through the SNVF, Christiansen and others (1977) note that several caldera complexes are aligned along the WL trend, and postulate that the coincidence of basin-and-range and WL faulting could have localized caldera formation. The same authors observed that the resurgent dome within the Timber Mountain caldera is aligned with the trend of the WL and may, therefore, also reflect the influence of deep structural systems on the development of the caldera.

Local structures appear to fall into two classes: those associated with caldera development and collapse, and those associated with movement along detachment faults to the south of the EC South area.

The edges of the caldera collapse structures are often demarcated by a zone of fracturing which circumscribes the caldera and are referred to as the ring-fracture systems (Figure 1.5). The Ammonia Tanks ring-fracture system/topographic wall passes through the EC South area in the Transvaal Hills (Figure 4.4). In addition, there are numerous north trending normal faults that are aligned sub-parallel to the edge of the caldera and dip both to the east and west. Based on field relationships, these faults do not appear to accommodate significant throw and are likely the result caldera resurgence or subsidence (Christiansen and others, 1977).

The Thirsty Canyon Fault Zone (TCFZ)/lineament is a prominent 35-km-long, steeply dipping, northeast trending zone defined by several gravity and magnetotelluric geophysical studies (Mankinen and others, 1999; Schenkel and others, 1999) (Figure 4.4). Up to 2 km wide, it was postulated by Hildebrand and others (1999) to be a deep-seated structure that likely pre-dated and influenced caldera development. No evidence of the TCFZ is discernable on the surface of the the EC South area due to deposition of tuffs associated with the Thirsty Canyon Group and the collapse of the Black Mountain caldera.

The Colson Pond fault and the Fleur-de-lis fault are approximately east-west striking, subparallel faults identified primarily through geophysical interpretation (Hildebrand and others, 1999) (Figure 4.4). The Colson Pond fault is strongly expressed in gravity; however, it is completely covered by un-faulted alluvial deposits. It is interpreted as juxtaposing intra- and extra-caldera deposits because of the drastic differences in the thickness of the volcanic sequence north and south of the fault. Additionally, Fridrich and others (2007) believed it to have a significant strike-slip component. The Fleur-de-lis fault has a north dipping paleoscarp with 1.5 km of throw defined by structural and stratigraphic offsets. The origin of these two similarly oriented faults is unresolved; however, two hypotheses were presented by Fridrich and others (2007): they are tear faults accommodating differential slip in the development of the detachment fault, or they are related to the development of the calderas. Neither model adequately describes the structures.

4.1.4 Mining History and Mineralization

The Transvaal Mining District is the only mining district within the EC South area (Figure 2.5). It received a short interval of intense interest in 1906. However, in spite of visible alteration, no precious metal system was discovered, and the camp, which at one point had up to 700 inhabitants, was abandoned within a year (Hall, 1981). Many shafts and adits, as well as innumerable prospect pits, were left behind. Tingley and others (1998) reported that there was little to no production of ore from the Transvaal Mining District.

In the Transvaal Mining District, alteration is localized around steep north-northeast trending normal faults and fracture sets that are often brecciated and oxidized. The area of most intense hydrothermal alteration in the district lies along the southern boundary of the North Range and was evaluated in the 1998 Assessment. Tingley and others (1998) identified this zone as occurring along the ring-fracture system on the edge of the Ammonia Tanks caldera, where intra-caldera ash-flow tuff and landslide deposits of the the Rainier Mesa Tuff are overlain by outflow deposits of the Ammonia Tanks tuff. The alteration was characterized by fine grained kaolinite, alunite, quartz, opal, and iron-oxides. Rye (1993) identified this alteration assemblage as resulting from the circulation of steam-heated, acid-sulfate fluids. Tingley and others (1998) described the alteration assemblage transitioning abruptly to weakly argillic moving away from the caldera margin. In the most distal areas of argillic alteration, Tingley and others (1998) reported zeolitic alteration of the tuffs with abundant veins and fracture coating of stilbite and alunite. Abundant chalcedony was observed in the EC South area, both within and outside areas of hydrothermal alteration.

The age of the alteration was determined by Christiansen and others (1977) to be between 10.5 and 9.5 Ma on the basis of stratigraphic relationships of unaltered tuffs. Jackson (1988) and McKee and Bergquist (1993) performed potassium-argon dating on alunite collected in the district and obtained an age date of 9.9 (±0.4) Ma. This date indicates that hydrothermal alteration in the Transvaal Mining District occurred approximately coeval with the waning stages and cessation of volcanic activity in the Timber Mountain caldera (Christiansen sand others, 1977).

4.1.5 Laboratory Results

The 56 samples collected within and adjacent to the EC South area were subjected to laboratory analysis for the current assessment. These included 19 MA samples, 18 silt samples, and 19 float chip samples. Figure 4.3 is a geologic map of the Transvaal Hills in the EC South area and shows the sample collection sites for the current assessment and the 1998 Assessment (Tingley and others, 1998). GSC parameters were described in Section 3.4.5. Laboratory data are in Appendix C.2.

Results from the XRD analyses confirm the alteration assemblages reported by Tingley and others (1998). Kaolin and smectite were the two most common alteration minerals detected in the MA samples and are indicative of argillic alteration. Heulandite, a zeolite, was a major component of two samples. Goethite was detected at low concentrations in several samples, likely representing the pervasive oxidation accompanying the hydrothermal alteration. No sulfide minerals were detected; however, two samples had low concentrations of the hydrous potassium iron sulfate jarosite.

Gold was detected at anomalously high concentration in five MA samples and one float chip sample; three of those samples, including the one with the highest gold concentration, 0.514 parts per million ([ppm]; equivalent to 0.514 grams per tonne or 0.015 ounces per ton) (sample 1424918), were collected from adits in the Oasis Hills, an upland area a few kilometers south of the EC South area.

The three samples with anomalous gold concentrations in the EC South area form a cluster along the southern border of the area. Two of those samples (samples 1213006 and 1213008) occur in the same small drainage, while sample 1213009 was collected along a fault system running adjacent to that drainage. Sample 1213006 (0.071 ppm gold) was a brecciated rhyodacite dike and adjacent hydrothermally altered tuff. Sample 1213008, a float-chip sample, collected down-drainage from sample 1213006, had the highest gold concentration from the EC South area, 0.144 ppm (Figure 4.3). This sample consisted of breccia with clasts of tuff whose matrix was extremely oxidized. It is possible that the float chip material was from the brecciated rhyodacite dike sampled in 1213006. Sample 1213009 (0.005 ppm gold) was collected from a test-pit in a northeast-trending, steeply dipping normal fault. Material in the test-pit was brecciated and heavily oxidized. The trace of the fault forms the western edge of the drainage where samples 1213006 and 1213008 were collected.

Silver concentrations were anomalously high in many of the same samples that had gold concentrations higher than background levels. No signature, or halo of pathfinder elements, was observed; rather, pathfinders such as arsenic and mercury were detected at anomalously high concentrations less frequently than were precious metals.

4.1.6 Geophysics

Figure 4.5 is a map of the EC South area displaying the Bouguer gravity anomaly data and major geologic structures. Gravity data across the Transvaal Mining District is dominated by regional trends. The Transvaal Mining District is between the gravity low of Pahute Mesa, a large thickness of low-density tuff, and the gravity highs of Bare Mountain and the Bullfrog Hills, which expose high-density Precambrian material at the surface. There is insufficient gravity data points within the Transvaal Mining District to resolve local trends from the overall regional gradient.

Regional magnetic anomaly data shown in Figure 4.6 indicate that a band of magnetic lows follows the fracture system along the western edge of the Ammonia Tanks caldera. This low-magnetic band likely represents hydrothermally altered tuffs whose magnetite components were de-natured by the alteration process. It is unlikely that lithological changes account for the magnetic low, as the band cuts across several distinct lithologic units. This is consistent with field observations and reports from Tingley and others (1998), which identified the main zone of hydrothermal alteration in the Transvaal Mining District as occurring along the ring-fracture system on the western edge of the Ammonia Tanks caldera.

Several local geophysical studies have deployed gravity, magnetic, and magnetotelluric methods (see Mankinen and others, 1999; Schenkel and others, 1999; Hildebrand and others, 1999) to investigate groundwater movement from Pahute Mesa into the Oasis Valley. While these studies have helped to characterize several of the buried structures in the region, they did not reveal any major alteration zones within those structures. Nor were they near enough to the Transvaal Mining District to enable inference of the properties of the material at depth beneath the surface alteration zone.

4.2 Alternative 3B – the 64C/D and 65D Area

4.2.1 Geological Setting

The 64C/D and 65D area encompasses the southwestern part of the Spotted Range, a Paleozoic sedimentary sequence that has undergone multiple stages of orogenesis and deformation (Figure 1.3). The 64C/D and 65D area is bordered to the north by the Cross Grain Valley, to the east and south by the Indian Springs Valley, and to the west by the Mercury Valley. The 64C/D and 65D area is just north of the LVSZ (Figure 1.5). It includes a narrow strip of land between the west boundary of the South Range and the east boundary of the NNSS, and along the southern boundary of the South Range, north of Highway 95.

4.2.2 Stratigraphy

The geology of the 64C/D and 65D area is shown on Figure 4.7. Figure 4.8 shows geology and sample collection sites in the Indian Springs Parcel area. The Spotted Range is comprised of east-northeast striking Paleozoic sedimentary rocks. Many of the local structures, including fold axes and faults, as well as the interior valleys and drainages of the the Spotted Range, follow the east/northeast trending structural fabric.

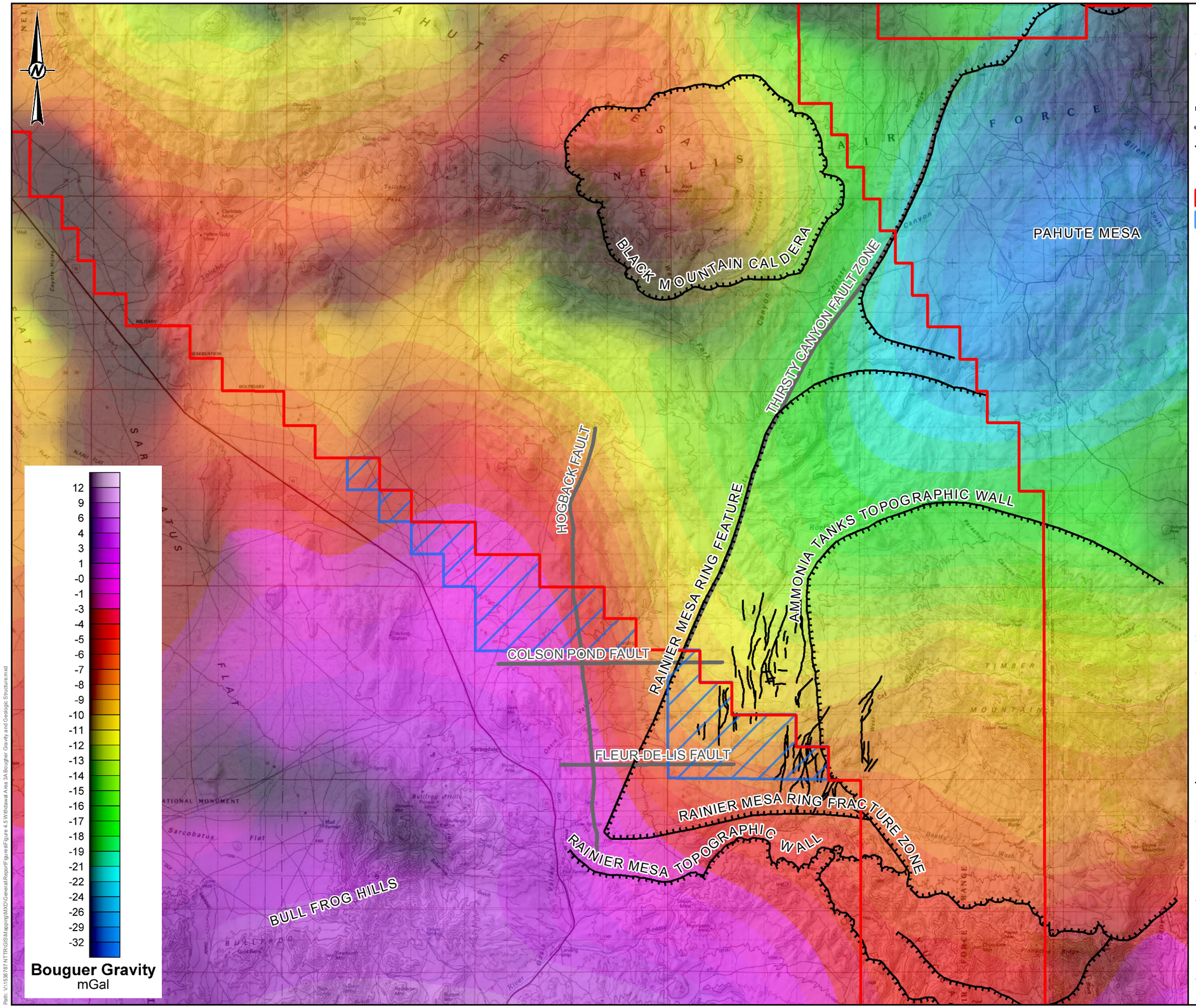


FIGURE 4.5
ALTERNATIVE 3A BOUGUER GRAVITY AND GEOLOGIC STRUCTURE

LEGEND

GEOLOGIC STRUCTURES
- CALDERA MARGIN
- FAULT/LINEAMENT
- MINOR NORMAL FAULT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION

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3 1.5 0 3 Miles

5 2.5 0 5 Kilometers

NOTES

SOURCE:
OASIS VALLEY STRUCTURES - FRIDRICH, C; MINOR, S; MANKINEN, E. GEOLOGIC EVALUATION OF THE OASIS VALLEY BASIN, NYE COUNTY, NEVADA USGS, 1999. OPEN-FILE REPORT 99-533-A.
GEOPHYSICS OF NORTH AMERICA: THIS DATA INCLUDES THE BOUGUER GRAVITY FIELD SAMPLED AT 6 KILOMETRES. THIS DATA IS FROM THE DNAG (DECADE OF NORTH AMERICAN GEOLOGY) GRAVITY COMPILATIONS. THIS DATA HAS BEEN OBTAINED FROM THE NOAA "GEOPHYSICS OF NORTH AMERICA" CD, WHICH WAS COMPILED BY ALLEN M. HITTELMAN, JOHN O. KINSFATHER AND HERBERT MEYERS, THIRD PRINTING, AUGUST, 1994. MORE INFORMATION CAN BE OBTAINED FROM: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) NATIONAL GEOPHYSICAL DATA CENTER 325 BROADWAY BOULDER, COLORADO 80303-3328 HTTP://WWW.NOAA.GOV/ JUNE 20, 2001

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787 NTTR\GIS\Mapping\MXD\General Report\Figure 4\Figure 4.5 Withdrawal Area 3A Bouguer Gravity and Geologic Structure.mxd

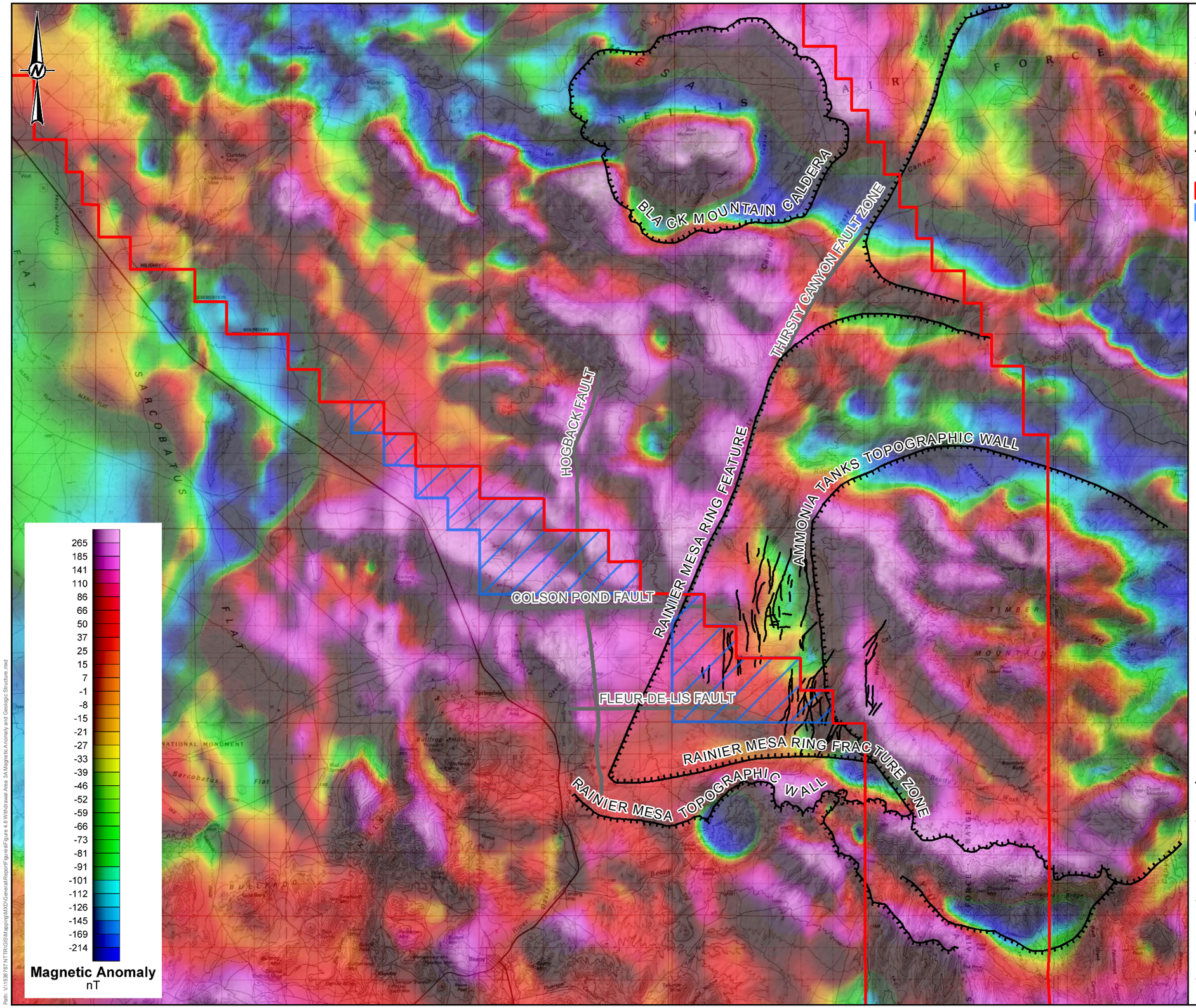


FIGURE 4.6
ALTERNATIVE 3A MAGNETIC ANOMALY AND GEOLOGIC STRUCTURE

LEGEND

GEOLOGIC STRUCTURES
- CALDERA MARGIN
- FAULT/LINEAMENT
- MINOR NORMAL FAULT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE
- ALTERNATIVE 3A - EC SOUTH EXPANSION

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3 1.5 0 3 Miles

5 2.5 0 5 Kilometers

NOTES

SOURCE:
OASIS VALLEY STRUCTURES - FRIDRICH, C; MINOR, S; MANKINEN, E. GEOLOGIC EVALUATION OF THE OASIS VALLEY BASIN, NYE COUNTY, NEVADA USGS, 1999. OPEN-FILE REPORT 99-533-A.
GEOPHYSICS OF NORTH AMERICA: THIS DATA INCLUDES THE TOTAL MAGNETIC FIELD OF NORTH AMERICA SAMPLED AT 2 KILOMETRES. THIS DATA SETS IS FROM THE DNAG (DECADE OF NORTH AMERICAN GEOLOGY) MAGNETIC COMPILATIONS, AND HAS BEEN OBTAINED FROM THE NOAA "GEOPHYSICS OF NORTH AMERICA" CD, WHICH WAS COMPILED BY ALLEN M. HITTELMAN, JOHN O. KINSFATHER AND HERBERT MEYERS, THIRD PRINTING, AUGUST, 1994. MORE INFORMATION CAN BE OBTAINED FROM: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) NATIONAL GEOPHYSICAL DATA CENTER 325 BROADWAY BOULDER, COLORADO 80303-3328 HTTP://WWW.NOAA.GOV/ JUNE 20, 2001

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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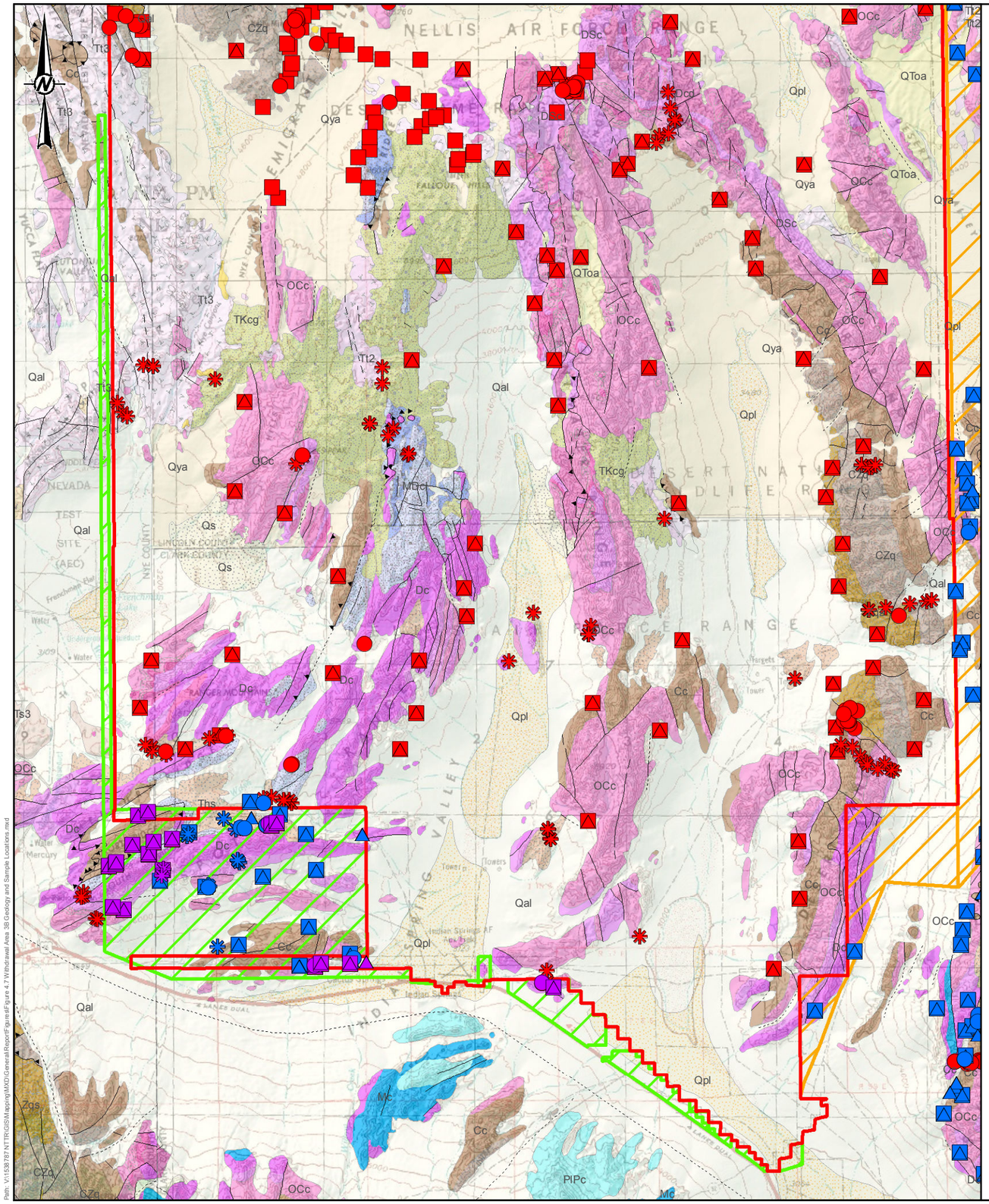
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**4.6**

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 4.6 Withdrawal Area 3A Magnetic Anomaly and Geologic Structure.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0



GEOLOGY

- Qal - Alluvium, undifferentiated
- Qya - Younger alluvium
- Qs - Sand dunes
- Qpl - Playa, lake bed, and flood plain deposits
- QToa - Older alluvium and alluvial fan deposits (Pleistocene and Pliocene)
- QTb - Basalt flows (Holocene to Pliocene)
- Ths - Tuffaceous sedimentary rocks (middle Miocene to upper Oligocene)
- Ts3 - Younger tuffaceous sedimentary rocks (Pliocene and Miocene)
- Tb3 - Basalt (Miocene)
- Ta3 - Younger andesite and intermediate flows and breccias (Miocene)
- Tt3 - Younger silicic ash flow tuffs (Miocene)
- Tt2 - Intermediate silicic ash flow tuff (lower Miocene and Oligocene)
- TKcg - Conglomerate and clastic rocks (Tertiary(?) and Cretaceous(?))
- PIPc - Limestone, dolomite, siltstone, sandstone, and shale (Lower Permian and Pennsylvanian)
- Mc - Limestone (Mississippian)
- Dc - Limestone and minor dolomite (Upper and Middle Devonian)
- Dcd - Dolomite, sandstone, and limestone (Middle and Lower Devonian)
- DSc - Dolomite (Lower Devonian and Silurian)
- SOc - Dolomite, limestone, and shale (Lower Silurian to Middle Ordovician)
- Ocq - Quartzite (Middle Ordovician)
- OCc - Limestone, dolomite, and quartzite (Middle Ordovician to Upper Cambrian)
- Cc - Dolomite, limestone, and shale (Cambrian)
- IPMcl - Shale, siltstone, sandstone, and conglomerate (Middle Pennsylvanian to Lower Mississippian)
- MDcl - Siltstone, limestone, shale, and sandstone (Lower Mississippian and Upper Devonian)
- CZq - Crossbedded quartzite, siltstone, and phyllite (Lower Cambrian and latest Proterozoic)
- Zqs - Quartzite, siltstone, conglomerate, limestone, and dolomite (Late Proterozoic)

5 2.5 0 5 Miles

8 4 0 8 Kilometers

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FIGURE 4.7
ALTERNATIVE 3B GEOLOGY AND SAMPLE LOCATIONS

LEGEND

2016 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1998 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1993 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

NOTES

SOURCE:
CRAFFORD, E. GEOLOGIC MAP OF NEVADA. U.S. GEOLOGICAL SURVEY DATA SERIES 249, 2007.
TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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NEVADA TEST AND TRAINING RANGE
MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	4.7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 4.7 Withdrawal Area 3B Geology and Sample Locations.mxd

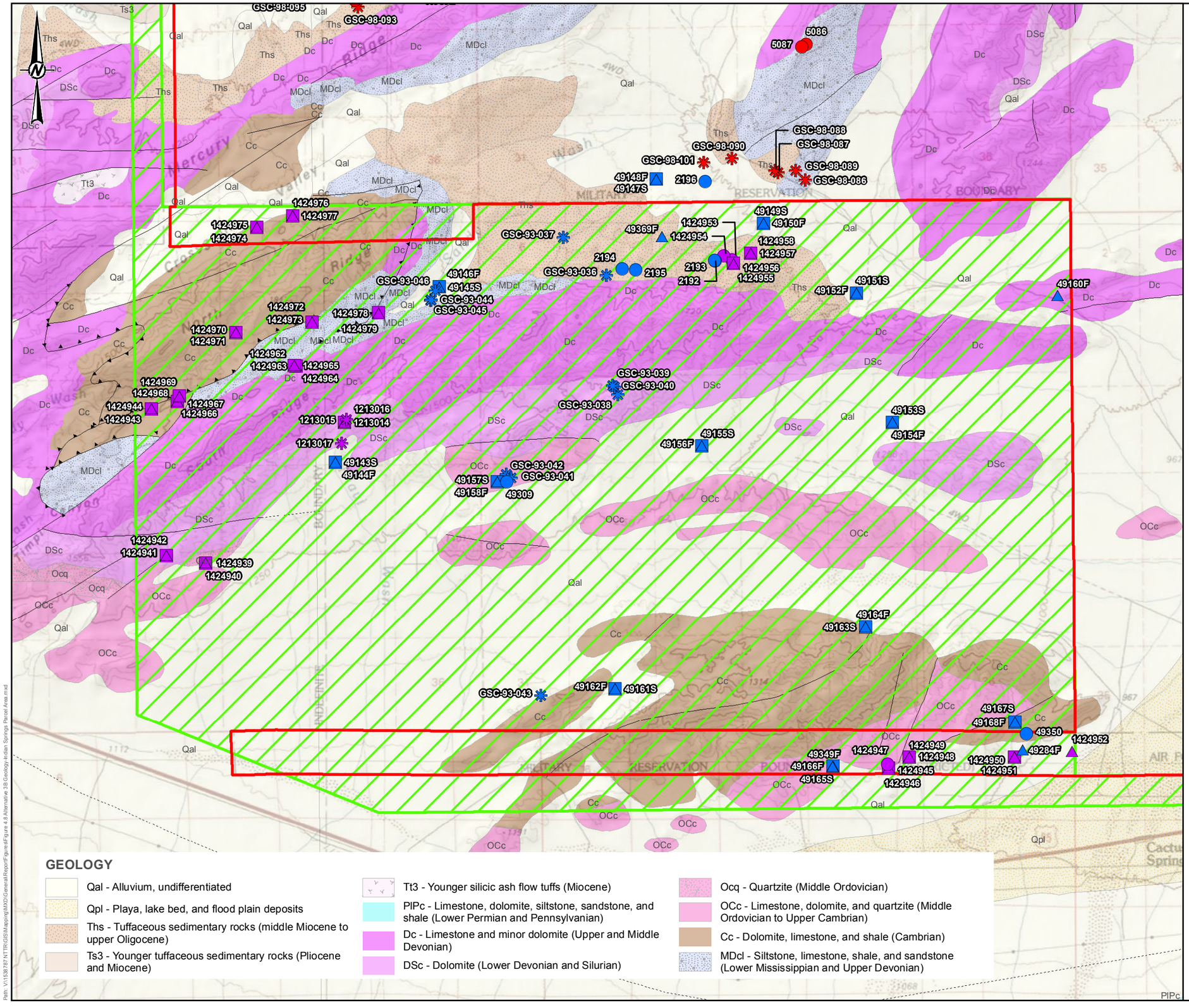


FIGURE 4.8
ALTERNATIVE 3B GEOLOGY-INDIAN SPRINGS PARCEL AREA

LEGEND

2016 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1998 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1993 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE
- GEOCHEMICAL SAMPLE COLLECTED BY NBMG IN 1993 AND RE-ANALYZED IN 2014

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

1 0.5 0 1 Miles

2 1 0 2 Kilometers

NOTES

SOURCE:
CRAFFORD, E. GEOLOGIC MAP OF NEVADA. U.S. GEOLOGICAL SURVEY DATA SERIES 249, 2007.
TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	4.8

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Path: V:\1538787 NTTR\GIS\Mapping\MXD\General Report\Figure\Figure 4.8 Alternative 3B Geology-Indian Springs Parcel Area.mxd

The rocks of the Spotted Range are passive-margin, miogeoclinal, sediments from Late Proterozoic to Middle Devonian, mostly carbonate facies with occasional clastic intervals. Sediments deposited between Late Devonian and Late Mississippian are syn-orogenic, deposited in a shallow marine setting during the Antler Orogenic event, and consist of carbonates and shales (Cole and Cashman, 1999). Within the 64C/D and 65D area, there are no rocks from the Mesozoic; however, in the Spring Mountains south of the South Range outside the study area thick Triassic and Jurassic deposits are found. Barnes and others (1982) suggest the proximity of these Mesozoic sedimentary deposits indicates that the Mesozoic section in the Spotted Range was probably eroded as a result of uplift beginning in the late Cretaceous and continuing in the Tertiary. Tertiary age lacustrine sediments and reworked ash-fall tuffs are found in the interior valleys of the Spotted Range, marking the initiation of volcanism in the nearby SNVF.

4.2.3 Structure

The structural history of the Spotted Range is complex, with episodes of contractional, extensional, and translational deformation (Barnes and others, 1982). The oldest structure in the Spotted Range, the Mercury Klippe, is the result of south-eastward thrusting along the Spotted Range fault (Cole and Cashman, 1999) (Figure 4.9). The Mercury Klippe consists of upper plate Cambrian carbonates thrust over synclinal Devonian and Mississippian carbonates. The lower plate sequence, believed to be autochthonous, is comprised of over 1,870 m of dolomite, limestone with minor quartzite, and shale. The allochthonous upper plate is approximately 1,645 m thick and almost all limestone and dolomite (Barnes and others, 1982). The age of thrusting is constrained by two post-deformation plutons intruded to the north, which have been dated at 93 Ma (Marvin and others, 1970), placing the deformation in the Late Cretaceous, during one of the Sevier-style contractional events.

Following the Late Cretaceous contraction and crustal thickening, there was a period of structural quiescence and erosion (Barnes and others, 1982). The next major tectonic event to affect the 64C/D and 65D area was the in initiation of basin-and-range extensional faulting, occurring around 17 Ma (Ekren and others, 1968). Extension along north-to-south oriented normal faults resulted in north-to-south oriented ranges bound by downdropped basins, this orographic relief resulted in further erosion and exhumation of the Mercury Klippe.

The LVSZ is a northwest-to-southeast trending zone of dextral strike-slip (Figure 4.9). Between 40 and 72 km of total movement occurred along the LVSZ, partitioned between slip-along faults and bending or rotation (Ross and Longwell, 1964; Fleck, 1970a). The LVSZ was formed approximately 13 to 12 Ma, possibly in response to changes in plate boundary conditions at the western margin of the North American plate. Those changes included southward stepping of the Rivera triple junction, and increased relative plate motion (Faulds and Henry, 2008). As plate boundary conditions evolved, the orientation of the LVSZ was no longer favorable to accommodate strain and motion across it ceased approximately 6 Ma (Barnes and others, 1982).

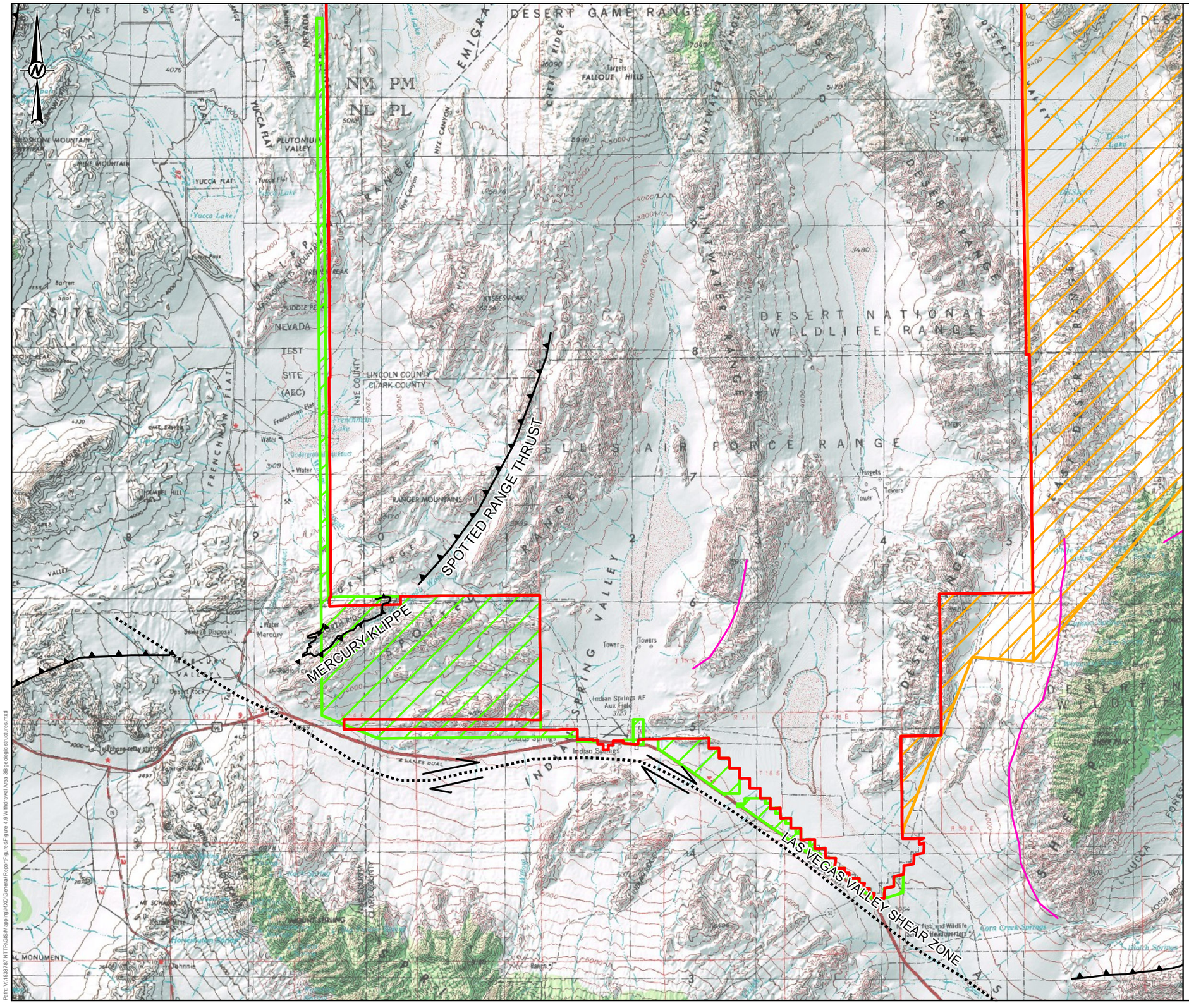


FIGURE 4.9
ALTERNATIVE 3B GEOLOGIC STRUCTURE

LEGEND

MAJOR GEOLOGIC STRUCTURES

- RANGE BOUNDING NORMAL
- MAJOR THRUST
- SHEAR ZONE

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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5 2.5 0 5 Miles

8 4 0 8 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**4.9**

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 4.9 Withdrawal Area 3B geologic structures.mxd

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The approximately east-to-west orientation of the Spotted Range has been interpreted differently by several authors. Cole and Cashman (1999) determined the east-to-west orientation to be related to the original orientation of thrust-sheet emplacement along the Spotted Range thrust fault; whereas Barnes and others (1982) attributed the Spotted Range's orientation to oroclinal flexure due to right-lateral displacement along the LVSZ. Barnes and others (1982) explained that dextral displacement along the LVSZ caused the north-to-south oriented Spotted Range to experience clockwise rotation, up to 90 degrees (°), eventually reaching its current, approximately east-to-west orientation. The originally north-to-south-striking basin-and-range normal faults in the Spotted Range were re-oriented during this process to parallel the northwest trending shear zone. A result of this rotation was to produce left-lateral "rotary slippage" along the re-oriented basin-and-range faults (Ekren and others, 1968). In addition to the second-order left-lateral rotary slippage along re-oriented faults, a pervasive set of first-order northeast trending left-lateral faults developed, likely as a conjugate set to the northwest oriented dextral faults of the LVSZ (Carr, 1974; Barnes and others, 1982). These faults would have helped to accommodate oroclinal clockwise rotation of the Spotted Range (Faulds and Henry, 2008). Stratigraphic relationships indicated that the majority of oroclinal deformation in the Spotted Range occurred between 13 and 6 Ma (Barnes and others, 1982).

The youngest faults within the Spotted Range are north trending normal faults which cut orthogonally across the range. These faults have minor displacements and do not off-set older alluvium. For this reason they are believed to be late Tertiary (Barnes and others, 1982).

4.2.4 Mining History and Mineralization

There are no known mining districts within the 64C/D and 65D area, nor are there well documented records of past prospecting in the area. On the basis of their GSC sampling of the East DNWR, Tingley and others (1993) reported an arsenic-antimony-bromine association along the northern the 64C/D and 65D area border/southern South Range boundary (along the northern boundary of the Indian Springs Parcel), and in the southeast corner of the Indian Springs Parcel they reported an anomalously high zinc-silver-lead association.

4.2.5 Laboratory Results

A total of 51 samples were collected within the 64C/D and 65D area. Of those, 4 were MA, 20 were silt, 20 were float chip samples, and 7 were GSC samples. Sampling collection sites from the current and 1993 Assessments are shown on Figure 4.7 and on Figure 4.8 Little evidence of hydrothermal alteration was observed during the field investigation in the 64C/D and 65D area. Where alteration was present, it was often localized iron-oxide staining within a fault system. Laboratory GSC analyses confirmed the limited mineralization. Gold was detected at an anomalously high concentration (0.02 ppm) in sample 1424970, a silt sample collected in Winding Wash. Silver was detected at anomalously high concentrations in four samples; three float chip and one MA sample. Two of the float chip samples were collected from the East Sandy drainage (samples 1424965 0.45ppm and 14244979 0.15ppm) and a third from the Upper West

Sandy drainage (1424967 0.15ppm). The MA sample was collected from a gossanous, brecciated quartzite outcrop located on north side of the south ridge of the Spotted Range (1424953, 0.12 ppm).The antimony anomaly identified by Tingley and others (1993) was not verified in this field investigation. Portions of the Spotted Range thrust fault at the Mercury Klippe were investigated, but alteration features indicative of a CTGD were not observed. Additionally, samples collected near the Mercury Klippe did not have a geochemical signature indicative of a CTGD.

4.2.6 Geophysics

Regional gravity and magnetic studies were reviewed for this assessment. Figure 4.10 and Figure 4.11 show local geologic structure with the Bouguer gravity anomaly and magnetic anomaly maps, respectively. Gravity data (Figure 4.10) show a uniform high, indicating the presence of relatively high density material. The gravity high is consistent with mapped thrust faults (Mercury Klippe and Spotted Range thrust fault), which have placed high density rocks close to the surface. The magnetic data (Figure 4.11) show a large, approximately uniform area of low magnetic values over the 64C/D and 65D area. This is consistent with the thick sequences of nonmagnetic carbonates present throughout the area. Both the gravity and magnetic data can be interpreted consistently with the known geological setting. Neither dataset indicates the presence of mineral deposits at depth.

4.3 Alternative 3C – the Alamo Area

4.3.1 Geologic Setting

The Alamo area primarily occupies the internally drained Desert Valley, with western portions of the East DNWR, the Sheep Range on the east, and the Pahranagat Range on the north (Figure 1.3). Elevations vary from approximately 977 m at the base of the ephemeral Desert Lake, to 2,448 m in the Sheep Range. Exposed bedrock is primarily deformed Paleozoic rocks, with mixed Tertiary volcanic and Paleozoic rocks at the north portions of the Alamo area (Figure 4.12).

Surficial geology of the Alamo area is predominantly Cambrian to Devonian miogeoclinal passive-margin sedimentary sequences that formed along the western margin of North America. These rocks were interpreted to represent deposits of the cordilleran miogeocline (Tschanz and Pampeyan 1970). The passive margin initially formed during Proterozoic rifting of the supercontinent Rodinia. Rocks were deposited in an offshore carbonate shelf and intertidal depositional settings. In addition to the miogeoclinal sedimentary sequence, the northern portion of the Alamo area has Tertiary volcanic rocks (Figure 4.12).

Paleozoic carbonate sequences are the oldest rocks exposed in the Alamo area. The oldest exposed Paleozoic FM is the Middle to Lower Cambrian Carrara FM, a formation consisting of limestones, shales, and sandstone. The youngest Paleozoic units are Middle Devonian to Silurian rocks.

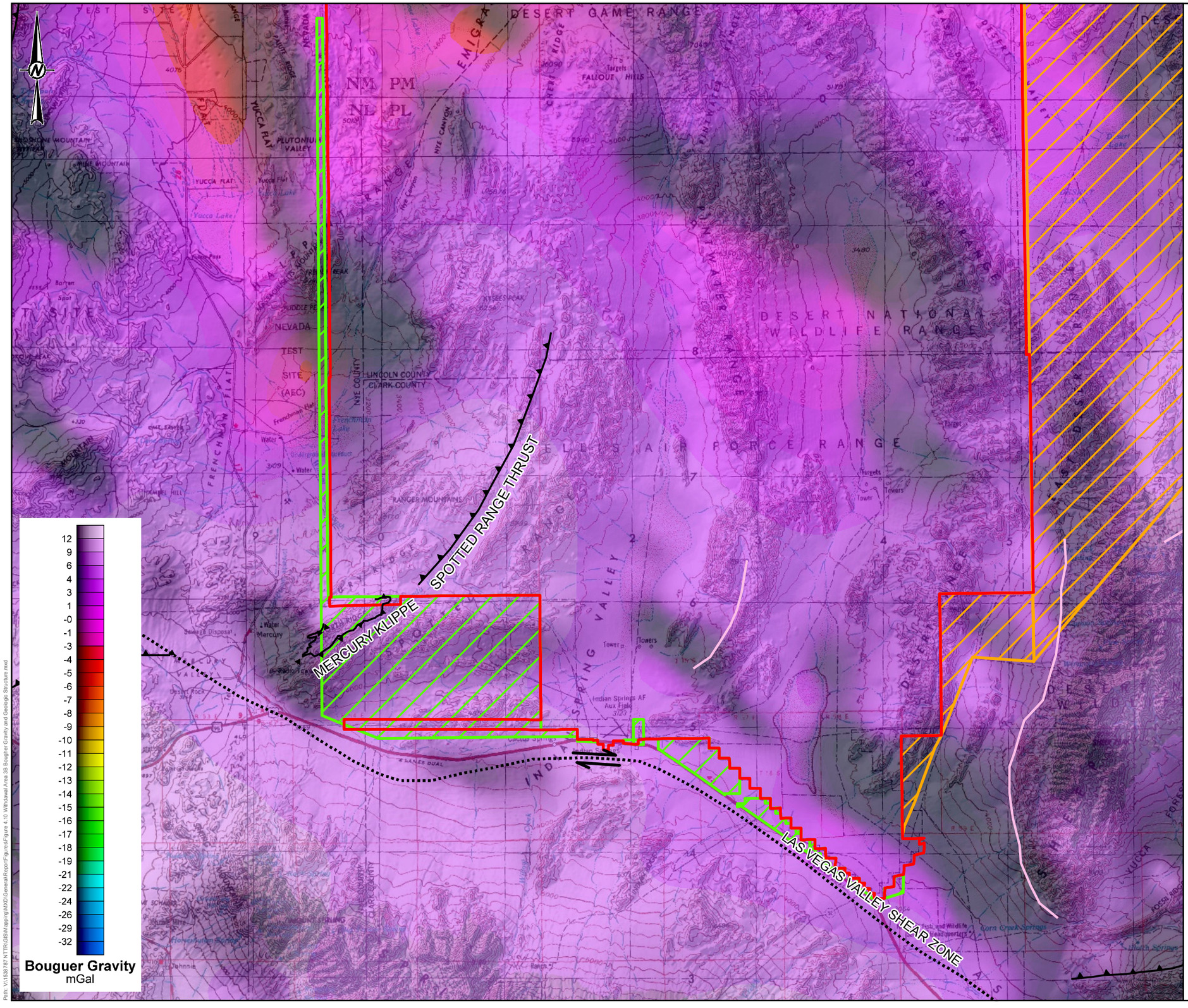


FIGURE 4.10
ALTERNATIVE 3B BOUGUER GRAVITY AND GEOLOGIC STRUCTURE

LEGEND

MAJOR GEOLOGIC STRUCTURES
- RANGE BOUNDING NORMAL
- MAJOR THRUST
- SHEAR ZONE

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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5 2.5 0 5 Miles
8 4 0 8 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
GEOPHYSICS OF NORTH AMERICA: THIS DATA INCLUDES THE BOUGUER GRAVITY FIELD SAMPLED AT 6 KILOMETRES. THIS DATA IS FROM THE DNAG (DECADE OF NORTH AMERICAN GEOLOGY) GRAVITY COMPILATIONS. THIS DATA HAS BEEN OBTAINED FROM THE NOAA "GEOPHYSICS OF NORTH AMERICA" CD, WHICH WAS COMPILED BY ALLEN M. HITTELMAN, JOHN O. KINSFATHER AND HERBERT MEYERS, THIRD PRINTING, AUGUST, 1994. MORE INFORMATION CAN BE OBTAINED FROM: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) NATIONAL GEOPHYSICAL DATA CENTER 325 BROADWAY BOULDER, COLORADO 80303-3328 HTTP://WWW.NOAA.GOV/ JUNE 20, 2001

REFERENCE

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1538787	---	---	**4.10**

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure#\Figure 4.10 Withdrawal Area 3B Bougher Gravity and Geologic Structure.mxd

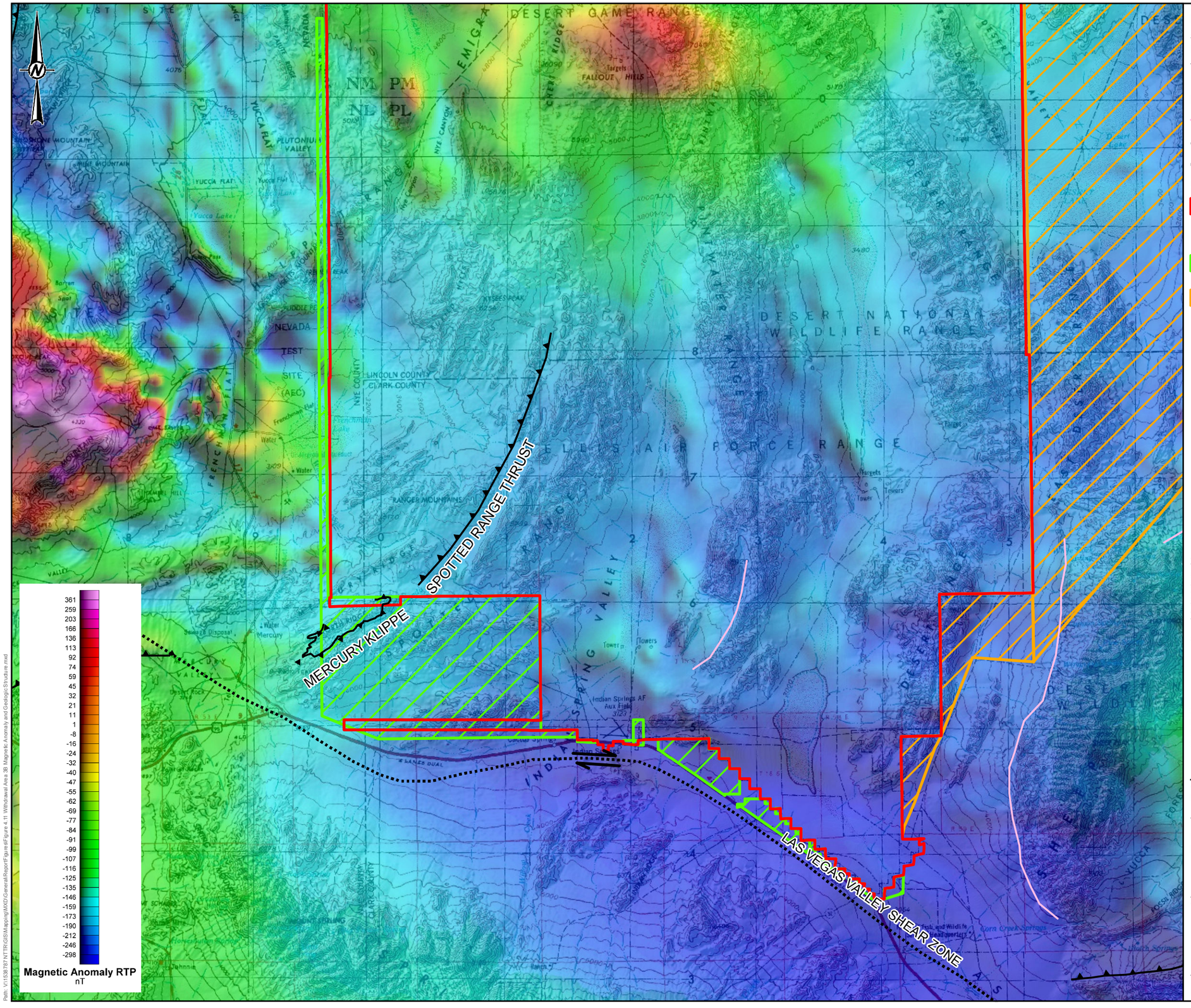


FIGURE 4.11
ALTERNATIVE 3B MAGNETIC ANOMALY AND GEOLOGIC STRUCTURE

LEGEND

MAJOR GEOLOGIC STRUCTURES
- RANGE BOUNDING NORMAL
- MAJOR THRUST
- SHEAR ZONE

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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5 2.5 0 5 Miles
8 4 0 8 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
GEOPHYSICS OF NORTH AMERICA: THIS DATA INCLUDES THE TOTAL MAGNETIC FIELD OF NORTH AMERICA SAMPLED AT 2 KILOMETRES. THIS DATA SETS IS FROM THE DNAG (DECADE OF NORTH AMERICAN GEOLOGY) MAGNETIC COMPILATIONS, AND HAS BEEN OBTAINED FROM THE NOAA "GEOPHYSICS OF NORTH AMERICA" CD, WHICH WAS COMPILED BY ALLEN M. HITTELMAN, JOHN O. KINSFATHER AND HERBERT MEYERS, THIRD PRINTING, AUGUST, 1994. MORE INFORMATION CAN BE OBTAINED FROM: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) NATIONAL GEOPHYSICAL DATA CENTER 325 BROADWAY BOULDER, COLORADO 80303-3328 HTTP://WWW.NOAA.GOV/ JUNE 20, 2001

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**4.11**

Path: \\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\Figure4\Figure 4.11 Withdrawal Area 3B Magnetic Anomaly and Geologic Structure.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787 NTTR\GIS\Mapping\MXD\General\ReportFigures\Figure 4.12 Geology of Withdrawal Area 3C.mxd

FIGURE 4.12
ALTERNATIVE 3C GEOLOGY

GEOLOGY

Surficial Units

- Qa - Channel alluvium (Holocene)
- Qay - Young alluvium (Holocene to latest Pleistocene)
- Qayo - Intermediate alluvium (late to middle Pleistocene)
- Qao - Old alluvium (middle to early Pleistocene)
- QTa - Oldest alluvium (early Pleistocene to Pliocene)
- Qayf - Young fine-grained alluvium (Holocene to latest Pleistocene)
- Qp - Playa deposits (Holocene to late Pleistocene)
- Qds - Modern and past ground-water discharge deposits (Holocene to late Pleistocene)
- QTls - Landslide and megabreccia deposits (Pleistocene to Miocene?)

Bedrock Units

- Tb - Older basaltic lava flows (Pliocene and Miocene)
- Ts4 - Sedimentary rocks, unit 4 (Miocene and Oligocene)
- Tt4 - Ash-flow tuffs and interbedded airfall tuffs, unit 4 (Miocene)
- Tt3 - Ash-flow tuffs and interbedded airfall tuffs, unit 3 (Miocene and Oligocene)
- Tt2 - Ash-flow tuffs and interbedded airfall tuffs, unit 2 (Oligocene)

Paleozoic

- PMb - Bird Spring Formation and related rocks (Lower Permian to Upper Mississippian)
- Mm - Monte Cristo Group of Langenheim and others (1962) (Upper and Lower Mississippian)
- MDu - Lower Mississippian to Middle Devonian, undivided
- DSu - Middle Devonian and Silurian Rocks, undivided
- Oes - Ely Springs Dolomite (Upper Ordovician)
- Oep - Eureka Quartzite (Middle Ordovician) and Pogonip Group (Middle Ordovician to Upper Cambrian)
- Oe - Eureka Quartzite (Middle Ordovician)
- OCp - Pogonip Group (Middle Ordovician to Upper Cambrian)
- Cn - Nopah Formation (Upper Cambrian)
- Cbk - Bonanza King Formation (Upper and Middle Cambrian)
- Cc - Carrara Formation (Middle and Lower Cambrian)

Proterozoic

- CZw - Wood Canyon Formation (Lower Cambrian and Late Proterozoic)
- Zs - Stirling Quartzite (Late Proterozoic)
- Zj - Johnnie Formation (Late Proterozoic)

GASS PEAK THRUST

LEGEND

STUDY AREA

- NEVADA TEST AND TRAINING
- ALTERNATIVE 3C - ALAMO EXPANSION

5 2.5 0 5 Miles

8 4 0 8 Kilometers

NOTES

SOURCE:
GEOLOGY: PAGE, W. R., DIXON, G. L., ROWLEY, P. D., AND BRICKEY, D. W., 2005, TEXT AND REFERENCES TO ACCOMPANY NEVADA BUREAU OF MINES AND GEOLOGY MAP 150 – GEOLOGIC MAP OF PARTS OF THE COLORADO, WHITE RIVER, AND DEATH VALLEY REGIONAL GROUNDWATER FLOW SYSTEMS, NEVADA, UTAH, AND ARIZONA. NEVADA BUREAU OF MINES AND GEOLOGY, 2005.

REFERENCE

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PROJECT No.	CONTROL	Rev.	FIGURE
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As mapped in Figure 4.12, these rocks are undivided and may include one or more of three dolomite units that include: the Simonson, Sevy, and Laketown dolomites. Additional Paleozoic rocks, listed oldest to youngest, include: the Bonanza King FM, Nopah FM, Pogonip Group, Eureka Quartzite, and Ely Springs Dolomite. The combined stratigraphic thickness of the Paleozoic section in the Alamo area is over 3,000 m. Of those 3,000 m, nearly 2,000 m are dolomitic, 120 m are quartzite, with the remaining section a mixture of limestones, dolomites, sandstone, and shales.

Mesozoic rocks are not found exposed in the Alamo area because the area was uplifted and eroded as a result of the Sevier Orogeny.

Cenozoic tectonics affected the rocks in the Alamo area, including volcanism, normal and strike-slip faulting, and basin development (Page and others, 2011). The northern portion of the Alamo area, between the Pahranagat and the Sheep ranges (Figure 1.3), has four mapped units of Oligocene and Miocene ash-flow tuffs (Figure 4.12), which were erupted from calderas outside the study area (Best and others, 2013). Tuff units include:

- Kane Wash tuff (Miocene, 14.39- to 4.67 Ma)
- Hiko Tuff (Miocene, 18.51 Ma)
- Harmony Hills Tuff (Miocene, 22.56 Ma)
- Shingle Pass Tuff (Oligocene, 26.38 to 24.15 Ma)

The volcanism was syntectonic, occurring during a time of extensional tectonism. Basin-and-range extensional tectonism followed the siliceous volcanic events and resulted in the formation of deep basins that are filled with Upper Neogene and Quaternary age sediments. These units consist predominantly of alluvium and colluvium, as well as minor eolian, lacustrine (i.e., Desert Lake), and streambed deposits.

4.3.2 Structures

Overall, the rocks of the Alamo area were deformed by folding and thrusting during the Mesozoic and by normal faulting, strike-slip faulting, and local broad, open folding during the Cenozoic. Normal faulting began during the Eocene and has continued, intermittently, until the present (Jayko, 2007).

There is no structural evidence of Paleozoic age deformation related to the Antler Orogeny in the Alamo area; however, major compressional deformation did occur in the area during the Mesozoic. The Mesozoic age structures are the oldest found in the Alamo area. The Alamo area lies between structures related to the Death Valley thrust belt (i.e., Spotted Range thrust) and the Sevier Orogeny (i.e., Gass Peak thrust) (Figure 1.5). Because the Gass Peak thrust, a major compressional feature, is interpreted to extend beneath the Alamo area, Mesozoic deformational events are likely more accurately considered Sevier in age. The Gass Peak thrust formed along a basal decollement near the base of the Late Proterozoic-Lower Cambrian sequence and daylights in the Las Vegas Range, approximately 10 km east of the Sheep Range

(Guth, 1980). The north-to-northeast striking Gass Peak thrust transported thick western facies rocks approximately 30 km eastward (Guth, 1980, 1981). The Gass Peak thrust has a stratigraphic displacement up to 6 km, juxtaposing the Neoproterozoic and Cambrian stratum against Lower Permian to Upper Mississippian stratum. The base of the fault is a complex zone of imbricate faulting. The east-vergent thrusting related to the Sevier Orogeny affected the area from Late Cretaceous to Early Tertiary time (Page and others, 2005).

Tertiary extensional tectonism resulted in classic basin-and-range normal faulting and strike-slip faulting. Guth (1981) estimated 44 percent extension near the Alamo area. The geometry of the predominantly north-to-south trending normal faults at depth is not understood. Page (2011) interpreted the faults to retain their surface attitude at depth, thus representing the tilted normal fault blocks as “tilted dominos.” Guth (1990) hypothesized that tertiary extension involved listric normal faults that are steep at the surface, but flatten into a deeper detachment, called the Sheep Range detachment fault. Guth (1980) further proposed that the Sheep Range detachment fault formed along the upper decollement in the Bonanza King FM, reactivating part of the Gass Peak thrust fault. Normal faults in the Alamo area are generally down-dropped to the west.

Two major strike-slip faults occur near the Alamo area, the LVSZ, approximately 5 km south, and the Pahranagat shear zone, on the northern portion of the Alamo area (Figure 1.5). These strike-slip shear zones represent transfer or accommodation zones that separate structural blocks within the Alamo area that have undergone different rates and amounts of extension (Guth, 1981; Wernicke and others, 1982; Duebendorfer and others 1992; Rowley, 1998).

The LVSZ is a northwest trending zone of dextral strike-slip. Several authors have estimated that between 40 km and 72 km (Ross and Longwell, 1964; Fleck, 1970a, respectively) of total movement occurred along the fault, partitioned between slip-along faults and bending or rotating. The LVSZ initiated approximately 13 to 12 Ma, possibly in response to changes in plate boundary conditions at the western margin of the North American plate. Those changes included southward stepping of the Rivera triple junction, and increased relative plate motion (Faulds and Henry, 2008). As plate boundary conditions evolved, the orientation of the LVSZ was no longer favorable to accommodate strain, and motion across it ceased approximately 6 Ma (Barnes and others, 1982). Guth (1990) proposed that the LVSZ formed the southern boundary of a large extensional terrain underlain by the Sheep Range detachment fault.

The Pahranagat shear zone consists of several northeast striking faults exhibiting sinistral shear and dip-slip offset (Figure 1.5). This shear zone is approximately 20 to 25 km wide and is composed of three major sinistral strike-slip faults. Tschanz and Pampeyan (1970) estimated approximately 6 to 9 km of left-lateral shear, while Hudson and others (1998) estimated up to 40 km of offset since 14 to 18 Ma. Modern fault scarps and fissures in alluvial deposits (Swadley, 1995), and current seismicity on faults in the Pahranagat shear zone (Rogers and others, 1987), indicate that it is currently active. The Pahranagat shear zone is

believed to act as transfer/accommodation zone, providing a kinematic connection between the Wasatch fault zone in Utah and the WL (Kreemer and others, 2010).

4.3.3 Mining History and Mineralization

There are no known metal mining districts in the portion of the East DNWR that is within the Alamo area.

4.4 NTTR Field Checks

Field checks were conducted on two previously identified geochemical anomalies within the NTTR, in the Limestone Ridge area and the Don Dale Mining District. These areas are shown on Figure 1.3 and Figure 2.5.

4.4.1 Limestone Ridge

Figure 4.13 shows the geology of the Limestone Ridge area. Limestone Ridge is a prominent north-to-south oriented outcrop composed of vertical to overturned Precambrian to Paleozoic sedimentary units located on the northwest side of the Belted Range (Figure 1.3). The Kawich Valley is to the west of Limestone Ridge, to the east is the Belted Range and Monotony Valley. Tertiary tuffs and lavas, like those which compose Belted Peak, unconformably overlie and obscure older rocks east of Limestone Ridge in the Belted Range.

4.4.1.1 Stratigraphy

Rocks of the Belted Range include late Precambrian through Mississippian sedimentary sequences, Tertiary volcanics, and sedimentary rocks associated with the Tertiary volcanics (Figure 4.13). The late Precambrian through Mississippian sedimentary sequence is approximately 9,000 m thick. Limestone Ridge includes this entire sequence, with the exception of the Devonian and Mississippian age rocks, which outcrop on the east side of the Belted Range. The entire sedimentary sequence was classified into three groups by Ekren and others (1971). The basal group was deposited from late Precambrian through the Middle Cambrian time. It is approximately 3,000 m thick and is predominately clastic, consisting of quartzite with siltstone, shale, and minor carbonate. After an eastward marine transgression, the middle group was deposited from the Middle Cambrian to Devonian. The middle group is approximately 4,200 m thick and consists predominately of carbonates with minor clastics. Lastly, the youngest group was deposited between the Late Devonian and the Mississippian. It is approximately 1,200 m thick and is dominated by fine clastics: argillite and siltstone with minor quartzite and conglomerate.

Deposition of the first two groups was miogeoclinal, occurring along the passive margin of the continent in a shallow marine environment. However, the margin was transformed in the Late Devonian by the formation of the Roberts Mountain thrust during the Antler Orogeny. This orogenic event resulted in the formation of shallower, less continuous basins and provided a new source of sedimentary material (Ekren and others, 1971). This event was recorded in the Mississippian Eleana FM as a transition from a carbonate depositional environment to a clastic depositional environment.

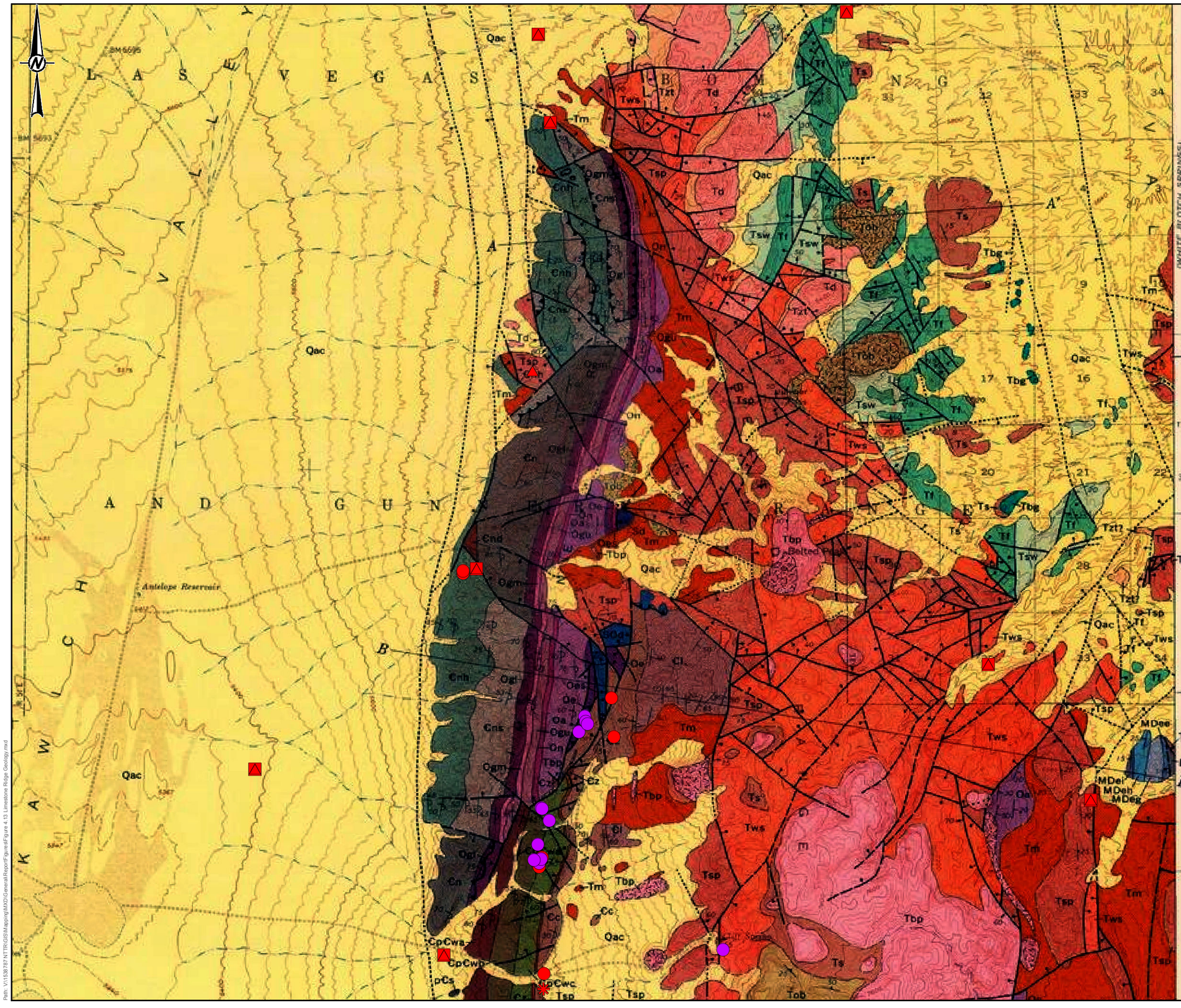
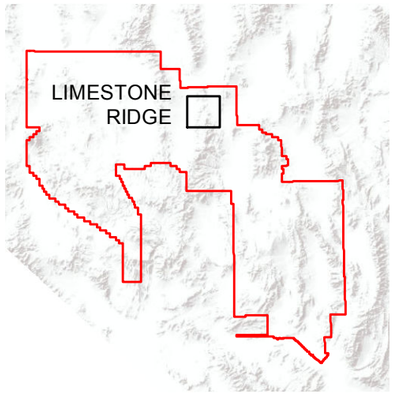


FIGURE 4.13
LIMESTONE RIDGE GEOLOGY AND SAMPLE LOCATIONS

LEGEND

2016 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

1998 SAMPLE LOCATIONS
- FLOAT CHIP SAMPLE
- GEOLOGIC CHARACTERIZATION SAMPLE
- MINERALIZED AREA SAMPLE
- SILT SAMPLE



1 0.5 0 1 Miles

1.6 0.8 0 1.6 Kilometers

NOTES

SOURCE:
EKREN, E.B., ROGERS, C.L., ANDERSON, R.E., AND BOTINELLY, THEODORE. GEOLOGIC MAP OF THE BELTED PEAK QUADRANGLE, NYE COUNTY, NEVADA. USGS, 1967, GQ-606.

REFERENCE

COORDINATE SYSTEM: NAD 1983 UTM ZONE 11N
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 4.13 Limestone Ridge Geology.mxd

After deposition of the Eleana FM in the Mississippian, there is an unconformity stretching into the Tertiary. No Mesozoic units are present near Limestone Ridge or within the Belted Range. However, there are buried granitic intrusions nearby that are believed to be Mesozoic in age (Ekren and others, 1971). In the Oligocene, the Monotony Tuff (27 Ma) and numerous felsic ash-flow tuffs were erupted from nearby calderas over approximately 20 million years. Interbedded within the ash-flow tuff units are minor sandstones and lacustrine deposits. Additionally, there are thick sequences of rhyolite lavas and hypabyssal intrusions, like those that make up Belted Peak and several other peaks to the north and south of Limestone Ridge.

4.4.1.2 Structure

Limestone Ridge consists of near vertical to slightly overturned, north-striking sedimentary rocks. It is cut by a low-angled, west-dipping gravity-slide, and numerous northeast-to-northwest striking faults. To the east of Limestone Ridge, tuffs and lavas dip shallowly to the east.

During the Mesozoic, eastward compression resulted in the advancement of thrust-sheets and fold-belts from the northwest. Caskey and Schweickert (1992) reported that the Belted Range thrust is east-vergent and likely related to the Last Chance thrust system of the early Mesozoic. Based on their study, the Belted Range thrust and the Spotted Range thrust are continuous and record a total displacement of over 24 km. It is unclear whether the Belted Range thrust extends as far north as the Limestone Ridge. If it does, Limestone Ridge could represent upper plate strata; however, normal faulting known to exist east of Limestone Ridge could have affected the thrust fault geometry such that Limestone Ridge represents lower plate strata. In short, it is unknown whether Limestone Ridge strata is autochthonous or para-autochthonous.

The Limestone Ridge strata are oriented vertical to slightly overturned and decrease in age from west to east. The majority of the strata deformation likely occurred during the Mesozoic compressional tectonic regime; however, additional rotation may have occurred during Mid-Tertiary and basin-and-range extensional tectonism. Structures of particular interest include “gravity slide” faulting that was hypothesized by Ekren and others (1967). These west-dipping structures are believed to have formed during Late Oligocene extension in the wake of the Mesozoic compressional event. Gravity sliding transported the Upper Cambrian through Silurian section approximately 6.5 km to the west, to sit stratigraphically on top of the Pre-Cambrian through Middle Cambrian (Ekren and others, 1971). Ekren and others (1971) reported intense brecciation at the base of the gravity slide blocks, with breccia up to 30 m thick, displaying local silicification and dolomitization. An alternate interpretation is that these structures are thrust faults. Nonetheless, the Tertiary volcanics were not affected by these faults, constraining the age of this event to pre-27 Ma.

There are two additional sets of normal faults which affect the structure at Limestone Ridge. The older set, which is common throughout Limestone Ridge, strikes northeast-to-northwest and has measured offsets on the order 1 km (Ekren and others, 1971). These faults are pre-Belted Range tuff age, or Late Miocene, as this unit is un-deformed by older fault set. The younger set of faults strike approximately north and include the range-bounding faults. These faults are inferred to be post-Timber Mountain Tuff age, approximately 10.8 Ma, because the measured thickness of this unit is the same in valleys as it is on mountain ranges (Ekren and others, 1971).

4.4.1.3 Mining History and Mineralization

There are numerous prospect pits and adits around Limestone Ridge, most of which are in tilted and deformed Paleozoic sedimentary units. The earliest reference to prospecting in the area was recorded by Ball (1907) who traveled through the area in 1905. It is likely that the workings date from around that time, when there was increased activity in the Gold Reed and Goldfields mining districts (Tingley and others, 1998). There are no available mine production records or evidence of significant mining activity; it is therefore assumed that there was no significant mineral production from Limestone Ridge.

Alteration at Limestone Ridge consists mainly of gossanous iron and manganese-oxides along faults in Paleozoic clastics and carbonates; oxidation is also prevalent adjacent to felsic dikes. Narrow quartz veins bearing copper-sulfides and copper-oxides were observed in an adit in the Wood Canyon FM; however, these veins did not appear to connect to a large structure or increase in density in the surrounding area. Tingley and others (1998) observed jasperoid, or silicified carbonates, at several locations on the north section of Limestone Ridge.

The age of mineralization at Limestone Ridge is not known. Tingley and others (1998) theorized that there were multiple mineralizing events. It is likely that hydrothermal alteration accompanied the intrusion of the Belted Peak rhyolite and other shallow intrusives in Miocene time as felsic dikes were observed oxidizing Paleozoic sediments on Limestone Ridge. The quartz veining is likely related to the adjacent Mid-Tertiary siliceous volcanism.

4.4.1.4 Laboratory Results

Twelve samples were collected from Limestone Ridge, all of which were MA samples and all of which were submitted for laboratory analysis. Figure 4.13 shows sample collection sites from the current and 1998 Assessments. The objective of this assessment was to investigate the potential that Limestone Ridge hosts CTGDs. Sampling focused on adits and prospect pits not included in the 1998 Assessment, as well as altered and as-yet unsampled structures. With the exception of one Tertiary tuff sample (1213035), collected at an adit intersecting a heavily oxidized normal fault plane at Cliff Spring, all the samples were collected from the Paleozoic sediments. Two of the Paleozoic sediment samples (samples 1213029 and 1213034) were collected from alteration zones adjacent to igneous dikes.

The only sample collected at Limestone Ridge that contained anomalous gold (sample 1213036, 0.006 ppm) was collected at an adit following two quartz veins. The veins were mineralized with copper sulfide and copper oxide minerals. Copper was the most enriched metal in this sample, assaying at approximately 6%. Anomalous silver was also detected in this sample (27.8 ppm). Mineralization was confined to the two 5- to 10-cm-thick quartz veins and did not penetrate into the country rock.

The pathfinder element arsenic was anomalous in sample 1213037 (179 ppm). This sample, collected from an iron-enriched quartzite, assayed 37% iron and was also anomalous in copper (148 ppm).

4.4.2 Don Dale Mining District

The Don Dale Mining District is at the northern terminus of the north-trending Groom Range (Figure 2.5). The Don Dale Mining District is comprised of numerous workings and prospect pits, both within and adjacent to the North Range's northeastern boundary, but has only two mines with historical production records. These are the Don Dale and Andies mines, both of which are outside the North Range boundary. The current assessment was limited to the Don Dale Mine and satellite workings outside of the NTTR boundary, as access into the NTTR to investigate other prospects in the southern part of the Don Dale Mining District was denied.

4.4.2.1 Stratigraphy

The geology of the Don Dale Mining District is shown on Figure 4.14. The northern Groom Range is comprised of lower Cambrian through Ordivician sediments and Eocene through Pliocene silicic volcanics with occasional genetically related intrusives The Don Dale Mine is in the Lower Cambrian Prospect Mountain FM. In other settings, the Prospect Mountain FM is sub-divided into the Stirling Quartzite and the Wood Canyon FM. At the Don Dale Mine, the Prospect Mountain FM is largely siliciclastic: including siltstone, shale, and quartzite. These rocks represent miogeoclinal deposition during the Cambrian. Minor Tertiary intrusions with felsic to intermediate composition, and dikes and sills with hypabyssal texture are common in the mineralized areas of the Prospect Mountain FM.

4.4.2.2 Structure

The principal structure at the Don Dale Mine is a 1.3 m wide quartz vein oriented N70^{o}E and dipping 80^{o} to the south. This vein cuts shaley material, which strikes approximately north-south and dips 25^{o} to the east. A zone of quartz breccia was observed between the vein and the country rock. Tingley (1991) reported a set of north-striking fractures dipping 40 to 60^{o} east, which are important conduits for mineralization.

4.4.2.3 Mining History and Mineralization

The Don Dale Mining District was officially organized in 1945; however, mining was likely initiated in the 1860s when the Groom Mining District was drawing prospectors to the area (Tingley, 1991).

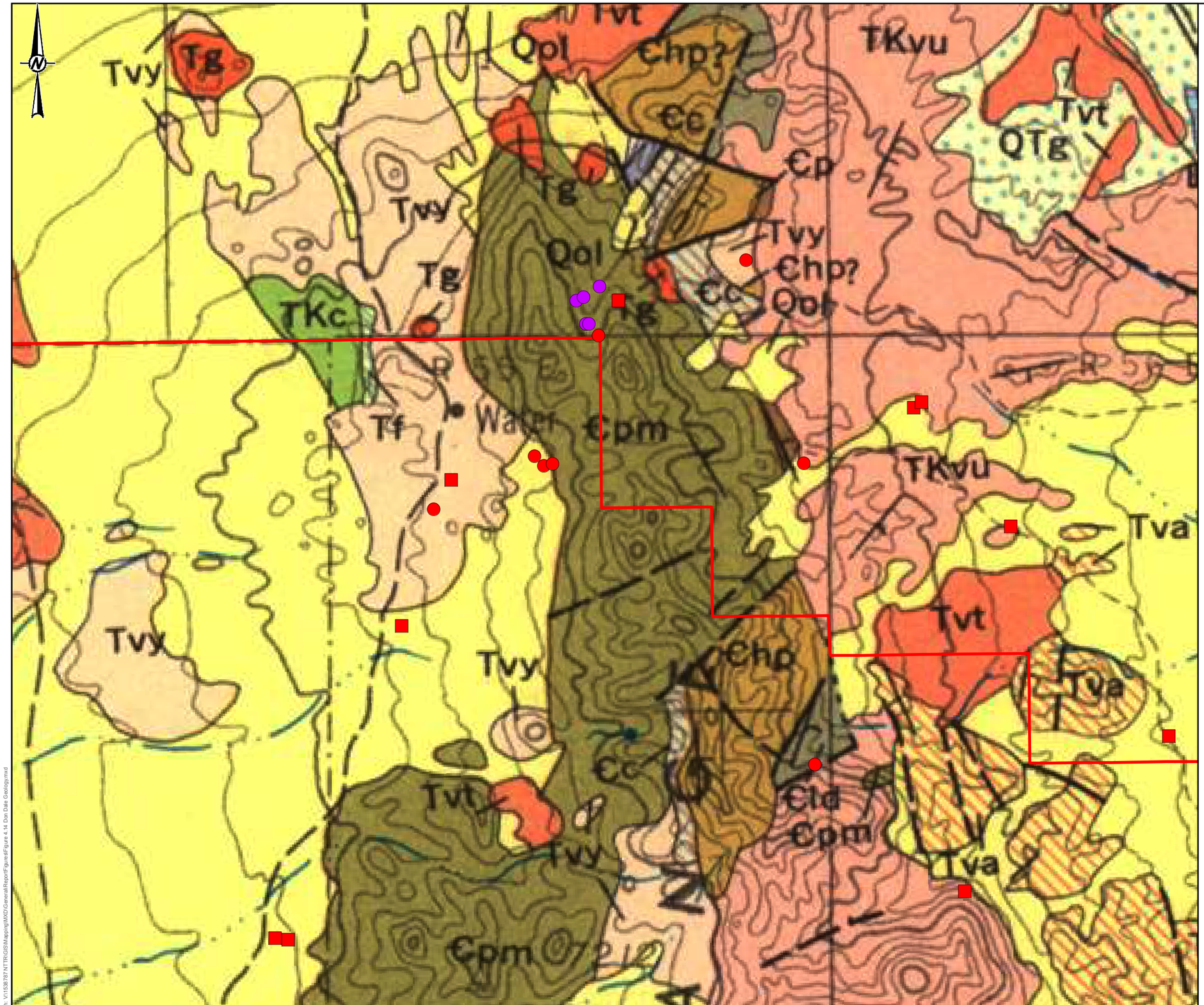


FIGURE 4.14
DON DALE GEOLOGY AND SAMPLE LOCATIONS

LEGEND

2016 SAMPLE LOCATIONS
- MINERALIZED AREA SAMPLE

1998 SAMPLE LOCATIONS
- MINERALIZED AREA SAMPLE
- SILT SAMPLE

NEVADA TEST AND TRAINING RANGE BOUNDARY

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1 0.5 0 1 Miles

1.6 0.8 0 1.6 Kilometers

NOTES

SOURCE:
TSCHANZ, C.M., PAMPEYAN, E.H. GEOLOGIC MAP OF LINCOLN COUNTY, NEVADA. NBMG, 1970, BULLETIN 73G.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 4.14 Don Dale Geology.mxd

By the time production ceased in the mid-1950s, the Don Dale Mine had produced 200 short tons of silver-lead-copper ore from a single 12-m-deep shaft (Tschanz and Pampeyan, 1970). Mineralization (and the mine workings) appears to follow bedding downdip from the quartz vein. In the field, copper and lead minerals were identified on the waste rock dump, in outcrops of the quartz vein, and in adjacent country rock. XRD analysis confirmed the presence of cerussite, a lead carbonate. Mineralization appears to be linked to both the intrusion of a small felsic porphyry body and the quartz vein.

4.4.2.4 Laboratory Results

Three samples were collected from the Don Dale Mine; one from the waste rock dump, one from the mine adit, and one from the nearby felsic porphyry intrusive outcrop. All three samples had high concentrations of lead, silver, gold, copper, and antimony. Sample sites are shown on Figure 4.14. The sample collected from the waste rock dump (sample 1213023) had the highest lead, silver, and antimony concentrations (respectively: 4%, 281 ppm, 1,465 ppm), while the sample collected from the quartz vein at the mine adit (sample 1213024) had the highest gold and copper concentrations (0.13 ppm, 2,600 ppm, respectively). The felsic porphyry sample (1213025), collected near the mine adit, was highly hydrothermally altered and was anomalous in the same elements as the above samples, however at lower concentrations. No ore minerals were observed in the porphyry in the field; however, chrysocolla was observed within the country rock near a contact with the porphyry. The alteration and mineralization of the porphyry likely indicates that mineralization occurred after the emplacement of the intrusion. The relationship between the quartz vein and the porphyry could not be determined from field observations, as they did not occur in the same outcrop.

5.0 COMPREHENSIVE MINERAL RESOURCE POTENTIAL

This section presents a comprehensive, area-wide update of the mineral resource assessment of the NTTR and the proposed Alternative 3 expansion areas. Geochemical data from the previous and current assessments were evaluated to update the site-wide metallic mineral resource potential in the existing NTTR boundaries and the expansion areas.

5.1 Geochemical Evaluation

5.1.1 Approach

The area-wide update of the mineral resource and energy assessment combines the approach of identifying single-element geochemical anomalies employed in the 1998 Assessment with that of identifying multi-element groupings as per the 1993 Assessment. Both assessments relied on the establishment of baseline trace element concentrations (GSC samples) and the identification of singular pathfinder elements or multi-element signatures associated with existing mines, mining districts, prospects, and mineralized outcrops (MA samples). In the following discussion, prospect refers to an area of interest where geochemical anomalies or multi-element signatures indicative of a metallic mineral deposit were identified. Prospects lie outside defined mining districts. GSC samples provided a benchmark for calculating anomalous concentrations and signatures in stream sediment (silt and float chip samples), while the MA samples provided information about existing elemental assemblages and concentrations in known mineralized areas. Silt samples represent active channel stream sediments, which are presumed to represent the chemistry of their weathered upgradient precursor. Float chip samples, also collected from the stream channels, were coarser, generally fractured, and gossanous, and thought to better represent the chemistry of hydrothermally altered upgradient material for low permeability, fractured lithologies such as carbonate rocks. Metal anomalies and elemental associations were often amplified in these intentionally biased float chip samples. In addition to GSC, MA, silt, and float chip samples collected as part of the 1993 and 1998 Assessments, the current assessment also relied on new data from the field investigation described in Section 4.0.

Following the methods of the 1998 Assessment, all samples were evaluated on a geographic basis. The study area was subdivided into three zones based on geology (Figure 5.1). The northwest section of the NTTR, including most of the North Range, was designated the Cenozoic Zone based on the predominance of Tertiary volcanic outcrops, reflecting volcanic activity in the Great Basin between 6 and 43 Ma. The southeast section of the NTTR that includes most of the South Range was designated the Paleozoic Zone based on the predominance of late pre-Cambrian to Permian carbonate sedimentary rocks formed in the Cordilleran miogeocline of western North America. The Transition Zone connects the Cenozoic and Paleozoic provinces and contains a mixture of Cenozoic volcanic and Paleozoic carbonate outcrops.

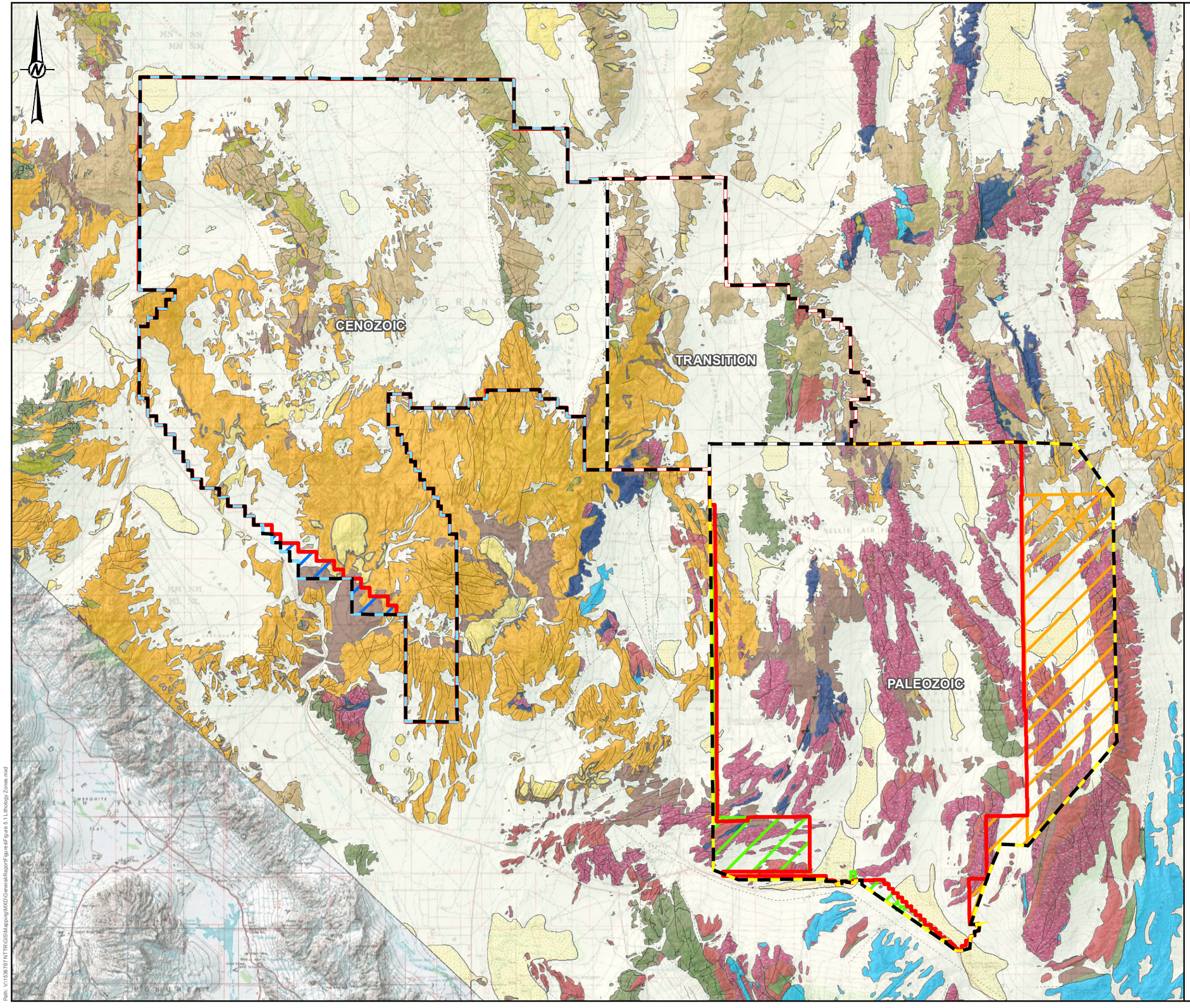


FIGURE 5.1
LITHOLOGY ZONES IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

LITHOLOGY ZONE
- TRANSITION
- PALEOZOIC
- CENOZOIC

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
GEOLOGY: CRAFFORD, E., GEOLOGIC MAP OF NEVADA, U.S. GEOLOGICAL SURVEY DATA SERIES 249. A DIGITAL CONODONT DATABASE OF NEVADA.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: \\r1538787 NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 5.1 Lithology Zones.mxd

The single-element anomaly evaluation output is a series of site-wide anomaly maps for relevant pathfinder elements. The multi-element association evaluation output is a number of factor score maps, which describe areas where multi-element associations, reflective of certain ore deposit types, are significant. The results from each evaluation were consolidated to establish overall mineral potential certainty designations for relevant deposit types. Results from each evaluation were interpreted using a modern ore deposit model framework, similar to that employed in the 2014 Assessment. Based on known mining districts and prospects in the study area, and on those common to the Great Basin, the following ore deposit types were targeted, listed here with their common geochemical attributes:

- Felsic Intrusion Related Deposits:
  - Epithermal systems – gold (and silver) deposits generally formed at shallow depths (less than 1.5 km) and low temperatures (less than 300 °C); associated with calc-alkaline to alkaline magmatism in collisional or back-arc rift settings (Simmons and others, 2005). The bulk of epithermal deposits in Nevada are alkaline low-sulfidation systems. Common pathfinder elements to epithermal gold deposits include arsenic, antimony, mercury, and thallium. Additional element associations include copper, gold, lead, silver, and tellurium.
  - Porphyry systems – copper, gold, molybdenum, tungsten, and tin deposits that are genetically related to the shallower epithermal systems, representing their deeper magmatic roots. Porphyry deposits are spatially and temporally associated with dioritic to granodioritic magmatism in subduction-related tectono-magmatic systems (Seedorff and others, 2005). Porphyry systems are characterized by a large hydrothermal footprint with recognizable hydrothermal alteration (potassic, sericitic, and argillic) halos with a late meteoric (propylitic) overprint, as well as a distinct base metal zonation pattern. Common metal associations include copper, gold, molybdenum, and tungsten, with peripheral lead, silver, and zinc. Additional associations include arsenic, antimony, cobalt, manganese, and selenium.
- Carlin-type gold deposits (CTGDs): submicron gold mineralization hosted in pyrite-bearing carbonaceous limestones, formed at relatively low temperature (180 to 240 °C) by regional, auriferous basinal fluids with meteoric and metamorphic/magmatic origins (Cline and others, 2005). Carlin deposits in Nevada are mostly Eocene aged (36 to 42 Ma) but older Carlin-type mineralization exists (e.g., Long Canyon in Elko County – early Paleozoic), while sedimentary-hosted gold deposits in other parts of the world exhibiting many similarities to CTGDs are frequently also of different age. Common metal associations, besides gold, include antimony, arsenic, mercury, and thallium, with secondary molybdenum and tungsten.
- Regionally dolomitized carbonates: base metal and silver mineralization in Paleozoic carbonates originally thought to be peripheral replacement-style deposits genetically associated with porphyry-style intrusion. Current understanding favors hydrothermal dolomitization of carbonate, with concomitant porosity and permeability increase, resulting void-space filling and deposition of argentiferous base metal sulfides from metalliferous saline brines. The brines reflect regional basinal fluid flow tied to Sevier age thrusting (Vikre and others, 2011). Common metal associations include copper, lead, silver, and zinc.

Pathfinder elements and metal assemblages used in the geochemical evaluation are based on the deposit models presented in Cox and Singer, 1992. The multi-element associations for these four deposit types overlap considerably, especially those of epithermal systems and CTGDs. The latter deposits can often be

separated based on host lithology, as epithermal deposits in the study area are likely to have a Cenozoic volcanic host, while CTGDs would more likely be hosted in Paleozoic carbonates (the two deposits can also be geochemically separated by their gold to silver ratios, provided gold concentrations are detectable in distal samples). Similarly, the metal associations for regionally dolomitized carbonates resemble those of peripheral base metal replacement and skarn deposits associated with porphyry deposits. In the discussion of single- and multi-element results that follows, ore deposit types are separated based on metal assemblage and geologic context where it was feasible to do so. In remaining cases, potential ore deposit types were grouped together.

5.1.1.1 Single-Element Anomalies

The single-element anomaly evaluation relied on a comparison of stream sediment sample (silt and float chip) geochemistry to the GSC baseline. Per the methodology of the 1998 Assessment, anomalous or threshold values were set at median GSC concentrations for each element, plus 3 standard deviations. Exceedances of these thresholds were plotted on a series of study area maps for 14 elements. The drainage basins representing the likely source for the anomalous silt and float chip samples were shaded immediately upgradient of the anomalous sample. Shaded areas with multiple associated anomalous silt or float chip samples were considered to have a higher mineral potential than those with a single associated sample, and were designated accordingly in the anomaly maps for each of the 14 elements. Given that this assessment relied on data used in the 1998 Assessment, many of the shaded drainage basins were identical to those identified in the 1998 Assessment. Exceptions to this were areas in which additional samples were collected (mostly in the Paleozoic Zone), and the East DNWR (Tingley and others, 1993), where the single-element anomaly evaluation was not previously conducted.

Threshold calculations in the 1998 Assessment were made for a study area subdivided into ‘pre-Tertiary rocks’ (southeast portion of study area; designated ‘Paleozoic Zone’ in this assessment) and ‘Tertiary rocks’ (northwest portion of study area; designated ‘Cenozoic Zone’ in this study). Lithologic zones are shown on Figure 5.1. In this assessment, threshold concentrations were calculated for a third zone of mixed Cenozoic and Paleozoic rock (or Transition Zone) that bridges the Cenozoic and Paleozoic zones. Since few GSC samples have been collected in the Transition Zone, threshold concentrations for the Transition Zone were calculated based on the entire GSC sample population. This is considered defensible, as the Transition Zone is a mix of both Cenozoic and Paleozoic materials.

Calculated GSC threshold concentrations used in this evaluation, as well as the number of identified stream sediment anomalies per analyte for each geologic zone, are summarized in Appendix D.1.

5.1.1.2 Multi-Element Associations

In addition to the single-element anomaly evaluation, multi-element associations were identified using multivariate principal component analysis (PCA), which is a statistical data reduction technique frequently

employed to evaluate large geochemical datasets. PCA uses an orthogonal transformation to convert a sample population into a smaller number of linearly uncorrelated variable groups, referred to as principal components or factor groups. This minimized set of factor groups represents the intrinsic dimensionality of the dataset. The factor groups were sorted in order of decreasing overall variance. Variables within each factor group were correlated, indicating some type of relationship between them. In some cases, the relationships revealed non-geologic processes (for example, PCA generally returns a high correlation between LOI, calcium, and calcite for datasets with both XRF and XRD data, reflecting carbonate volatilization during XRF bead fusion), while in other cases they revealed actual geochemical relationships. The artificial processes can serve as a proof of method. The geochemical relationships that can exist within a factor group were often ambiguous and required careful and rigorous interrogation and interpretation by the PCA operator.

To quantify correlations among variables within a factor group, a loading value was assigned to each variable that represents the strength of correlation with the entire factor group. These loading values were subsequently sorted into categories defined in terms of the standard error of the correlation coefficient calculations. By focusing primarily on variables with loading values higher than several times the standard error, the risk of over-interpreting correlations between variables and factors that are simply due to random chance was minimized. For this assessment, a loading value for a variable within a factor group was considered statistically meaningful if it represented at least 3 standard deviations from the mean. This value implies a greater than 99.7 percent probability that the strength of the relationship of that variable with the factor group cannot be explained by random chance. In addition, PCA assigned factor scores to each sample within a factor group, which allows for the identification of the samples that explain the bulk of the variance within a factor. These samples and their factor scores were plotted on study area maps introduced in Section 5.1.3.2 for those factor groups that are considered geochemically meaningful.

The geochemical dataset required modification prior to conducting the PCA. Concentrations below their respective laboratory method detection limit were replaced with half detection limits. Given that the database was assembled over multiple assessments and numerous years, different sets of analytes were analyzed for different sample groups, by different laboratories, and using different method detection limits. Since PCA cannot be conducted when a significant number of analytes are missing, samples and/or analytes were removed from the dataset to create a dataset that maximized either the number of complete samples or the number of variables that could be evaluated. Three different databases were prepared as input for the PCA:

- All samples, consisting of 40 analytes from 2,280 samples
- Rare earth elements ‘(REE), no Au, no Nd,’ consisting of 50 analytes from 1,578 samples
- REE, consisting of 52 analytes from 983 samples

The three datasets were further subdivided by sample material type (GSC, MA, silt, and float chip) and zone (Cenozoic, Paleozoic, and Transition) for input. In some cases, especially for Transition Zone GSC and float chip samples, such subdivision resulted in an insufficient sample number (less than 30) to conduct a statistically meaningful PCA. In all, 53 separate datasets were evaluated by PCA. A matrix of datasets is provided in Appendix D. Even for datasets with a sufficient number of samples (greater than 30), relatively few samples for the Transition Zone generally yielded ambiguous results. However, the three-zone (Cenozoic, Paleozoic, and Transition) data structure was maintained in this assessment, as the results were readily comparable to single-element anomalies, which were evaluated according to the same structure. Furthermore, the existence of the Transition Zone results in 'cleaner' Cenozoic and Paleozoic datasets. That is, the Cenozoic dataset contains mostly volcanic lithologies, whereas the Paleozoic dataset contains primarily carbonate lithologies.

The purpose of conducting PCA on the mineralized area sample datasets was to establish multi-element associations within known mining districts and prospects. PCA was conducted on GSC samples to identify multi-element associations in unmineralized materials. PCA results for silt and float chip samples were evaluated to assess mineral potential for a variety of ore deposit types, and compared against known mineralization (ore) and the baseline multi-element signature (GSC).

Statistical analysis of the dataset modified this way was conducted using statistical software by NCSS, LLC. of Kaysville, Utah. The data was auto-normalized (using the correlation matrix setting) to account for variable numeric ranges caused by the existence of different variable units. A maximum of 20 factors was specified (the bulk of the variance of natural datasets can typically be explained by 6 to 7 factors). The analysis was conducted using a normal orthogonal projection, as this projection captures the maximized variance of each individual factor. Following analysis, the relevant factors, explaining the dataset variance, were identified using scree plots of eigenvector values. Factor group loadings were interpreted to identify multi-element associations that reflect deposit types. Finally, for the relevant factor groups, factor scores were combined with anomalies to develop deposit scores, which were plotted on study area maps to identify areas of mineral potential.

Once calculated, the deposit scores were evaluated to provide a quantitative basis for the Resource Potential designation as defined by Goudarzi (1983). Deposit scores exceeding the mean plus 3 standard deviations within their sample population were designated as Moderate Potential, while scores exceeding the mean plus 4 standard deviations were classified as High Potential for each of the four deposit types.

Deposit scores were plotted for each silt and float chip sample (samples with a score of zero were omitted) in ArcGIS and coded as Low, Moderate, and High Potential. The drainage basins immediately upgradient of moderate and high potential samples were delineated with corresponding colored polygons. Each of the deposit types included isolated samples with deposit scores of either Moderate or High, but the geological

context was not consistent with the occurrence of that particular deposit type. In such cases no polygon was delineated for the drainage basin upgradient of the sample.

Lastly, the Resource Potential polygons were assigned a certainty designation as per the BLM Mineral Classification System presented in Section 1.4. A Resource Potential polygon was designated certainty level C if the geological environment was consistent with deposit type, and there was known mining activity within or adjacent to the polygon. A Resource Potential polygon was designated certainty level B if the geological environment was consistent with the deposit type but there was no known mining activity in the vicinity.

5.1.1.3 Update to the 1993, 1998, and 2014 Assessments

Given the considerable effort of the previous assessments of mineral potential within the NTTR and DNWR, this geochemical evaluation focused on additions or revisions to the existing body of work. The primary areas of contribution in the current geochemical evaluation can be summarized as follows:

- The geochemical anomaly assessment was extended from the NTTR (1998 Assessment) to the entire study area.
- The multi-element grouping evaluation was extended from the East DNWR (1993 Assessment) to the entire study area.

Results for the geochemical single-element anomaly evaluation are discussed in Section 5.1.2, and results of the multi-element association evaluation are discussed in Section 5.1.3. Results were then combined to update the assessment of mineral potential on a prospect or occurrence basis, employing the definitions for mineral resource potential and certainty (BLM, 1985), as in the previous assessments.

5.1.2 Geochemical Anomalies

The geographic distribution of single-element anomalies for the 14 primary pathfinder elements within each of the three geologic provinces is dicussed in Sections 5.1.2.1 and 5.1.2.2. The majority of anomalies in the silt and float chip samples are associated with known mining districts and prospects. Figure 5.2 llustrates the known mining districts and prospects in the NTTR and proposed Alternative 3 expansion areas.

5.1.2.1 Precious Metals

In the following discussion, anomaly strength is defined by the number of samples within a drainage basin or contiguous drainage basins that exceed the element threshold concentrations (Appendix D.1).

Silver anomalies (Figure 5.3) occurred predominantly in the volcanic rocks of the Cenozoic Zone. Strong anomalies were observed throughout the Pahute Mesa area and were associated with the Tolicha, Gold Crater, Jamestown, Wilsons, and Trappmans mining districts and the Mount Helen prospect, and in the Cactus Springs, Antelope Springs, and Wellington mining districts immediately north of the Pahute Mesa.

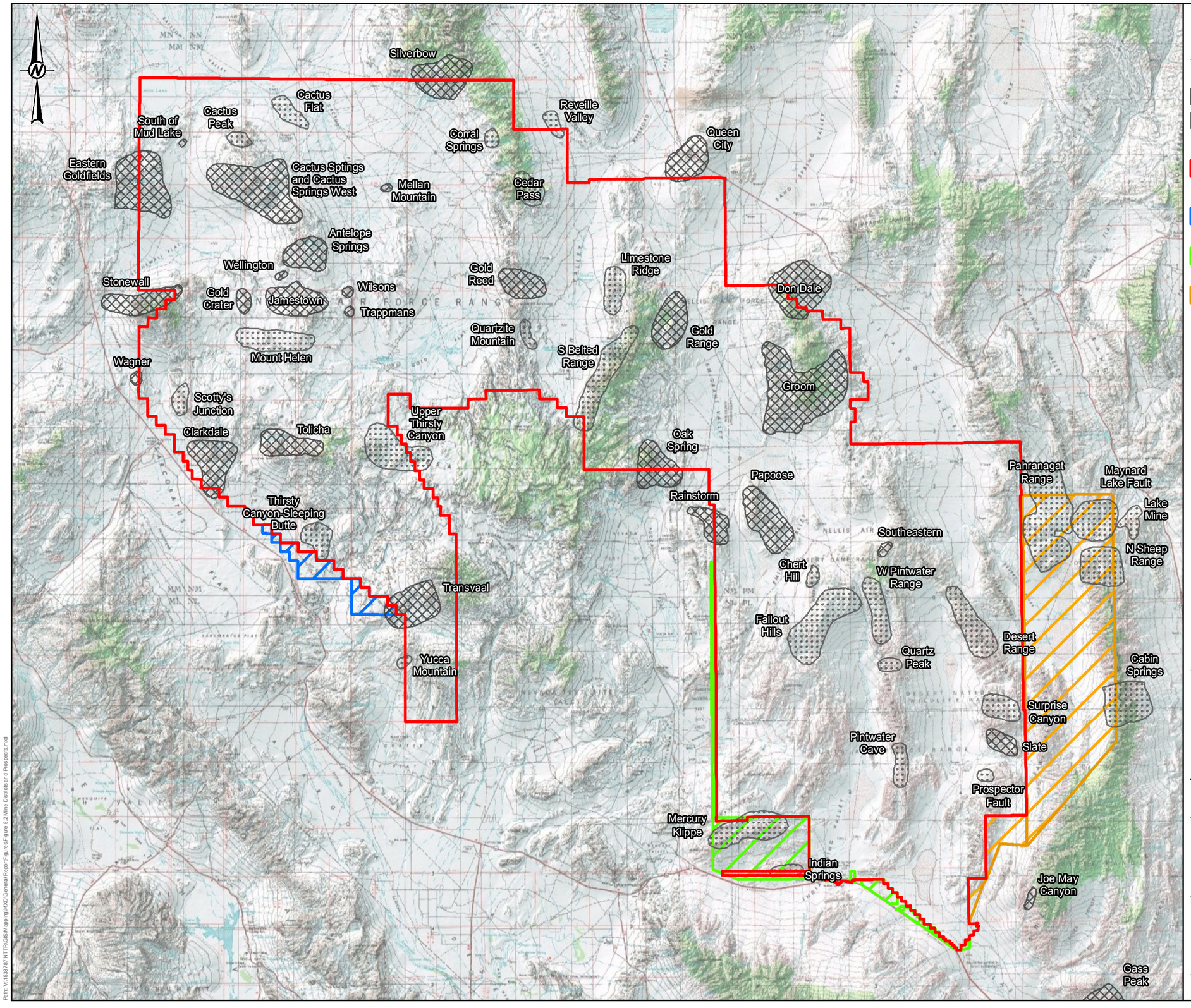


FIGURE 5.2
MINING DISTRICTS AND PROSPECT AREAS IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: V:\1538787\NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.2 Mine Districts and Prospects.mxd

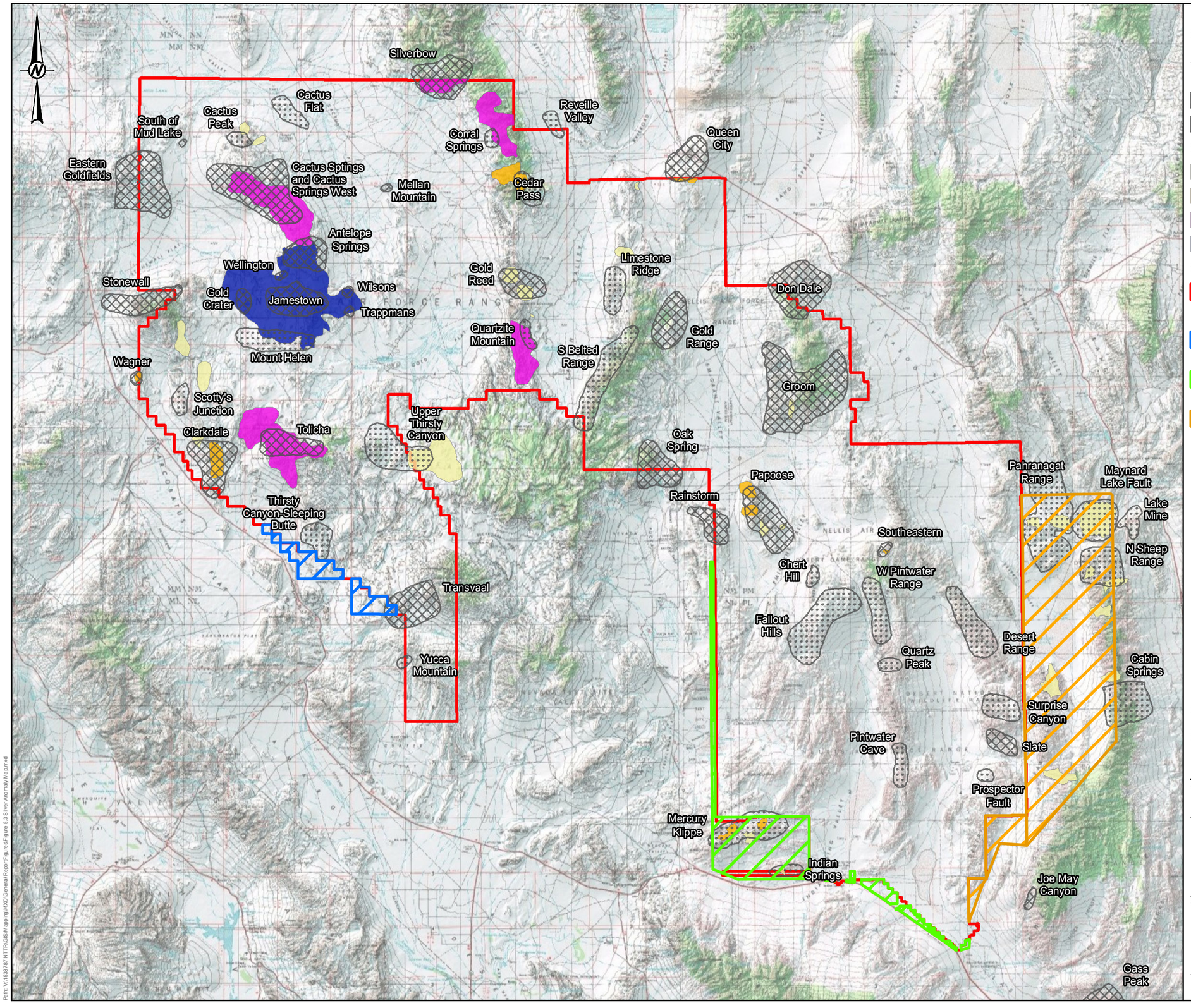


FIGURE 5.3
SILVER ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

SILVER ANOMALY STRENGTH

- 0 - 1
- 2 - 4
- 5 - 11
- 12 - 16

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	5.3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0

Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.3 Silver Anomaly Map.mxd

Additional anomalies were observed in the Kawich Range in the Silverbow Mining District, and at the Corral Springs and Quartzite Mountain prospects. In the Paleozoic Zone, the only significant anomalies were observed in the Papoose Range. Lesser anomalies were frequently observed in the East DNWR in the Alamo area.

Similar to silver, the strongest gold anomalies (Figure 5.4) occurred in the six mining districts surrounding the Jamestown Mining District, in the Silverbow Mining District, and in the Papoose Range in the Paleozoic Zone. However, considerable anomalies also exist in the Clarkdale, Tolicha, and Cactus Springs mining districts, and in the Cedar Pass prospect area. In the Alamo area, anomalies occurred in the Pahranagat Range and east of the Surprise Canyon prospects.

5.1.2.2 Base Metals

Primary copper anomalies (Figure 5.5) were observed in the Cactus Springs, Antelope Springs, and Wagner mining districts in the Cenozoic Zone, as well as in the Rainstorm and Papoose mining districts in the Paleozoic Zone. Additional anomalies were observed in the Cenozoic Zone in the Gold Crater Mining District and the Quartzite Mountain, South Belted Range, and Upper Thirsty Canyon prospect areas.

Strong lead anomalies (Figure 5.6) were observed at the Mount Helen prospect, in the Gold Crater and Jamestown mining district cluster in the Cenozoic Zone, and in the Papoose Mining District, the Southeastern Mining District, and the northern portion (Pahranagat Range and Maynard Lake Fault prospect areas) of the Alamo area in the Paleozoic Zone.

Zinc anomalies (Figure 5.7) were relatively scarce, occurring only in the Thirsty Canyon-Sleeping Butte and Upper Thirsty Canyon prospect areas in the south Cenozoic Zone, and in the Papoose Mining District and Fallout Hills prospect area in the Paleozoic Zone.

5.1.2.3 Pathfinder Elements

Arsenic anomalies (Figure 5.8) were ubiquitous, occurring across all three zones. The strongest anomalies occurred in the north Pahute Mesa and Cactus Peak areas and Kawich Range of the Cenozoic Zone, in the Belted Range of the Transition Zone, and throughout the Paleozoic Zone, including significant anomalies in the 64C/D and 65D and Alamo areas.

Antimony anomalies (Figure 5.9) occurred in all three zones. The strongest anomalies were observed in the Cenozoic Zone, in the Jamestown and six adjacent mining districts and prospects, and at the Silverbow Mining District to the north. Arsenic anomalies in the Transition Zone occurred in the Belted Range, at Limestone Ridge prospect, the Gold Range Mining District, the South Belted Range prospect area, and in the Groom Mining District. In the Paleozoic Zone, stronger anomalies occurred at the Rainstorm, Papoose, and Southeastern mining districts, and in the 64C/D and 65D area (the Mercury Klippe prospect area).

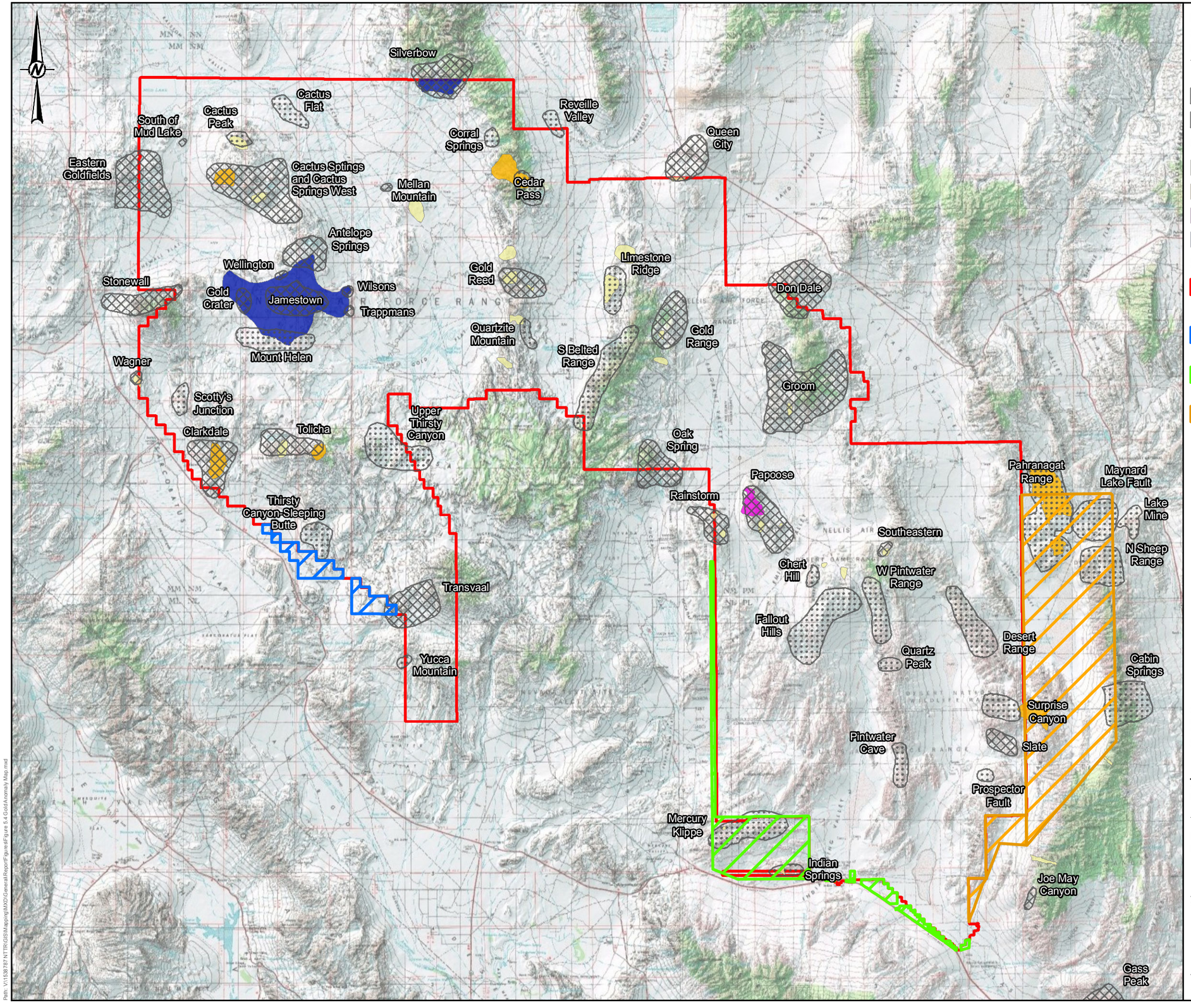


FIGURE 5.4
GOLD ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

GOLD ANOMALY STRENGTH

- 0 - 1
- 2 - 3
- 4 - 5
- 6 - 8

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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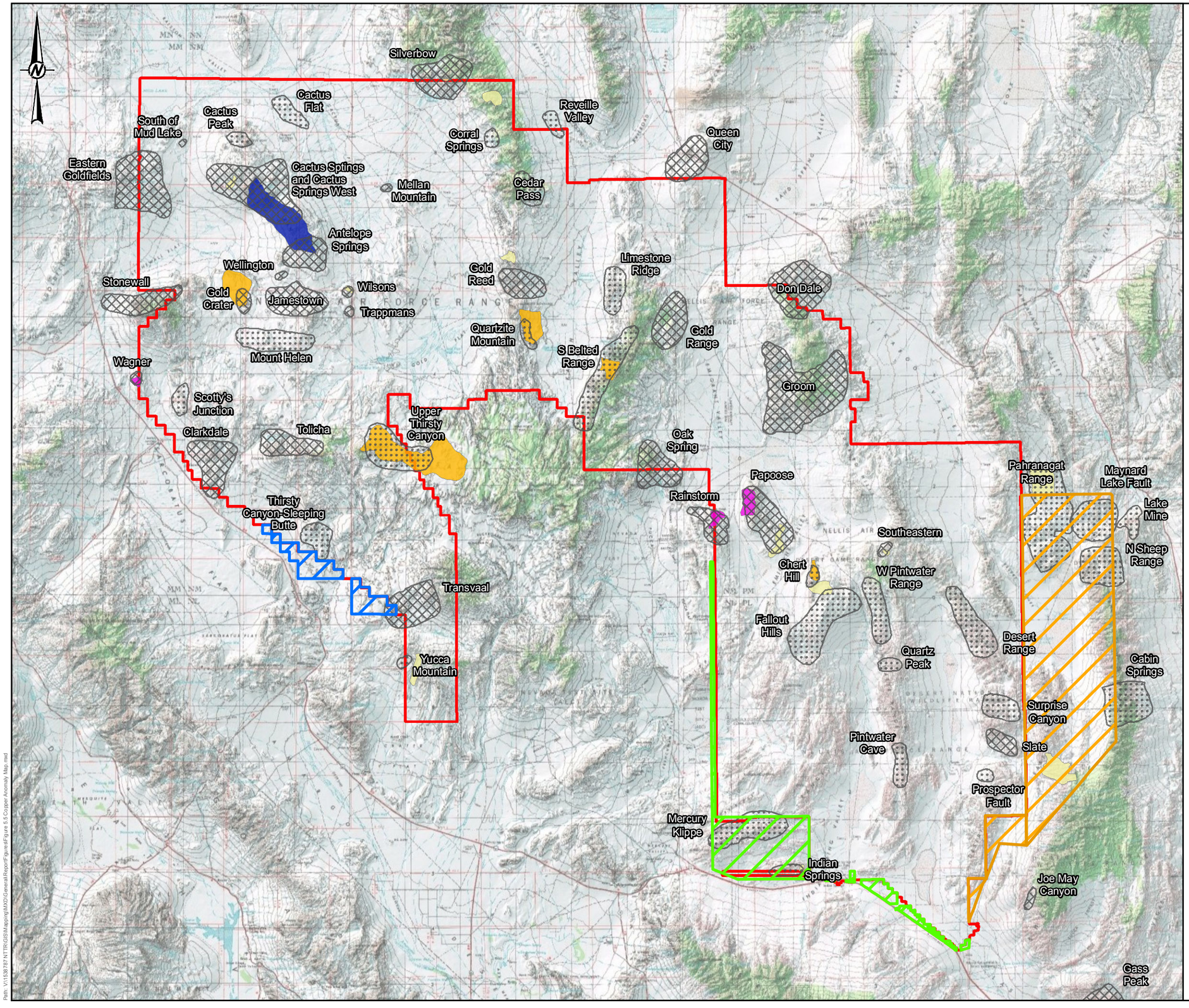


FIGURE 5.5
COPPER ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

COPPER ANOMALY STRENGTH

- 1.0
- 2.0
- 3.0
- 4.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.5 Copper Anomaly Map.mxd

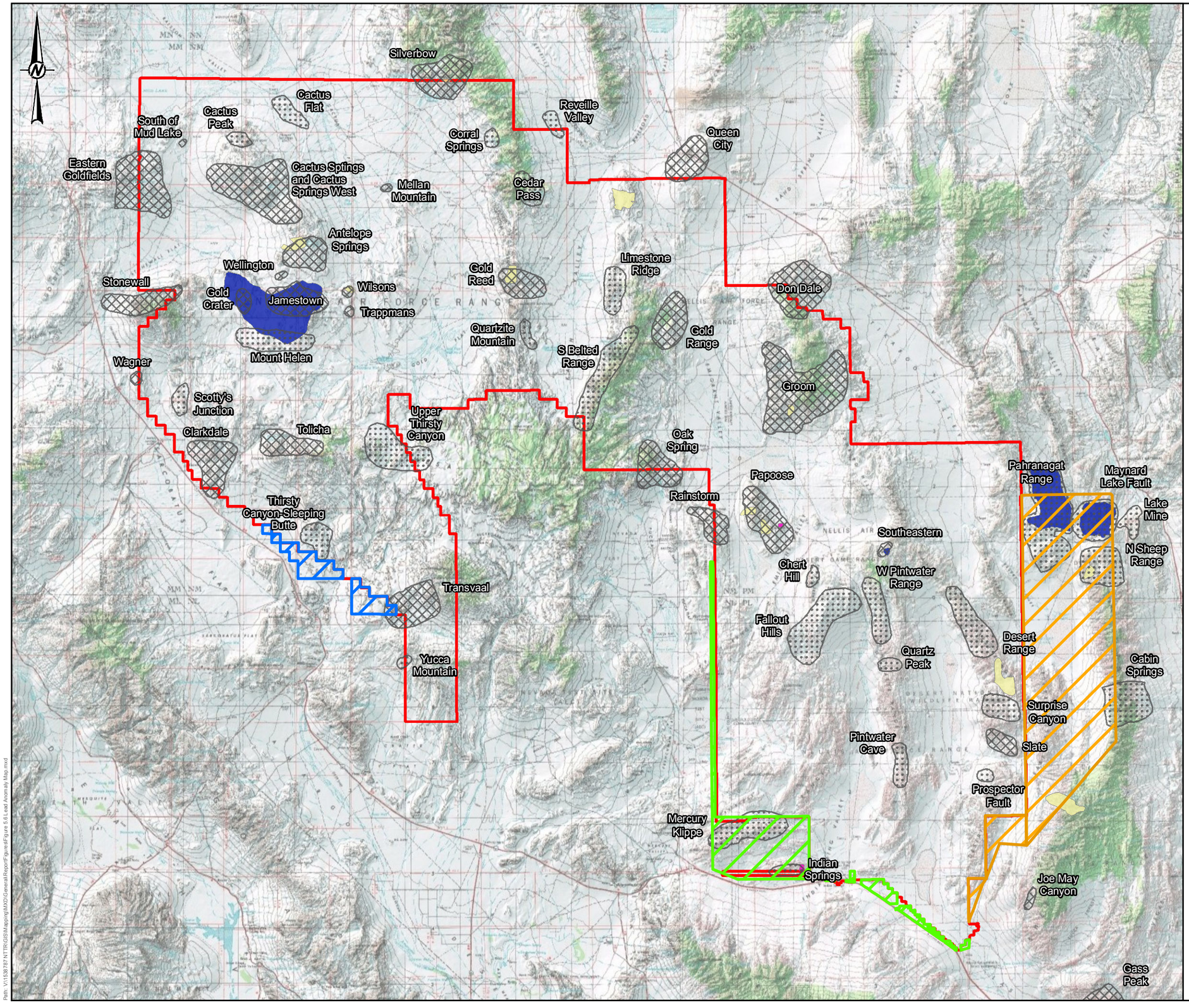


FIGURE 5.6
LEAD ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

MINING DISTRICT

MINERAL PROSPECT

LEAD ANOMALY STRENGTH

1.0

2.0

3.0

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	5.6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.6 Lead Anomaly Map.mxd

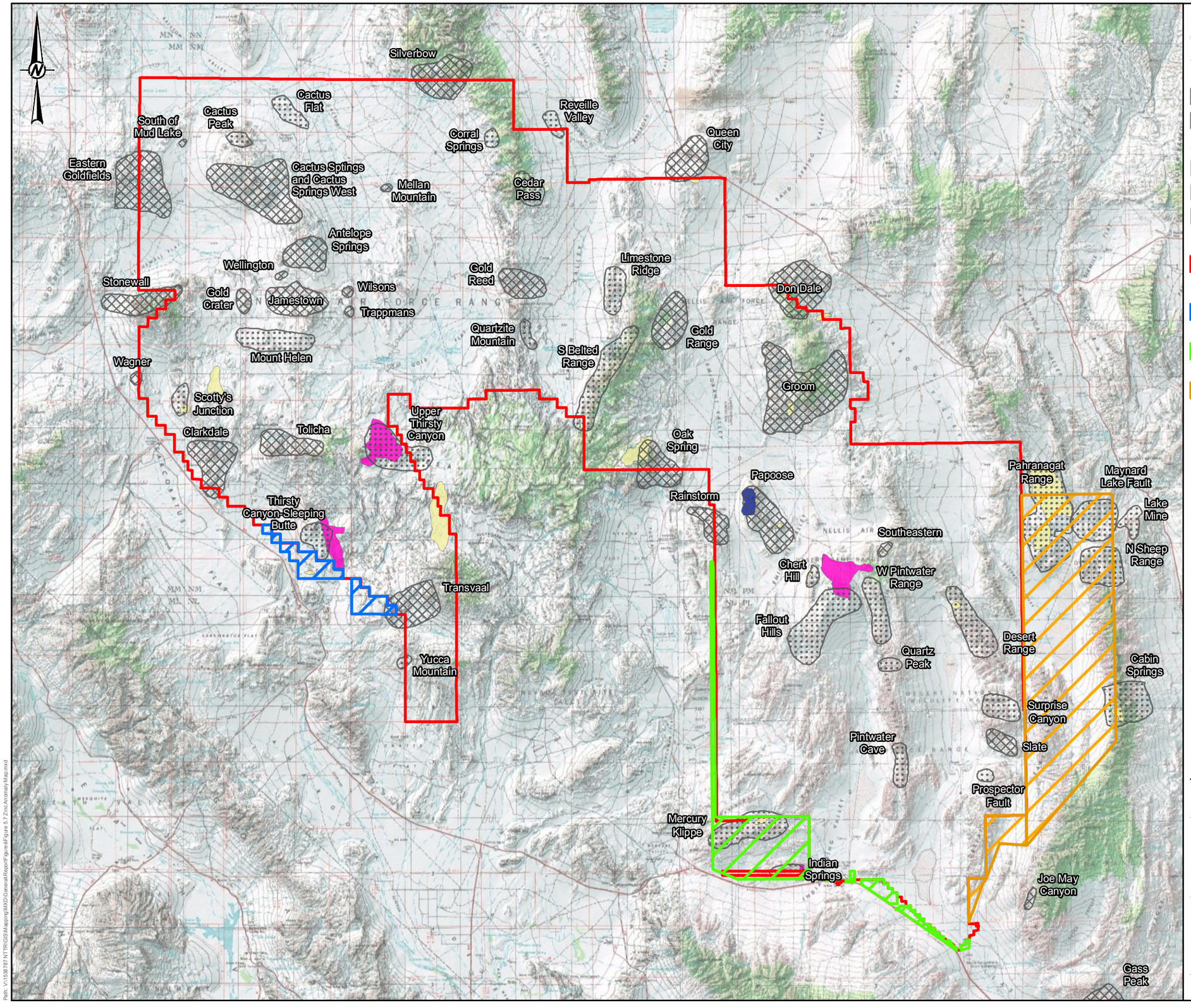


FIGURE 5.7
ZINC ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

MINING DISTRICT

MINERAL PROSPECT

ZINC ANOMALY STRENGTH

1.0

2.0

3.0 - 4.0

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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1538787	---	---	5.7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.7 ZincAnomaly Map.mxd

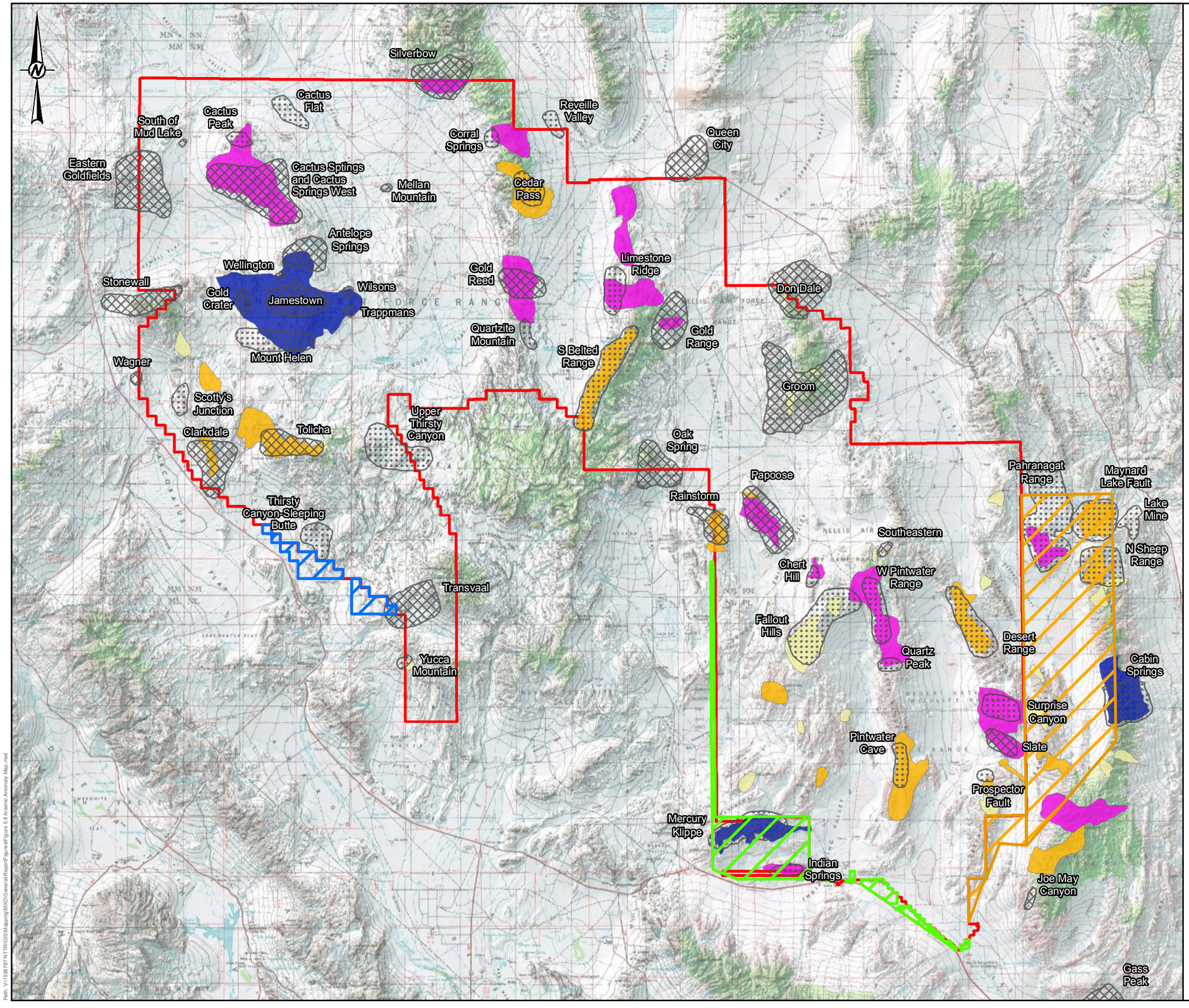


FIGURE 5.8
ARSENIC ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

ARSENIC ANOMALY STRENGTH

- 1.0
- 2.0 - 4.0
- 5.0 - 11.0
- 12.0 - 22.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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1538787	---	---	5.8

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 5.8 Arsenic Anomaly Map.mxd

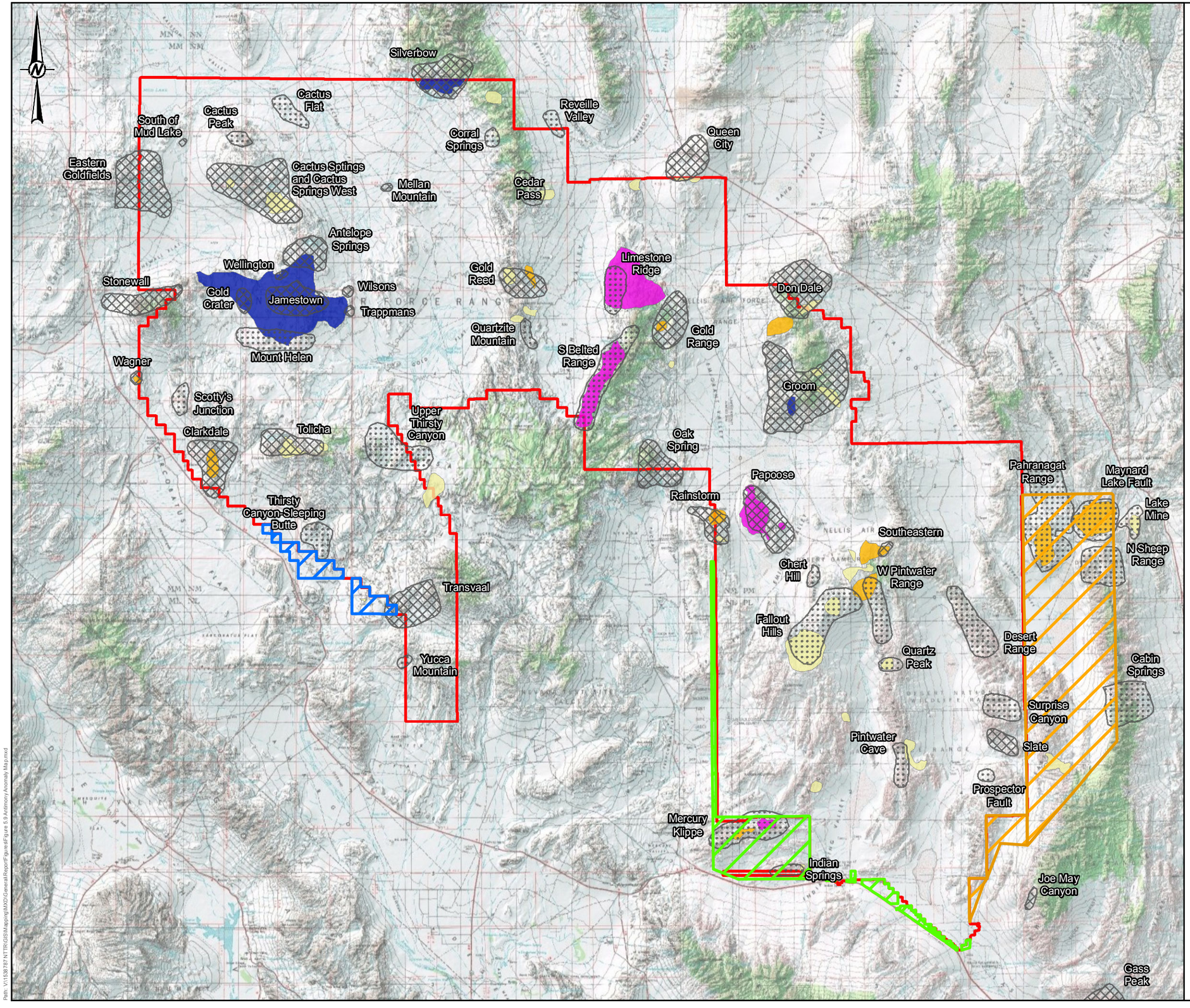


FIGURE 5.9
ANTIMONY ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

ANTIMONY ANOMALY STRENGTH

- 1
- 2 - 3
- 4 - 6
- 7 - 10

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	5.9

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.9 Antimony Anomaly Map.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Strong cobalt anomalies (Figure 5.10) were uncommon, observed only in the Scotty's Junction prospect area and the Papoose mining district.

Mercury anomalies (Figure 5.11) were concentrated almost exclusively in the Cenozoic Zone, with strongest anomalies occurring in the Kawich Range at the Gold Reed Mining District and the Quartzite Mountain prospect, with other anomalies observed to the west at Jamestown, Gold Crater, and Trappmans mining districts and Mount Helen prospect, to the southwest in the Wagner, Clarkdale, and Transvaal mining districts, and to the north in the Silverbow Mining District.

The primary molybdenum anomalies (Figure 5.12) also occurred in the Cenozoic Zone, and were concentrated in the north Pahute Mesa and Cactus Range areas in the Jamestown and adjacent mining districts, the Cactus Peak prospect, and Cactus Springs Mining District. Other anomalies occurred in the Kawich Range in the Silverbow and Gold Reed mining districts, and in the Corral Springs and Quartzite Mountain prospect areas.

Selenium anomalies (Figure 5.13) were uncommon, observed only in the Cenozoic Zone at Cactus Springs, and Gold Crater mining districts and Mount Helen prospect, and at Gold Reed mining district in the Kawich Range. An anomaly was also identified in the Administrative Incorporation area.

Strong tellurium anomalies (Figure 5.14) were scarce, observed only in the Cenozoic Zone in the Mount Helen prospect and the Jamestown and Gold Crater mining districts, and to the east at Gold Reed Mining District.

Significant thallium anomalies (Figure 5.15) were observed only in the south Cenozoic Zone, near the Yucca Mountain and Transvaal mining districts, and in the Kawich Range at Quartzite Mountain.

Tungsten anomalies (Figure 5.16) occurred only in the Paleozoic Zone, to the west at the Papoose Mining District and to the east in the Alamo area (the Pahranagat prospect area).

The overall mineral potential associated with the various single-element anomalies is discussed in combination with multi-element factor scores, and in light of an updated ore deposit model framework, in Section 5.2.1.

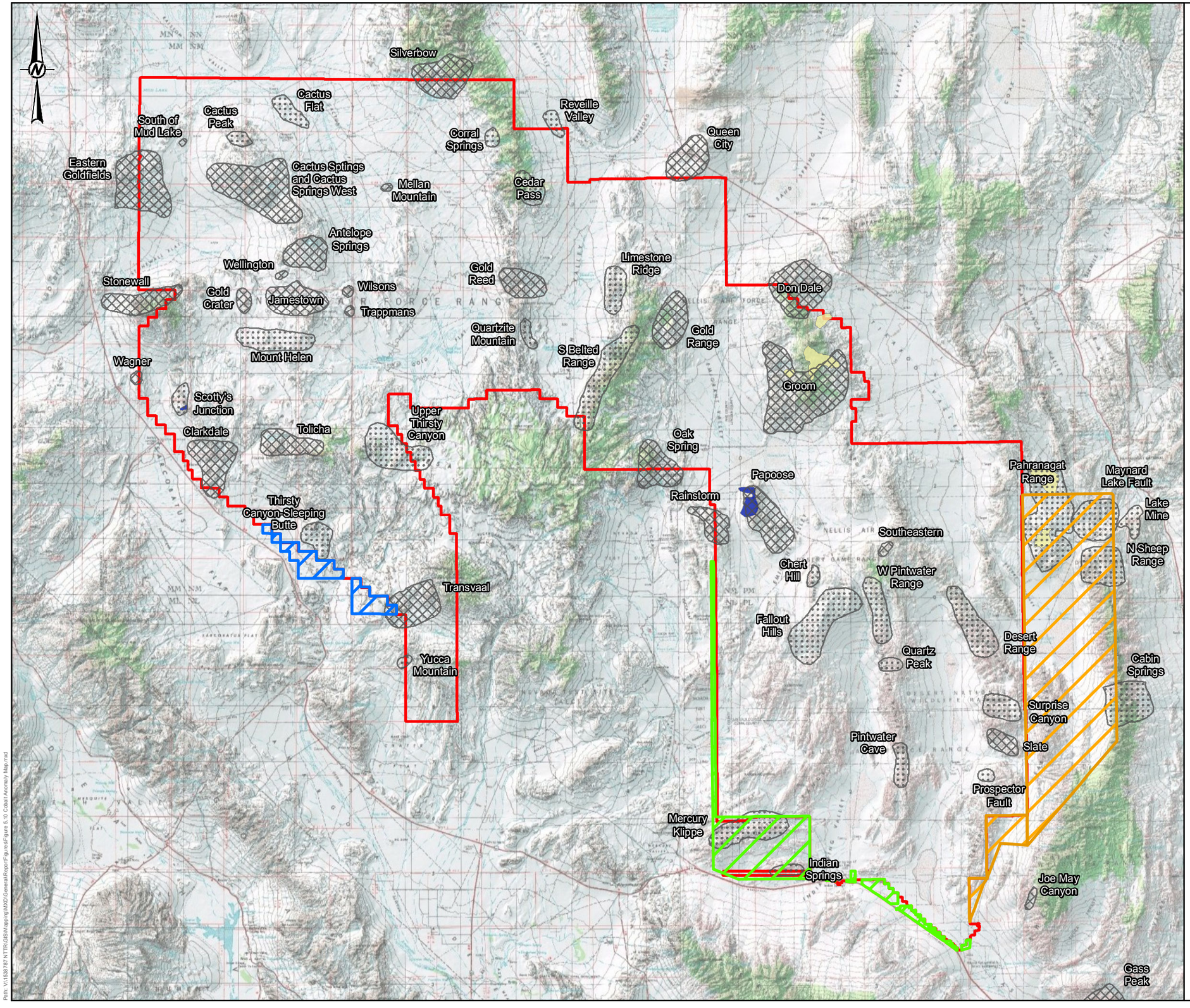


FIGURE 5.10
COBALT ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

COBALT ANOMALY STRENGTH

- 1.0
- 2.0 - 3.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

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1538787	---	---	**5.10**

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.10 Cobalt Anomaly Map.mxd

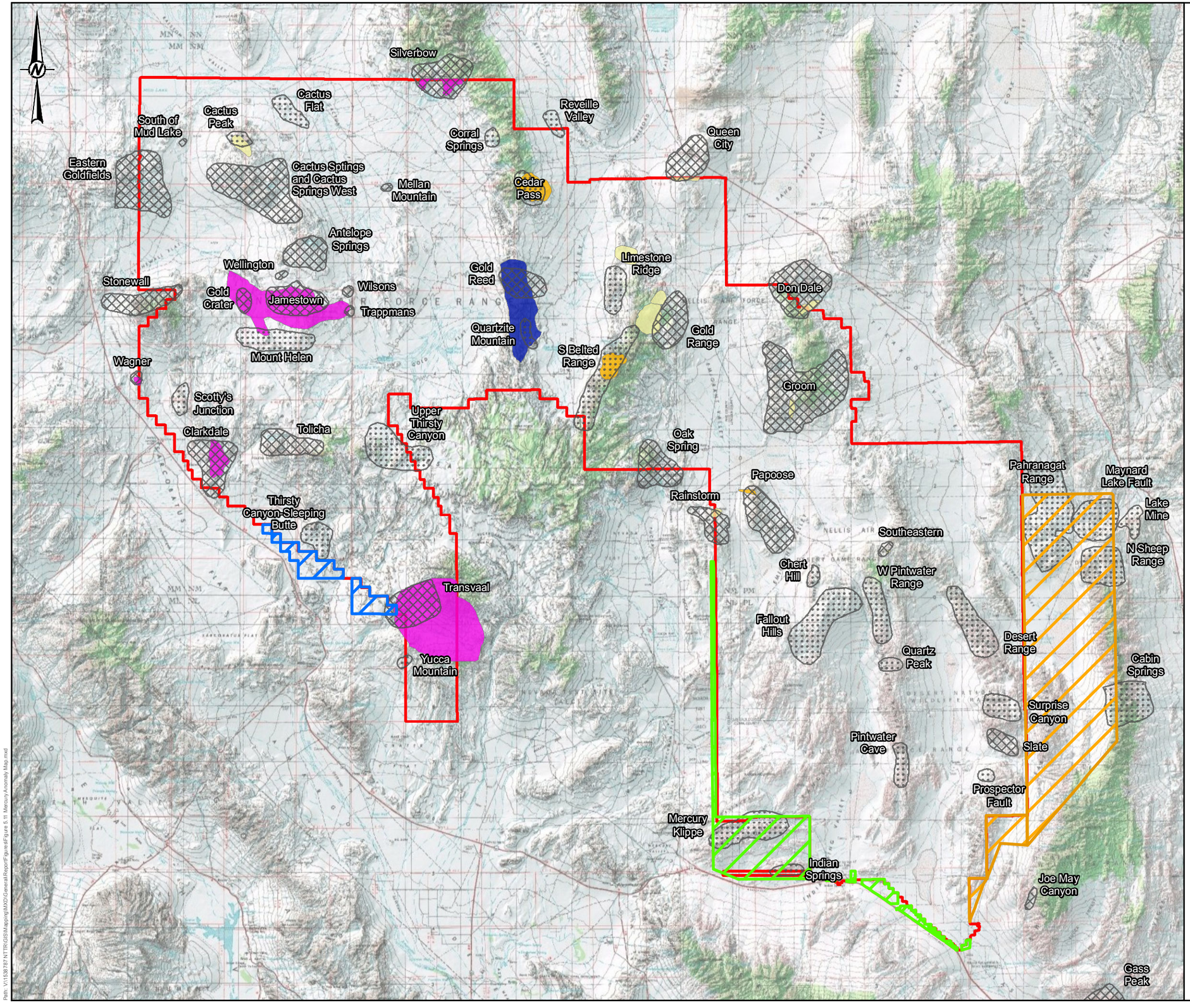


FIGURE 5.11
MERCURY ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

MERCURY ANOMALY STRENGTH

- 1.0
- 2.0
- 3.0 - 4.0
- 5.0 - 7.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.11 Mercury Anomaly Map.mxd

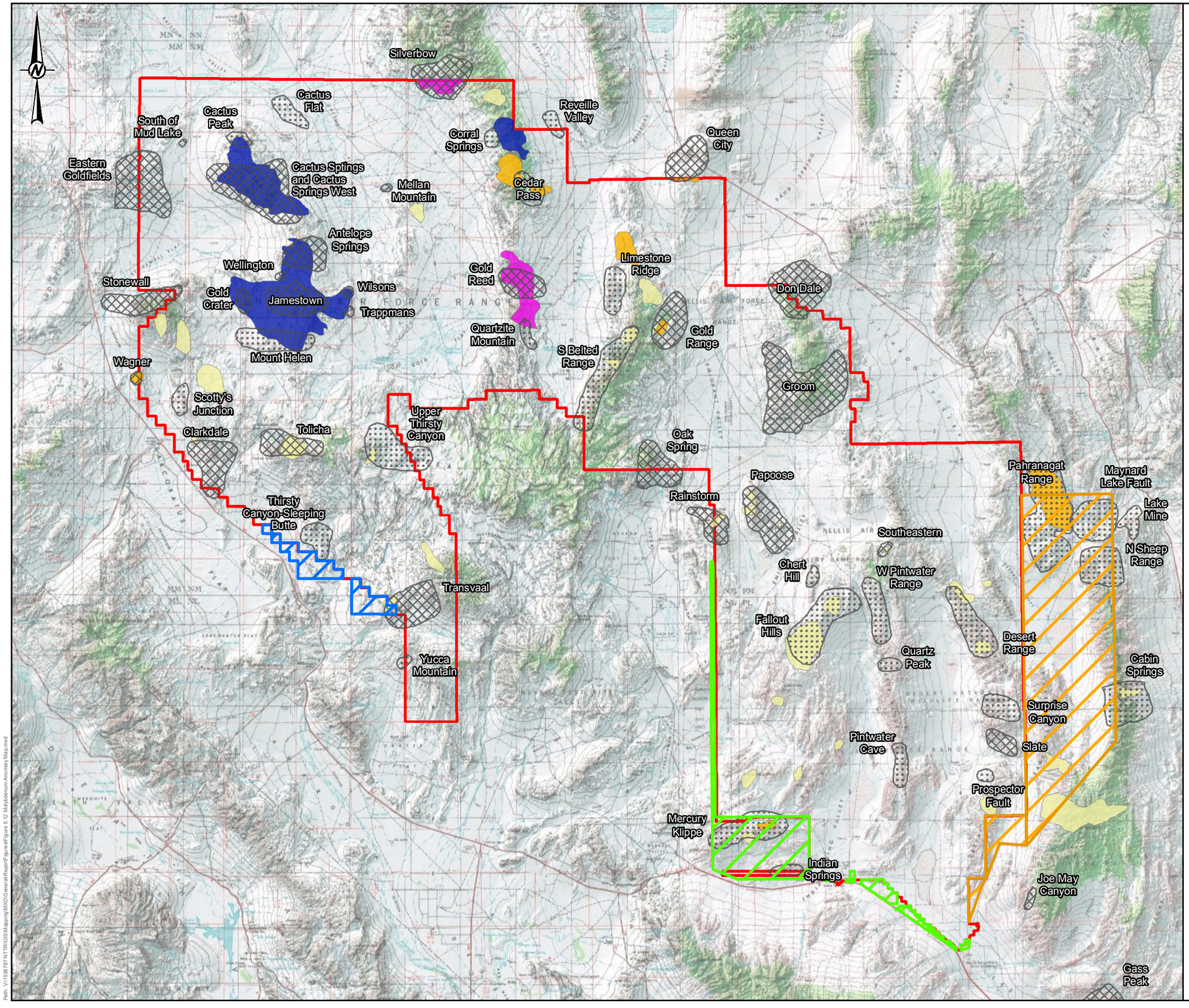


FIGURE 5.12
MOLYBDENUM ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

MOLYBDENUM ANOMALY STRENGTH

- 1.0
- 2.0 - 3.0
- 4.0 - 5.0
- 6.0 - 9.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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1538787	---	---	**5.12**

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 5.12 Molybdenum Anomaly Map.mxd

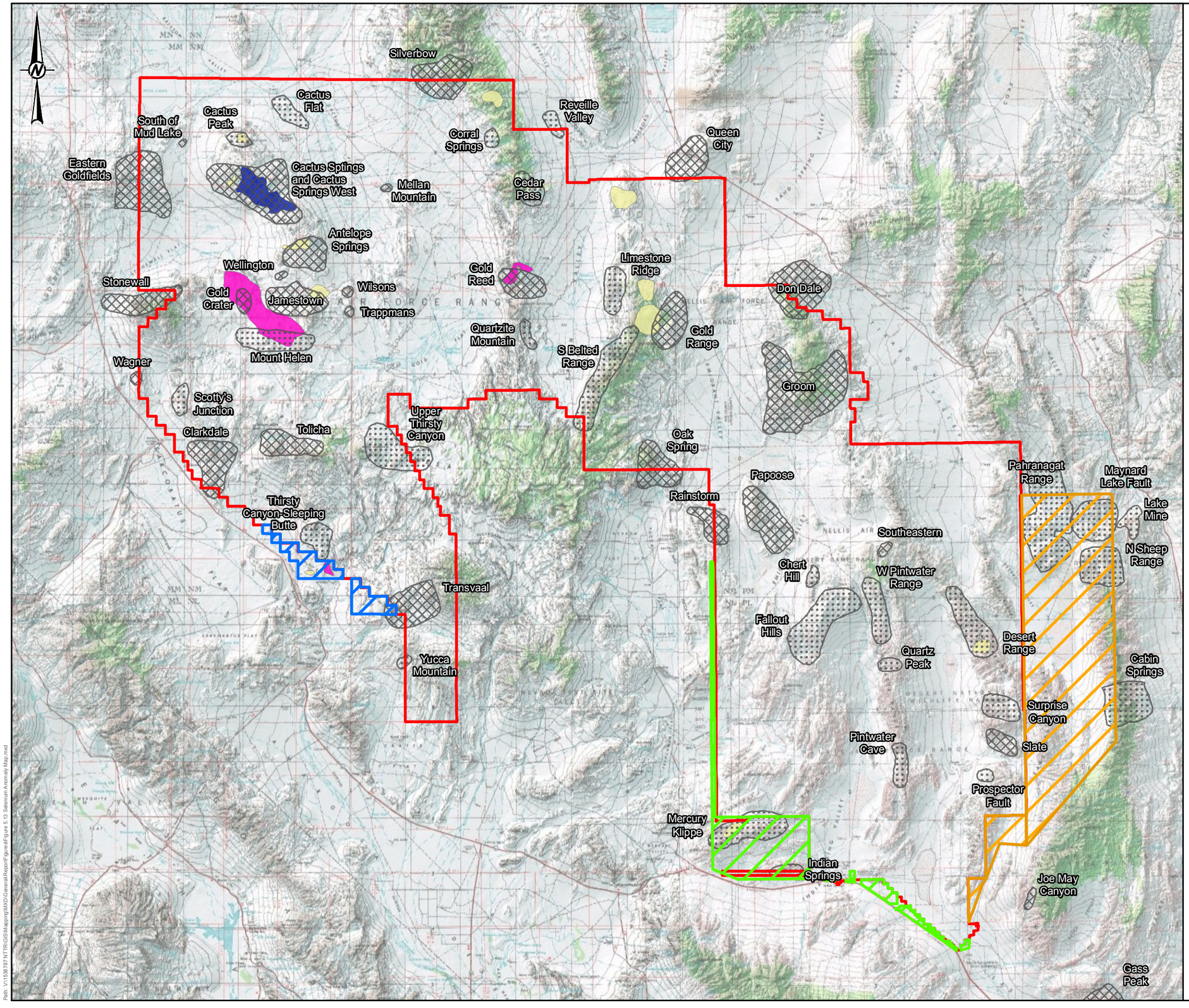


FIGURE 5.13
SELENIUM ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

MINING DISTRICT

MINERAL PROSPECT

SELENIUM ANOMALY STRENGTH

1.0

2.0

3.0

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.13**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.13 Selenium Anomaly Map.mxd

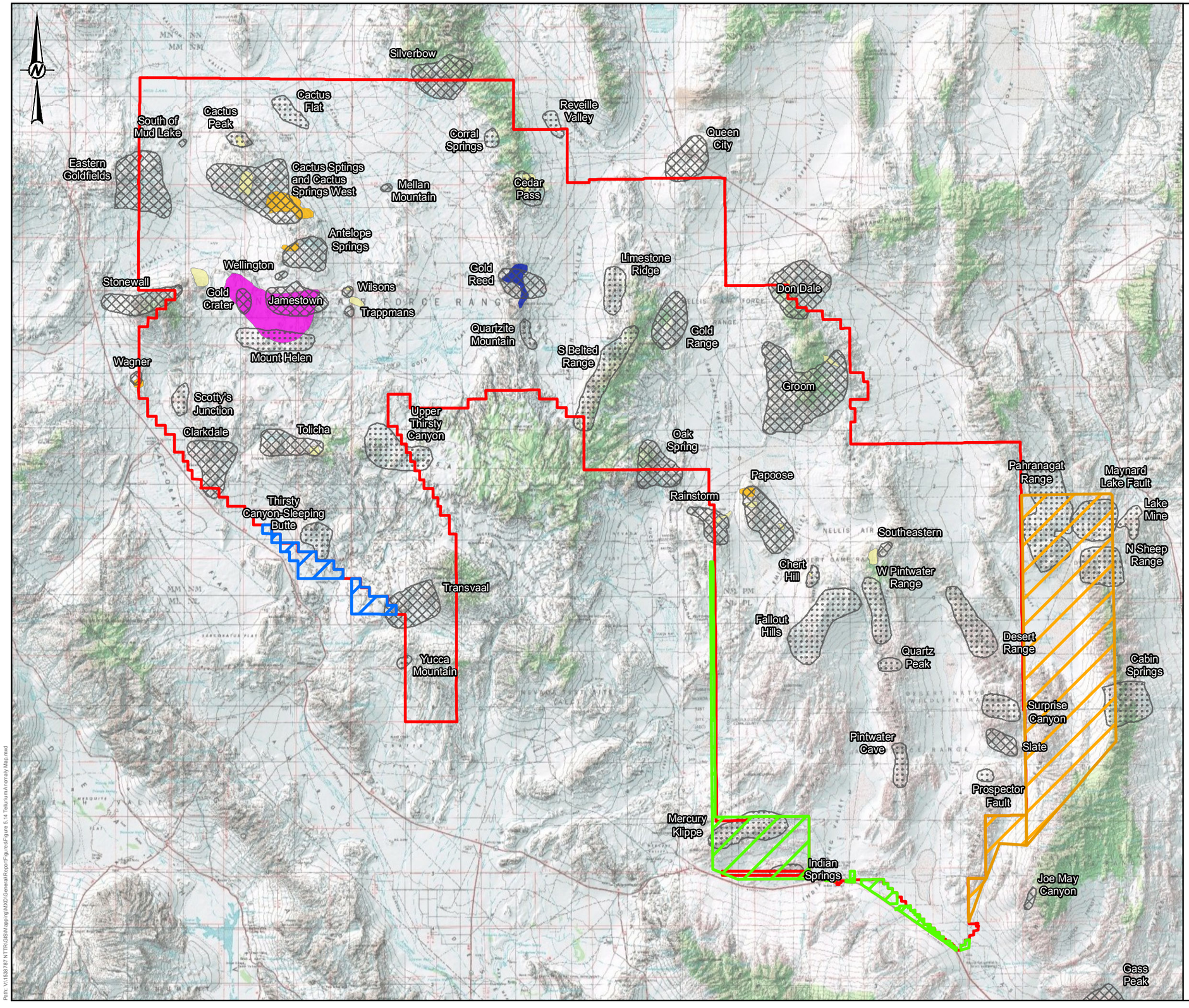


FIGURE 5.14
TELLURIUM ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

TELLERIUM ANOMALY STRENGTH

- 1.0
- 2.0
- 3.0
- 4.0.

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.14**

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1 in
0

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.14 Tellurium Anomaly Map.mxd

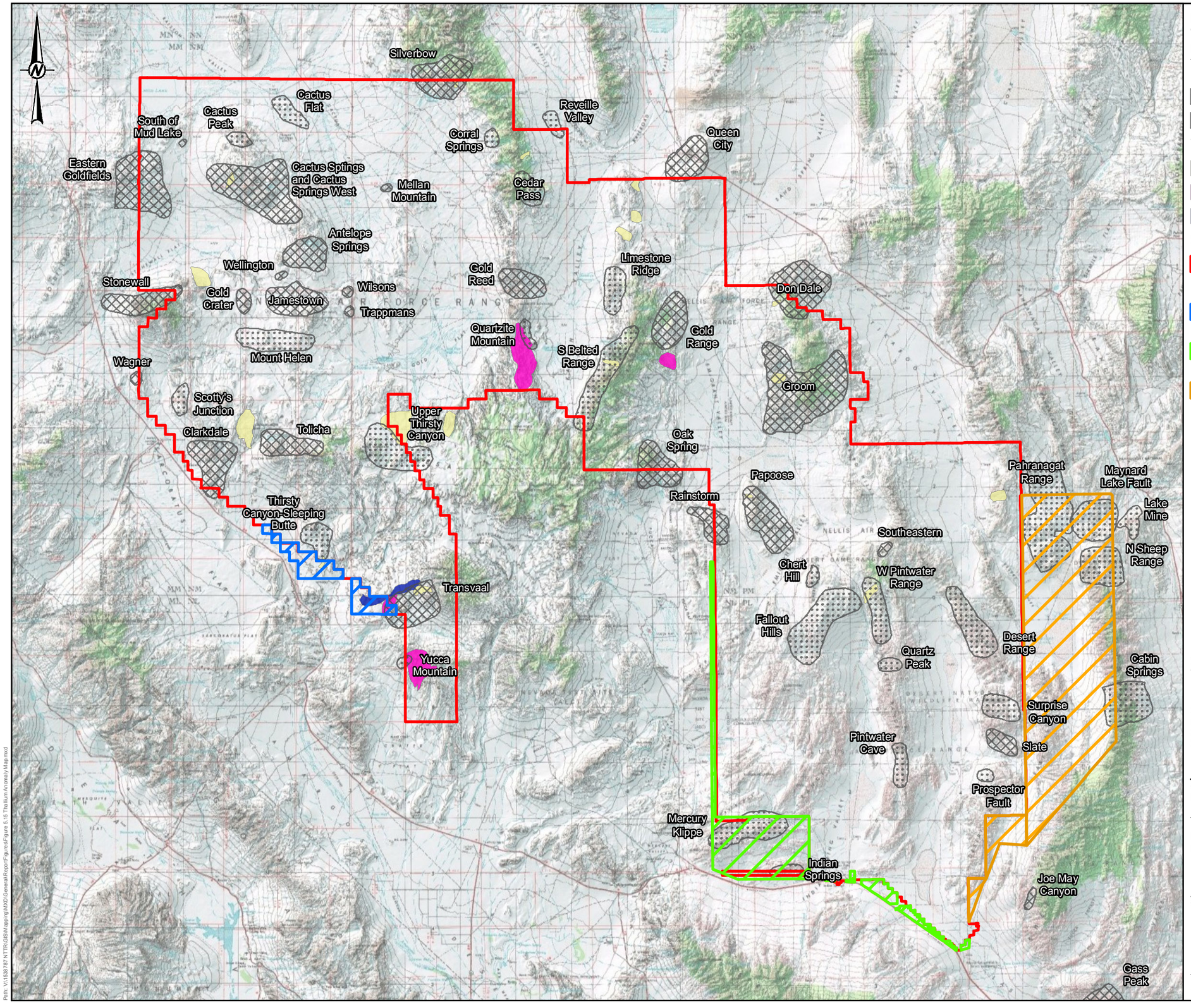


FIGURE 5.15
THALLIUM ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

THALLIUM ANOMALY STRENGTH

- 1.0
- 2.0 - 3.0
- 4.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

10 5 0 10 Miles

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
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1 in
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Path: V:\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 5.15 Thallium Anomaly Map.mxd

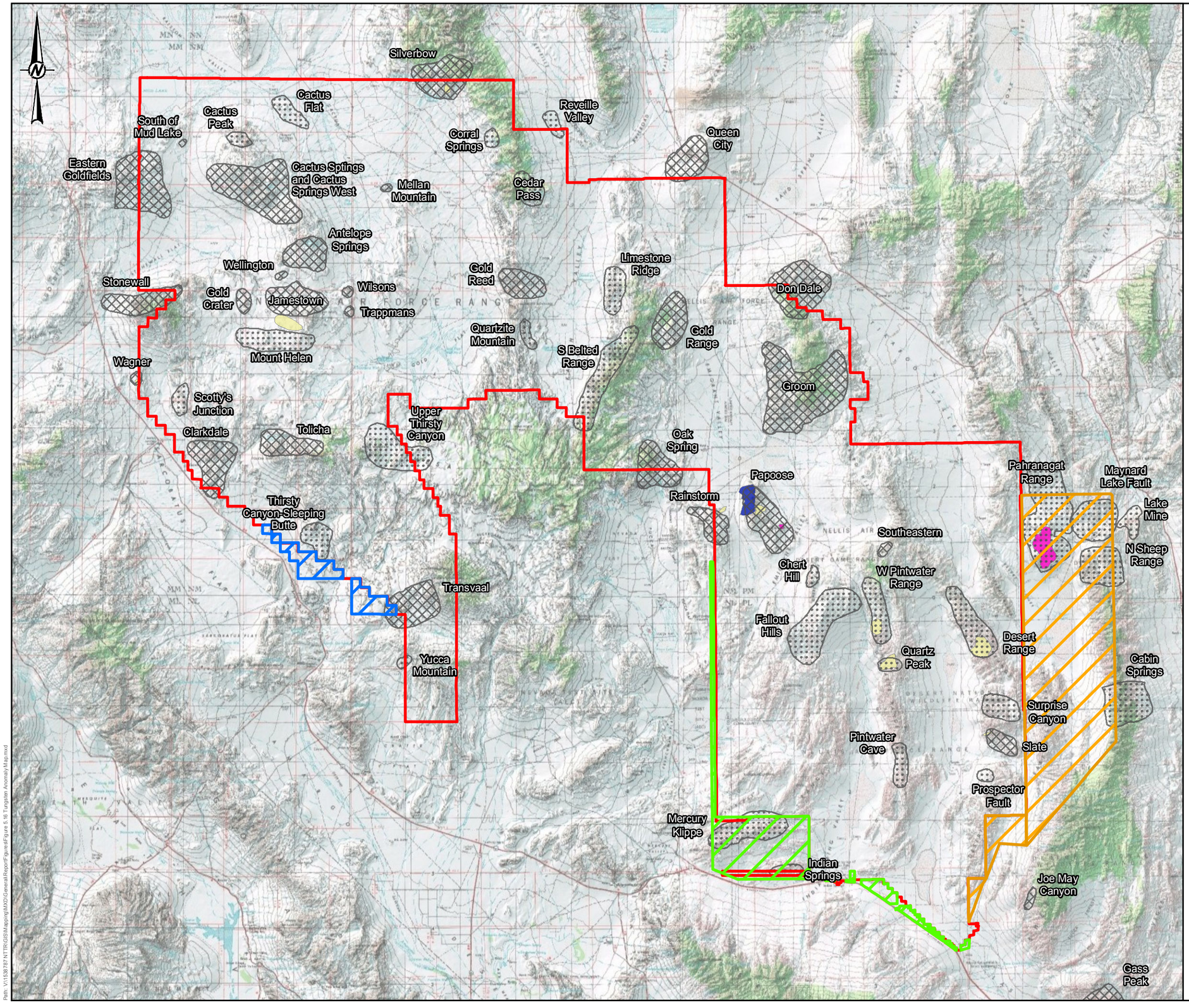


FIGURE 5.16
TUNGSTEN ANOMALY STRENGTH IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MINING DISTRICT
- MINERAL PROSPECT

TUNGSTEN ANOMALY STRENGTH

- 1.0
- 2.0
- 3.0 - 4.0

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.16**

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1 in
0

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 5.16 Tungsten Anomaly Map.mxd

5.1.3 Element Groupings

5.1.3.1 Primary Factor Group: Heavy Minerals

The predominant factor group for virtually all datasets included REEs and elements typically found in heavy minerals (i.e., hafnium, niobium, scandium, tantalum, titanium, thorium, tungsten, yttrium, and zirconium). This is expected as these elements are co-associated in the heavy mineral fractions of granitic materials and their sedimentary derivatives. Given these multivariate associations were expected and reflect known geochemical and mineralogical assemblages, the primary factor can be considered a proof of method.

In many cases, additional elements such as cobalt, gold, nickel, and sodium positively correlated with this group. Cobalt and nickel are likely high in certain heavy minerals (such as magnetite), whereas the correlation with gold and sodium appears to reflect association of the heavy minerals with felsic magma differentiates (and their weathered derivatives), which provide the heat source for porphyry and epithermal ore systems. The latter were prevalent in the Cenozoic Zone; the association with gold and sodium was particularly noticeable in the Cenozoic Zone datasets. Conversely, a negative correlation of REEs and heavy mineral elements with calcium and, in some cases, base metals and silver, reflected the fact that the heavy mineral fraction decreases in carbonate systems, which are more likely to host base metals and silver as replacement-style alteration. The negative correlation with calcium was more commonly observed in Paleozoic Zone datasets.

5.1.3.2 Additional Factor Groups: Metals

The second through fourth factor groups generally included metal associations that reflected the mineralized signature of the sample population. PCA results for the background (GSC) samples did not indicate a strong signature that might interfere with interpretation of PCA results for the other material types. Rather, GSC factor groups were, for the most part, composed of five or fewer elements, generally representing those that are commonly co-associated in a variety of geologic environments such as cobalt/copper/nickel, arsenic/molybdenum, and lead/silver.

Factor groups with metals for MA samples reflected the known ore deposit types for the mining districts and prospects in the study area, as well as those common to the Great Basin. Base metal and silver associations existed within the entire ore sample population, as well as within both the Cenozoic and Paleozoic zone populations. In the Cenozoic Zone, the base metal and silver associations correlated inversely with heavy minerals and REEs, reflecting their occurrence in carbonate-dominant rather than quartz/feldspar dominant lithologies. A second Cenozoic Zone factor group reflected intrusion-related mineralization (a combined porphyry-epithermal assemblage) based on the co-association of antimony, copper, molybdenum, silver, and tellurium, among others. Paleozoic Zone factor groups indicated potential influence from both base metal and silver mineralization in regionally dolomitized carbonates (based on copper, lead, and silver

co-association) with a possible additional CTGD or low-sulfidation epithermal signature (based on arsenic, mercury, and molybdenum co-associations).

PCA results for silt samples indicated that signatures from at least three of the four target deposit types were detected:

- For the entire silt sample population, regionally dolomitized carbonate or peripheral porphyry copper mineralization (based on copper, lead, silver, and zinc co-association) was detected, as well as epithermal low-sulfidation or CTGD (based on antimony, arsenic, and mercury co-association mineralization. Factor scores for this hybrid grouping were plotted on Figure 5.17. Highest scores for this grouping occurred in the Upper Thirsty Canyon prospect area in the Cenozoic Zone, in the Groom Mining District in the Transition Zone, and in the Southeastern Mining District in the Paleozoic Zone.
- In Cenozoic Zone samples, epithermal mineralization was detected (based on arsenic, antimony, lead, and tellurium associations). Factor scores for this group were plotted on Figure 5.18. High factor scores occurred in the northern Pahute Mesa and Cactus Range areas; the factor scores outlined drainage basins representing the Mount Helen prospect and the Jamestown, Gold Crater, Trappmans, Wellington, Antelope Springs, and Cactus Springs mining districts. High factor scores were also observed in the Quartzite Mountain prospect and the Tolicha and Silverbow mining districts. In the overall mineral resource potential figures (Section 5.2.1.1), this was designated as the epithermal mineralization factor group.
- Paleozoic Zone factor groups suggest influence from both regionally dolomitized carbonates (based on copper, lead, silver, and zinc co-association) and from CTGD or low-sulfidation epithermal deposits (based on arsenic, antimony, and mercury co-association). Factor scores for one such factor group were plotted on Figure 5.19. High factor scores were observed in the Papoose and Southeastern mining districts. In the overall mineral resource potential figures, this was designated as the carbonate/CTGD factor group.
- Mineralization signatures in float chip samples were more diffuse and complex. Base metal plus silver mineralization was detected in Paleozoic Zone float chip samples and plotted on Figure 5.20. High factor scores were only observed in the Papoose Mining District.

Although other factor groups contained element associations reflective of each of the four target deposit types, none were deemed complete enough to be definitive. PCA was successful in identifying, for the most part, mixed ore deposit signatures. This was because the sample populations reflected a regional dataset spanning several geologic provinces and containing numerous separate hydrothermal systems that represent several different ore deposit types. Careful, rigorous splitting of the sample population into district level sub-populations would likely result in a more discrete geochemical fingerprint for individual hydrothermal systems. Such splitting might separate high arsenic/antimony, high-sulfidation epithermal mineralization from lower arsenic/antimony, low-sulfidation mineralization, since the two alteration styles are genetically linked and often spatially co-associated at the district scale. Other methods of discretizing the dataset (i.e., by lithology, alteration, or proximity to known geologic features such as plutons) would likely also improve the strength and clarity of individual factor groups. Finally, analysis of data using different rotations, such as Varimax, to maximize contrast among factor scores (rather than the normal orthogonal rotation, which maximizes variance) could serve to strengthen the factor group variable relationships.

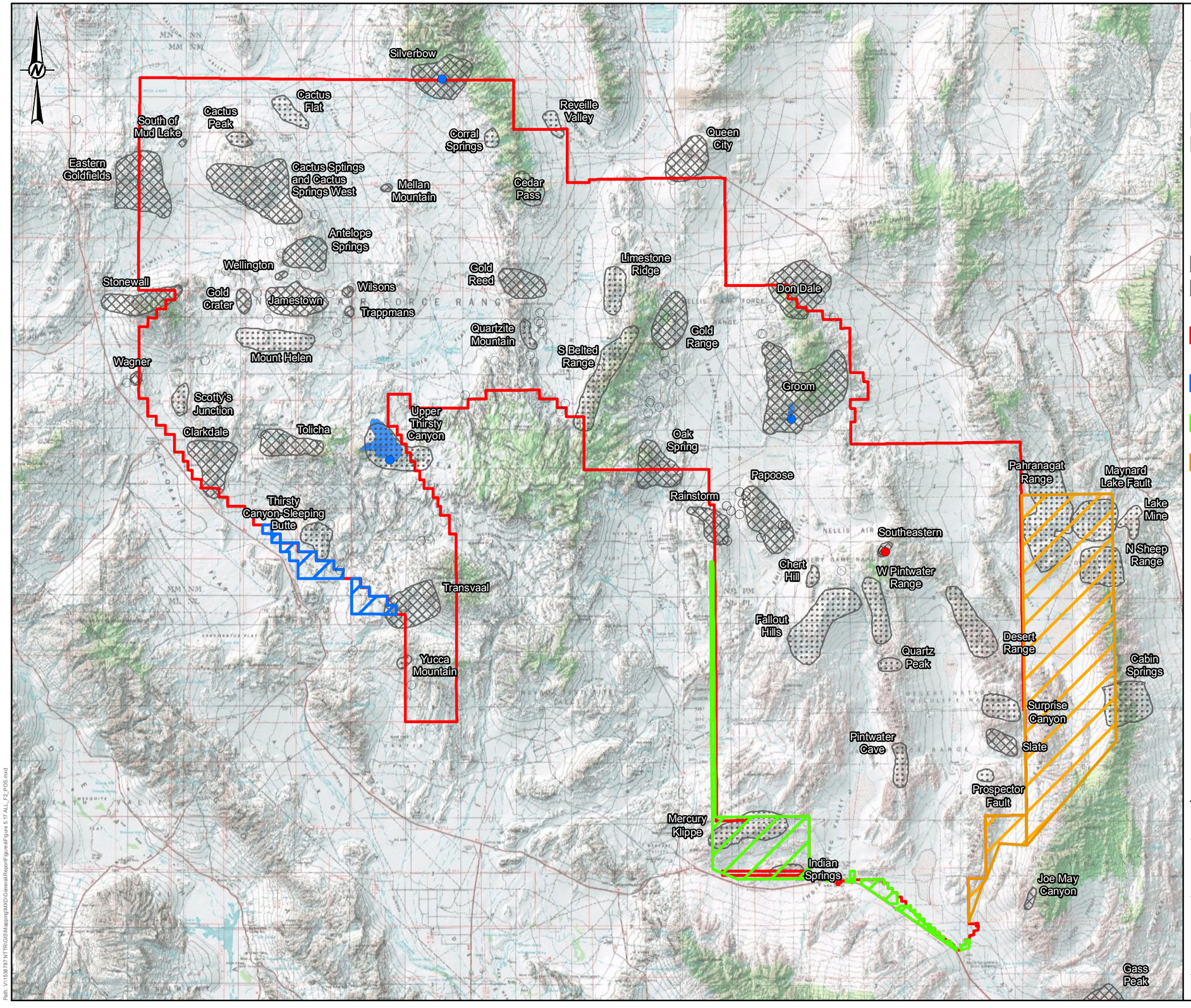


FIGURE 5.17
FACTOR SCORES – SILT SAMPLES: MULTI-ELEMENT SIGNATURE FOR ALL DEPOSIT TYPES

LEGEND

FACTOR SCORE MAP

- 1.2186 - 1.5946
- 1.5947 - 15.2930

FACTOR SCORES

- 0.0026 - 1.0000
- 1.0001 - 2.0000
- 2.0001 - 15.2930
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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1538787	---	---	**5.17**

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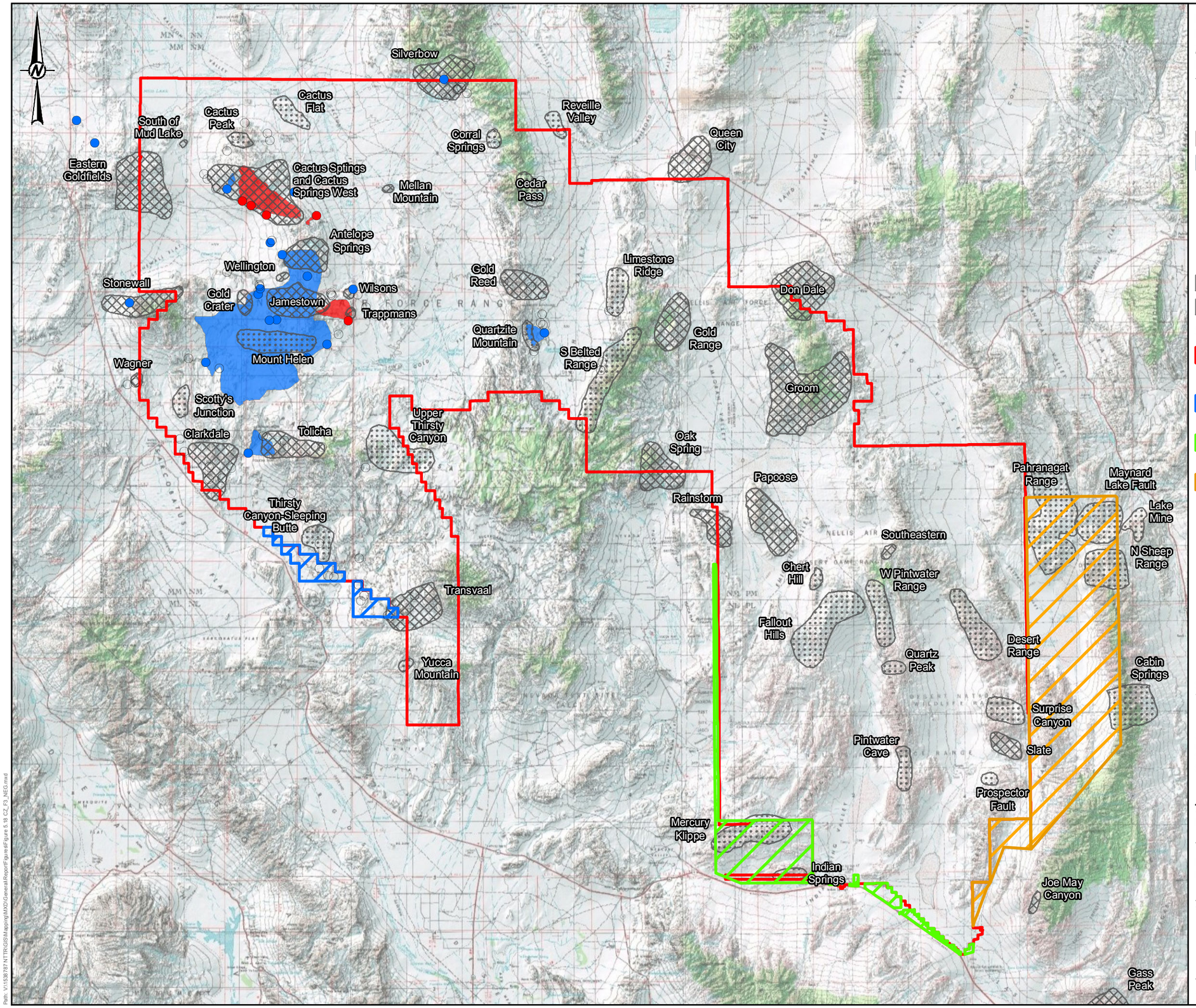


FIGURE 5.18
FACTOR SCORES – SILT SAMPLES, CENOZOIC ZONE: MULTI-ELEMENT SIGNATURE FOR EPITHERMAL MINERALIZATION

LEGEND

FACTOR SCORE MAP

- -3.8010 - -2.5000
- -2.4999 - -1.0000

FACTOR SCORES

- -3.8001 - -2.5000
- -2.4999 - -1.0000
- -0.9999 - -0.0045
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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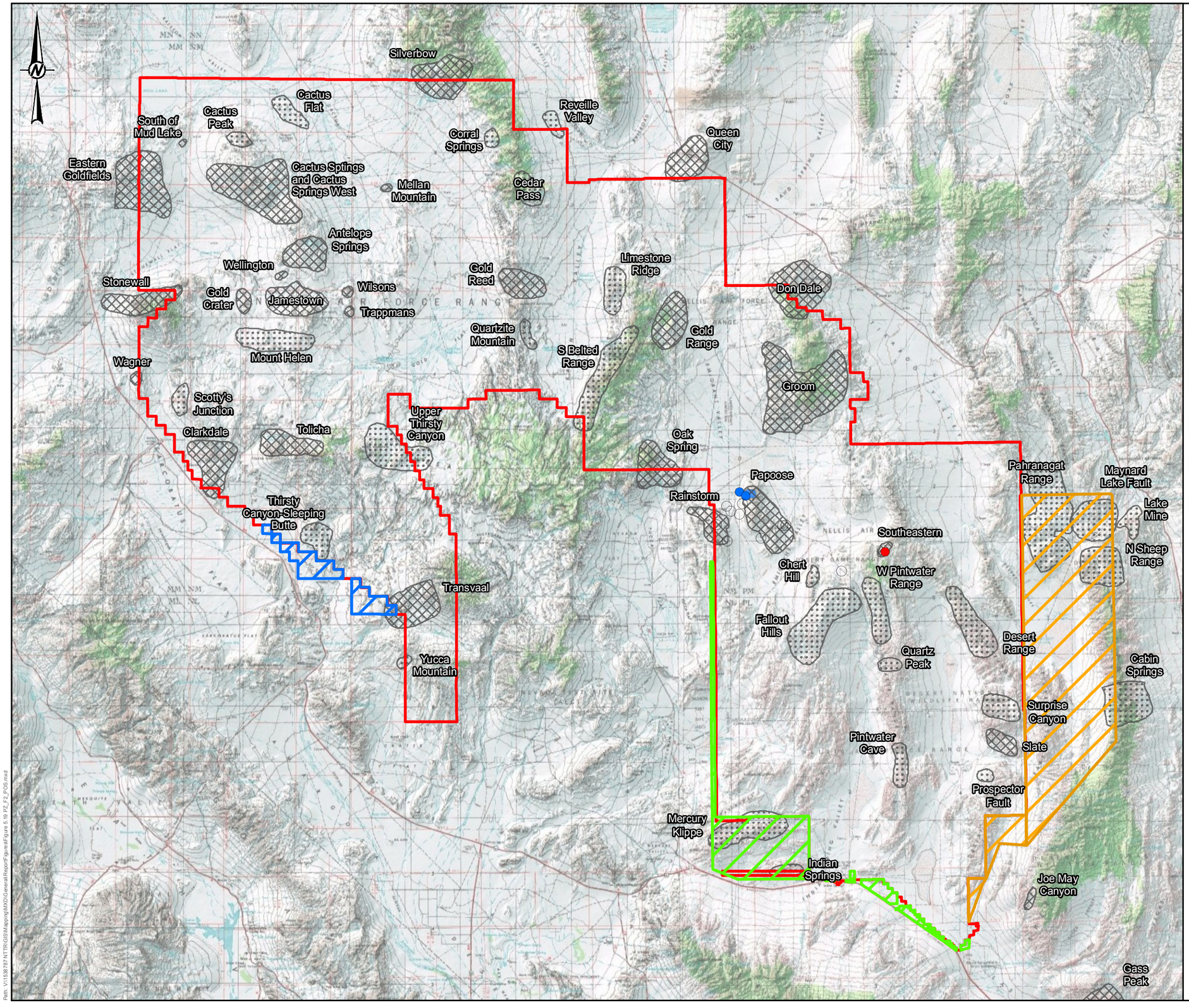


FIGURE 5.19
FACTOR SCORES – SILT SAMPLES, PALEOZOIC ZONE: MULTI-ELEMENT SIGNATURE FOR DOLOMITIZED CARBONATE, CARLIN-TYPE OR EPITHERMAL MINERALIZATION

LEGEND

FACTOR SCORE MAP
- 0.4000
- 0.4001 - 6.9720

FACTOR SCORES
- 0.0159 - 0.2500
- 0.2501 - 1.0000
- 1.0001 - 6.9723
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.19**

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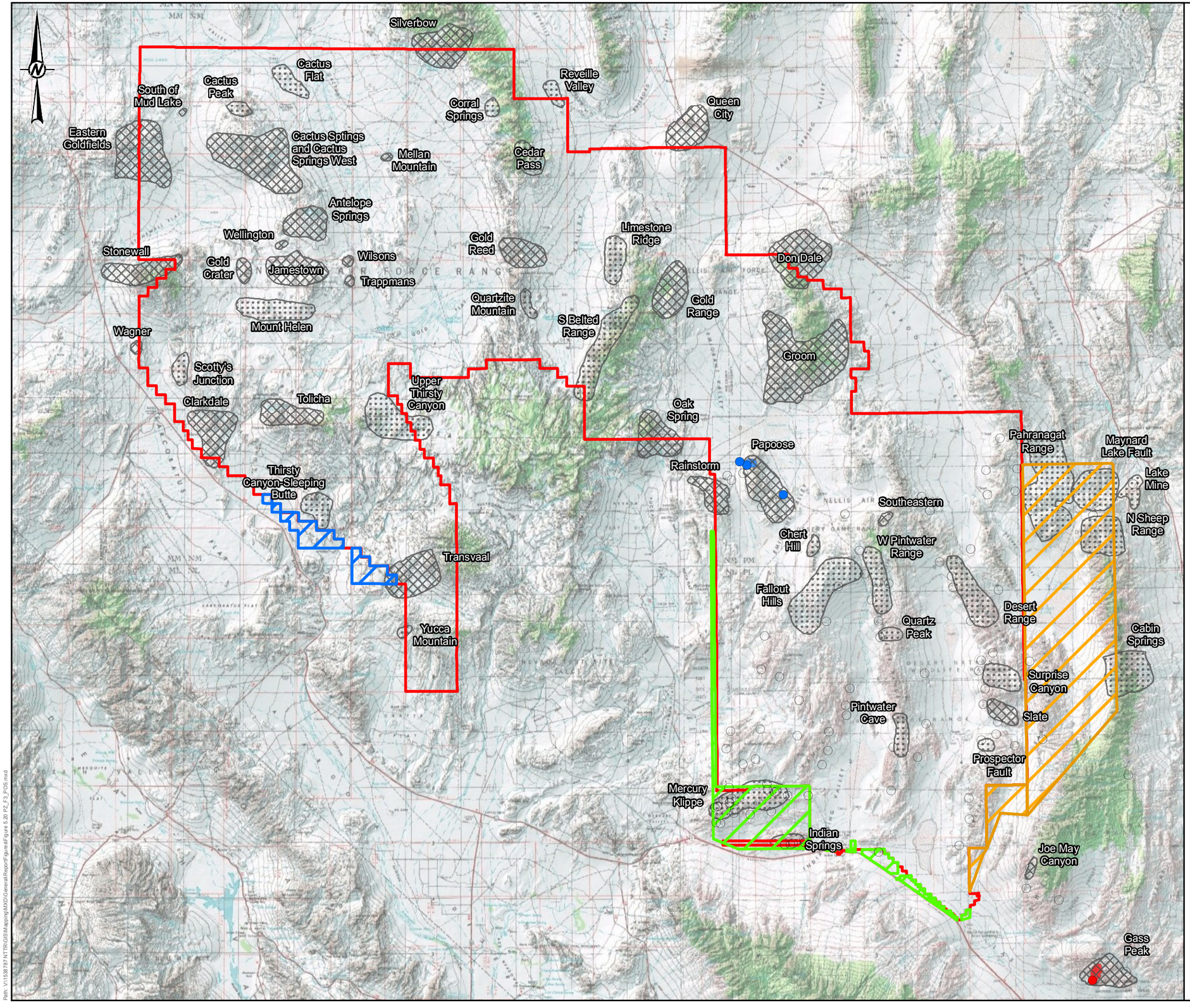


FIGURE 5.20
FACTOR SCORES – FLOAT SAMPLE, PALEOZOIC ZONE: MULTI-ELEMENT SIGNATURE FOR DOLOMITIZED CARBONATE, CARLIN-TYPE OR EPITHERMAL MINERALIZATION

LEGEND

FACTOR SCORE MAP
- 2.9800 - 4.0000
- 4.0001 - 8.3088

FACTOR SCORES
- 0.0012 - 2.0000
- 2.0001 - 4.0000
- 4.0001 - 8.3088

MINING DISTRICT

MINERAL PROSPECT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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1538787	---	---	**5.20**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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5.1.4 Interpretation of Anomalies by Zone

The results of the single- and multi-element evaluations and deposit association are summarized in Appendices D.2a and D.2b, for mining districts and prospects, and in appendices D.3a and D.3b for mineral prospects. It is useful to contrast these results to Figure 5.2 and Figure 5.21, which show mining districts and prospects and the location of inferred buried plutons, given that epithermal mineralization has been recognized at multiple mining districts in the Cenozoic Zone, and that both low- and high-sulfidation deposits are genetically linked to deeper porphyry deposits. These results are discussed in the subsections that follow by geologic zone and in the context of the primary deposit types known to exist within the NTTR and the Great Basin region.

Arsenic represents the best regional pathfinder element, as arsenic anomalies are associated with 71 percent of mining districts and 80 percent of prospect areas. Antimony anomalies are associated with 55 percent of mining districts and 53 percent of prospect areas. Molybdenum anomalies are associated with 58 percent of mining districts and 47 percent of prospect areas. These elements reflect the predominance of epithermal and CTGD mineral potential within the NTTR.

The regional geochemical evaluation was completed before a detailed review of previous studies of field investigations at individual mining districts and prospect areas was conducted. This was done intentionally to reduce bias in interpreting the results of the current single- and multi-element evaluations prior to comparing them to previously observed mineralization-styles in the study area.

5.1.4.1 Cenozoic Zone

All of the significant geochemical anomalies identified within the Cenozoic Zone appear to be indicative of intrusion-related deposit types (epithermal and/or porphyry style mineralization). This is consistent with the geologic setting and tectonic history of this zone.

The strongest intrusion-related ore deposit anomalies occurred in the west-central Cenozoic Zone and were focused around the Jamestown Mining District, and extended into the peripheral Mount Helen prospect and the Gold Crater, Trappmans, Wilsons, Wellington, and Antelope Springs mining districts. The anomalies also extended into the Cactus Springs and Cactus Springs West mining districts, to the northwest of the Jamestown mining district cluster (Figure 5.2). Figure 5.21 shows a large, inferred, buried pluton beneath this entire cluster of mining districts, which likely represents the regional magmatic source for the observed district scale mineralization. This mining district cluster was also identified in the 1998 Assessment as having the most geographically extensive, high potential for precious metals within the NTTR. Each of these mining districts was sampled and mapped as part of previous assessments and results indicated the presence of low-sulfidation (i.e., adularia, calcite, and chalcedony) or high-sulfidation (i.e., acid-sulfate leaching, alunite) style alteration. In some cases, a broader porphyry footprint (i.e., propylitic alteration, base metal replacement, bismuth/molybdenum/tellurium enrichment) was also visible.

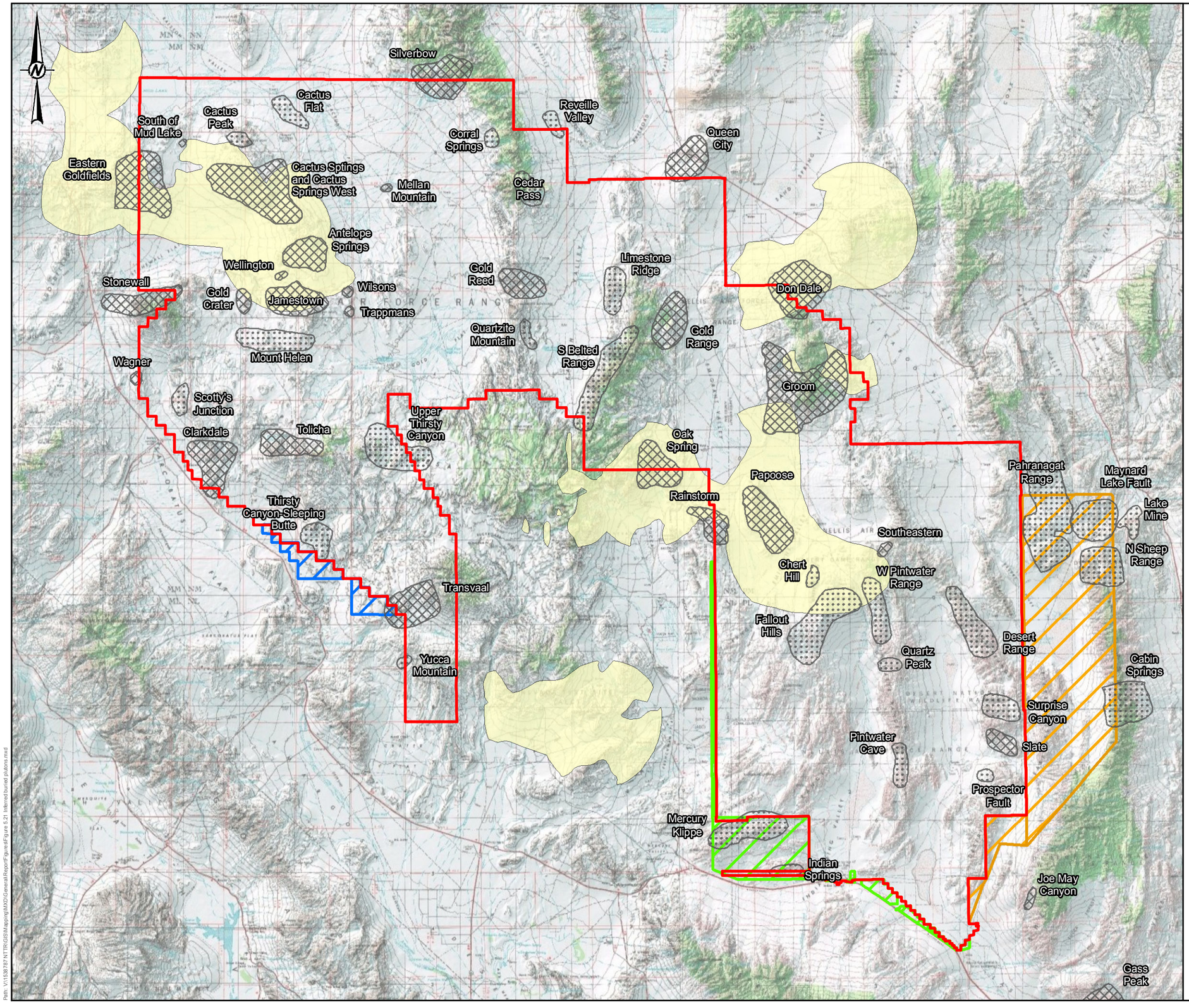


FIGURE 5.21
INFERRED BURIED PLUTONS IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- TRACTS PERMISSIVE FOR PLUTON RELATED DEPOSITS (FROM SINGER '96)
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.21**

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Path: V:\1538787-NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 5.21 Inferred buried plutons.mxd

The porphyry footprint was also visible based on copper/zinc ratios in mineralized samples (Figure 5.22). Very high ratios were observed in the Eastern Goldfield, Cactus Springs, Antelope Springs, Jamestown, and Gold Crater mining districts.

Strong epithermal mineralization signatures were also visible in the Tolicha and Clarkdale mining districts in the southwest Cenozoic Zone, while the nearby Wagner Mining District showed a more porphyry-dominant signature. A strong epithermal anomaly was also observed for the Transvaal Mining District in the south Cenozoic Zone. In the eastern portion of the Cenozoic Zone, epithermal and porphyry anomalies were identified at the Silverbow and Gold Reed mining districts, as well as in the Quartzite Mountain, South Belted Range, Cedar Pass, and Upper Thirsty Canyon prospect areas. These anomalies were consistent with the areas of moderate and high precious metal potential identified in the 1998 Assessment, and with observed intrusion-related deposit style mineralization within each of the mining districts.

5.1.4.2 Transition Zone

Within the Transition Zone, single-element anomalies reflective of both CTGD- and epithermal-style mineralization, as well as a high factor score for the hybrid CTGD/epithermal multi-element group were observed within the Groom Mining District. Figure 5.21 shows an inferred buried pluton beneath the Groom Mining District. The district is inferred to have the potential for both CTGD and epithermal ore deposit types based on these observed and inferred occurrences.

Arsenic, antimony, and molybdenum anomalies were also observed for both the Limestone Ridge prospect and Gold Range Mining District. Given the lack of an inferred buried pluton beneath either of these districts, they are assumed to have the potential for CTGD-type mineralization. This is consistent with conclusions from field investigations conducted during the 1998 Assessment.

5.1.4.3 Paleozoic Zone

The strongest geochemical anomalies in the Paleozoic Zone are associated with the Papoose and Southeastern mining districts. Base metals, silver, and gold are prominent within both districts, as are arsenic and antimony. Both districts are likely underlain by a buried pluton. Based on the strength of the individual anomalies, these two districts are inferred to have the highest potential for dolomitized carbonate-hosted base metal and silver deposits, followed by CTGD mineralization, with lesser potential for low-sulfidation mineralization.

Strong anomalies reflecting epithermal- or CTGD mineralization were also observed in the Rainstorm Mining District and West Pintwater Range prospect area; strong CTGD mineralization anomalies were observed for the Mercury Klippe prospect area (in the 64C/C and 65D area) and the Pahranagat Range, Maynard Lake Fault, and Cabin Springs prospect areas (in the Alamo area).

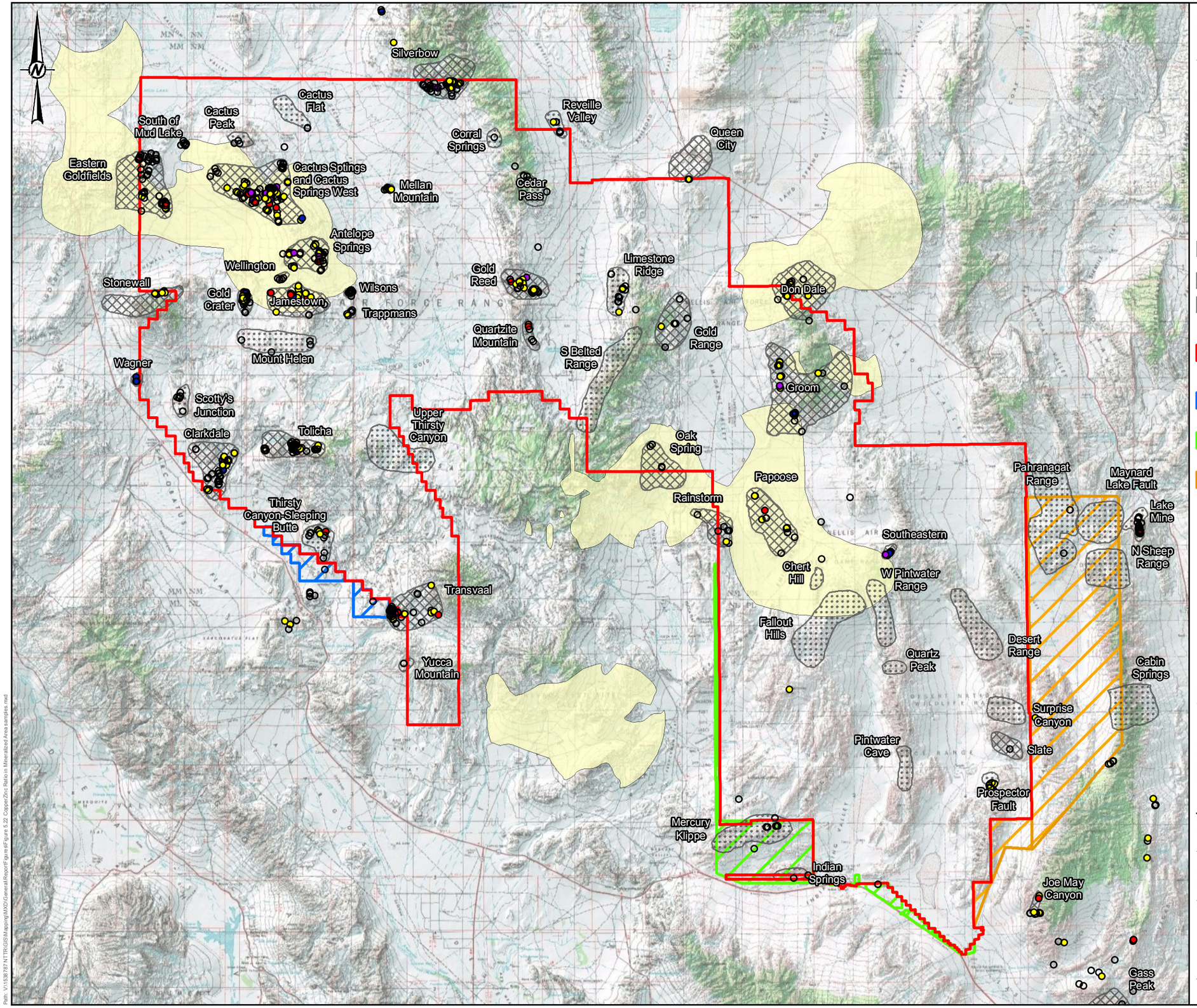


FIGURE 5.22
COPPER/ZINC RATIO IN MINERALIZED AREA SAMPLES

LEGEND

COPPER/ZINC RATIO

- 0.00180 - 1.00000
- 1.00001 - 5.00000
- 5.00001 - 10.00000
- 10.00001 - 15.00000
- 15.00001 - 30.00000

TRACTS PERMISSIVE FOR PLUTON RELATED DEPOSITS (FROM SINGER '96)

MINING DISTRICT

MINERAL PROSPECT

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.22**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787 NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 5.22 Copper/Zinc Ratio in Mineralized Area samples.mxd

5.2 Mineral Resource Potential Update

5.2.1 Regional and District Scale Mineral Resource Potential

5.2.1.1 Approach

Mineral resource potential was designated on a regional scale following the approach of the 1998 Assessment. Given that district level field investigation and sampling occurred only in areas not previously investigated, and was minor in scope relative to that undertaken as part of the previous assessments, and given that the district level mineral resource potential designations from the 1998 Assessment were identified by commodity and not deposit type, they remain unchanged in this assessment.

On a regional level, for each deposit type, geochemical anomalies and multi-element grouping factor scores were combined into a bulk quantitative score on an equally weighted basis, as follows:

- Epithermal systems: antimony, arsenic, mercury, thallium, epithermal mineralization factor group
- Porphyry systems: copper, gold, molybdenum, tungsten, copper/zinc, and copper/zinc ratios
- CTDG: antimony, arsenic, mercury, thallium, and carbonate/CTGD factor group
- Regionally dolomitized carbonates: copper, lead, silver, zinc, carbonate/CTGD factor group

The bulk quantitative scores were converted to overall mineral potential for each of the four deposit types in Figure 5.23 through Figure 5.26. Samples were classified as having low (uncolored), moderate (red), and high (blue) potential based on their bulk score. Drainage basins immediately upgradient from samples with moderate and high potential are indicated by shaded polygons in these figures, with the shading according to certainty level B or C. The certainty designation was based on qualitative factors such as geologic provenance, distance to buried plutons or fault systems, and the existence of prospects and known deposits with alteration assemblages and genetic features matching those of the mineralizing system that was mapped. In some cases, upgradient drainage basins for samples with moderate or high potential were not identified, as it was clear that the high score reflected another deposit type; for instance, on the porphyry system mineral potential map (Figure 5.24), samples from the southeast portion of the NTTR with high scores were more likely reflective of regionally dolomitized carbonate base metal mineralization. Although not shaded or further discussed in Section 5.2.1.2, the upgradient drainage basins and general areas surrounding low potential (uncolored) samples should be considered as having low potential, certainty level B.

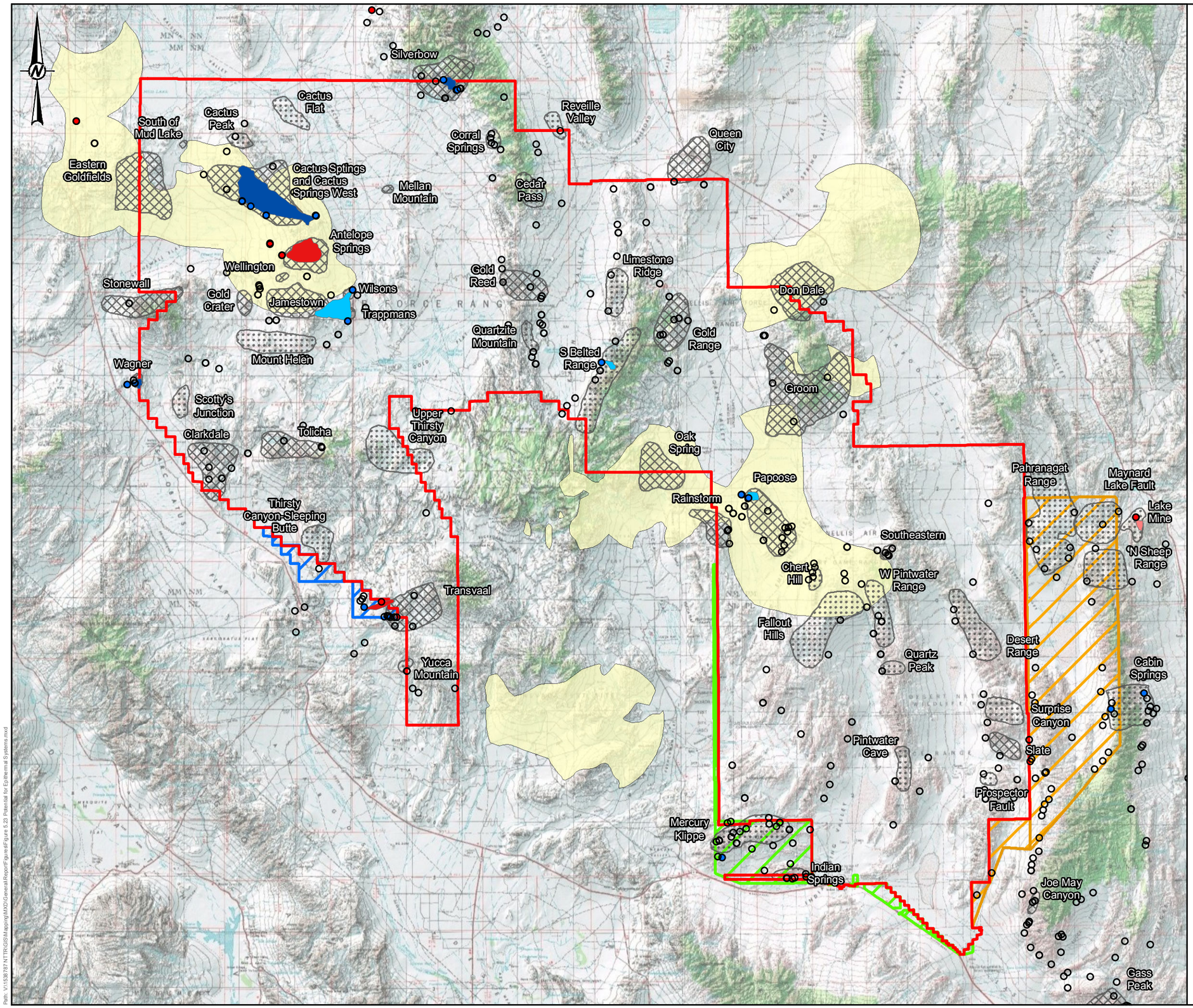


FIGURE 5.23
POTENTIAL FOR EPITHERMAL SYSTEMS

LEGEND

POTENTIAL FOR EPITHERMAL SYSTEMS
- HIGH/C
- HIGH/B
- MODERATE/C
- MODERATE/B

EPITHERMAL DEPOSIT SCORE
- 0.000001 - 0.095949
- 0.095950 - 0.124689
- 0.124690 - 0.367931

TRACTS PERMISSIVE FOR PLUTON RELATED DEPOSITS (FROM SINGER '96)

MINING DISTRICT

MINERAL PROSPECT

STUDY AREA
- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS
- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.23**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787 NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 5.23 Potential for Epithermal Systems.mxd

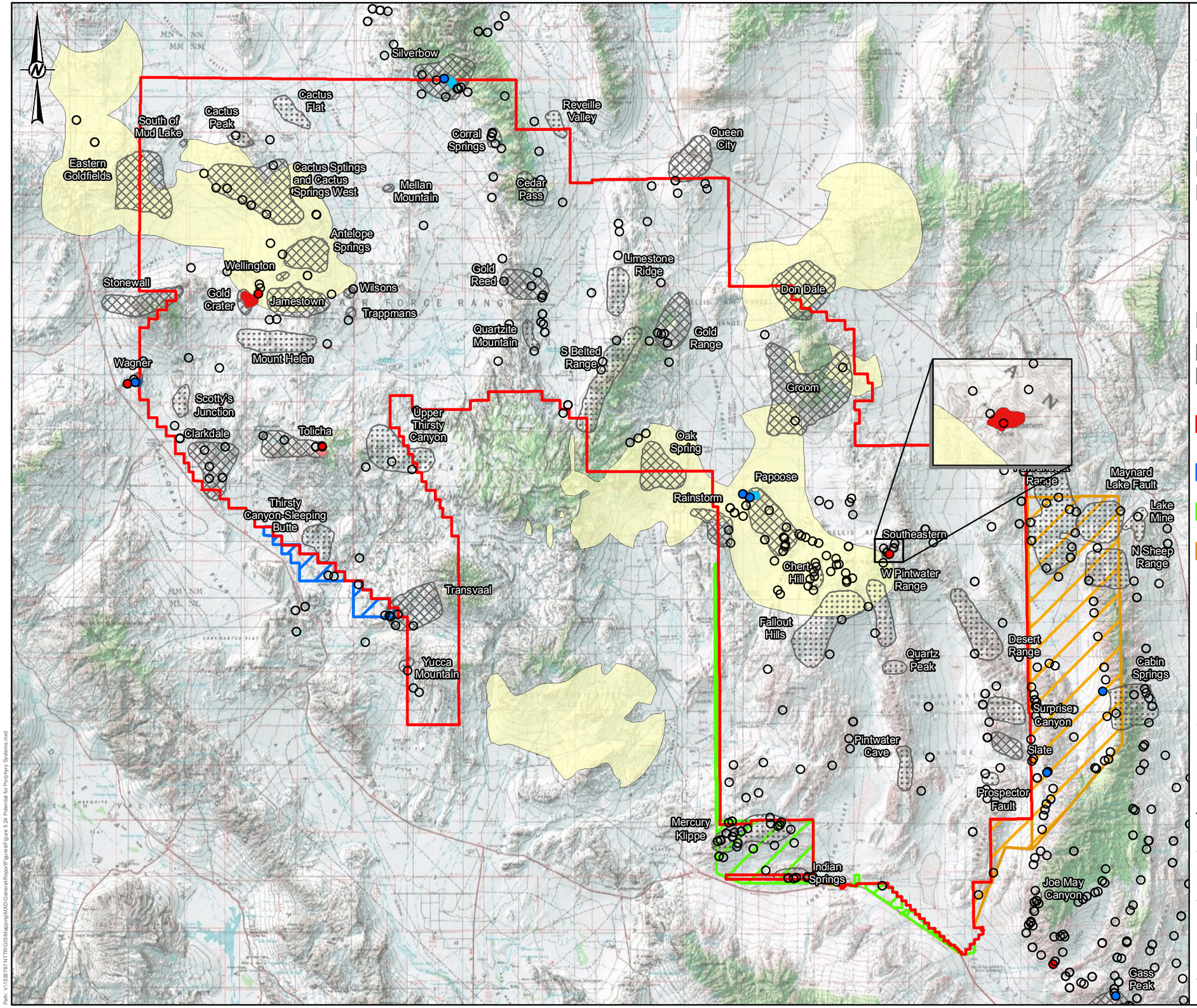


FIGURE 5.24
POTENTIAL FOR PORPHYRY SYSTEMS

LEGEND

POTENTIAL FOR PORPHYRY SYSTEMS

- HIGH/C
- HIGH/B
- MODERATE/C
- MODERATE/B

PORPHYRY DEPOSIT SCORE

- 0.000001 - 0.072667
- 0.072668 - 0.095227
- 0.095228 - 0.393053

- TRACTS PERMISSIVE FOR PLUTON RELATED DEPOSITS (FROM SINGER '96)
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.24**

Path: V:\1538787\NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 5.24 Potential for Porphyry Systems.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

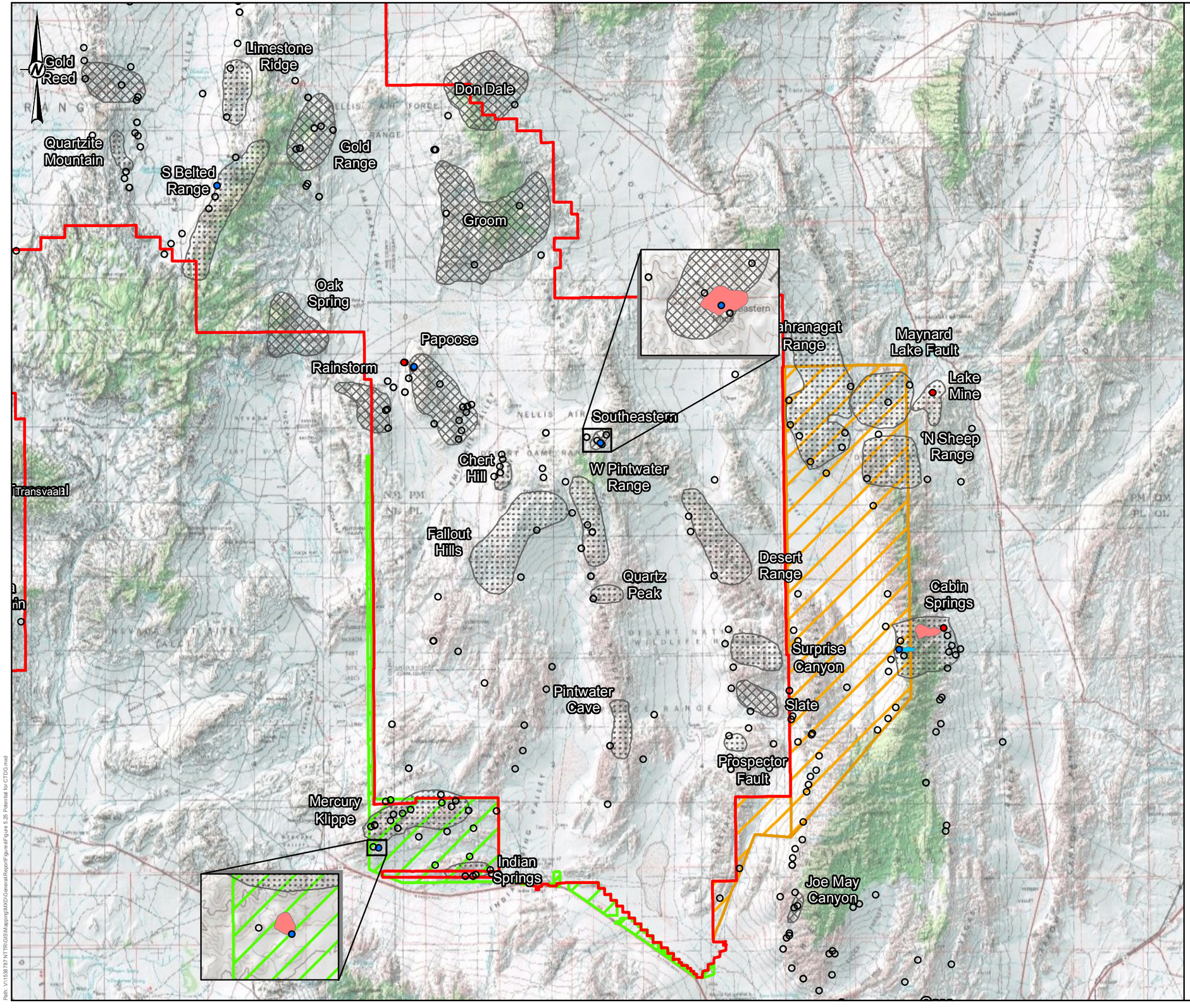


FIGURE 5.25
POTENTIAL FOR CTGD

LEGEND

POTENTIAL FOR CTGD SYSTEMS

- HIGH/B
- MODERATE/B

CTGD DEPOSIT SCORE

- 0.000000 -
- 0.090582 -
- 0.118149 -
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.25**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: \\V1538787 NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 5.25 Potential for CTGD.mxd

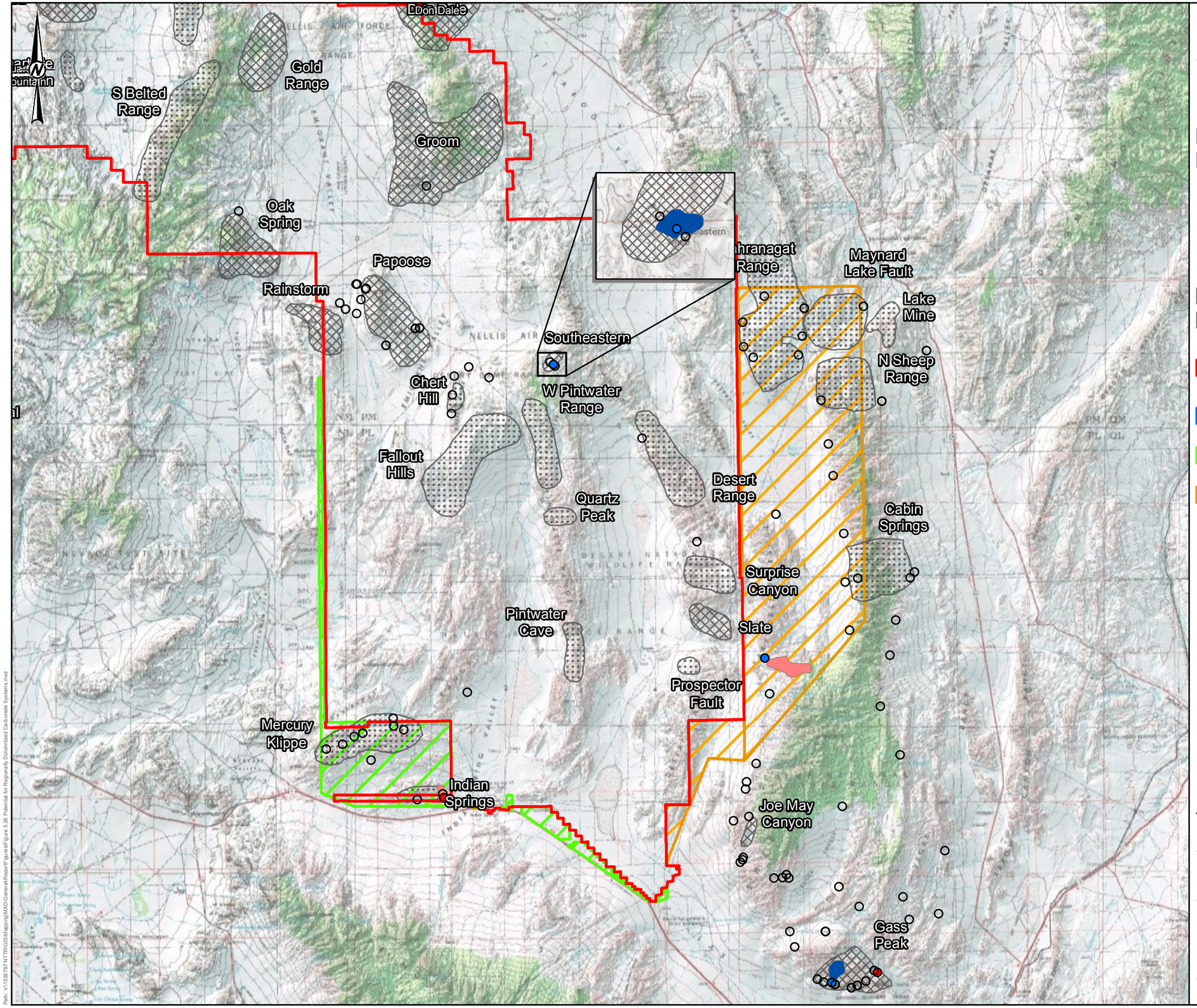


FIGURE 5.26
POTENTIAL FOR REGIONALLY DOLOMITIZED CARBONATE SYSTEMS

LEGEND

POTENTIAL FOR REGIONALLY DOLOMITIZED CARBONATE SYSTEMS

- HIGH/C
- MODERATE/B

REGIONALLY DOLOMITIZED CARBONATE DEPOSIT SCORE

- 0.000001 - 0.058398
- 0.058399 - 0.077415
- 0.077416 - 0.504976
- MINING DISTRICT
- MINERAL PROSPECT

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**5.26**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 5.26 Potential for Regionally Dolomitized Carbonate Systems.mxd

5.2.1.2 Discussion

Figure 5.23 shows overall mineral resource potential in the NTTR for epithermal systems. Sedimentary basins in the Cactus Springs, Cactus Springs West, Silverbow, and Wagner mining districts were designated as high potential, certainty level C, while basins in the Jamestown, Wilsons, Trappmans, and Papoose mining districts and in the South Belted Range prospect area are designated high potential, certainty level B. Basins in Antelope Springs Mining Districts and just west of Transvaal Mining District are designated as moderate potential, certainty level C. A basin just east of the Maynard Lake Fault prospect area is designated as moderate potential, certainty level B.

Figure 5.24 shows overall mineral resource potential in the NTTR for porphyry systems. Areas that are identified as having moderate or high potential are highly correlated with those identified for epithermal systems in Figure 5.23, which is likely a function of their genetic co-association as part of the larger felsic-intrusion related deposit type. A basin in the Wagner Mining District is designated as high potential, certainty level C, while basins in the Silverbow and Papoose mining districts are designated as high potential, certainty level B. Basins in the Southeastern and Gold Crater mining districts are classified as moderate potential, certainty level C, while a basin in the Tolicha Mining District is designated as moderate potential, certainty level B.

Figure 5.25 shows overall mineral resource potential in the NTTR for CTGDs, which is restricted by geologic provenance to the Transition and Paleozoic zones. The figure indicates a basin with high potential, certainty level B, in the Cabin Springs prospect area of the Alamo area. Another basin in this prospect area is designated as moderate potential, certainty level B, as are basins in the Southeastern Mining District and just south of the Mercury Klippe prospect area in the 64C/D and 65D area.

Figure 5.26 shows overall mineral resource potential in the study area for regionally dolomitized carbonate base metal replacement deposits, which are also limited by geologic provenance to the Transition and Paleozoic zones. Basins with high potential, certainty level C, are in the Southeastern Mining District, and outside of the study area boundaries in the Gass Peak Mining District. Additional basins designated as moderate potential, certainty level B, are in the Indian Springs prospect area in the 64C/D and 65D area, and in the southern part of the Alamo area. The latter is unaffiliated with known mining districts or prospects.

5.3 Update Summary

5.3.1 NTTR

The findings of the geochemical evaluation were, for the most part, highly consistent with the 1993, 1998, and 2014 Assessments. The district scale evaluation shown in Figure 2.6 and Figure 2.7 and summarized in Table 2.2 and Table 2.3 remain essentially unchanged. The overall metal resource potential and associated uncertainty determined as part of the current assessment deviates from the previous

assessments only in that mineral potential classification is given for specific deposit types rather than specific metal commodities (as in the 1998 Assessment). The current geochemical evaluation also identified high potential, certainty level B, for epithermal mineralization in the South Belted Range prospect area (Figure 5.23). This potential was not identified in previous assessments.

Although the areas with metal resource potential identified in previous assessments were confirmed in this evaluation, no commercially exploitable resources were identified, and the overall metal resource potential of the NTTR is considered low.

5.3.1.1 Limestone Ridge

Tingley and others (1998) classified Limestone Ridge as having moderate potential, certainty level B, for CTGDs based on the presence of jasperoid alteration and relatively high concentrations of arsenic and antimony. There are, however, several aspects of the geology at Limestone Ridge that deviate from the accepted model for CTGDs. CTGDs are most commonly found in the lower plate of the Roberts Mountain thrust, beneath the Antler allochthon. This creates a geometry of permeable and reactive carbonates overlain by unreactive and relatively impermeable siliciclastics (Cline and others, 2005). Often, high-angled structures penetrate the lower plate, but are truncated by the upper plate, creating a conduit-and-trap scenario for fluid flow. Limestone Ridge, while being composed of the many of the same lithologies associated with CTGDs, does not have a similar geometry. The younger carbonate material sits stratigraphically above the older siliciclastic rocks, effectively eliminating the possibility for auriferous fluids, if present, to be trapped within the reactive carbonates. However, given the complex structural setting, there is a chance that Limestone Ridge is underlain by the Belted Range thrust, hence creating a geometry favorable for CTGDs.

Cline and others (2005) noted that deep-seated Precambrian structures associated with Neoproterozoic rifting and basin formation, as well as thick accumulations of Neoproterozoic to Early Cambrian siliciclastic strata, are associated with CTGDs. Both of these scenarios may exist at Limestone Ridge given the thick accumulation of Precambrian strata and the adjacent graben filled with Tertiary volcanics, which could be a consequence of the deep-seated Precambrian structures.

Commonly, gold in CTGDs occurs in secondary pyrite or arsenian-pyrite and there is late-stage deposition of orpiment, realgar, and stibnite in open spaces (Muntean and others, 2011). None of these characteristic minerals were observed in the field. Neither were void spaces suggestive of hydrothermal replacement of wall rock observed within the carbonate units. Laboratory analytical results confirmed the absence of anomalous mercury or antimony concentrations in samples collected at Limestone Ridge for this assessment. The only sample collected at Limestone Ridge that contained gold (sample 1213036, 0.006 ppm) was collected at an adit on a quartz vein, which was mineralized with copper sulfides and copper oxides. Copper was the most enriched metal, approximately 6 percent in this sample. Mineralization was

confined to 5- to 10-cm-thick quartz veins and did not penetrate into the wall rock. These observations were not consistent with the host-rock replacement associated with CTGDs.

This assessment, due to time and access constraints, was confined to the southern portion of Limestone Ridge, and therefore did not investigate or sample the areas to the north where Tingley and others (1998) observed jasperiod development. The observed “incorrect” geometry of carbonates above siliciclastics, the absence of replacement-style alteration in carbonates, and the low mercury and arsenic concentrations are not indicative of a CTGD. The geochemical evaluation conducted for this assessment did not identify Limestone Ridge as a potential CTGD. No change to moderate potential, certainty level B, for a CTGD previously assigned to the Limestone Ridge area is warranted based on information obtained for this assessment.

5.3.1.2 Don Dale Mining District

Access to the the southern portion of the Don Dale Mining District inside the NTTR was not granted for the current assessment. Therefore, the potential for the area to host a CTGD cannot be updated. Observations made outside the NTTR boundaries, from the northern portion of the Don Dale Mining District, did not indicate that the mineralization is associated with CTGDs. The geochemical evaluation conducted for the current study did not identify the Don Dale district as having a potential for CTGDs.

5.3.1.3 South Belted Range

A float chip sample (117708) collected during the 1998 Assessment from the southern Belted Range recorded the highest epithermal deposit score. The sample had highly anomalous concentrations of arsenic, mercury, antimony, and thallium (335 ppm, 4.74 ppm, 232 ppm, and 6.12 ppm, respectively). No prospects were noted on USGS topographic maps and no historical prospect activity was reported in the 1998 Assessment.

Sample 117708 was collected in an area characterized by Tertiary felsic to intermediate volcanic flows, including: trachyte, comendite, and rhyolite (Minor and others, 1993). There are two inferred buried plutons of Mesozoic age within 25 km of the sample site (Singer and others, 1996). Bouguer gravity anomaly data show a small local high near the southern Belted Range. Taking into account its proximity to inferred buried plutons, it is possible that the area is underlain by a small pluton. Based on the PCA, this area was classified as having high potential, certainty level B, for pluton-related epithermal mineralization (Figure 5.23).

A field investigation would be required to more accurately assess the resource potential near the southern Belted Range. No MA samples were collected for the 1998 Assessment. There is no information available on the alteration style(s) observed in the float chip sample, or field observation notes.

5.3.2 Alternative 3A – the EC South Area

The geochemistry and the alteration assemblages in the Transvaal Mining District are characteristic of a shallow, vapor-dominated phase of a larger hydrothermal system (Tingley and others, 1998). There are documented examples (e.g., the Sulphur Bank Mine in California) of economically significant mercury deposits forming above hydrothermal systems where hydrogen-sulfide-bearing vapor is oxidized (White and Roberson, 1962). Based on that analogy, observed cinnabar in an outcrop, and a high mercury concentration sampled from the same area, Tingley and others (1998) classified the Transvaal District as having moderate potential, certainty level C, for hot-spring-type mercury deposits.

One float chip sample collected for this assessment had an anomalously high concentration of mercury (sample 1424987, 0.545 ppm). The sample was collected in the extreme southeastern corner of the EC South area, consistent with the area identified by Tingley and others (1998). Data from this assessment do not support the presence of a mercury deposit extending very far west or south of the North Range boundary and into the EC South area.

In addition to mercury deposited in the upper, vapor-dominant part of the hydrothermal system, there is also the potential for a deeper, below-water-table, epithermal deposit (Tingley and others, 1998). There are no records of drilling in the Transvaal Mining District; therefore, sub-surface information concerning the potential presence of a deposit at depth is available only from geophysical studies. As discussed in the Section 4.1.6, regional gravity and magnetic anomaly data have been reviewed. While the magnetic data show a low that could correlate to hydrothermally altered structures in the Transvaal Mining District, the gravity data are dominated by regional trends and do not provide useful subsurface information concerning mineralization.

Based on the geochemical evaluation conducted for the current assessment, high bulk scores for epithermal mineralization were determined in the EC South area in and adjacent to the Transvaal Mining District. The previous ranking of moderate potential, certainty level C, for hot springs deposits should be extended to include epithermal mineralization, in general.

5.3.3 Alternative 3B - the 64C/D and 65D and Administrative Incorporation Areas

There are no known mineral deposits or historical mining districts within the Alterative 3B area. Tingley and others (1993) identified the northwestern portion of the 64C/D and 65D area as having a low potential, certainty level C, for precious metals. This judgement was based on high concentrations of silver and antimony in silt and MA samples collected south of the East Sandy drainage. Tingley and others (1993) extrapolated their precious metals potential area to the west of their sample sites into un-sampled territory (Figure 4.7), presumably to include the Mercury Klippe. Muntean and others (2014), in their update of the mineral and energy assessment of the East DNWR, identified the same area along the northern boundary of the Indian Springs Parcel, in the 64C/D and 65D area, as having low potential, certainty level C, for

CTGDs. Both assessments recognized that the thrusting which emplaced the Mercury Klippe had the potential to create favorable conditions for CTGDs.

However, until this assessment, no samples were collected from within or immediately adjacent to the Mercury Klippe, so the potential for a CTGD was based principally on the identification of the Spotted Range thrust. For this assessment 20 silt and float chip samples were collected from within and adjacent to the Mercury Klippe. Of those, only one sample, a silt sample, collected from the Winding Wash, a drainage within the Cambrian upper-plate units of the Mercury Klippe, produced an anomalous gold concentration (sample 1434970, 0.02 ppm). Three float chip samples collected from the West Sandy and East Sandy drainages had anomalously high silver concentrations. Both of these drainages occur in Mississippian carbonates that form an overturned syncline in the lower plate of the Mercury Klippe.

A geochemical signature of many CTGDs is a relatively high gold to silver ratio (Cline and others, 2005), it is therefore inconsistent with the accepted CTGD model to observe a greater number of samples with anomalous silver than gold. While the geochemical evaluation did reveal elevated antimony and arsenic within and adjacent to the klippe, very little evidence of the alteration assemblage associated with CTGD mineralization was observed in the field; silicification was absent, and no jasperiod bodies were observed. Also, no sulfide minerals were observed which are the primary host minerals for gold in CTGDs. Additionally, neither the gravity nor magnetic survey data suggested the presence of a pluton at depth, or the presence of a large body of altered rock near the Mercury Klippe (Figure 4.9).

One sample collected for this current geochemical evaluation produced a high bulk score for CTGDs. The potential for a CTGD has been changed to moderate, certainty level C, in the Mercury Klippe prospect area in the 64C/D and 65D area (Figure 5.25) based on the current geochemical evaluation.

Anomalies and bulk scores suggest moderate potential, certainty level B, for mineralization associated with regionally dolomitized carbonate base metal mineralization in the southeast corner of the Indian Springs Parcel in the 64C/D and 65D area (Figure 5.26).

5.3.4 Alternative 3C – the Alamo area

As noted above, access to the Alamo area for this assessment's field investigation was denied by the USFWS. As such, this assessment of mineral and energy resources in the Alamo area relies on the 1993 and 2014 Assessments, and regional studies and data compilations that include the area.

A summary of the previously identified metallic mineral deposits and prospects in the East DNWR is included in Section 2.0. While a source of building stone was identified, no metal mining districts occur within the Alamo area, and there are no records of historical mining production in the area.

For this geochemical evaluation, high potential, certainty level C, was estimated for a CTGD in the Cabin Springs prospect area of the Alamo area (Figure 5.25) based on sample bulk scores. Based on the 2014 Assessment, this area was classified as having low potential, certainty level C, for a CTGD (Figure 2.9).

Moderate potential, certainty level B, for regionally dolomitized carbonate base metal replacement deposits was identified in a sedimentary basin unaffiliated with a known mining district or prospect in the southern part of the Alamo area (Figure 5.26).

5.3.4.1 Yellow Jacket Canyon

Sample 49070F, a float chip sample collected for the 1993 Assessment, had anomalous concentrations of silver, arsenic, and copper (0.7 ppm, 20 ppm, and 449 ppm, respectively), and was assigned a moderate score for mineralization associated with regional dolomitization of carbonates (Figure 5.26. A float chip sample collected from the adjacent drainage to the north, 49068F, had anomalous concentrations of silver, arsenic, and molybdenum (0.25 ppm, 64.5 ppm, and 12 ppm, respectively). No prospects are identified on USGS topographic maps and no historical prospect activity was reported in the 1993 Assessment. No MA samples were collected in the drainage basin upstream of the float chip sample, and there was no indication of the host lithology of the mineralized material. The metallic mineral potential of this area was not identified in the previous assessments.

The drainage where float chip sample 49068F was collected contains Cambrian through Devonian sedimentary strata. Structurally, this drainage lies to the west of the Gass Peak fault in an area where two roughly north-trending normal fault systems converge. This area is characterized by steeply dipping sedimentary sequences repeating as fault-blocks that are down-dropped and rotated to accommodate extension (Page and others, 2011). Tingley and others (1993) observed that often localized anomalous metals are encountered where east-west lineaments cross-cut the trace of the Gass Peak thrust. While no lineament cross-cutting the Gass Peak fault is mapped near this drainage, there are east-west lineaments which cross-cut the tilted and faulted sedimentary sequence possibly creating pathways for metalliferous fluids. Therefore, Yellow Jacket Canyon was classified as moderate potential, certainty level B, for replacement deposits associated with regionally dolomitized carbonates.

6.0 COMPREHENSIVE OIL AND GAS RESOURCE POTENTIAL

The NTTR and the DNWR were closed to mineral exploration in 1940 and 1936, respectively, and the closures pre-date the majority of oil and gas exploration in Nevada. Oil was first discovered in 1954 in Railroad Valley, approximately 130 km northeast of the study area. Following the discoveries at Railroad Valley and later in Pine Valley, Nevada, approximately 200 km north of the study area, the Neogene basins and the overthrust belts of the eastern Great Basin have been the focus of exploration.

As a consequence of closure, no significant oil and gas exploration has taken place within the NTTR and DNWR since the previously completed mineral and energy resource assessments. There is a scarcity of oil and gas exploration data within the study area and the broader eastern Great Basin remains largely underexplored (Davis and Namson, 2014) though hydrocarbon reservoirs and traps are expected to be present.

In the previously completed oil and gas potential assessments of the East DNWR (Tingley and others, 1993) and the NTTR (Tingley and others, 1998), the approach to assessing the potential for oil and gas resources focused on the identification of adequate hydrocarbon source rocks. Available supporting information related to source rock hydrocarbon generation potential and hydrocarbon preservation was presented. In the 2014 Assessment (Muntean and others, 2014), no new oil and gas exploration or oil and gas potential data was identified.

The previous assessments of the NTTR and East DNWR were relatively comprehensive. Because no advanced oil and gas surface or subsurface exploration have been conducted since completion of the previous assessments, this assessment summarizes the results of previous eastern Great Basin and local oil and gas evaluations. Additional information from a state-wide qualitative petroleum potential study (Garside and Hess, 2011) is also presented.

Commercially viable accumulations of oil and gas require a hydrocarbon source rock, a migration pathway for generated hydrocarbons, a reservoir where hydrocarbons are accumulated and a trap or seal to contain the hydrocarbons. To date, all producing Nevada oil fields occur in Neogene basins where the combination of source rock burial, heating, and valley fill seals have resulted in oil generation and preservation. The following sections discuss these requirements.

6.1 Source Rock Evaluation

6.1.1 Source Rock Maturity

Tingley and others (1993, 1998) presented information on study area source rock evaluation, including source rock maturity and analytical results from GSC samples.

Maturity refers to the state of a source rock relative to its ability to generate petroleum, which includes hydrocarbons in the liquid or gaseous state. A potential source rock may contain organic matter and under the right circumstance could generate hydrocarbons. An undermature source rock has not been subjected to sufficient heating to convert organic matter to hydrocarbons. A source rock that has been heated to thermal maturity has the potential to generate hydrocarbons, or may have generated hydrocarbons that have migrated to a reservoir. As heating increases, the rock passes through the oil generation window, from oil to wet gas (oil and gas), dry gas (gas-only generation), and finally to overmaturity, where hydrocarbons are destroyed and not preserved. Heating is typically a result of burial and geothermal gradients.

A method for evaluating source rock maturity is the conodont Color Alteration Index (CAI). Conodonts are the tooth-like fossils of extinct chordates that date from Precambrian to Triassic age. They are composed of apatite and when subjected to heating, they change color. By correlation to the CAI, the color exhibited by conodonts can be used to estimate the maximum temperature exposure of a source rock and assess source rock maturity. Table 6.1 summarizes the CAI and temperature ranges responsible for observed conodont color.

Table 6.1: CAI Index and Temperature Range

Color Alteration Index (CAI)	Temperature Range (^{0}Celsius)	Comments
1	<50 to 80	Undermature
1.5	50 to 90	Oil-generation window
2	60 to 140	
3	110 to 200	Limit of oil generation, gas-only generation
4	190 to 300	Overmature
5	300 to 400	Supermature, hydrocarbons unpreserved

Notes:
Source - Epstein and others, 1977

CAI data represent the most extensive set of source rock evaluation data for the NTTR, East DNWR, and expansion areas.

6.1.2 Source Rock Richness

ROCK-EVAL is a source rock analysis method that uses pyrolysis in the absence of oxygen to decompose organic matter and evaluate hydrocarbon generation potential. During pyrolysis, free hydrocarbons are volatilized and as the heat of pyrolysis is increased, contained kerogens are converted to hydrocarbons, hydrocarbon-like substances, and carbon dioxide. Analysis of the releases versus the temperature of

pyrolysis enables source rocks to be evaluated in terms of hydrocarbon-generation potential and thermal maturation.

Total organic carbon (TOC) content is used to evaluate source rock richness. Based on information presented by Chinn (1991), the TOC in percent for all shales averages 0.8 percent, while for shale source rocks, TOC averages from 1.8 to 2.2 percent. The mean TOC content for carbonate source rocks is 0.7 percent. Table 6.2 summarizes the richness of shale and carbonate source rocks based on TOC content.

Table 6.2: Source Rock Richness Based on Total Organic Carbon Content

Hydrocarbon Generation Potential	Wt% TOC, Shales	Wt% TOC, Carbonate Rocks
Poor	0.0 to 0.5	0.0 to 0.2
Fair	0.5 to 1.0	0.2 to 0.5
Good	1.0 to 2.0	0.5 to 1.0
Very Good	2.0 to 5.0	1.0 to 2.0
Excellent	>5.0	>2.0

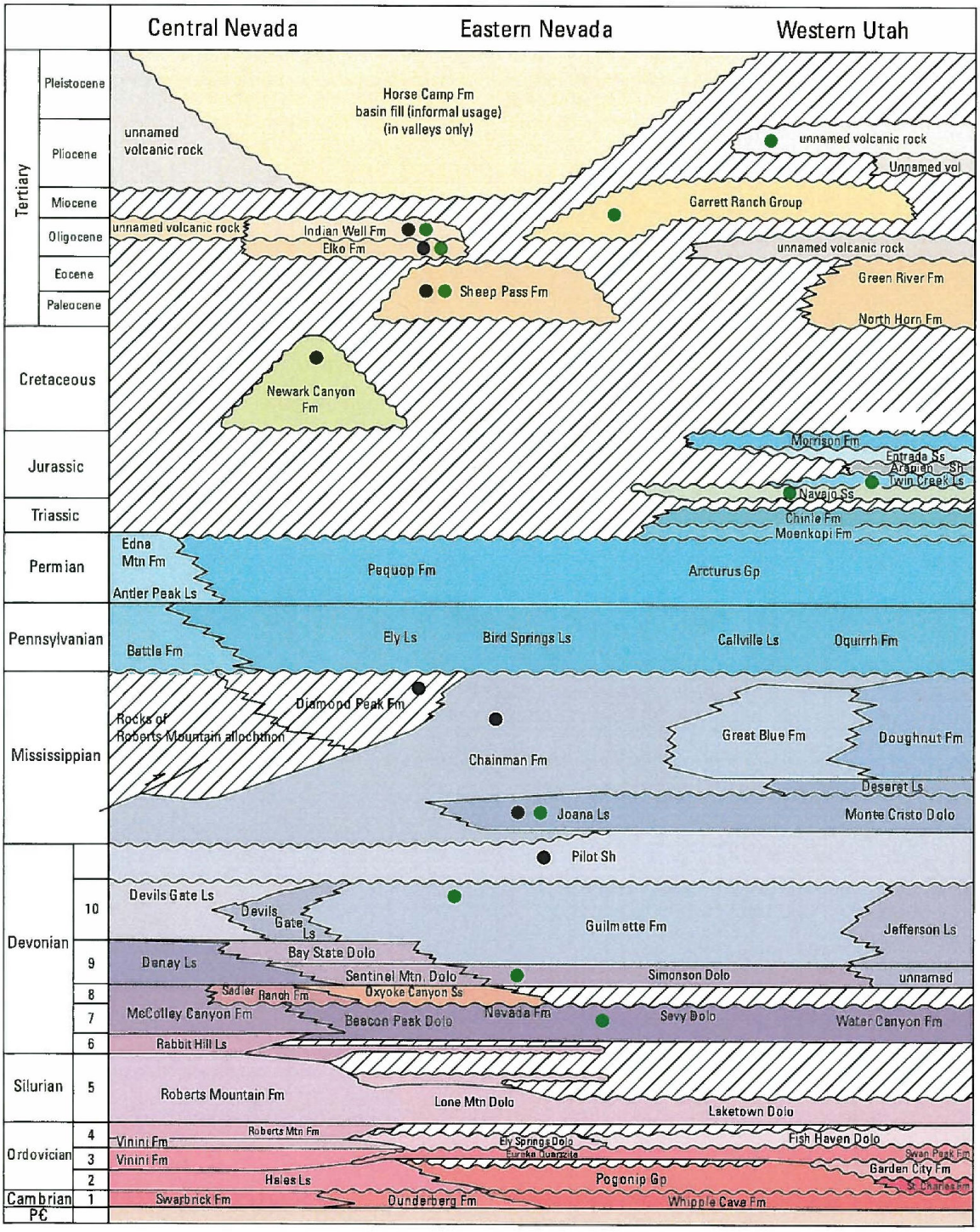
Notes:
Source - Chinn, 1991
Wt %TOC = weight percent Total Organic Carbon

6.1.3 Eastern Great Basin Source Rocks

Figure 6.1 is a generalized section through the eastern Great Basin of central Nevada, eastern Nevada, and Western Utah and identifies known hydrocarbon source and reservoir rocks. The most important hydrocarbon source rocks in the eastern Great Basin are the upper Devonian/Mississippian Pilot Shale and the Mississippian Chainman Shale. Subunits and temporal equivalents of the Pilot and Chainman FMs occur within the NTTR and East DNWR (Tingley and others, 1998).

Source rocks that are well to the north of the study area include the Oligocene Indian Well FM and Elko FM. The Newmark FM extends into the Pancake Range north of the study area, but is not known inside the study area. The Sheep Pass FM extends into Lincoln County, but occurs east of the study area.

The Joana Limestone of early Mississippian age has been identified as a source rock, although no produced oil has been typed to the Joana Limestone (Anna and others, 2007). In the NTTR and East DNWR in Clark County is represented by the age-equivalent Monte Cristo Dolomite, which has not been identified as a source rock in the eastern Great Basin. Due to its stratigraphic position between the Pilot and Chainman shales, the Joana Limestone and the age-equivalent Monte Cristo Dolomite are potential reservoir rocks. Locally, the Joana Limestone grades laterally into rocks mapped as the Pilot FM (Western Cordillera, 2006).



NOTES

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REFERENCE

L ANNA AND OTHERS, 2007. GEOLOGIC ASSESSMENT OF UNDISCOVERED OIL AND GAS IN THE PALEOZOIC-TERTIARY COMPOSITE TOTAL PETROLEUM SYSTEM OF THE EASTERN GREAT BASIN, NEVADA AN UTAH. U.S. GEOLOGICAL SURVEY DIGITIAL DATA SERIES DDS-69-L.

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FIGURE 6.1
GENERALIZED STRATIGRAPHIC SECTION ILLUSTRATING EASTERN GREAT BASIN PETROLEUM SOURCE AND RESERVOIR ROCKS

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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: V:\1538787.NTR\GIS\Mapping\MXD\General\Report\Figures\Figure 6.1 Generalized stratigraphic section.mxd

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6.2 Pilot Shale

Pilot Shale is reported to represent the first clastic deposition following a long period of deposition of Paleozoic shelf carbonate rocks (Anna and others, 2007).

Clastic sediments were deposited eastward into a foreland basin from the highland associated with early Mississippian Roberts Mountain thrust. The Pilot Shale has been subdivided into three units based on fossil records and depositional history (Anna and others, 2007):

- A basal unit unconformably overlies the Guilmette FM and consists of mudstone, limestone, shale, and carbonate debris deposited in a rapidly subsiding foreland basin.
- A middle unit consisting of basal sandstone and organic-rich shale.
- An upper unit composed of organic-rich shale interbedded with deep water limestone, siltstone, and chert that is unconformably overlain by the Joana Limestone or Chainman shale in central and eastern Nevada.

The Pilot Shale is reported to be up to 330 m thick elsewhere in the eastern Great Basin (Anna and others, 2007), but is thinner in the East DNWR (Tingley and others, 1993), and consists of light colored siltstone or silty limestone that is estimated to be organic-poor. A sample collected from the Pilot Shale in the NTTR for the 1993 Assessment and tested by ROCK-EVAL had a TOC of 0.17, indicating an organic-poor source rock. Tingley and others (1998) noted that in the NTTR, the Pilot FM is dominated by a limestone, dolomite, and sandstone facies. More favorable Pilot Shale source rocks occur approximately 200 km north of the study area in White Pine County, Nevada.

6.3 Chainman FM

The Mississippian Chainman FM is considered the most prolific source rock in the eastern Great Basin; it has been identified as the source in several producing oil fields. It is regionally extensive and reported to be up to 2,000 m thick (Anna and others, 2007). Similar to the Pilot Shale, it was deposited in a north-south trending foreland basin associated with the Antler Orogeny and Roberts Mountain thrust. The organic-rich units of the Chainman FM are reported to occur to the north, northeast, and northwest of the East DNWR, but has not been observed in the East DNWR or the NTTR; however, Mississippian Chainman temporal equivalents occur in portions of the North and South ranges of the NTTR, and the Indian Springs Parcel. They are generally organic poor. In the East DNWR, the dark shale of the Chainman is replaced by a carbonate unit (Tingley and others, 1998).

Tingley and others (1998) presented ROCK-EVAL results for four possible Chainman Shale or Chainman Shale-age-equivalent samples collected as part of the 1998 Assessment. One sample exhibited a TOC of 1.16 percent; however, the ROCK-EVAL results for this sample suggested its maturity is beyond the oil-generation window. The remaining Chainman samples exhibited TOC contents between 0.0 and 0.75 percent, indicating poor to fair hydrocarbon generation potential.

6.4 Potential for Oil and Gas Resources

6.4.1 NTTR Update

Figure 6.2 shows the potential for oil and gas resources in and near the NTTR based on the 1998 Assessment (Tingley and others, 1998). The figure has been modified to include the expansion areas. The area east of an approximately north-south line from Hot Creek Valley toward the Eleana Range in the NNSS represents the approximate western limit of the Chainman FM (Tingley and others, 1998). West of this line, the Mississippian rocks consist of Eleana FM, coarse clastic rocks with low TOC in the NNSS. The Pilot FM is also not known to occur west of the Eleana Range in the NNSS. Therefore, the primary eastern Great Basin source rocks likely do not occur in most of the North Range of the NTTR. There are also no outcrops of Pennsylvanian and Permian carbonate rocks in the North Range of the NTTR.

Figure 6.3 from Garside and Hess (2011) shows available source rock maturity; CAI data; oil and gas well locations, including producing wells and the locations of oil and gas shows; and oil and gas seeps. Along and west of the Hot Creek Valley/Eleana Range line, CAI data also indicate potential source rocks are overmature.

The lithology of the North Range west of the Hot Creek Valley/Eleana Range line is dominated by Cenozoic volcanic and sedimentary rocks, and lesser pre-Tertiary basement rocks. The thickest accumulations of tertiary sedimentary rocks can be expected to occur in Neogene basins associated with basin and range extension. Neogene sedimentary rocks and lacustrine deposits in this region could possibly contain organic matter, but given the relatively shallow basin depths estimated by Jachens and others (1996), they are likely to be undermature. Calderas and associated deposits make up a significant percentage of the North Range outcrops. Intra-caldera deposits were considered to have low potential for oil and gas (Tingley and others, 1998; Garside and Hess, 2011).

Tingley and others (1998) assigned a low potential, certainty level C, for oil and gas resources across most of the North Range. East of the Hot Creek Valley/Eleana Range line, and extending across most of the South Range of the NTTR was classified as having low potential, certainty level B for oil and gas resources. CAI data indicate that potential source rocks have been heated to within the window for gas generation. While gas generation may occur or is occurring, Tingley and others (1998) note that traps and seals suitable for the accumulation for commercial quantities of gas are not expected to occur in the intermountain basins with alluvial valley fill cover.

While the Chainman Shale facies may occur locally in the South Range of the NTTR, the majority of the CAI values are indicative of source rock overmaturity with respect to oil generation. The Pilot Shale is reported to be thin and is represented by organic-poor siltstone or silty limestone (Tingley and others, 1993).

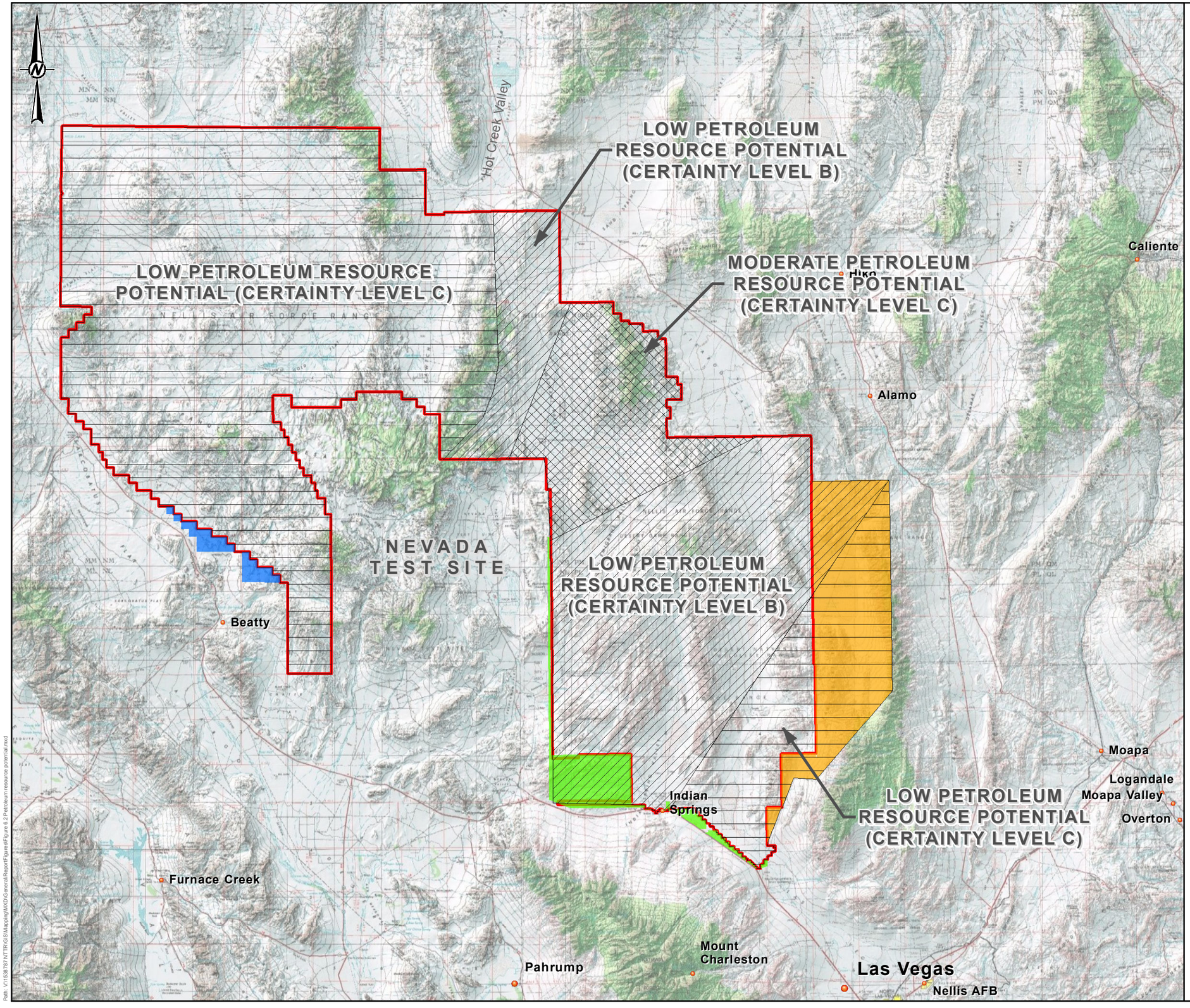


FIGURE 6.2
PETROLEUM RESOURCE POTENTIAL OF THE NTTR AND VICINITY

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STUDY

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PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

- THERMAL POTENTIAL FOR OIL AND GAS *BASED ON CAL INDEX AND PRESENCE OF MISSISSIPPIAN SHALE FACIES*
- THERMAL POTENTIAL FOR GAS *BASED ON CAL INDEX*
- LOW TO NO PETROLEUM POTENTIAL *MISSISSIPPIAN SHALE FACIES ABSENT*

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
MODIFIED FROM TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED

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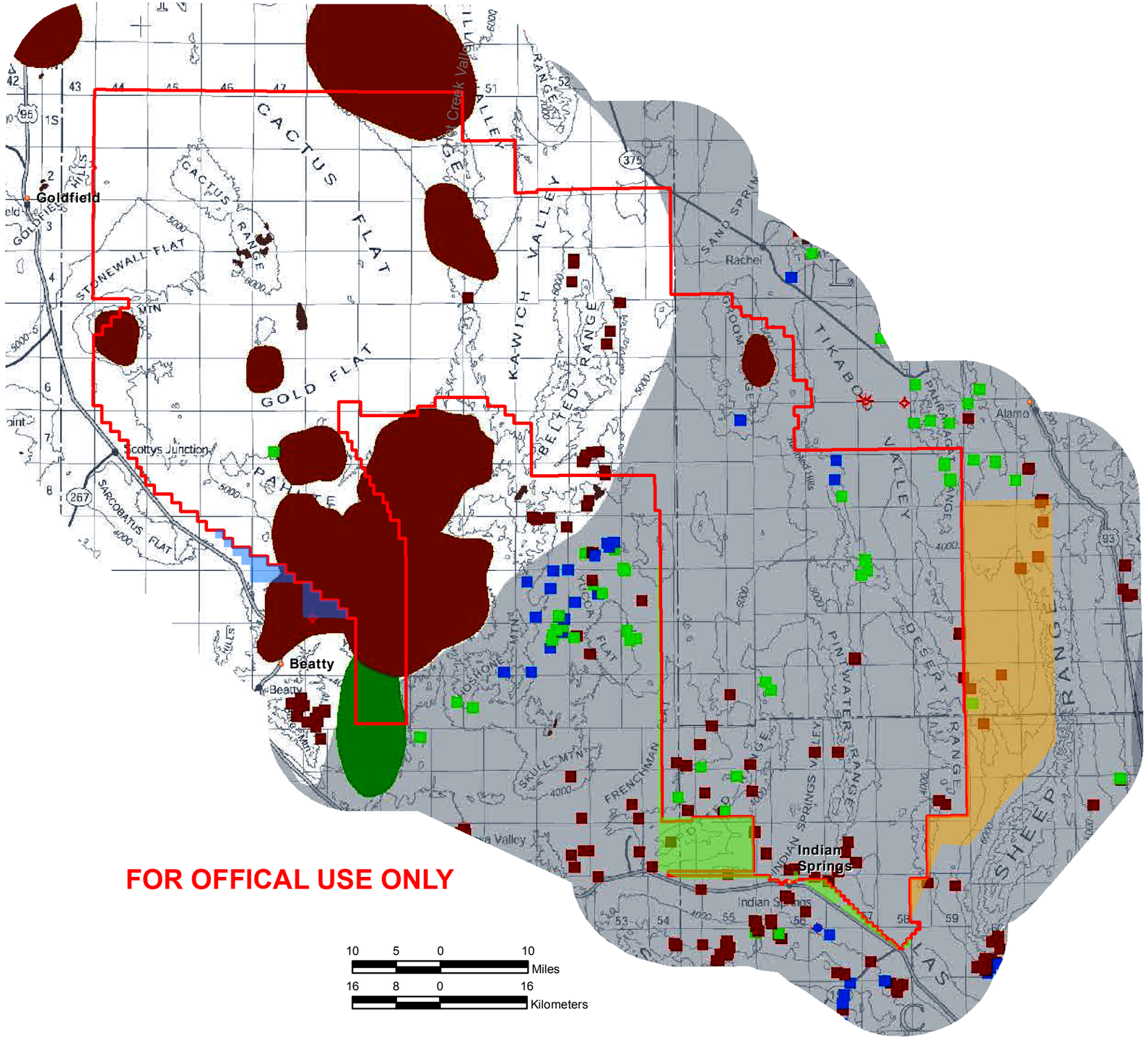
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PROJECT No.	CONTROL	Rev.	FIGURE
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Path: \\1538787 NTTR\GIS\Mapping\MXD\GeneralReport\Figure#Figure 6.2 Petroleum resource potential.mxd

FIGURE 6.3
STUDY AREA PETROLEUM POTENTIAL MAP



LEGEND

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

ALTERNATIVE 3A - EC SOUTH EXPANSION

ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION

ALTERNATIVE 3C - ALAMO EXPANSION

Nevada Oil and Gas Well Database

Conodont Samples

CAImin

- < 2.5
- 2.5 - 3.5
- > 3.5

Oil and Gas Wells

- Gas show
- No show or no data

Calderas and Other Low Potential Areas

- Certain, probable, and unevaluated calderas
- Doubtful calderas

Oil and Gas Potential

- Low potential
- Very low to no potential - shown as white

NOTES

SOURCE:
GARSIDE AND HESS, 2011. NBMG OFR 2011-2.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY

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PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: \\v1538787.NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 6.3 Study area petroleum potential map.mxd

Tingley and others (1998) noted that southeast of a line extending from the town of Indian Springs to Caliente (Figure 6.2), the dark organic-rich shale facies of the Chainman FM are not expected to occur. Consequently, the southeastern portion of the South Range of the NTTR was classified as having low potential, certainty level C, for oil and gas resources.

The highest potential for oil and gas resources inside the existing boundaries of the NTTR, moderate potential, certainty level C, is in the area in and around Tikaboo Valley in the northern portion of the South Range (Figure 6.2). Tingley and others (1998) noted that the Tikaboo Valley may be the only local basin where the burial depth of Neogene sediments could be sufficient to cause heating to thermal maturity. In addition, both Pilot and Chainman shale facies may occur in this area. CAI values from surface outcrops in the northern portion of the South Range and west of the Pahranagat Range indicate that thermal maturity is within the oil generation window. Garside and Hess (2011) also report a gas seep in the Tikaboo Valley a few kilometers north of the NTTR.

6.4.2 Proposed Expansion Areas

6.4.2.1 Alternative 3A – the EC South Area

No potential shale or carbonate source rocks were observed during the field investigation of the EC South area. Local outcrops include Holocene to Pliocene basalt flows and siliceous rhyolitic ash-flow tuffs of Miocene age that are associated with the SNVF, and tuffaceous sedimentary rocks of Pliocene to Miocene age. As noted above, the shale facies of the Pilot and Chainman FMs are not predicted to occur to the west of the Eleana Range, and burial depths for the volcanic sedimentary rocks that could contain lacustrine, organic-material-bearing deposits are likely to be insufficient for heating to thermal maturity. CAI values from Cambrian to Pennsylvanian sedimentary rock outcrops around Bare Mountain, approximately 15 km south of the EC South area, indicate overmaturity. Similar to the areas to the north, inside the existing boundaries of the NTTR, the potential for oil and gas resources in the EC South area is considered low, certainty level C (Figure 6.2).

6.4.2.2 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Areas

Outcrops in the Indian Springs Parcel include Neoproterozoic to Lower Cambrian clastic rocks and Cambrian to Devonian platform shelf carbonates. Barnes and others (1982) identified a minor occurrence of Chainman Shale within the core of an overturned syncline between the north and south ridges of the Spotted Range. Tingley and others (1993) noted that the latest Proterozoic to Lower Cambrian rocks do not contain likely source rocks, and they have been metamorphosed beyond the hydrocarbon generation and preservation window. Carbonate samples collected from the Indian Springs Parcel for the current study, including a gray dolomitic limestone and a solution-brecciated grey limestone containing dark petroliferous limestone fragments had a maximum organic carbon contents of 0.05 percent, indicating poor source rocks. It should be noted that organic carbon measurements completed for the current study were not determined

in conjunction with ROCK-EVAL analyses, but were calculated by the difference between total carbon and carbonate carbon. CAI data for samples collected from the Indian Springs Parcel in Figure 6.3 indicated overmaturity for oil generation in all samples, with the majority of the samples indicating a CAI of 3.5 or greater. Paleozoic units located beneath thrust sheets in the East DNWR may contain potential source rocks, but as they are buried by overlying thrust sheets, they are also likely to be heated to overmaturity.

Tingley and others (1993) noted the occurrence of dark, petroliferous limestone east of the town of Mercury in the Indian Springs Parcel. Black, petroliferous limestone outcrops were observed during field investigation for this assessment but these units were observed to be thin.

The Administrative Incorporation area is along the southern boundary of the South Range of the NTTR, where geologic conditions are similar to in the southeastern portion of the South Range. For the reasons stated in Section 6.4.1, the potential for oil and gas resources in this area was classified as low, certainty level C.

6.4.2.3 Alternative 3C – the Alamo Area

Tingley and others (1993) conducted ROCK-EVAL analyses on five Paleozoic rock samples collected as part of the GSC assessment in the East DNWR, and one possible Chainman Shale sample collected from an exploration well completed 24 km north of the study area in the Tikaboo Valley. TOC content ranged from 0.04 to 0.14 percent, indicating organic-poor source rock quality.

Within the Alamo area, 8 of 9 CAI results were greater than 3.5, indicating overmaturity with respect to oil generation (Figure 6.3). One sample exhibited a CAI between 2.5 and 3.5, indicative of an overmature rock with respect to oil generation, but could be within the gas-only generation window. No oil and gas seeps or oil and gas shows have been reported in the Alamo area.

Based on Garside and Hess (2011), the Alamo area is within an area of low potential for oil and gas resources. Tingley and others (1993) assigned a low potential, certainty level C, for oil and gas resources in the East DNWR based on the following considerations:

- The latest Proterozoic and Lower Cambrian rocks were deposited in an unfavorable environment and have been metamorphosed to phyllite, indicating heating beyond the hydrocarbon generation and preservation window.
- Lower Cambrian to Mississippian rocks are miogeoclinal carbonate shelf sediments that are generally recognized as unfavorable source rocks. This conclusion is supported by low TOC content in samples subjected to ROCK-EVAL analyses, as well as CAI data indicating overmaturity. The Pilot Shale is recognized as a favorable source rock north of the study area, but is represented by organic-poor siltstone and silty limestone in the Alamo area and East DNWR.
- The shale facies of the Mississippian Chainman FM is not present in the study area. Instead the Chainman Shale temporal equivalents are composed of carbonate rocks that are

considered poor candidates for hydrocarbon source rocks, based on an unfavorable depositional environment, thermal overmaturity, and low TOC.

- Pennsylvanian and Permian rocks that occur in the Alamo area and East DNWR are shelf carbonate rocks that do not include organic-rich shales in the East DNWR.
- Rocks of the Tertiary age Horse Springs FM in the East DNWR were deposited under unfavorable conditions relative to the preservation of organic matter.

Based on these considerations and the lack of new subsurface exploration data that could indicate otherwise, the oil and gas potential of the Alamo area was classified as a low, certainty level B, for the area northwest of a line extending from the town of Indian Springs to Caliente (Figure 6.2), where Chainman Shale facies may occur. Southeast of the line was classified as, having low potential, certainty level C, for oil and gas resources.

6.5 Ultra Deep Hydrocarbons

Rasmussen and Keith (1991) are proponents of an ultra-deep hydrocarbon (UDH) model that, briefly stated, involves the generation of methane-hydrocarbon stable fluids through serpentinization of peridotite in intracratonic failed rifts or basement collision sutures, that ascend though transpressive conduit systems. They identified Crater Flat, south of the NNSS and southeast of the EC South area as a potential UDH occurrence, based on late-stage basaltic volcanism, extensive dolomitization in local Paleozoic sediments, tectonic history, and other thermal and groundwater chemistry conditions in the NNSS, Crater Flat, and Yucca Mountain area. Crater Flat overlies a coincident magnetic high and gravity low that suggests an analogue to their observations from the Glodes Corner gas field in New York State. They cite a UDH system as the possible source for the oil resources in the Railroad Valley and identify Crater Flat as the most likely location for oil near the NNSS.

While there is only infrequent mention of a possible deep source for oil in the Railroad Valley in the literature reviewed for this assessment, the lack of references to UDH systems in Nevada may be indicative of the lack of acceptance of the UDH model, or the speculative nature of their existence. The evaluation of the potential for oil and gas in Nevada typically is focused on hydrocarbon source rocks that contain biogenic carbon deposited in environments conducive to the preservation of organic material and/or hydrocarbons. No change to the oil and gas potential of the study area is proposed in response to the speculative prediction of a UDH system beneath Crater Flat.

6.6 Summary of Oil and Gas Potential

The low potential for oil and gas resources over most of the study area is confirmed by the qualitative assessment of Garside and Hess (2011), as shown on Figure 6.3. They indicated very low to no potential over the North Range west of the Hot Creek Valley/Eleana Range line, including the EC South area. Across the remainder of the North Range, and in the South Range, and the 64C/D and 65D and Alamo areas, they considered the potential for oil and gas resources to be low. There are few locations within and near the

study area where CAI data indicate source rock maturity within the oil-generation window. These areas are inside the NNSS and in the Pahranagat Range/Tikaboo Valley area. Over most of the study area, CAI data indicate rocks that are overmature for oil generation (i.e., CAI less than or equal to 3.5). Locally, source rocks may be within the gas-only generation window; however, as noted above, the traps and seals required to generate commercially viable gas resources are not expected to occur in the local alluvium-filled basins.

7.0 COMPREHENSIVE COAL RESOURCE POTENTIAL

There are no commercial coal deposits in the State of Nevada and few reported occurrences of coal in southern Nevada. Garside and others (1980) concluded that Nevada contains only minor occurrences of poor quality coal in low tonnage deposits that would be difficult to mine.

A coal occurrence is reported near Hiko, approximately 25 km north of the DNWR. Tingley and others (1998) noted that coal beds may occur in the Chainman Shale, which occurs east of the Hot Creek Valley/Eleana Range line in the NTTR and the northern portion of the Alamo area, but no coal has been identified within the current limits of the NTTR or the expansion areas.

In both the 1993 Assessment of the East DNWR (Tingley and others, 1993) and the 1998 Assessment of the NTTR (Tingley and others, 1998) classified the potential for coal resources as low, certainty level D. No change from the previously reported potential for coal resources in the study area is warranted.

8.0 COMPREHENSIVE URANIUM RESOURCE POTENTIAL

Tingley and others (1993, 1998) identified limited potential for economically viable uranium resources in Nevada in general, and within the NTTR and East DNWR in particular. They state that there are no references to uranium prospects within the NTTR in available literature. Globally, a large portion of uranium deposits occur in intrusive rocks, sedimentary rocks, metasedimentary rocks and metavolcanic rocks, as well as in volcanic rocks. In the study area, uranium is likely to be associated with silicic volcanic rocks and may be concentrated within the volcanic unit itself and in adjacent sedimentary basins. The North Range of the NTTR, where silicic volcanic rocks and tuffs predominate, and locally where volcanic rocks occur within the South Range and the East DNWR are permissive for volcanogenic uranium deposits. Sherlock and others (1996) identified one volcanogenic uranium deposit in the Bullfrog District, located a few kilometers south of the EC South area. According to Bagley (1996), these deposits are associated with high silica alkali rhyolite and potash trachytes and are hosted in peralkaline and peraluminous rhyolites.

Geochemical investigation conducted for the East DNWR 1993 Assessment and the 1998 Assessment of the NTTR identified a few anomalous concentrations of uranium, but nothing that could be considered indicative of an economically viable uranium deposit. Sampling conducted for the current assessment did not identify uranium in significant concentrations. Tingley and others (1993) assigned a low potential, certainty level D, for uranium resources in the East DNWR. In the NTTR, a low potential, certainty level B, was assigned to the areas containing volcanic rocks and adjacent basins, and low potential, certainty level C, to non-volcanic terrains.

There is no new data that supports modification of the potential for uranium resources in the study area although it should be noted that the majority of the study area has been closed to uranium exploration since the 1940s. Most uranium exploration activity occurred between 1948 and 1960 (Garside, 1973) and the NTTR and the expansion areas can be considered underexplored. Uranium is strategically important as a fuel for electrical power generation and nuclear weapons. A disruption of the current uranium supply could lead to seeking uranium in underexplored areas, such as the study area.

8.1 Domestic Uranium Reserves and Usage

The quantity of US uranium reserves is dependent on uranium price. Based on the US Energy Information Administration (USEIA, 2016; various pages at http://www.eia.gov) at a price of $100 per pound of triuranium octoxide (U_3O_8), US uranium reserves were 1,227 million pounds in 2015. The price per pound of U_3O_8 peaked at $136.66 in June of 2007 but has been declining for the last several years. At the current price of $28.80 per pound, economically viable domestic reserves are substantially less.

US annual uranium production capacity is currently 26.98 million pounds of U_3O_8 from operating, developing, and partially licensed US producers in Texas, Wyoming, Nebraska, South Dakota, and New

Mexico (USEIA, 2016). Domestic production of uranium in 2015 was 3.3 million pounds of U_3O_8 equivalent. Total domestic usage was 57 million pounds in 2015.

Demand in excess of current domestic production is currently satisfied with low cost imports. Of the total domestic usage of U_3O_8 in 2015, less than 10 percent was from U.S. producers. Listed in order of decreasing purchases, Russia, Canada, Australia, Kazakhstan, and Namibia provided 85 percent of the domestic uranium supply (USEIA, 2016).

Looking forward, US reserves in combination with the availability of inexpensive uranium imports are adequate to maintain current domestic supply well into the future. A supply disruption would be anticipated to increase the price of uranium and consequently increase domestic reserves as lower grade ores become economically viable to mine and process. In the event of a disruption, a combination of the existing reserve domestic production capacity, which was approximately 27 million pounds of U_3O_8 in 2015, and imports from the “friendly” and politically stable countries of Canada and Australia, are anticipated to be adequate to support domestic uranium demand in the foreseeable future. As such, the proposed renewed withdrawal of the NTTR, and the withdrawal of the expansion areas, is not expected to impact the availability of uranium and the uranium market.

9.0 COMPREHENSIVE GEOTHERMAL RESOURCE POTENTIAL

The geothermal resource potential evaluation for the current assessment consists of a general discussion of geothermal potential within the Great Basin, a review of previous geothermal resource assessments completed within the existing boundaries of the NTTR and the East DNWR, and a review of data and findings from regional geothermal studies. This updated assessment of the NTTR and expansion areas considered the potential for extensional systems, as well as deep stratigraphic reservoirs, and blind geothermal resource potential. Data were reviewed from a number of local sites with indications of geothermal potential, and selected accessible sites were investigated with field checks.

9.1 Geologic Setting

As discussed above, the geologic terrain of the NTTR and DNWR can be divided into a southeastern area of largely Paleozoic sedimentary rocks, and a northwestern area of mainly volcanic rocks of late Cenozoic age. The WL fault system bounds the study area along the southwest (Figure 1.5 and Figure 1.6). The WL is a system of right-lateral strike-slip faults accommodating approximately 15 to 25 percent of relative motion between the Pacific and North American plates. Granitic plutons are not abundant in the NTTR, although they may be concealed by younger rocks. A Cretaceous granitic pluton is present in the Oak Springs area of the southern Belted Range, just south of the North Range-north NNSS boundary (Figure 1.3). Mesozoic granitic plutons crop out in a small area on the southern Kawich Range and in another small area about 3 km south-southwest of the Urania Peak in the Cactus Range. A weakly foliated, coarse grained granite of unknown age is exposed in the Trappman Hills (Tingley and others, 1998). Figure 5.18 shows the inferred location and extent of granitic plutons based on the limited outcrops discussed above and evaluation of geophysical data (Grauch, 1996).

The pre-Cenozoic rocks of the NTTR are unconformably overlain and intruded by volcanic rocks erupted during two periods of magmatic and volcanic activity that swept through the Great Basin from north to south, from Eocene to early Miocene time (43 to 17 Ma) and mid to late Miocene time (17 to 6 Ma) (Tingley and others, 1998). Rocks of the SNVF in volcanic centers and related flow rocks from Stonewall Mountain to south and east of Yucca Mountain overlie the Oligocene to early Miocene units. Major units of this volcanic series erupted largely between 15.2 and 10.0 Ma from vent areas of overlapping and nested volcanic centers in near Timber Mountain. Between 9.5 and 7.5 Ma, major volcanism shifted to the outlying Black Mountain and Stonewall Mountain volcanic centers, with the eruptive rocks of the Thirsty Canyon Group and the Stonewall Flat Tuff (Tingley and others, 1998).

There are no known shallow silicic igneous bodies in the study area young enough to be a local source of geothermal heat for magmatic geothermal systems. Silicic volcanism in the NTTR ended about 11.5 Ma in the SNVF and at about 7 Ma at the Stonewall caldera on the western boundary of the NTTR and the Black Mountain caldera northeast of the Timber Mountain caldera complex (Sawyer and others, 1994)

(Figure 1.5). Magma bodies below larger calderas (greater than10 km diameter) cool slowly and may be post-active heat sources for up to 2 million years (Wohletz and Heiken, 1992). Quaternary basalt volcanism is present in several areas in and adjacent to the NTTR (e.g., Reveille Valley, Buckboard Mesa, Kawich Valley, and Crater Flat). These basalt flows are believed to be from deep mantle sources that rose quickly through the crust to the surface and did not form shallow magma chambers, such as those that occur below calderas of basaltic shield volcanos, and do not provide sufficient long-term crustal heat to drive a geothermal system (Wohletz and Heiken, 1992).

Lacustrine and fluvial sedimentary units, deposited in shallow basins in the middle to late Tertiary, crop out in several areas within the South Range of the NTTR, particularly in the southern Spotted Range, Pintwater Range, and the Desert Range. Quaternary alluvial units, in large part consisting of alluvial, fan, pediment, valley fill, and playa deposits, are the most recent sedimentary formations within the NTTR and make up nearly one-half of the surface exposures (Tingley and others, 1998).

9.2 Geothermal Setting and Genetic Models

The term “thermal waters” refers to groundwater that has higher temperature than it would if affected only by “normal” wall rock and/or surface temperatures. Subsurface temperatures are affected by climatic conditions to a depth of about 30 m. Below 30 m, temperatures in most of Nevada normally increase about 1 ºC for every 30 m of depth, but temperatures increase more rapidly in areas of high heat flow (Garside and Schilling, 1979). Spring-water temperatures are affected by heating or cooling in the near surface and mixing with groundwater. It is generally not possible to determine the minimum temperature necessary for a well or spring to be considered thermal. Previous geothermal assessments for Nevada have typically considered water temperature greater than 20 ºC as thermal.

Productive high temperature geothermal systems capable of electric generation are generally considered economically viable where temperatures exceed 150 °C at depths of less than 1,000 m, and where rocks exhibit high hydraulic conductivity to allow high water production flow rates. Lower temperature geothermal systems can be used for direct-use applications, in which the thermal energy is used as a source of heat for buildings, greenhouses, and industrial uses. The approximate lower limit at which thermal waters are readily used in direct-use applications is 50 ºC.

The Basin and Range province is considered favorable for geothermal resources because it has higher than average heat flow and is in an area of crustal extension, where faults can provide permeable conduits for deep circulation. The most productive geothermal areas in the Great Basin are in northwest Nevada and are related to structurally controlled deep circulation of groundwater in a region with greater than 100 milliwatts per square meter (mW/m^2) of heat flow, referred to as the Battle Mountain High. Much of the NTTR is within a region of less than 60 mW/m^2 heat flow, referred to as the Eureka Low (Allis and others, 2011); however, the heat flow within the Eureka Low is considerably higher than areas outside the Basin

and Range province, where a heat flow is typically less than 30 mW/m^2. Figure 9.1 shows the location of the Battle Mountain High and Eureka Low.

The Great Basin is host to more than 400 known geothermal systems with temperatures ranging from 37 to 270 ºC (Faulds and others, 2011). Two types of geothermal systems are recognized in the Great Basin: magmatic and extensional. Magmatic geothermal systems are found on the margins of the Great Basin, where Quaternary silicic volcanic rocks are present, but extensional geothermal systems occur throughout much of the Basin and Range province (Coolbaugh, 2003).

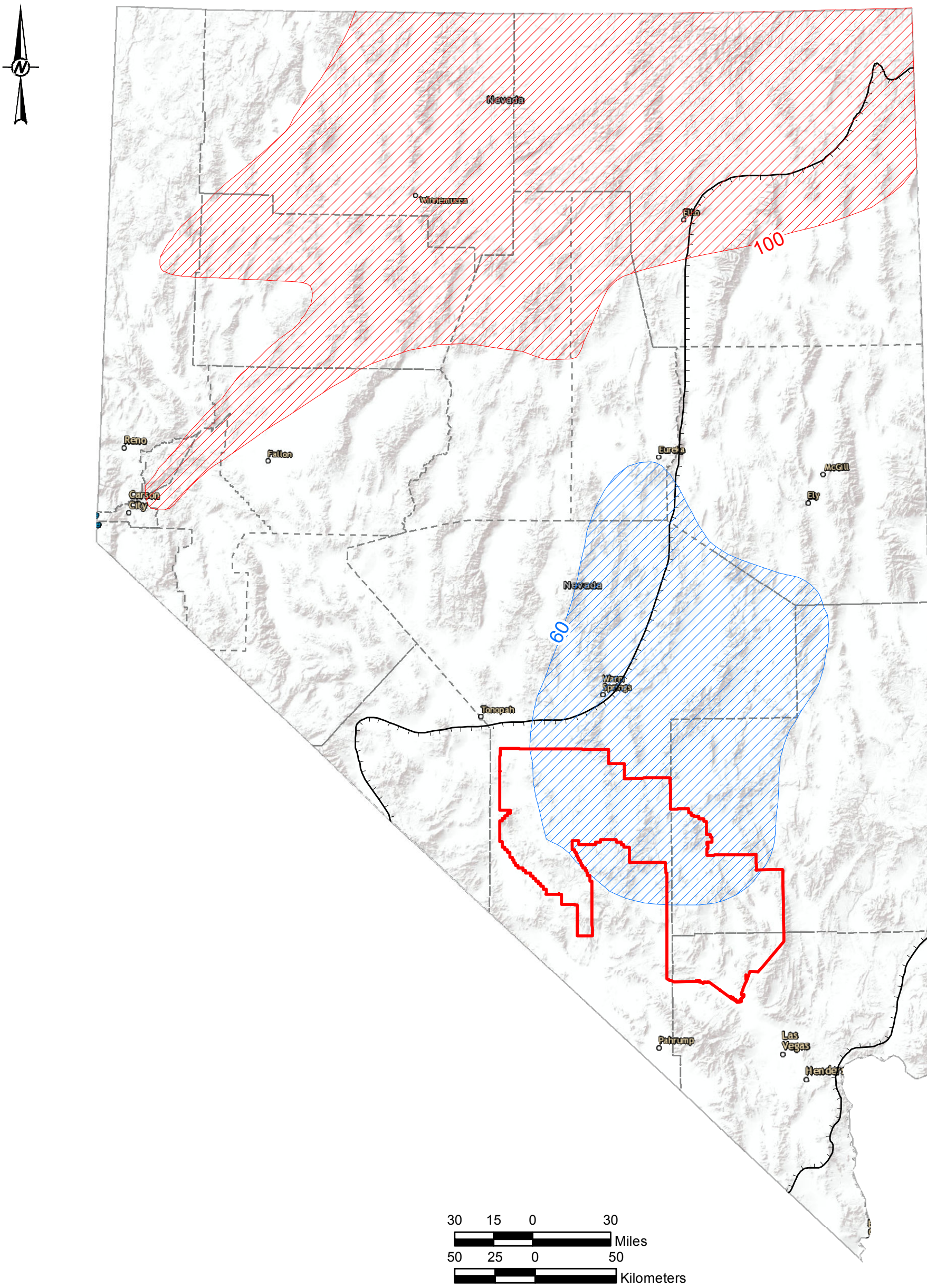
Productive geothermal systems related to shallow magmatic sources are present at Casa Diablo near Mammoth, California; Coso Hot Springs, north of Ridgecrest, California; Roosevelt Hot Springs geothermal area near Cedar City, Utah; and Steamboat Hot Springs near Reno, Nevada (Penfield and others, 2010). Shallow magmatic potential is not recognized within the NTTR or DNWR.

Extensional geothermal systems are associated with high heat flow and active faulting. Active faulting associated with extension creates reservoirs and conduits for the circulation of thermal waters. The Great Basin is unusual in the world in that extensional systems attain reservoir temperatures greater than 150 ºC and support geothermal power plants (Coolbaugh, 2003). Extensional systems in Nevada associated with high regional heat flow and active faulting occur at Dixie Valley, Wabuska, Beowawe, Desert Peak, Brady's, Stillwater, Salt Wells, and Blue Mountain (Penfield and others, 2010).

Faulds and others (2011) inventoried the structural settings of more than 400 known geothermal systems in the extensional terrain of the Great Basin. Of the known systems, 39 percent are blind (no surface hot springs, fumaroles, tufa towers, sinter terraces, etc.). However, a much higher percentage of the total undiscovered geothermal resources may be blind. Considerable research of the controls on the location of blind, structurally controlled geothermal systems in the Basin and Range province has been carried out over the past 15 years (Coolbaugh and others, 2002; Faulds and others, 2004, 2006, 2011; Faulds and Hinz, 2015; and Fossen and Rotevatn, 2016).

Deep sedimentary basins with hot water aquifers are potential sources of geothermal energy. The best conditions for deep stratigraphic reservoirs are associated with thick sedimentary basins with low-thermal-conductivity sedimentary cap rocks overlying highly-permeable host rocks collocated with areas of high heat flow. The eastern Great Basin has been identified as having deep stratigraphic geothermal potential with the thick sedimentary intermountain basin fills of the Basin and Range province providing the low-thermal-conductivity cap. The Paleozoic carbonates in the eastern Great Basin provide the necessary high permeability, and the generally high heat flow that characterizes the Basin and Range province provides a potential source of heat (Allis and others, 2011).

Path: V:\1538787 NTTR\GIS\Mapping\MXD\General\ReportFigures\Figure 9.1 Heat Flow in Nevada.mxd



LEGEND

- BATTLE MOUNTAIN HIGH (>100 mW/m ^{2})
- EUREKA LOW (<60 mW/m ^{2})
- CARBONATE ZONE
- NTTR AND EXPANSION AREAS

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

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REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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FIGURE 9.1
HEAT FLOW IN NEVADA

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Worldwide, the development of deep sedimentary basin geothermal resources has been infeasible due to moderate temperatures, low permeability, and/or the cost-prohibitive depth at which these aquifers commonly occur (Hinz and others, 2015). However, recent documentation shows that in western Utah and eastern Nevada, these aquifers could have higher-than-typical temperatures at potentially exploitable depths (Allis and others, 2011). These “deep stratigraphic reservoirs” or “hot sedimentary aquifers” have been proposed as a potential, yet unproven, geothermal resource. The eastern Great Basin has laterally extensive, high permeability associated with the Paleozoic carbonate rocks. In areas of high heat flow there is the potential for temperatures of 150 to 300 ºC at 3- to 5-km depths in basins with thick basin fill, as supported by several oil exploration wells in the eastern Great Basin encountering groundwater temperatures greater than 200 ºC at 3 km deep (Allis and others, 2011).

In the southern Great Basin and the study area, regional scale groundwater flow toward the Colorado River in the Paleozoic carbonates has depressed heat flow. Eastern Nye and northwestern Lincoln counties, which make up a significant portion of the study area, lie within the Eureka Low where heat flow is less than 60 mW/m^2 (Allis and others, 2011) (Figure 9.1). Therefore, the potential for deep stratigraphic reservoir geothermal potential is considered to be low in the NTTR and the expansion areas.

9.3 Recent Great Basin Geothermal Studies

9.3.1 Temperature Gradient

A temperature gradient map of the Great Basin was developed (Blackwell and Richards, 2004) from a database compiled by Southern Methodist University (SMU), the USGS (Sass and others, 1999); and other sources. Temperature gradients were derived in a multi-step process beginning with calculation of heat flux at individual wells, interpolation of heat flux between wells to produce heat flux maps (e.g., Blackwell and Richards, 2004), and conversion of the heat flux map to a temperature gradient map using thermal conductivities assigned for grouped geological formations. Improvements in the spatial resolution of the gradient map in the Great Basin were obtained by assigning separate thermal conductivities to graben-filled Quaternary sediments, basement rocks in horst blocks, and regions of late Tertiary and Quaternary volcanic rocks. The calculations used to develop this map excluded geothermal wells and other wells drilled in known geothermal areas, so that the predicted temperature gradients would be independent of the degree of geothermal exploration. Based on Blackwell and Richards (2004) work, portions of the NTTR are in an area of moderate heat flow compared the coterminous US. With respect to the Great Basin, areas of higher heat flow occur outside the study area.

9.3.2 Structural Setting of Geothermal Occurrences

Over the past decade, research has advanced the understanding of structurally controlled geothermal systems and the potential for deep stratigraphic reservoirs in the Great Basin (Hinz and others, 2015). An inventory of structural settings of 426 known geothermal systems in the Great Basin has established a

correlation to certain structural settings (Faulds and Hinz, 2015). Regional tectonism appears to be a primary driving force for geothermal activity in the Great Basin, as evidenced by strong correlations between strain rates and the distribution of geothermal fields (Faulds and Hinz, 2015; Zehner and others, 2005).

A geodetic strain rate map developed by Kreemer and others (2012) is shown in Figure 9.2. The map is derived from geodesy (i.e., GPS measurements of horizontal station velocities) and represents the spatial distribution of present day strain rates on the Pacific plate boundary. The data span 20 years. Local strain rates are typically less than 10 mm/year in the NTTR and expansion areas, and are relatively low compared to most other areas in the Great Basin province.

9.3.3 Blind Systems

In areas where geothermal potential is indicated, the search for blind, structurally controlled targets can be based on reviews of structural information such as described by Fossen and Rotevatn (2015) and Faulds and others (2006, 2011, 2012, 2015). Potential surface expressions of geothermal systems include warm ground, silicified sediments, ephemeral springs and seeps, borate deposits, and advanced argillic alteration (Coolbaugh and others, 2006. In the absence of these indicators, the structural setting may indicate favorable geothermal potential.

Faulds and others (2006) describe structural associations in better studied geothermal systems within the WL belt and the northern Great Basin. In general, the structural settings result in crustal dilation and the development of permeable conduits that favor circulation and upwelling of thermal waters that are not associated with magmatic activity. Their proposed exploration strategy for blind geothermal systems focuses on the following:

- Relay ramps and step-overs in range front fault settings
- Intersections of range front faults with transversely oriented strike-slip or oblique slip faults
- Normal fault terminations where horse tailing occurs
- Interbasin highs associated with oppositely dipping normal faults
- Low discontinuous mountain ranges that are indictors of en echelon normal faults
- The lateral termination of major mountain ranges that are indicative of terminating faults and fault splays, and the potential for intersection of normal and oblique strike-slip fault zones

Recent faults have also been identified as having a close association with geothermal systems (Bell and Ramelli, 2007). An association with Quaternary faults indicative of ongoing extension was also noted.

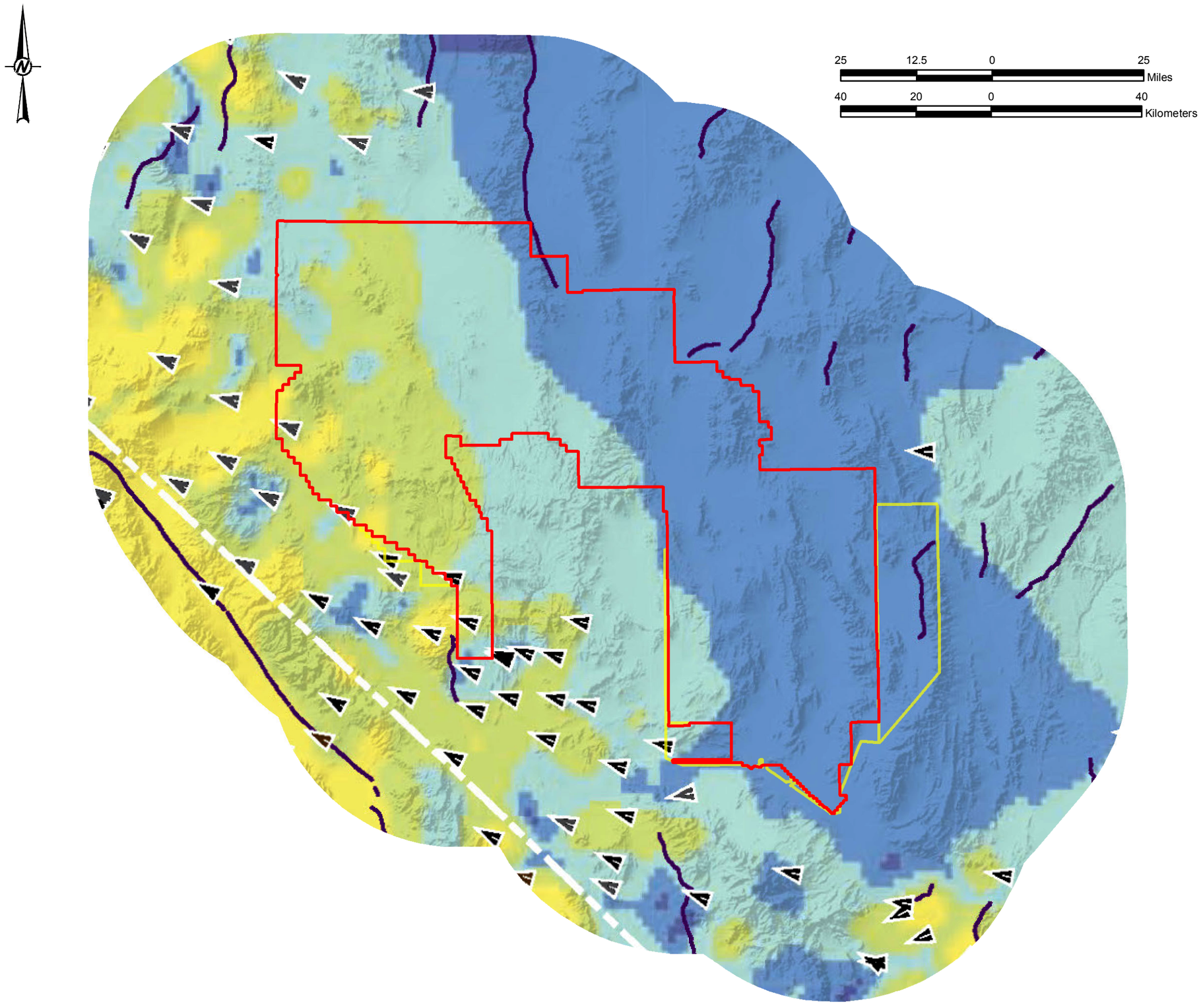


FIGURE 9.2
GEODETIC STRAIN RATES IN THE NTTR AND VICINITY

LEGEND

STUDY AREA

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PROPOSED EXPANSION AREAS

GEODETIC VELOCITY RELATIVE TO NORTH AMERICA

< 10 MM/YR

FAULTS WITH KNOWN SLIP RATES

RATE OF DEFORMATION

0 2 6 14 30 72 136 264 520 1032 3600

2nd invariant strain rate tensor (10^{-9}/yr)

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SOURCE:
KREEMER AND OTHERS, 2012. NBMG MAP-178.

REFERENCE

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 9.2 Geodetic Strain Rates in the NTTR and Vicinity.mxd

9.3.4 Geothermometry

Groundwater temperatures can be estimated based on the temperature-dependent solubility of silica and temperature-dependent exchange reactions of certain dissolved constituents (e.g., silica dioxide, calcium,sodium, potassium, magnesium) (Fournier, 1981). These geochemical geothermometers can be affected by fluid dilution, and some have limited applicability in waters having high calcium or magnesium. The chalcedony geothermometer is considered the most reliable for use in the NTTR where thermal spring and well waters are known to be low temperature. Calculated geothermometer temperatures are available for many of the springs within the study area for a number of geothermometers. Chalcedony and silica geothermometry data for local thermal waters have been catalogued for the current assessment and are discussed below relative to areas of geothermal interest in the study area.

9.3.5 Great Basin Geothermal Potential

Geothermal assessments for the state of Nevada have been completed by the NBMG (Garside and Schilling, 1979; Penfield and others, 2010). Several geothermal areas (geothermal clusters) were identified within or near the study area. These geothermal clusters are defined as having at least one known occurrence of thermal water (i.e., greater than 20 ºC), form a geographic cluster, and/or appear to have a common source and could represent a continuous anomaly at depth. Springs and wells and geothermal clusters within 50 km of the study area are shown on Figure 9.3 (after Penfield and others, 2010). Note there are a few spas or thermal pools within the region with direct uses.

Figure 9.4 presents a geothermal potential map for the Great Basin that incorporates probabilistic spatial correlation of multiple data sets compiled by Coolbaugh and others (2005). The figure identifies high-temperature geothermal systems that could support electrical power generation (greater than 150 ºC). The potential for extensional (not magmatic, or amagmatic) geothermal systems is indicated by shading. The potential for magmatically heated systems was qualitatively assessed based on the occurrence of Quaternary silicic volcanic vents; however, no such vents occur near the study area. Additional geothermal data (heat flow measurements, well and spring geothermometry results, and temperature gradient) are also shown.

Data presented in Figure 9.4 are based on a combination of input evidence maps Coolbaugh and others (2005) that included:

- A map combining crustal dilation as measured by GPS and crustal extension calculated from slip rates along Quaternary faults
- A map of the number, magnitude, and distance to historical earthquakes
- A map of combined horizontal gravity gradient and horizontal topographic gradient
- The temperature gradient in the upper crust

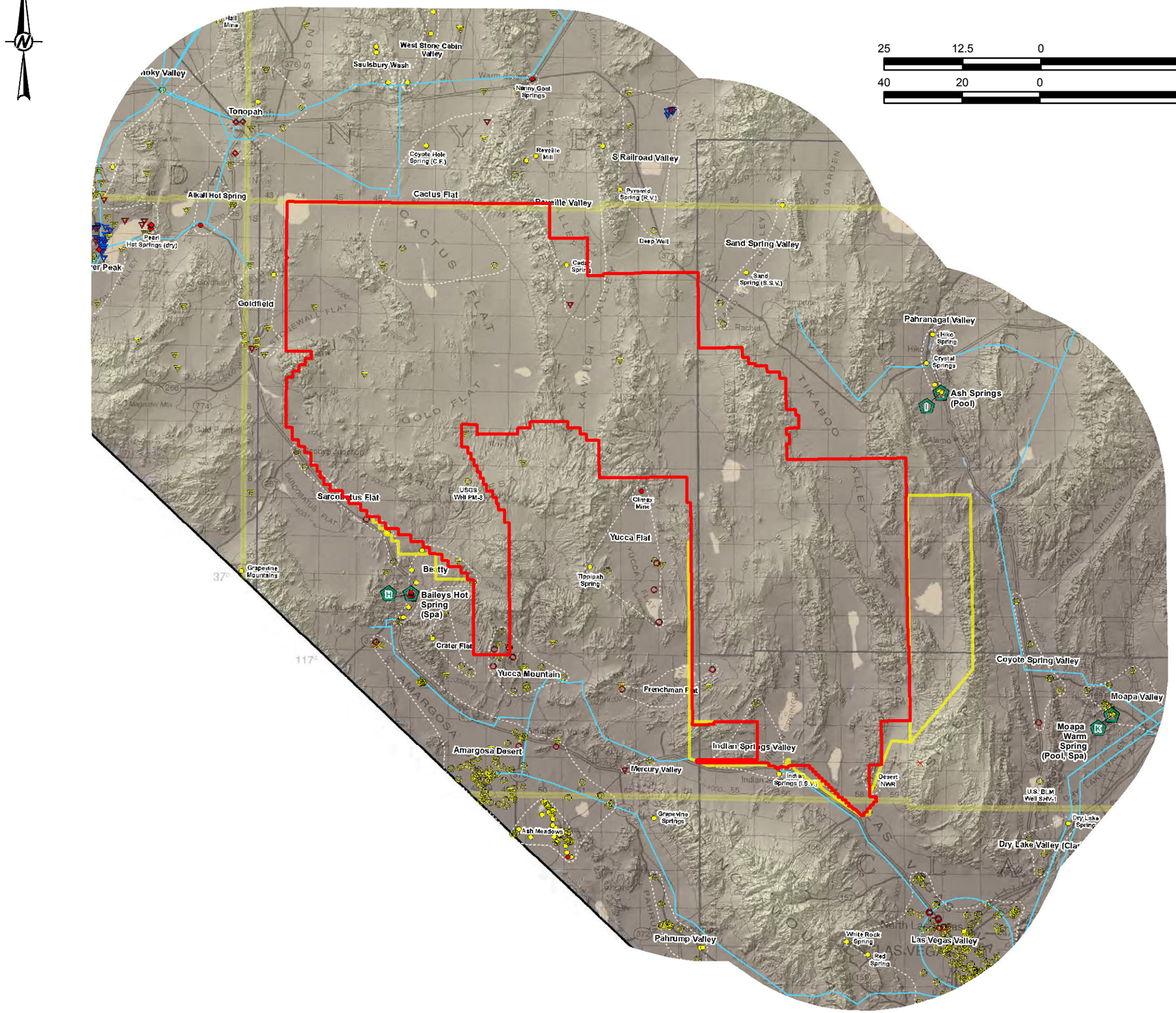


FIGURE 9.3
GEOTHERMAL OCCURENCES IN THE NTTR AND VICINITY

LEGEND

STUDY AREA

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PROPOSED EXPANSION AREAS

GEOTHERMAL

- Hot spring (>37°C)
- Warm spring (20°–37°C)
- Hot well (>37°C)
- Warm well (20°–37°C)
- Hot heat-flow well (>100°C/km)
- Warm heat-flow well (25°–100°C/km)
- Defunct warm well
- Permitted Geothermal Well
- Direct Use Application
- Areas containing thermal springs and wells

Transmission lines
(The utility lines are shown with approximate locations, which may be inaccurate by a kilometer or more.)

- High voltage DC
- >55 Kilovolts

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SOURCE:
PENFIELD AND OTHERS, 2010. NBMG MAP-161.

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figures\Figure 9.3 Geothermal Resource in the NTTR and Vicinity.mxd

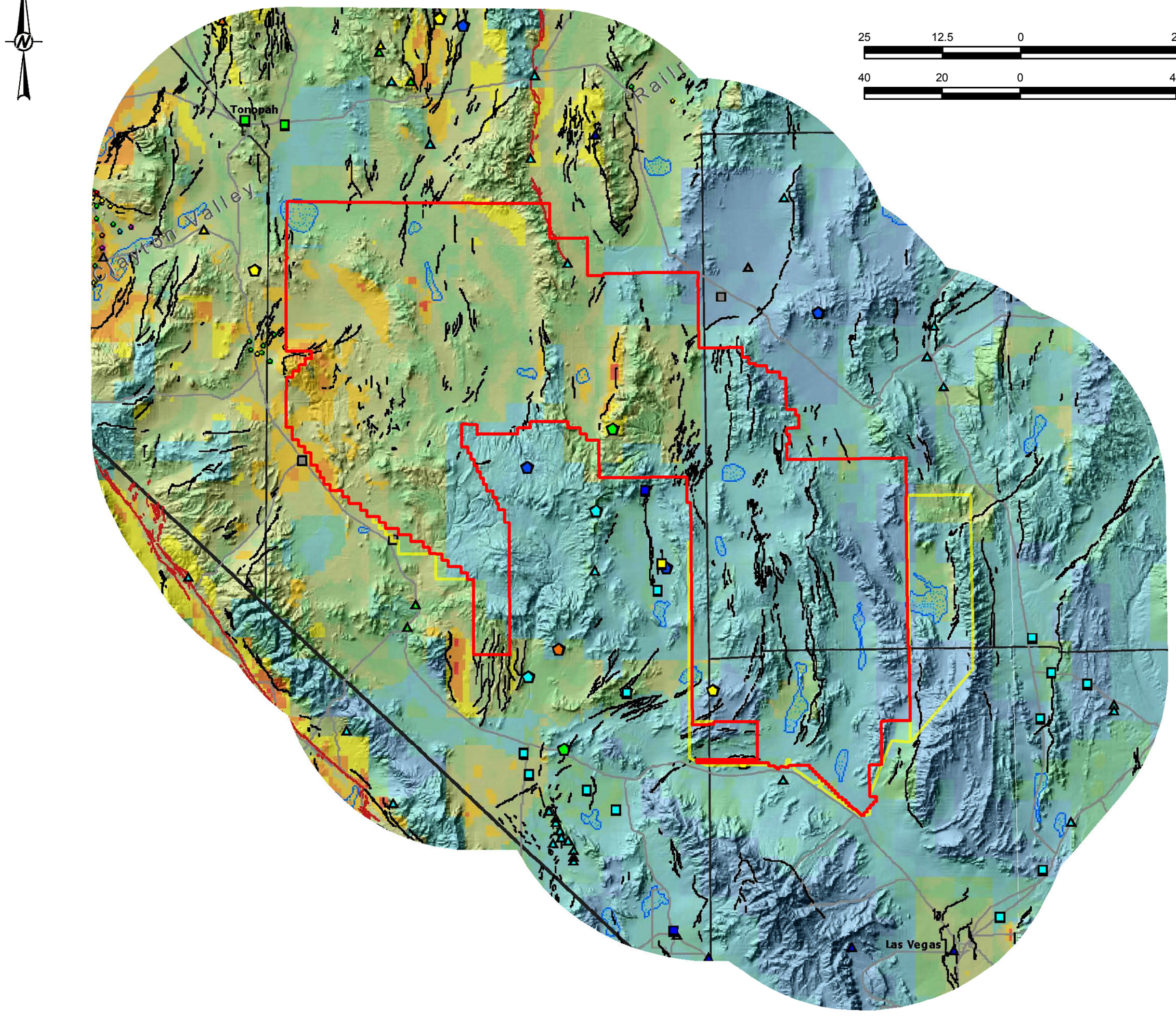


FIGURE 9.4
STUDY AREA GEOTHERMAL POTENTIAL

LEGEND

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

Roads

County Lines

State Lines

Quaternary Faults
- >0.3 mm/year displacement
- <0.3 mm/year displacement

Well Geothermometer (°C)
- >190
- 150 - 190
- 100 - 150
- 70 - 100
- 37 - 70
- 0 - 37
- Well >20° C with no geothermometer data

Spring Geothermometer (°C)
- >190
- 150 - 190
- 100 - 150
- 70 - 100
- 37 - 70
- 0 - 37
- Spring >20° C with no geothermometer data

Temperature Gradient (°C/km)
- >200
- 160 - 200
- 120 - 160
- 80 - 120
- 40 - 80
- 20 - 40
- 0 - 20
- No Data

Heat Flow Measurement (mW/m^2)
- >145
- 105 - 145
- 90 - 105
- 80 - 90
- 60 - 80
- 0 - 60

GEOTHERMAL POTENTIAL

Posterior Probability [1]
- 0.03
- 0.01 — Most favorable[2]
- 0.003 — Very favorable[2]
- 0.0014 — Favorable[2]
- 0.0003 — Marginally favorable[2]
- 0.0001
- 0.00003 — Permissive[3]
- 0.00001

Prior or average probability (the probability of finding a geothermal system by random chance without considering the evidence layers)

Increasing Favorability

[1] Posterior Probability: The probability of occurrence of a >150°C amagmatic geothermal system per 9-km^2 unit area after all evidence layers are considered. Error of estimation is equivalent to approximately two color rank boxes in the legend.

[2] Favorable: Areas with higher favorability rankings have better combinations of evidence indicative of geothermal activity, as determined by logistic regression statistics. The "Most Favorable" ranking is characterized by high gravity/topographic gradients, high strain rates, and high temperature gradients, whereas the "Permissive" ranking encompasses areas with low temperature gradients, low strain rates, and low gravity/topographic gradients.

[3] Permissive: All portions of the Great Basin are tectonically active to some degree and have an elevated potential for hosting a geothermal system compared with most of North America; consequently all portions of the Great Basin are considered at least permissive for high-temperature geothermal activity.

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NOTES

SOURCE:
COOLBAUGH, M. AND OTHER, 2005. GEOTHERMAL POTENTIAL MAP OF THE GREAT BASIN REGION, WESTERN UNITED STATES. NBMG MAP-151.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\General Report\Figures\Figure 9.4 Geothermal Potential Great Basin Study Area.mxd

Active faults are related to the crustal strain rate. The combined gravity and topography gradient maps are intended to identify unmapped active faults by sharp contrasts in gravity due to displacement of dense basement against relatively light unconsolidated sediments. Temperature gradient is a direct indicator of geothermal potential.

All portions of the Great Basin are tectonically active and have potential for hosting a geothermal system relative to the contiguous US. All locations within the Great Basin have some potential for geothermal systems; therefore, in the absence of physical evidence a rating of “permissive” is applied. Within the study area, the most favorable areas are in the North Range of the NTTR, where the strain rates and heat-flow gradients are greatest, where several localized areas are associated with specific well data.

Zehner and others (2009) categorized the geothermal potential of Nevada from low to high based on geological, geochemical, and thermal data. The preliminary geothermal potential map they compiled divided areas into four categories: 1) high local potential for geothermal systems greater than 150 ^{o}C, 2) regional potential for geothermal systems greater than 150 ^{o}C, 3) regional potential for geothermal systems greater than 100 ^{o}C, and 4) lower regional potential. The information used to develop the rankings included:

- Direct evidence in the form of well and spring data
- Geological or geophysical features known to be associated with geothermal activity including:
  - Felsic Quaternary volcanic rocks
  - Quaternary faults
  - Earthquake epicenters
  - High temperature gradients
  - High crustal strain rates.
- Proximity to known geothermal features

Figure 9.5, from Zehner and others (2009), illustrates the geothermal potential in and near the study area and includes local well and spring water temperature data. The majority of the study area is characterized as Lower Regional Potential. The remainder of the study area is characterized as having Regional Potential for geothermal systems with temperatures less than 100 ^{o}C, with a few areas in the North Range of the NTTR characterized as having the potential for geothermal systems warmer than 150 ^{o}C.

9.4 Current Assessment

The geothermal potential of the study area was reviewed based on the information discussed above. Table 9.1 lists sites of interest where geothermal characteristics have been documented. The following sections discuss the basis for geothermal favorability for local sites based on recent regional studies. They are listed in Table 9.1 and shown on Figure 9.3. In Section 9.5, geothermal potential of the study area is classified as per BLM classification system presented in Table 1.1.

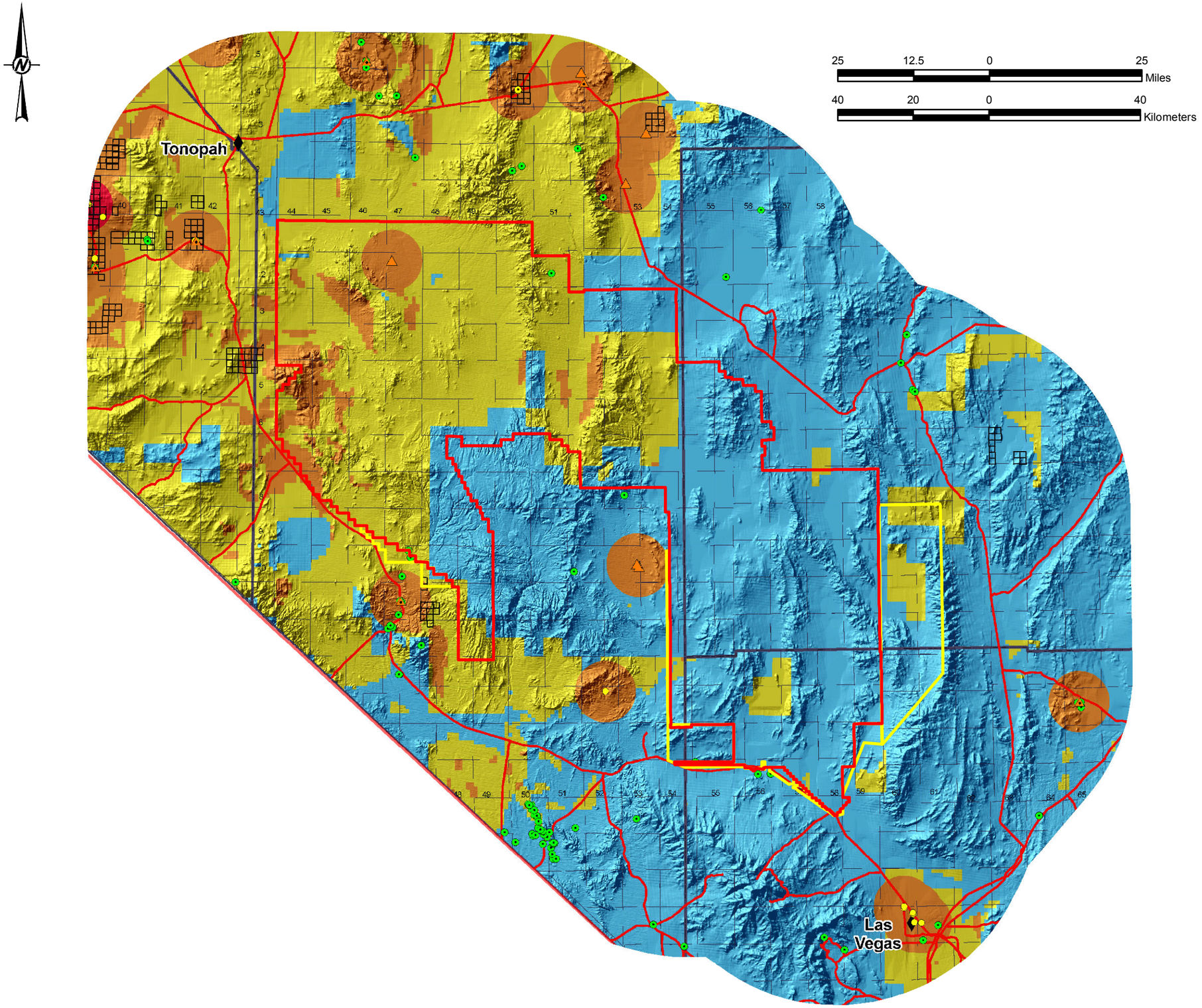


FIGURE 9.5
GEOTHERMAL POTENTIAL IN THE NTTR AND VICINITY

LEGEND

STUDY AREA

NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

GEOTHERMAL POTENTIAL

- High Local Potential for Geothermal Systems ≥150°C
- Regional Potential for Geothermal Systems ≥150°C
- Regional Potential for Geothermal Systems ≥100°C
- Lower Regional Potential

Actual Spring Temperatures
20° - 50°C

Actual Well Temperatures
92° - 150°C

Spring Geothermometer Temperature
150° - 236°C

Well Geothermometer
100° - 150°C

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SOURCE:
ZEHNER AND OTHERS, 2009 NBMG OPEN FILE REPORT 2009-10.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: \\1538787 NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 9.5 Geothermal Potential in the NTTR.mxd

3577 **Table 9.1: Data Summary for Geothermal Occurrences in the NTTR and Vicinity**

Location	Strain Rate [1]	Temp Gradient [2]	Geo-thermal Potential [3]	Geothermal Cluster [4]	Geothermal Site of Interest [5]	Well Temp (°C) (depth [m])	Spring Temp (°C)	Si Geo-thermometer (°C)	Structural Setting	Other Notes
Bailey-Hicks Burrell Hot Spring	Mod.	Mod.	Very Favorable	Beatty	Bailey-Hicks Burrell Hot Spring		42.8	80.4 (Chal) 109.7 (Q-no steam)	No mapped Active faults	Outside NTTR
Sarcobatus Flat	Mod.	High	Most Favorable	Sarcobatus Flat	Hot Well Sarcobatus Flat	42.2 (8.8) [6]		-	WL. Alluvial fans do not show recent offset. No Quaternary faults mapped.	Well temperature should be confirmed
Sarcobatus Flat	Mod.	High	Most Favorable	Sarcobatus Flat	NWIS Well 146 S08 E44 03BAAA1		21.5 [7]	-		
Sarcobatus Flat	Mod.	Mod.	Most Favorable	Sarcobatus Flat	Sarcobatus Warm Well	22.2 (ND)		-		
Sarcobatus Flat	Mod.	Mod.	Most Favorable	Sarcobatus Flat	Colson Pond	-	22.2	-	Margin of WL. On a N-S trend with Bailey Hicks-Burrell HS and WNW structural intersection.	
Crater Flat	Mod.	Mod.	Most Favorable	Crater Flat	Crater Flat Well 1	31 (213.4)				
Crater Flat	Mod.	Mod.-High	Most Favorable	Crater Flat	Specie Spring	-	22.5	82.6 (Chal) 111.7 (Q-no steam)	Holocene to late-Quaternary N-S faults	2010 BLM geothermal lease. Outside NTTR.
Crater Flat	Mod.	Mod.-High	Most Favorable	Crater Flat	USW Well VH-2	33 (1219.5)		40.3 (Si)		

3578

Table 9.1: Data Summary for Geothermal Occurrences in the NTTR and Vicinity (continued)

Location	Strain Rate [1]	Temp Gradient [2]	Geo-thermal Potential [3]	Geothermal Cluster [4]	Geothermal Site of Interest [5]	Well Temp (°C) (depth [m])	Spring Temp (°C)	Si Geo-thermometer (°C)	Structural Setting	Other Notes
Yucca Mountain	Low	Mod.	Favorable	Yucca Mtn	USW Well H-6 HTH USW Well UE-25c 3 HTH USW Well G-2	37.8 (552) 38.3 (914) 34.2 (ND)	-	69.8 (Chal) 73.9 (Chal) 72.9 (Chal)	late Pleistocene and Holocene N-S normal faults	Partly outside NTTR
Sand Spring Valley	Low	Mod.	Permissive	Sand Spring Valley	Sand Spring	-	30	-		Warm springs outside NAFR
Sand Spring Valley	Low	Mod.	Permissive	Sand Spring Valley	NJ Gunderson Well	28.3 (73)		111.7 (Chal) 138.3 (Q-no steam)	Wells are in Valley bottom. Holocene to late Pleistocene faults along range front east and south	Target may be at step-over faults along range front; outside NTTR
Cactus Flat	Mod.	High	Favorable	Cactus Flat	NWIS Well 149 S02E47 07AA1	-	25	90.4 (chal) 118.9 (Q-no steam)	Late-Quaternary faults. Stepover and splay on fault system north of the well	High heat-flow well 4.5 km northeast
Cactus Flat	Mod.	High	Favorable	Cactus Flat	NWIS Well 148 S01 E47 15 1	-	17.5	88.1 (Chal) 116.7 (Q-no steam)		
Stonewall Mountain	Med.	Med.	Very Favorable	Near Goldfield	NV-03073 NV06508	17.8 (21.3) 23.1 (100)	-	-	Relay Ramp on Quaternary faults	Warm gradient hole
Cedar Pass	Low	Mod.	Very Favorable	Cactus Flat	Cedar Pass Water Well	26.7 (260.3)		104.7 (Chal) 132.0 (Q-no steam)	No mapped recent faulting	Warm well (Penfield, 2010) USAF Well TTR

3581 **Table 9.1: Data Summary for Geothermal Occurrences in the NTTR and Vicinity (continued)**

Location	Strain Rate [1]	Temp Gradient [2]	Geo-thermal Potential [3]	Geothermal Cluster [4]	Geothermal Site of Interest [5]	Well Temp (°C) (depth [m])	Spring Temp (°C)	Si Geo-thermometer (°C)	Structural Setting	Other Notes
Cedar Springs	Low	Mod.	Very Favorable	Reveille	NV-06511		25	58.7 (Silica)	Late Pleistocene fault terminus. Distinct north-northwest range front. E-W lineament. NE Quaternary faults.	High gradient well (NV-06511) approximately 10 km south of spring. Geothermal lease 18 km north of well outside NTTR. Warm spring at Pedro Spring 18 km north of well along same range front system.
Belted Range	Low	Med.	Very Favorable		NV_TEC22 AMAX Data U-12t03 UG-2 Spring	17.2 (100)		97.9 (Chal) 125.8 (Q-no steam)	NE Lineament intersection with range front at step-over	High geo-thermometer
White Sage Gap	Low	Low	Marginally Favorable	-	-	-	-	ND		Reference to occurrence of Travertine in 1993 Assessment of East DNWR
Yucca Flat	Low	Low	Marginally Favorable	Yucca Flat	Climax Seep	-	41.5	25.2 (Chal) 57.4 (Q-no steam)		Partially Outside NTTR; inspect to determine whether spring temp is valid
Yucca Flat	Low	Low	Marginally Favorable	Yucca Flat	Test Well C 79-69A	37.2 (519)	-	48.1 (Chal) 79.4 (Q-no steam)		Outside NTTR

3582

Table 9.1: Data Summary for Geothermal Occurrences in the NTTR and Vicinity (continued)

Location	Strain Rate [1]	Temp Gradient [2]	Geo-thermal Potential [3]	Geothermal Cluster [4]	Geothermal Site of Interest [5]	Well Temp (°C) (depth [m])	Spring Temp (°C)	Si Geo-thermometer (°C)	Structural Setting	Other Notes
Yucca Flat	Low	Low	Marginally Favorable	Yucca Flat	USW Test Well E 84-69	42.2 (572)	-	82.1 (Chal) 111.3 (Q-no steam)		Outside NTTR
Yucca Flat	Low	Low	Marginally Favorable	Yucca Flat	USW Well U - 3cn PS-2	35.2 (ND)	-	73.9 (Chal) 103.6 (Q-no steam)		In the center of test crater; outside NTTR
Groom Lake			Marginally Favorable to Highly Favorable			-	-	ND	Area of numerous NNE late Pleistocene to Holocene, en echelon faults	Near Climax Seep
Indian Springs Valley	Low	Mod.	Permissive	Indian Springs	Test Well 10	-	27.2	20.5 (Chal) 53.0 (Q-no steam)		
Indian Springs Valley	Low	Mod.	Permissive	Indian Springs	Indian Springs Valley	-	26.1	25.2 (Chal) 57.4 (Q-no steam)		
Frenchman Flat	Low	Mod.-High	Very Favorable	Frenchman Flat	USW Test Well F	64.5 (1005.8)	-	58.6 (Chal) 89.4 (Q-no steam)		Outside NTTR
Frenchman Flat	Low	Low	Marginally Favorable	Frenchman Flat	Test Well 75-73	37.8 (14)	-	36.8 (Chal) 70.4 (Q-no steam)		

Notes:
1 - Kreemer and others, 2012
2 - Blackwell and Richards, 2004
3 - Coolbaugh and others, 2005
4 - Penfield and others, 2010
5 - NBMG geothermal database www.unr.edu/geothermal/geochemDB.htm
6 - Malmberg and Eakin, 1962
7 - Desert Research Institute, 1973
ND = No Data, Unknown depth; Chal = chalcedony geothermometer; Q-no steam = quartz, no steam geothermometer; Silica = silica geothermometer

The work required to quantitatively identify geothermal resources, which would include detailed geologic mapping, geophysical surveys, temperature probe surveys, and subsurface investigation, is outside the scope of a mineral and energy resource assessment. Access restrictions to the NTTR and East DNWR also preclude conducting detailed field investigations.

9.4.1 Sarcobatus Flat/Beatty

Sarcobatus Flat, a northwest trending feature along the southwest boundary of the NTTR, is partially inside in the EC South area, and is nearly continuous with the Beatty geothermal cluster (Figure 9.3). The Sarcobatus Flat and Beatty areas are previously identified geothermal clusters. The 1998 Assessment (Tingley and others, 1998) discusses Sarcobatus Flat as an area just outside the NTTR with five wells with groundwater temperatures of 22 to 24 °C. One data source (Garside and Schilling, 1979) lists a 42.2 ºC temperature from a well with a legal description “NE1/4 S20 T9S, R46E.” The reference cited for this 42.2 ºC well temperature was CWRR (1973). Garside and Schilling (1979) list another well temperature, within the same township, range, and quarter section designation, with a 22.2 °C temperature with a reference of Mamlberg and Eakin, 1962 The reported temperature of 22.2 ºC would be consistent with other wells in the Sarcobatus Flat area. The NBMG 2014 EQ_All0712_DBwchemSpringData database designates the well at this same location as “Hot Well Sarcobatus Flat” and lists a 42.2 ºC temperature for May 25, 1957, and January 1, 1986. It is uncertain whether the 42.2 ºC well temperature has been verified by any additional testing or whether a data error in the CWRR (1973) database was carried through in subsequent databases. The well is in an alluvial fan where there is no evidence of Quaternary or recent faults.

The Sarcobatus Flat and Beatty area is along the margin of the WL, where the strain rates and temperature gradients are moderate but higher than most of the rest of the NTTR. Faulds and Hinz (2015) recognized areas of extensional and transtensional strain, particularly directly northeast of the dextral shear zone of the WL, to be favorable for geothermal systems. The Beatty area is a known geothermal area with the Bailey Hicks-Burrell Hot Spring Spa (Figure 9.3).

The Beatty area is generally south of the NTTR but there is a north-south trend from the Bailey Hicks Hot Spring 11.5 km outside the existing NTTR boundaries, where spring temperatures up to 43.3 °C have been recorded, to the Burrell Hot Springs (38 ºC), to Colson Pond (22.2 ºC) which is immediately adjacent to the EC South area on the southwest side of the NTTR. At Colson Pond fault, a north-to-south trending lineament from the Bailey-Hicks hot spring and Burrel warm springs intersects northwest trending structures of the WL.

The investigation of the Colson Ponds area did not reveal the location of the spring feeding the ponds; consequently, it is assumed that the springs feeding the ponds upwell directly into the ponds such that it is not currently recognizable. Field parameters of the pond (not the spring vent) were recorded as a pH of 8.7, specific conductance of 705 microSiemens per centimeter (uS/cm), and a temperature of 25 ºC. Water

discharges from the ponds at approximately 100 gallons per minute (gpm), presumably this is approximately the same inflow rate from the spring(s) upwelling into the ponds.

The highest geothermometer temperature at Bailey Hicks-Burrell Hot Springs is 80.4 º C for the chalcedony geothermometer. Coolbaugh and others (2005) rated the site as most favorable for geothermal resources, although high temperature waters have a low probability of occurrence based on geothermometry.

The Bailey Hicks-Burrell Hot Spring area was investigated on September 12, 2016. Three spring vents were observed. Two were developed as pools for soaking and one discharged immediately south of the developed springs. Field parameters indicated the following:

- Flowrates of approximately 5 to 10 gpm
- Temperatures from 41.2 to 41.6 ºC
- pH range from 7.4 to 7.6
- Specific conductance from 740 to 831 uS/cm

9.4.2 Crater Flat

Crater Flat is outside the study area (Figure 9.3). It is in an area of relatively high strain rate, moderately high heat flow and has a most favorable geothermal potential ranking by Coolbaugh and others (2005). Specie Spring has a temperature of 22.5 ºC, a chalcedony geothermometer temperature of 82.6 ºC, and a quartz (no steam) geothermometer of 111.7 ºC. Well water temperatures of 31 ºC (at a depth of 213.4 m) and 33 ºC (at a depth of 1219.5 m) are indicative of slightly thermal to nonthermal temperatures. Apart from the cooler 22.5 ºC spring water, well water data are narrowly distributed over a 30.5 to 35.5 ºC range. The structural setting includes moderate strain rates, north-to-south Holocene and Quaternary faults with numerous Holocene fault offsets and basaltic cinder cones throughout the piedmont slopes. Crater Flat may have formed through volcanic caldera eruptions, detachment faulting, or graben faulting. A geothermal lease was taken out at Crater Flat in 2007.

9.4.3 Yucca Mountain

Yucca Mountain is at the southeastern tip of the North Range of the NTTR (Figure 9.3). Of 13 wells measured at Yucca Mountain, 6 are hot (37.2 to 41.7 ºC) and 7 are warm (26.1 to 34.2 ºC). The thermal anomaly encompasses Busted Butte and Jackass Flat east of Yucca Mountain, as well as Crater Flat to the west. The reservoir temperature, as estimated by geothermometry, is moderate: chalcedony-based calculations produced 73.4 ± 6.5 ºC. Strain rates are moderate, the temperature gradient is moderate to high, and the area is considered favorable for geothermal resources (Coolbaugh and others, 2005).

The geology of Yucca Mountain is predominantly volcanic with over 1,000 m of silicic volcanic tuff, underlain by Paleozoic sedimentary rocks (NBMG, 2016). Yucca Mountain lies within a faulted, 25-km-wide Neogene

graben bounded on the west by the Bare Mountain fault and on the east by a normal fault. Small basalt flows and cinder cones erupted in Crater Flat, west of Yucca Mountain, as recently as 80,000 years ago.

The Agency for Nuclear Projects (1997) concluded that the potential for exploitable geothermal resources is low. There are no hot or warm springs in the area, and the geothermal gradient measured in wells suggests that high-temperature water is unlikely at economically feasible production depths. However, there is evidence of historical geothermal activity on and under Yucca Mountain; therefore, some exploration potential exists in the area.

9.4.4 Cactus Flat

The Cactus Flat geothermal cluster is partially within the NTTR boundary, generally covering a broad alluvial valley extending from east of Cactus Peak, to the Kawich Range (Figure 1.3 and Figure 9.3). Data are sparse but borehole and spring water data indicate a thermal anomaly, or perhaps multiple individual anomalies. Near Mellan Mountain, the Cedar Pass water well had a well temperature of 26.7 ºC and a silica geothermometer temperature of 104.7 ºC.

Near Cactus Peak, a well temperature of 25 ºC and a chalcedony geothermometer temperature of 90.4 ºC was recorded at NWIS Well 149. Approximately 12 km northeast of this well, at well NV-06512, a high (suspect) heat flow value of 154 mW/m^2 was recorded. The well is on a north-northeast trending Quaternary fault with a step-over and a splay north of the well.

Coyote Hole Spring, within the Cactus Flat geothermal cluster, is approximately 16 km north of the NTTR boundary (Figure 9.3). The water was recorded at 29.4 ºC with a quartz geothermometer temperature of 72.0 ºC.

Strain rates are low at Cactus Flat, while the temperature gradient is high, and the geothermal potential is rated as favorable (Coolbaugh and others, 2005). The favorability of the Cactus Flat area is based primarily on the relatively high geothermometry temperatures.

9.4.5 Sand Spring Valley

The Sand Spring Valley geothermal cluster is approximately 10 km northeast of the northeast boundary of the NTTR (Figure 9.3). The area has low strain rates, moderate temperature gradient, and the lowest geothermal potential rating of permissive (Coolbaugh and others, 2005). However, the water temperature at Sand Spring was 30 ºC and was one of the higher spring temperatures near the NTTR. The NJ Gunderson well had a temperature of 28.3 °C at a depth of 73 m, corresponding to an approximate surface temperature of 26.5 ºC, and would be considered thermal. The chalcedony geothermometer for the NJ Gunderson well is relatively high, 111.7 ºC. Potential extension of the geothermal trend to the southwest could offer some exploration potential within the NTTR. Along the north side of Chalk Mountain, northeast

trending mapped Quaternary faults have step-overs and relay ramps that represent potential structural targets.

9.4.6 Stonewall Mountain

Stonewall Mountain is in the northwest corner of the North Range (Figure 9.3). It is east of the Goldfield geothermal cluster in an area of moderate strain rate and thermal gradient and is rated Very Favorable geothermal potential by Coolbaugh and others (2005) (Figure 9.5). Northeast Quaternary faults are present along a distinct linear north boundary of the Stonewall Mountains and extending to the northeast, south of Mud Lake. The faults have a number of step-overs and relay ramps that could provide favorable structural settings. Heat flow wells have temperatures up to 23.1 ºC at a depth of 100 m and would only be marginally thermal. They are listed as warm gradient holes.

As part of the current assessment, two areas with range front fault step-overs on the north side of the Stonewall Mountain range were field checked. The first field check focused on faults along the lower reaches of the range in an area due south of the Stonewall Flat and Mud Lake. The second field check focused on Holocene range front faults covered by alluvium near the mouth of Pack Rat and Civet Cat Canyons. No surface evidence of geothermal activity (i.e., spring mounds or sinter deposits) were noted in either area.

9.4.7 Cedar Springs

Cedar Spring is at the south end of the Reveille geothermal cluster (Figure 9.3) that extends north, outside of the NTTR boundaries, to thermal springs at Pedro Spring (25 ºC) and Reveille Mill spring (28.9 ºC). A BLM geothermal lease was taken out east of Pedro and Reveille Mill springs in 2010. Cedar Spring is inside the NTTR at the southern end of a mapped Quaternary range front fault. The silica geothermometer temperature was 58.7 ºC. A high gradient heat flow well (NV-06511) is present approximately 10 km south of Cedar Spring.

The Cedar Springs area was field checked as part of the current assessment. Cedar and Sumner Spring, as well as the area between these springs, were checked, as they are both correlated to a northwest trending range front fault. Both springs were developed by ranchers to deliver water miles away from the spring vents. Cedar Springs consisted of two approximately 10 m-deep stilling wells constructed of 3-meter-diameter corrugated steel tubing, spaced approximately 15 m apart. Water collected from these stilling wells was not accessible for observation at the stilling wells; however, a break in the aqueduct pipe approximately 15 m downgradient of the lowermost stilling well was discharging approximately 5 gpm. Field parameters were as follows: pH = 7.7, specific conductance = 494 uS/cm, and a temperature of 20.0 º C.

Sumner Springs consisted of two approximately 10-m-deep stilling wells, separated by approximately 15 meters, and constructed of 1.2-m diameter corrugated steel pipe. Field personnel used a bailer to collect

a water sample from the uppermost stilling well. The discharge was estimated to be 5 to 10 gpm and the depth to water was approximately 8.5 m. A water sample collected via a bailer had the following field parameters: pH = 7.56, specific conductance = 531 uS/cm, and a temperature of 16.9ºC.

No sinter deposits or paleo spring mounds were noted in the area.

9.4.8 Belted Range/Limestone Ridge

The Limestone Ridge area was field checked as part of the current assessment. It is not part of a geothermal cluster but has a moderate temperature gradient and is rated as Favorable for geothermal resources (Coolbaugh and others, 2005) (Figure 9.5). The structural setting includes the intersection of a northeast lineament with a north-south range front fault with a step over. No evidence of geothermal activity was noted.

9.4.9 White Sage Gap

White Sage Gap is not part of a known geothermal cluster. However, based on mention of a travertine spring deposit reported by Tingley and others (1993), the area was field checked for this assessment. White Sage Gap is inside the South Range of the NTTR and was reported to be associated with a structure known as the Prospector Fault (Guth and others, 1988). Sinter deposits or morphologic features suggesting a paleo spring mound and possible geothermal springs were not observed. However; very white/bleached limestone units (part of the Cambrian Bonanza King FM) that may have been misidentified as travertine/sinter deposits were identified.

9.4.10 Yucca Flat/Climax Seep

Climax Seep is in the NNSS a few kilometers south of the boundary of the NTTR within the Yucca Flat geothermal cluster (Figure 9.3). The NBMG database lists a measured temperature of 41.5 ºC and cites a date of March 7, 1978, referencing Garside (1994) who lists the WATSTORE database as the source. The relatively high temperature was not confirmed by any other data source, and is thus somewhat suspect (Tingley and others, 1998). The chalcedony geothermometer has a low temperature of 25.2 °C which may cast further doubts on the reliability of the seep data.

Wells within the Yucca Flat cluster have quartz (no steam) geothermometers of up to 111 ºC. The Yucca Flat area is considered Marginally Favorable for geothermal resources (Coolbaugh and others, 2005).

9.4.11 Groom Lake

Groom Lake is not part of a geothermal cluster and there are little data available for the site. It is rated as Marginally Favorable for geothermal resources due to the presence of north-northeast trending late Pleistocene to Holocene en echelon normal faults

9.4.12 Indian Springs

The Indian Springs geothermal cluster is south of and partially within the South Range of the NTTR, in the 64C/D and 65D area (Figure 9.3). Widespread warm spring temperatures range from 26.1 to 27.5 °C. Geothermometer temperatures are 20.5 to 25.3 °C. Coolbaugh and others (2005) assigned the site the lowest favorability ranking of permissive.

9.4.13 Frenchman Flat

The Frenchman Flat geothermal cluster is primarily outside the NTTR and within NNSS. The eastern end of Frenchman Flat is within the South Range of the NTTR (Figure 9.3). A well (Test Well 75-73) has a temperature of 37.8 ºC at a depth of 564.8 m. Applying a gradient of 25 ºC/km the corresponding surface temperature would be 23.7 ºC, which would be considered slightly thermal.

9.4.14 Goldfield Geothermal Clusters

The Goldfields geothermal cluster is outside the NTTR boundary, but is near the northwest corner of the North Range (Figure 9.3). NBMG (2011) reported that hot water was encountered below 300 m in the Big Divide Mine during the 1920s. However, other well data in the area indicate only slightly warm water.

9.5 Geothermal Potential Summary

9.5.1 NTTR Update

In general, the NTTR has relatively low potential for high temperature geothermal resources. The known near-surface thermal waters within the existing NTTR boundaries have temperatures that are too low for most practical applications. The heat flow and strain rates within the NTTR are relatively low compared to the rest of the Great Basin. The highest well temperature recorded near the NTTR is 64.5 ºC at a depth of 1 km in Frenchman Flat. Highest temperatures at depths of 3 to 4 km would be expected to be less than 150 ºC based on the available geothermometry data. If a blind geothermal system were to be discovered, the temperature would most likely be too low for power generation, but could be suitable for direct uses such as heating, greenhouses, or other direct industrial uses.

There are no known recent silicic intrusive bodies in the NTTR that would provide shallow magmatic geothermal potential. The potential for deep stratigraphic geothermal potential in the carbonate basement rocks of the South Range is considered to be low due to the relatively low heat flow in this part of the Great Basin. Therefore, the potential for deep stratigraphic reservoir geothermal potential is considered to be low in the NTTR.

Within the existing boundaries of the NTTR, Tingley and others (1998) determined the potential for moderate- and high-temperature geothermal systems to be low, certainty level C. Data compilations and regional studies published after the 1998 Assessment suggest that no change to the geothermal resource potential ranking of the NTTR is warranted.

9.5.2 Proposed Expansion Areas

9.5.2.1 Alternative 3A – the EC South Area

Based on the presence of the Beatty area geothermal cluster, and an existing direct use at the Bailey Hicks Hot Spring, there is a moderate potential, certainty level B, for low temperature geothermal systems capable of supporting direct-use applications in the EC South area. The potential for high temperature geothermal resources in the EC South area is considered low, certainty level C.

9.5.2.2 Alternative 3B – the 64C/D and 65D Area and Administrative Incorporation Area

The 64C/D and 65D and the Administrative Incorporation Areas are underlain by the Paleozoic sedimentary rocks that underlie most of the South Range of the NTTR and the East DNWR. For the reasons cited for the greater NTTR, the potential for high-temperature geothermal resources in the 64C/D and 65D and Administrative Incorporation area is considered low, certainty level C. There are a few occurrences of low-temperature thermal waters near the 64C/D and 65D area. As such, there is a low potential, certainty level B, for geothermal resources for direct uses such as spas, building heating, and other low-temperature uses.

9.5.2.3 Alternative 3C – the Alamo Area

Muntean and others (2014) updated the 1993 geothermal assessment of the East DNWR based on the data compilations and regional studies discussed in Section 9.3 for the NTTR and vicinity. Deep stratigraphic reservoirs and structurally controlled systems were addressed. It was concluded that there is a low potential for high-temperature geothermal systems, certainty level C, within the East DNWR and the Alamo area. There are a few occurrences of low-temperature thermal waters near the Alamo area. As such, there is a low potential, certainty level B, for direct-use geothermal resources that could be used for spas, building heating, and other low-temperature uses.

10.0 COMPREHENSIVE INDUSTRIAL MINERALS RESOURCE POTENTIAL

The 1993 Assessment and 1998 Assessment of the NTTR and East DNWR (Tingley and others, 1993, 1998) included comprehensive evaluations of industrial minerals and construction materials within the existing boundaries of the NTTR and portions of the proposed Alternative 3 expansion areas. There is widespread potential for aggregate, limestone, and dolomite within the study area. These are important commodities for the construction industry in the Las Vegas metropolitan area, and a discussion of their availability outside the study area is included in this section. There is the potential for other materials of industrial importance to occur within the study area. Pressure to exploit these resources is affected by their location relative to a market and transportation costs, and readily available off-range domestic resources and inexpensive imports. This section provides a discussion of these issues and presents industrial mineral potential maps.

10.1 Overview of Industrial Mineral Deposits in the NTTR and Vicinity

Table 10.1 summarizes information on industrial mineral deposits identified during the 1998 study. Figure 10.1 illustrates the industrial mineral deposits and prospects identified within the existing NTTR boundaries in previous assessments.

Table 10.1: Identified Industrial Mineral Deposits in and near the NTTR and Vicinity

Deposit Number	Deposit Name	Description
1	Desert Range Slate [1]	Green-grey flagstone composed of phyllitic siltstone
2	Pahute Mesa Clay [2]	Montmorillonite clay in altered welded tuff
3	Sarcobatus Flat Clay [2]	Montmorillonite clay in altered ash-flow tuff, high swell potential
4	Tonopah Test Range Sand and Gravel [2]	Sand and gravel used for base fill and concrete aggregate; high fines content and poor sulfate soundness limit its potential value
5	Sleeping Butte Volcanic Cinders [2]	Basaltic scoria, remote from market
6	Little Black Peak Cinders [2]	Basaltic scoria, remote from market
7	Tolicha Wash Perlite [2]	Potential resource with few impurities, but exposed in steep slopes, overburden removal required
8	Tufa Limestone [2]	Potential for 100 million tons of cement limestone reported, possible source of high calcium limestone
9	Little Black Peak Fluorspar [2]	Up to 20 percent fluorite observed in hand sample, deposit not extensive based on surface observation
10	Limestone Ridge Fluorspar [2]	Up to 60 percent fluorite observed in breccia sample, deposit not extensive based on surface observation
11	Sugar Quarry Quartzite [3]	Quarry in Eureka Quartzite, west of the 64C/D and 65D area

Notes:
1 - Source: Tingley and others, 1993
2 - Source: Tingley and others, 1998
3 - Located outside the study area

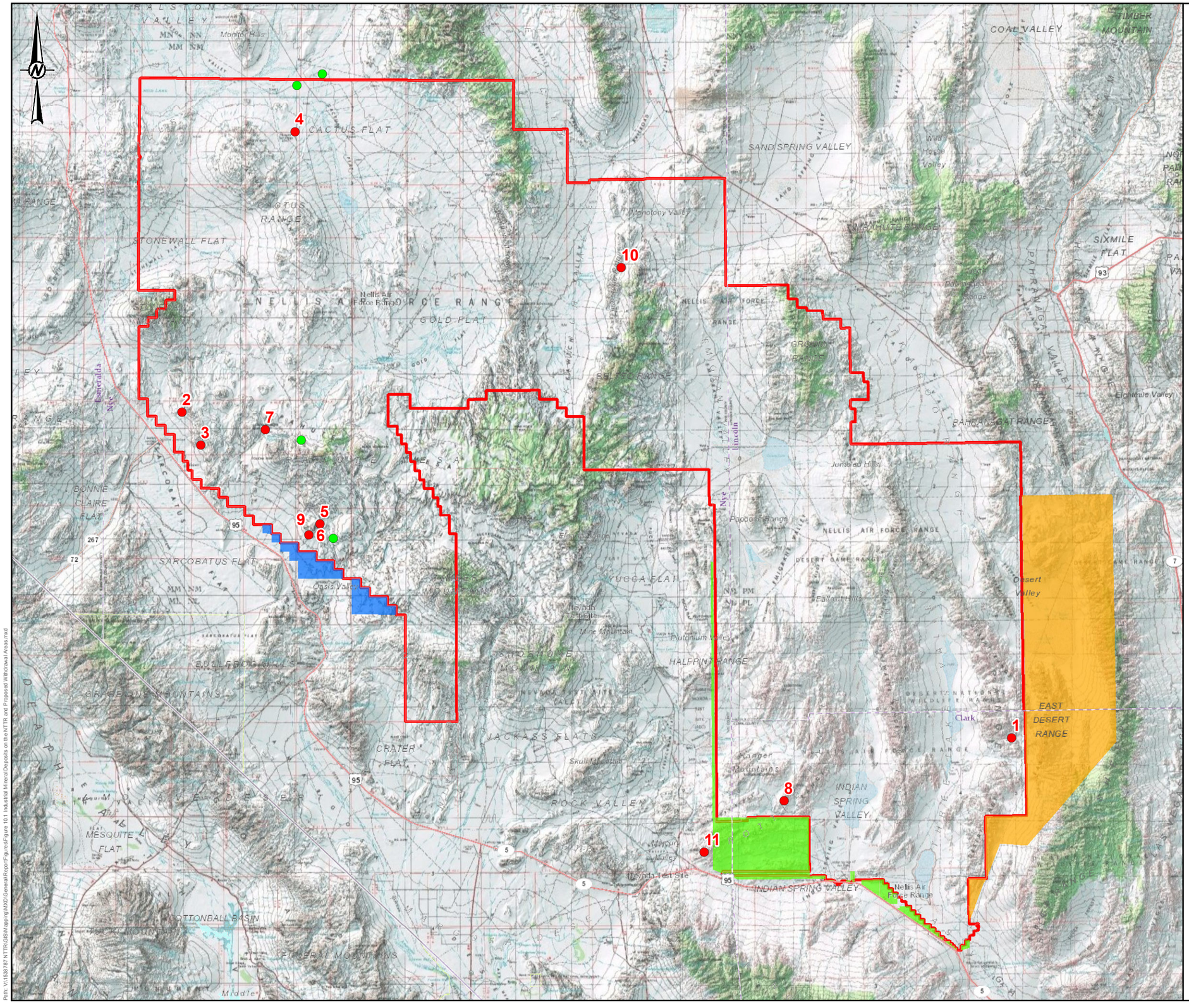


FIGURE 10.1
INDUSTRIAL MINERAL DEPOSITS ON THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

INDUSTRIAL MINERAL DEPOSITS

- SAND AND GRAVEL BORROW PIT
- 1 DESERT RANGE SLATE
- 2 PAHUTE MESA CLAY
- 3 SARCOBATUS FLAT CLAY
- 4 TTR AIRPORT SAND AND GRAVEL
- 5 SLEEPING BUTTE VOLCANIC CINDERS
- 6 LITTLE BLACK PEAK VOLCANIC CINDERS
- 7 TOLICHA WASH PERILITE
- 8 TUFA LIMESTONE
- 9 LITTLE BLACK PEAK FLUORSPAR
- 10 LIMESTONE RIDGE FLUORSPAR
- 11 SUGAR QUARTZITE/SILICA

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, MODIFIED FROM 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED
SOURCES: ESRI, DELORME, USGS, NPS

CLIENT
LEIDOS, INC.

PROJECT
NEVADA TEST AND TRAINING RANGE
MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	10.1

Path: V:\1538787.NTTR\GIS\Mapping\MXD\General\Report\Figures\Figure 10.1 Industrial Mineral Deposits on the NTTR and Proposed Withdrawal Areas.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

10.2 Sand and Gravel

Aggregate is produced from natural deposits of sand and gravel, and from selected quarried materials that are mined and processed to meet material gradation requirements. In the Las Vegas area, the majority of the aggregate operations exploit alluvial fan deposits. The materials are recovered from borrow pits by open-pit methods and processed by washing, screening, and crushing to produce saleable products. Siliceous and altered volcanic rocks are likely to be unsuitable for use as aggregate due to a lack of durability and/or, the potential for alkali-silica reactions when used as concrete aggregate. In the Las Vegas area, alluvial deposits derived from the erosion of carbonate rock highlands are preferred (Tingley and others, 1998). Carbonate rocks are abundant in the South Range of the NTTR and in the East DNWR, as are the sand and gravel deposits derived from these rocks. These materials are relatively inexpensive and require sources relatively close to markets to be economically viable.

Davis (2014) reported that 63 percent of the construction aggregate produced in the Las Vegas area in 2013 was from sand and gravel operations. Lesser amounts of construction aggregate are produced in quarry operations that require drilling, blasting, crushing, and screening to produce saleable products. Again, carbonate rocks are a common source of quarried aggregate; however, rhyolite and volcanic cinders are of value for lightweight aggregate, and basalt is of value for use in asphaltic concrete. Where quarried materials possess specialized properties or can be mined at low cost, they can fetch higher prices and may support the added cost of shipping from source locations to more distant markets.

As noted in the previous assessments, aggregate derived from on-range sources would require transport into the high-demand Las Vegas area, where the majority of aggregate produced in Nevada is currently consumed. Under present conditions, the exploitation of on-range aggregate resources is likely to be economically infeasible. At present there is no pressure to exploit on-range resources but this could change due to a number of factors, including:

- Urban encroachment near the NTTR and development along Highways 93 and 95
- Residential encroachment in existing sand and gravel and quarry resource areas, rendering those deposits unavailable for mining
- Political and regulatory limitations on the exploitation of Las Vegas area public lands containing resources.
- Construction of a railway line to the NNSS waste repository, which could significantly reduce transportation costs

Davis (2014) estimated 13.4 million tons of aggregate were produced in the Las Vegas area in 2013. Statewide demand for aggregate peaked at 48 million tons in 2007 and declined to approximately 22 million tons in 2014; the reduction was in response to the collapse of the housing market and the recession. The 1998 Assessment (Tingley and others, 1998) projected the annual demand for aggregate in the Las Vegas area to increase to 74 million tons by the year 2020. Clearly, economic conditions have changed since this

projection was made. Muntean and others (2014) noted that sand and gravel deposits and rock suitable for use as construction aggregate are common in the Las Vegas area, are already being mined and are adequate for the foreseeable future.

10.2.1 Potential for Sand and Gravel

10.2.1.1 NTTR Update

Figure 10.2 shows areas with high and moderate potential for sand and gravel deposits within the NTTR and expansion areas. Tingley and others (1998) noted moderate potential for sand and gravel, and certainty level B exists in the North Range of the NTTR; however, the widespread presence of altered volcanic rocks reduces the potential for suitable materials that can meet durability and stability requirements. Several small sand and gravel pits occur within the North Range. These local sand and gravel deposits could potentially support on-range construction activities, as they have in the past, when demand was relatively low.

The potential for sand and gravel deposits in the South Range of the NTTR is considered high, certainty level B, based on the presence of carbonate rocks and associated alluvial deposits that are the similar to those current being exploited in the Las Vegas area.

10.2.1.2 Alternative 3A – the EC South Area

Alluvial materials in the the EC South area are derived from the weathering of volcanic rocks and are less likely to be suitable for use as construction aggregate. The EC South area is considered to have a low potential, certainty level B, for sand and gravel deposits.

10.2.1.3 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Areas

In general, the highest potential for sand and gravel deposits of suitable quality lies adjacent to areas of Paleozoic carbonate rocks, which outcrop in the 64C/D and 65D area. Paleozoic carbonate units exposed in the South Range locally extend into the area north of Highway 95 near Indian Springs. The Administrative Incorporation Area is underlain by Quaternary alluvium and playa sediments.

10.2.1.4 Alternative 3C – the Alamo Area

Paleozoic carbonate rocks outcrop extensively in the Alamo area. The Alamo area is considered to have a high potential, certainty level B, for sand and gravel deposits suitable for use as construction aggregate.

10.2.2 Potential for Quarried Aggregate

As noted above, preferred bedrock source rocks for construction aggregate consist of carbonate rocks, and where these rocks outcrop there is moderate potential, certainty level B, for materials suitable for quarried aggregate production.

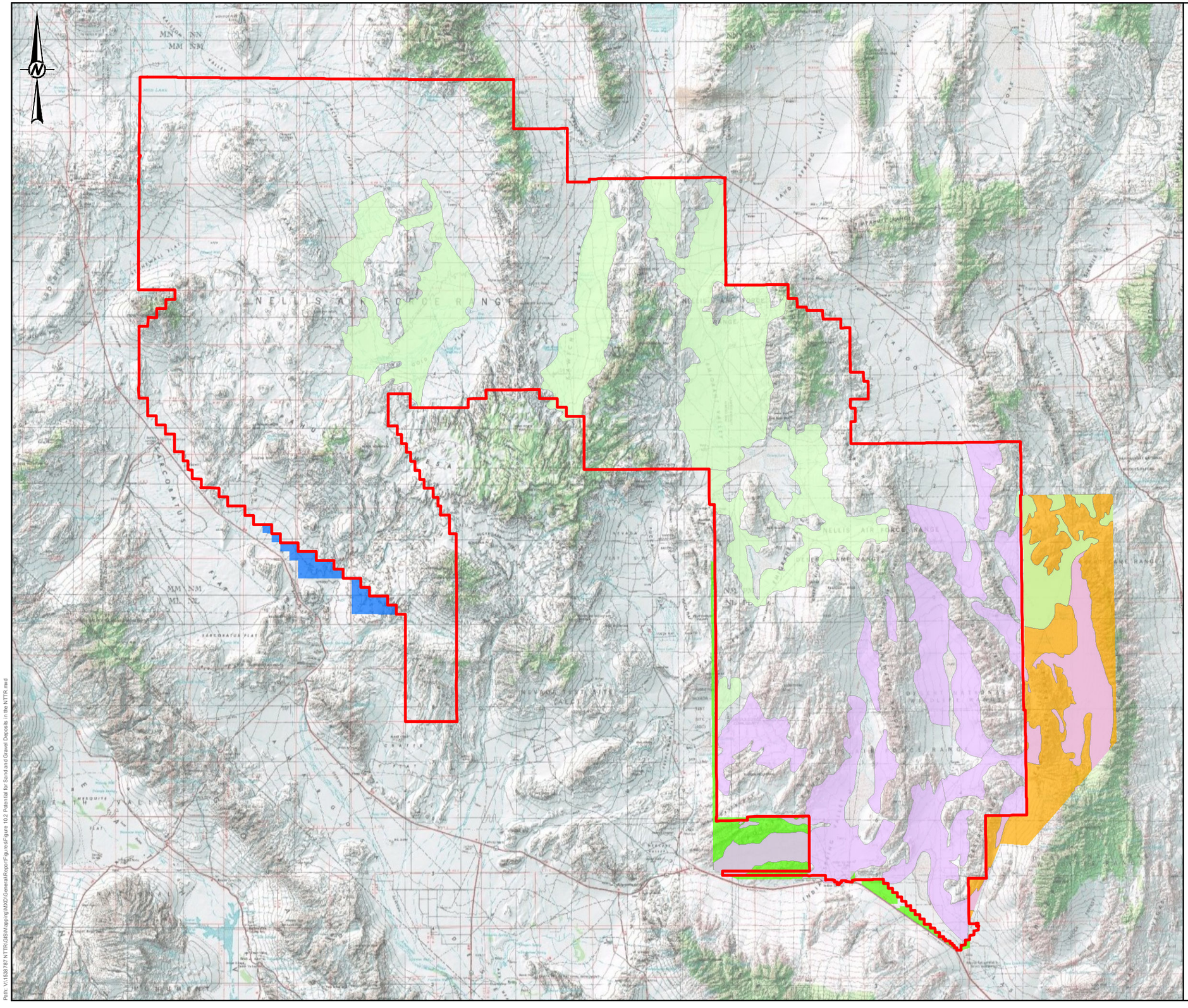


FIGURE 10.2
POTENTIAL FOR SAND AND GRAVEL DEPOSITS IN THE NTTR AND NEW EXPANSION AREAS

LEGEND

POTENTIAL FOR SAND AND GRAVEL

- HIGH POTENTIAL CERTAINTY LEVEL
- MODERATE POTENTIAL CERTAINTY LEVEL

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:.
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureaFigure 10.2 Potential for Sand and Gravel Deposits in the NTTR.mxd

Areas with moderate potential for bedrock materials suitable for quarried aggregate are summarized as follows:

- NTTR
  - Paleozoic carbonate rocks outcrop extensively in the South Range of the NTTR.
  - Paleozoic carbonates outcrop, but are less prevalent in the North Range, north and northwest of the NNSS.
- Alternative 3A – the EC South area
  - No Paleozoic rocks occur in the EC South area. Tuffaceous rocks predominate, and alteration of these rocks is locally extensive.
- Alternative 3B – the 64C/D and 65D area
  - Paleozoic rocks potentially suitable for quarrying outcrop over a large portion of the 64C/C and 65D area.
- Alternative 3C – the Alamo area
  - Paleozoic rocks dominate in the Alamo area. Source rocks for quarried aggregate are potentially abundant.

10.3 Building Stone

Building stone consists of dimension stone that can be cut and finished in specific shapes for use in building construction, and well as decorative rock that can be used in landscaping, wall facing, and floor tiles. Requirements for building stone include durable materials with aesthetically desirable colors and textures, and low fracture density and/or favorable fracture orientation. Tingley and others (1998) noted only isolated instances of building stone production within the study area and there is limited evidence of past production.

Davis (2014) noted that there are two producers of building stone near the NTTR. Kalamazoo Materials Inc. produces crushed landscaping stone from the Modoc Quarry in Pliocene tuff near Beatty, Nevada. Las Vegas Rock produces cut slabs, flagstone, ashlar, and landscape rock from its Rainbow Quarries near Goodsprings, southwest of Las Vegas. Las Vegas Rock mines Jurassic Aztec Sandstone to produce these materials.

Table 10.1 includes one slate quarry in the Slate Mining District of the South Range, near the Alamo area (Figure 2.5). Tingley and others (1993) noted that unique deposits of decorative stone are not known with the East DNWR. One small inactive marble quarry in the Gass Peak Mining District was identified in the East DNWR outside the current study area. Tingley and others (1993) also noted that deposits of materials with desirable characteristics suitable for dimension stone are not known in the East DNWR.

Figure 10.3 illustrates the site-wide potential for building stone within the study area. There is moderate potential, certainty level B, for building stone where pre-Tertiary and Tertiary rocks are exposed.

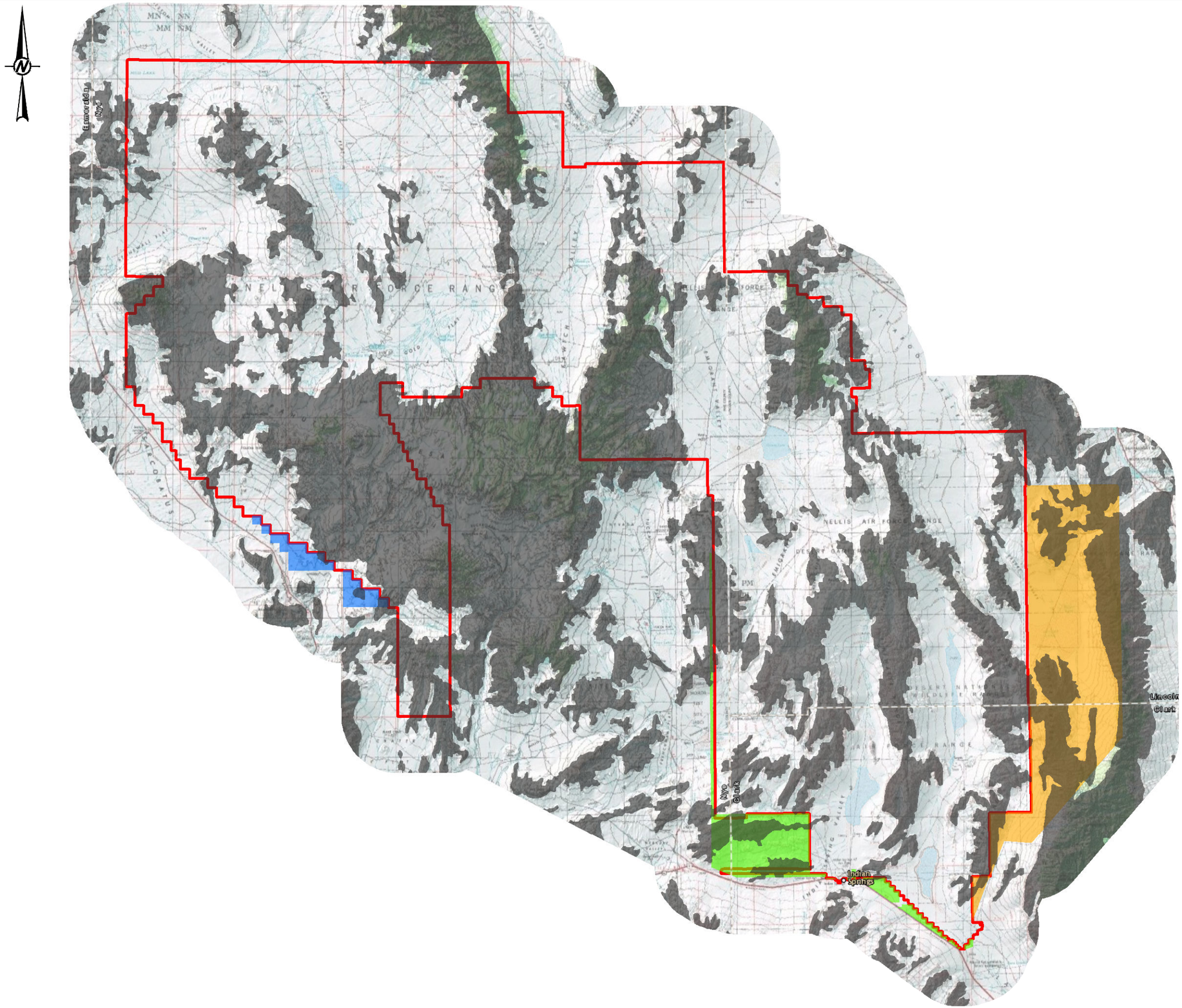


FIGURE 10.3
POTENTIAL FOR BUILDING STONE IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

- MODERATE POTENTIAL FOR BUILDING STONE, CERTAINTY LEVEL B

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, MODIFIED FROM 1998. NMBG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
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PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0

Path: V:\1538787\NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 10.3 Potential for Building Stone.mxd

The moderate potential and low certainty for building stone deposits are due in part to the degree of rock fracturing associated with tectonic activity in the region, and the relatively widespread alteration of Tertiary volcanic rocks.

10.4 Limestone and Dolomite

Limestone and dolomite are common in the south range of the NTTR, the 64C/D and 65D area, and the Alamo area. As noted above, limestone and dolomite are often the source of sand and gravel deposits, and quarried rock for use in aggregate production. In addition, limestone and dolomite have a number of industrial uses. Limestone uses include in Portland cement, in agriculture, in metallurgical processing, and in the manufacture of feeds, paints, plastics, paper, and rubber. Lhoist North America mines high-calcium lime at its Apex Quarry in Henderson, Nevada, and produces quicklime. Dolomite and dolomitic limestone are used in agriculture, in glass and ceramics, as a source of magnesia, and in metal processing. The particular uses of a limestone or dolomite deposit are subject to its chemical properties. Hydrated dolomitic lime is also produced at Apex Quarry.

Table 10.2 summarizes the chemical properties of limestone suitable for use in the manufacture of cement.

Table 10.2: Properties of Limestone Suitable for Cement in Oxide Weight Percent based on X-Ray Fluorescence (XRF)

Constituent	Required concentration
Calcium oxide (CaO)	More than 45 percent
Phosphorous (as P_2O_5)	Less than 1 percent
Total Alkalis (K, Na, Li, Rb, Cs)	Less than 0.6 percent
Magnesium oxide (MgO)	Less than 3 percent
Ferric Oxide (Fe_2O_3)	1 to 2 percent, less than 0.01 percent in specialty cements

Notes:
Source - British Geologic Survey (2005)

Raw limestone used in cement is commonly mixed with clay, shale, and sand to meet requirement for iron, alumina, and silica, constituents that occur in low concentrations in pure limestone. In the 1998 Assessment of the NTTR, NBMG personnel collected a number of limestone and dolomite samples as part of the GSC sampling program. Table 10.3 summarizes the analytical results for limestone GSC samples that could potentially meet cement limestone specifications.

High-calcium limestone suitable for the manufacture of high-calcium lime requires greater than 97 percent calcium carbonate (greater than 54.5 percent CaO with less than 1 percent silica and 1.4 percent MgO (Tingley and others, 1998).

Table 10.3: Summary of South Range NTTR Limestone Samples Indicating Suitability for use in Cement Manufacture based on XRF Analysis

Sample ID	CaO (%)	MgO (%)	Fe_2O_3 (%)	P_2O_5 (%)	K_20 + Na_2O (%)	Unit, location
GSC-1	53.0	0.67	0.16	0.00	0.19	Pogonip Group, Pahranagat Range
GSC-19	53.0	0.49	0.11	0.00	0.03	Guilmette, northern Pintwater Range
GSC-27	54.5	0.66	0.06	0.00	0.11	Simonson Dol, southern Desert Range
GSC-38	51.6	1.49	0.27	0.06	0.16	Bonanza King, southern Desert Range
GSC-46	51.1	1.49	0.14	0.47	0.2	Ops Ls, southern Pintwater Range
GSC-56	56.3	0.46	0.06	0.00	0.01	Joana Ls, northern Desert range
GSC-82	53.3	0.31	0.06	0.00	0.02	Tys, Tertiary sediment, southern Pintwater Range
GSC-85	52.1	0.50	0.17	0.18	0.07	Ops Ls, southern Pintwater Range
GSC-88	54.5	0.62	0.11	0.06	0.02	Tys, Tertiary sediment, north of Indian Springs Parcel
GSC-90	54.5	0.62	0.04	0.06	0.02	Tys, Tertiary sediment, north of Indian Springs Parcel
GSC-114	53.1	0.99	0.14	0.06	0.05	Joana Ls, Spotted Range
5087	54.6	0.40	0.07	0.00	0.07	Guilmette Ls
5089	52.7	1.6	0.13	0.00	0.12	Guilmette Ls

Notes:
Source - Tingley and others, 1998
Ls = limestone

10.4.1 Limestone and Dolomite in the NTTR

The data shown in Table 10.3 indicate that limestone suitable for cement is potentially present in the South Range of the NTTR. Areas underlain by the Joana Limestone and Guilmette FM are potential sources of cement limestone based on data presented in Table 10.3. The NBMG assigned a moderate potential, certainty level B, for the cement limestone in the exposures of Paleozoic rock in the NTTR. These exposures occur primarily in the South Range. Figure 10.4 illustrates the potential for cement-grade limestone in the study area.

The limestones of the Devonian Guilmette FM, Mississippian Joana FM, and Simonson Dolomite locally may meet high-calcium limestone specifications. Tingley and others (1998) noted that most of the high-calcium limestone in southern Nevada tends to be coarsely crystalline, which can result in decrepitation during calcination, making it unsuitable for lime production. Figure 10.5 illustrates the potential for high-calcium limestone and dolomite within the study area. The NBMG assigned a low potential, certainty level B, for high-calcium limestone in the NTTR. Certainty level B was assigned due to the coarse crystalline nature observed at Guilmette and Joana Limestone outcrops.

Within the NTTR, areas underlain by upper Devonian to lower Mississippian limestones have a moderate potential, certainty level B, for cement limestone.

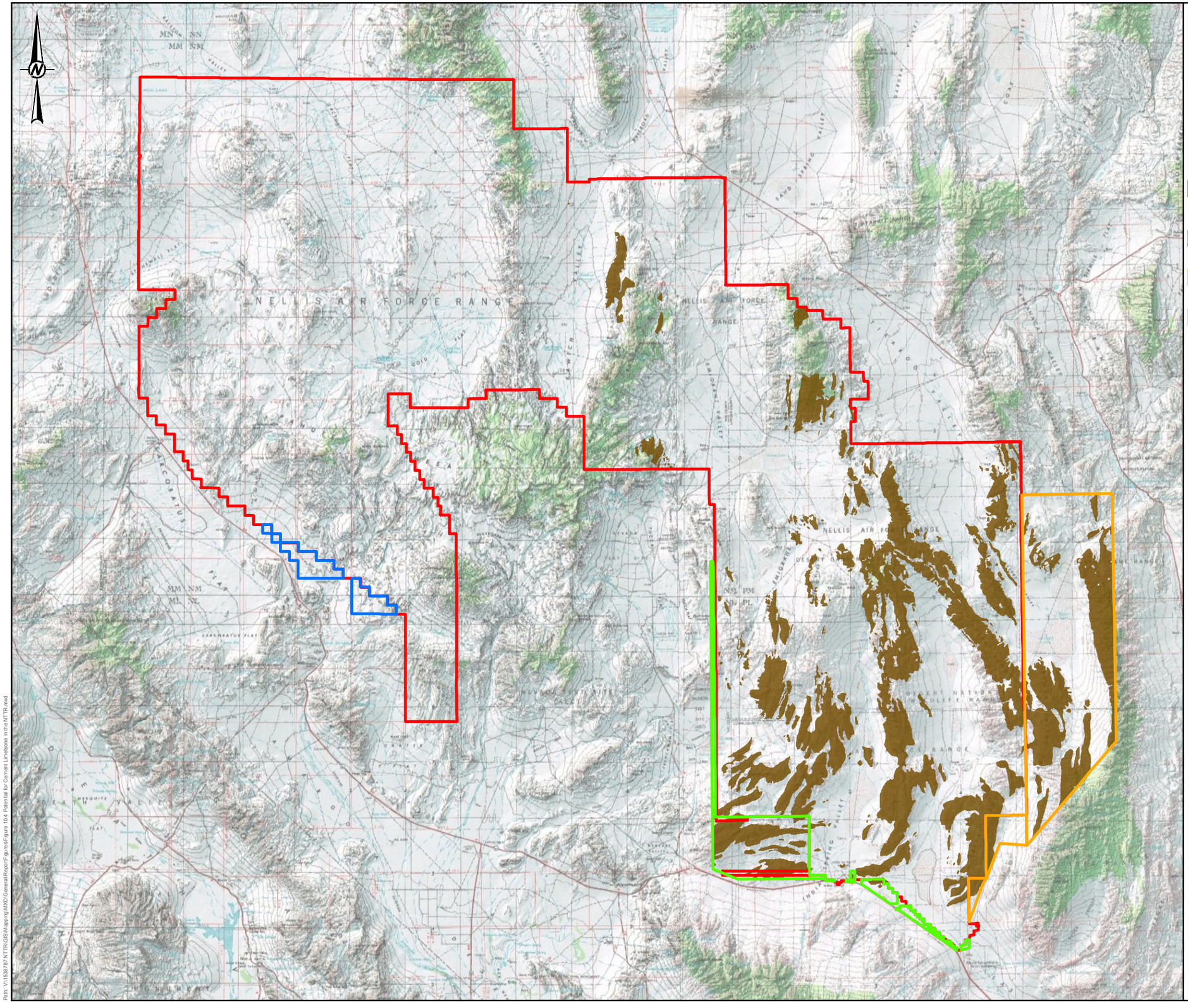


FIGURE 10.4
POTENTIAL FOR CEMENT LIMESTONE IN THE NTTR AND NEW EXPANSION AREAS

LEGEND

POTENTIAL FOR CEMENT LIMESTONE

- MODERATE POTENTIAL, CERTAINTY LEVEL B

STUDY

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles

16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.
MUNTEAN AND OTHERS, 2014. NBMG OFR 14-3.

REFERENCE

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Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\FigureSFigure 10.4 Potential for Cement Limestone in the NTTR.mxd

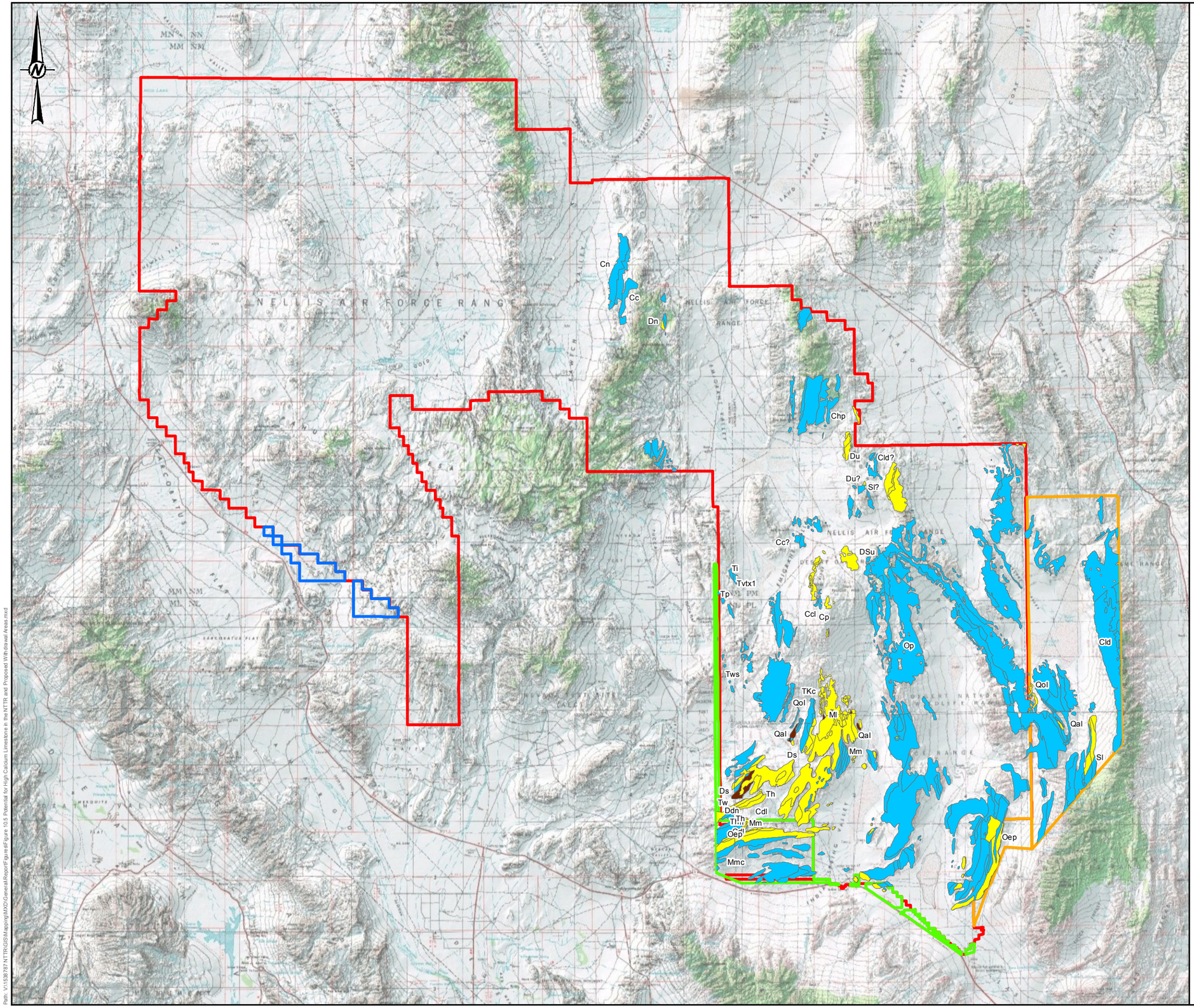


FIGURE 10.5
POTENTIAL FOR HIGH CALCIUM LIMESTONE AND DOLOMITE IN THE NTTR AND PROPOSED EXPANSION AREAS

LEGEND

POTENTIAL FOR HIGH-CALCIUM LIMESTONE

- MODERATE POTENTIAL, CERTAINTY LEVEL B

POTENTIAL FOR DOLOMITE

- LOW POTENTIAL, CERTAINTY LEVEL B

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

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10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

MODIFIED FROM TINGLEY AND OTHERS, 1993. NBMG OFR 93-2.

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Path: V:\1538787 NTTR\GIS\Mapping\MXD\General\Report\Figure\Figure 10.5 Potential for High Calcium Limestone in the NTTR and Proposed Withdrawal Areas.mxd

Dolomite is common in the early Paleozoic rocks that outcrop extensively in the South Range of the NTTR. In the 1998 Assessment, no “pure” dolomites suitable for the manufacture of dolomitic lime (dolime) were identified, and the NTTR was assigned a low potential, certainty level B, for dolomite suitable for dolime.

10.4.2 Limestone and Dolomite in the EC South Area

As noted above, limestone and dolomite do not outcrop within the EC South area. There is no potential for either cement or high-calcium limestone, or dolomite.

10.4.3 Limestone and Dolomite in the Alternative 3B Area

Tschanz and Pampeyan (1970) mapped limestones of the Sultan and Monte Cristo FMs across the northern portion of the Indian Springs Parcel in the 64C/D and 65D area. Lhoist North America mines high-calcium limestone from the Sultan FM, which is correlative with the Guilmette FM, at its Apex quarry near Henderson. Analyses reported by Tingley and others (1993) indicate the Guilmette, Joana, and Monte Cristo limestone are potentially suitable for cement limestone and high-calcium lime production. Based on these occurrences there is moderate potential, certainty level B, for cement limestone in the 64C/D and 65D area. There is moderate potential, certainty level B, for high-calcium limestone in areas underlain by the Guilmette FM and the Sultan FM limestones. As noted by Tingley and others (1998), limestones in the area tend to be coarsely crystalline, which adversely impacts their use in lime manufacture. There is also moderate potential, certainty level B, for cement limestone in the 64C/D and 65D area.

Dolomites of Cambrian to Ordovician age have been mapped across the southern portion of the Indian Springs Parcel (Stewart and Carlson, 1978). Data presented in the 1993 Assessment did not identify dolomitic compositions similar to those formerly mined at the Sloan Quarry south of Las Vegas and used for the manufacture of hydrated dolime. There is a low potential certainty level B for dolomite in the 64C/D and 65D, and Administrative Incorporation areas.

10.4.4 Limestone and Dolomite in Alternative 3C – the Alamo Area

Testing similar to that shown in Table 10.3 was conducted in the East DNWR for the 1993 Assessment. While there is potential for cement and high-calcium limestone within the East DNWR, most of the carbonate units within the Alamo area are Cambrian to mid-Devonian, are dolomitic, and are unsuitable for either cement or high-calcium lime manufacture due to high magnesium concentrations (Tingley and others, 1993). Based on the 1993 Assessment and the 2014 Assessment, there is high potential for dolomite to occur within the Alamo area. However, the GSC analyses of dolomitic rocks reported in the 1993 Assessment did not identify units with properties similar to the dolomite formerly mined at the Sloan Quarry for dolime manufacture. Therefore, the Alamo area is considered to have a low potential, certainty level B for dolomite suitable for industrial uses.

There are a few outcrops of upper Devonian to lower Mississippian carbonates in the southwestern portion of the Alamo area that have moderate potential, certainty level B, for high-calcium limestone (Figure 10.5). An isolated outcrop of cement limestone was identified within the southern portion of the Alamo area. In this assessment, the majority of the Alamo area is classified as having low potential, certainty level B, for cement limestone based on the prevalence of dolomitic carbonates.

10.4.5 Off Range Availability of Cement Limestone

One long-term cement manufacturing operation and one intermittent cement operation are reported in Nevada (Davis, 2014). Nevada's largest cement producer is in Fernley (Nevada Cement), which has a cement capacity of 500,000 tons per year and a clinker capacity of 560,000 tons per year. Limestone is obtained primarily from Tufa deposits near the plant. Davis (2014) reported at least 50 years of limestone reserves on company-owned and -leased lands.

Shortages of cement were reported in the Las Vegas area prior to the collapse of the housing market in 2008. Similar shortages could be realized in the future if, and when, economic conditions improve. Muntean and others (2014) noted at least five attempts were made to construct new cement plants in the Las Vegas area between 1998 and 2008. Infrastructure Materials Corporation was said to own 12 cement limestone projects in 2009 and was evaluating 2 sites in Clark County and 4 sites in Lincoln County. One near Caliente was under consideration for a cement plant in 2012. While none of the proposed cement plant projects have come to fruition, it is clear that there are a number of off-range resources that could support cement manufacture in the event of cement industry expansion in the Las Vegas area.

10.5 Zeolites

Zeolites of purest quality and of commercial interest most commonly occur in volcanic tuffaceous and sedimentary rocks in closed lacustrine basins (Tingley and others, 1998). Zeolitized tuffs are reported to be common in the North Range of the NTTR, but the potential for zeolites exists elsewhere in the study area where tertiary volcanic rocks occur less extensively. Several zeolitized tuffs were identified by Tingley and others (1998).

Several GSC samples of Tertiary volcanic rocks collected during the 1998 Assessment contained greater than 50 percent heulandite-clinoptilolite. Heulandite was also identified in concentrations ranging from 40 to 66 percent in samples collected in the EC South area during the current assessment. There is moderate potential, certainty level B, for zeolites in the North Range of the NTTR and other locations elsewhere in the study area where Cenozoic volcanic rocks and volcanic detritus occur. Outside Cenozoic volcanic terrains, there is no potential for zeolites. This includes the majority of the areas in the South Range, the 64C/D and 65D area, the Administrative Incorporation area, and the Alamo area.

Domestic reserves of zeolites exceed 10 trillion tons and unmined zeolite deposits occur south of the NTTR in the Beatty, Nevada area. While zeolites may be common, particularly in the North Range, they have little commercial value due to an abundance of off-range zeolite resources, and low consumption (71,900 tons domestic production in 2013). Davis (2014) noted that KMI Zeolite Inc. processes clinoptilolite from a 53.7-million-ton deposit near Death Valley. Demand for zeolites from deposits within the study area is not anticipated in the long term.

10.6 Barite

In the 1998 Assessment, Tingley and others (1998) found no favorable rocks for barite deposits in the NTTR. No assessment of the potential for barium deposits was conducted for the 1993 Assessment and 2014 Assessment of the East DNWR.

Bedded barite deposits are considered the most attractive source of barite due to their size and grade. The Paleozoic rocks exposed in the South Range and the East DNWR were reported by Tingley and others (1998) to be unfavorable for barite deposits. No barite deposits were identified inside or within 50 km of the South Range. A low potential, certainty C, was assigned for barium deposits in the NTTR and in the expansion areas.

10.7 Borates

Minable deposits of borates are associated with lacustrine sediments in closed, nonmarine basins in arid to semiarid regions, such as the southwest US. Tingley and others (1993, 1998) noted that Tertiary sedimentary rocks of the Horse Springs FM, in the Muddy Mountains approximately 70 km southeast of the NTTR, were mined for bedded borate deposits in the 1920s. Borate minerals, or rocks with geochemical signatures similar to those that occur at the Muddy Mountain borate deposits, were not identified in the NTTR.

Muntean and others (2014) assigned a low potential, certainty level C, for borates in the East DNWR. This potential is also assigned to the 64C/D and 65D area, the Administrative Incorporation area, and the Alamo area, where potentially favorable Tertiary rocks occur less frequently.

10.7.1 NTTR Update

The reconnaissance of Horse Springs FM contemporaneous rocks within the NTTR for the 1998 Assessment did not reveal borate minerals, or rocks with geochemical signatures similar to those that occur at the Muddy Mountain borate deposits. Within the NTTR, Tingley and others (1998) noted that Tertiary rocks that could host borate deposits may be covered by alluvium and younger volcanic rocks. A low potential, certainty level B, was assigned for borates in the NTTR. No change in the 1998 ranking of borate potential within the NTTR is warranted.

10.7.2 Alternative 3A – the EC South Area

Reconnaissance in the EC South area for the current assessment did not indicate the potential for bedded borate deposits, although the potential for lacustrine deposits buried beneath younger alluvium and volcanic rocks also exists in the EC South area. The EC South area is considered to have a low potential, certainty level B, for borates.

10.7.3 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Areas

In the 2014 Assessment, Muntean and others (2014) noted that the borate occurrence nearest the DNWR is 32 km to the southeast, in the Calleville Wash and White Basin, in a 2- to 6-m-thick bed within the Horse Springs FM. They noted that the Horse Springs FM does not occur in the East DNWR (or the Alternative 3B area). Playa sampling within the East DNWR was conducted as part of the 2014 Assessment of the East DNWR. Samples subjected to XRD analyses did not indicate the presence of common, ore-forming borate minerals. The potential for borates in the Alternative 3B area is considered low, certainty level B.

10.7.4 Alternative 3C – the Alamo Area

As noted above, favorable host rocks for borates do not occur in the East DNWR (or the Alamo area) and geochemical sampling did not indicate the presence of borate minerals. The potential for borates in the Alamo area is considered low, certainty level B.

10.8 Lithium

The only currently active lithium producer in Nevada and the US is in Clayton Valley, 50 km west of the NTTR. Lithium is produced from brines, which are pumped to surface evaporation ponds for further concentration before processing. Surface sediments in all playas in the NTTR and East DNWR were sampled during previous assessments for lithium and lithium does occur, but in concentrations that are not high relative to Clayton Valley, where lithium concentrations in surface sediments have been an order of magnitude higher. Active exploration for lithium is ongoing in the Clayton area. There has also been recent exploration interest in Mud Lake, which lies partially inside the northeast corner of the North Range (England, 2016).

The preliminary model of lithium brine deposits proposed by Bradley and others (2013) postulates lithium sources in brine as follows:

- From the weathering of older rocks within the basin
- Delivered in primary magmatic hydrothermal fluids
- Contained in airfall tuffs
- In Loess (windblown dust)
- Exhumed from basin deposits where it may be preconcentrated
- In groundwater inflows from interconnected and adjacent basins

Lithium is associated with felsic igneous rocks. Evaporation is the primary method of concentration.

Ashburton states that their Area 51 claims in Mud Lake share many geologic features with Clayton Valley; however, there is a significant difference that may account for the higher concentrations of lithium at Clayton Valley than that in the playas within the study area. Tingley and others (1998) reported that Clayton Valley is topographically lower relative to the other basins in the region, and it is postulated that Clayton Valley may be the terminus of groundwater flow from interconnected and adjacent basins. This condition could provide an additional source of lithium that does not appear to exist elsewhere in the area. Evaporation of upward-welling lithium-bearing groundwater inflow further concentrates the lithium. Clayton Valley is also the only location where halite was detected in surface sediments. This is thought to be another indication of groundwater inflow and evaporation due to upwelling.

10.8.1 NTTR Update

All playas within the NTTR were sampled for lithium content in the previous assessments. Based on the relatively low lithium content measured in playa sediments, and the absence of groundwater flow conditions that contribute to increased lithium concentrations, the potential for lithium deposits in the NTTR is low, certainty level B.

10.8.2 Alternatives 3A - EC South

There are no playas inside the EC South area Alternative 3A and 3B area, where lithium could be anticipated to be concentrated. The potential for lithium in the EC South area is considered low, certainty level C.

10.8.3 Alternative 3B -64CD/65D and Administrative Incorporation Areas

There are playa deposits where lithium could be concentrated in the 64C/D and 65D area. Figure 4.7 indicates playa sediments occur along the southern boundary of the South Range of the NTTR and extend into the 3B area north of Highway 95. Paleozoic sedimentary rocks, which are not known to be a source of lithium, are the primary geologic units within the basin contributing the playa sediments. The potential for lithium in the 64CD/65D and Administrative Incorporation Areas is considered low, certainty level C.

10.8.4 Alternative 3C – the Alamo Area

NBMG sampled Alamo area playa sediments during the 2014 Assessment of the East DNWR (Muntean and others, 2014). They concluded that the potential for lithium deposits in the East DNWR (including the Alamo area) is low, certainty level C.

10.9 Perlite

One deposit of perlite is noted in Table 10.1, in Tolicha Wash in the North Range of the NTTR. It is reported to outcrop on steep slopes, indicating that significant overburden removal would be required to mine the

material. Davis (2014) reports that there is a large number of high-quality perlite deposits in Nevada, including in Clark and Lincoln counties. Perlite may be common in the North Range, where Tertiary volcanic rocks are common, but due to the presence of significant off-range resources, no pressure to exploit on-range perlite resources is anticipated in the foreseeable future.

10.10 Silica

Tingley and others (1993, 1998) analyzed a number of quartzite samples collected from the East DNWR and NTTR. Most samples were of Eureka Quartzite, and it was noted that the Eureka contains too many impurities for most industrial uses (glass, silicon metal, ferrosilicon, etc.). Other samples from the Wood Canyon, Carrara, Zabriskie, and Emigrant FMs were typically lower in silica content and contained more impurities.

The Sugar Quarry, where Eureka Quartzite has been mined, occurs west and outside of the 64C/D and 65D area. Christiansen and others (1969) reported that the quarry was mined intermittently and the quartzite was marketed in the Las Vegas area for domestic use. The Sugar Quarry was characterized as having no significant past production by Papke and Castor (2003). The quarry was reported to be active in 2002 (Caster, 2003), and a plan of operations was submitted to the BLM in 2001 to mine 80,000 tons per year. No mining equipment or activity was noted at the Sugar Quarry in September 2016. Additional analysis would be required to determine if quartzite at the Sugar Quarry meets specifications for industrial uses and if the geologic unit extends into the 64C/D and 65D area.

Highly altered rhyolite was reported to have been mined south of the NTTR, near Beatty, as a source of silica. Altered rhyolite samples analyzed for the 1998 Assessment indicated relatively low silica and high alumina content. The potential that other occurrences of silicified rhyolite exist in the study area, particularly within the North Range, is moderate.

Tingley and others (1993) noted that demand for silica from the study area could increase if there was a local market for metallurgical lump silica. Tingley and others (1993) assigned a low potential, certainty level B, for silica deposits in the NTTR. There are no new data that warrant a change in that classification of the potential for silica in the NTTR, or that suggest silica deposits occur within the expansion areas.

10.11 Clays

There are several producers of processed clay products in the region of the NTTR. In the Ash Meadows area, IMV Nevada (Lhoist North America) mines deposits of sepiolite, montmorillonite, and saponite from Pliocene lacustrine sediments. These are valuable clay minerals with important industrial uses due to special properties such as swelling potential, cation exchange capacity, viscosity, and gel stability. Davis (2014) reports intermittent processing of smectite clay from local deposits at the White Caps Mill near Beatty, Nevada. Figure 10.6 shows areas of moderate potential for clay deposits in the NTTR and expansion areas.

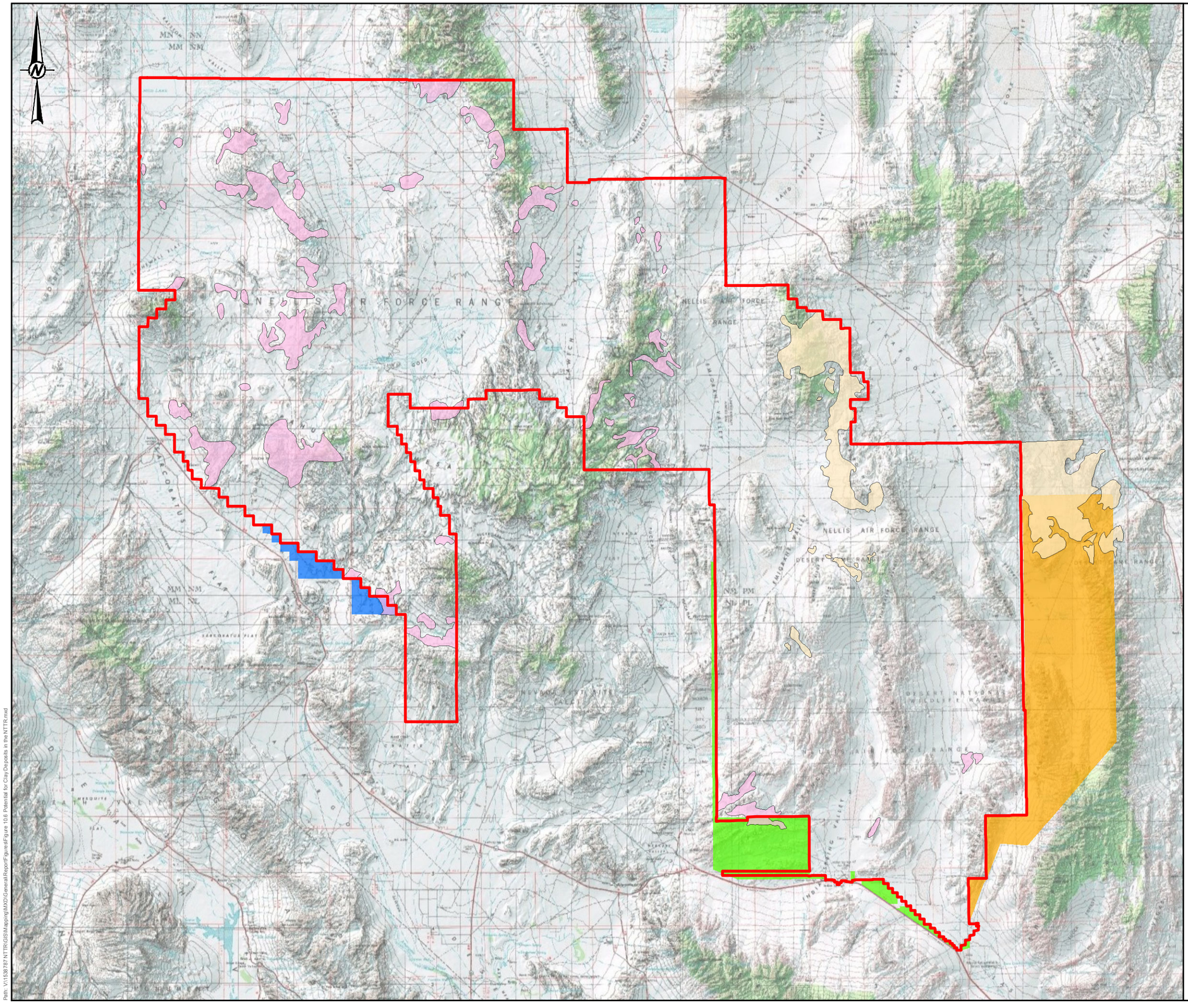


FIGURE 10.6
POTENTIAL FOR CLAY DEPOSITS IN THE NTTR AND NEW EXPANSION AREAS

LEGEND

POTENTIAL FOR CLAY DEPOSITS

- MODERATE POTENTIAL, CERTAINTY LEVEL B
- UNKNOWN POTENTIAL FOR CLAY

STUDY AREA

- NEVADA TEST AND TRAINING RANGE

PROPOSED EXPANSION AREAS

- ALTERNATIVE 3A - EC SOUTH EXPANSION
- ALTERNATIVE 3B - 64C/D AND 65D EXPANSION AND ADMINISTRATIVE INCORPORATION
- ALTERNATIVE 3C - ALAMO EXPANSION

FOR OFFICAL USE ONLY

10 5 0 10 Miles
16 8 0 16 Kilometers

NOTES

SOURCE:
TINGLEY AND OTHERS, 1998. NBMG OFR 98-1.

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEVADA CENTRAL FIPS 2702 FEET
SERVICE LAYER CREDITS: COPYRIGHT:© 2013 NATIONAL GEOGRAPHIC SOCIETY, I-CUBED

CLIENT
LEIDOS, INC.

PROJECT
NEVADA TEST AND TRAINING RANGE
MINERAL AND ENERGY RESOURCE ASSESSMENT

CONSULTANT
Golder Associates

PROJECT No.	CONTROL	Rev.	FIGURE
1538787	---	---	**10.6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: V:\1538787.NTTR\GIS\Mapping\MXD\GeneralReport\Figure\Figure 10.6 Potential for Clay Deposits in the NTTR.mxd

10.11.1 NTTR Update

Pahute Mesa Clay and Sarcobatus Flat Clay are deposits within the North Range of the NTTR. Both deposits were evaluated by NBMG as part of the 1998 Assessment. Both deposits contain montmorillonite in variably altered Tertiary tuffs. A sample collected from Sarcobatus Flat was one of the higher quality clay samples evaluated in the region, based on swelling capacity and viscosity (Papke, 1970).

Tingley and others (1998) reported that altered volcanic rocks in the North Range of the NTTR were considered to have moderate potential, certainty level B, for clay deposits with potential industrial uses, similar to the Pahute Mesa and Sarcobatus Flat deposits. Moderate potential was extended to areas underlain by Tertiary sedimentary rocks. In general, the potential for clay deposits is less favorable in the South Range of the NTTR, where pre-Tertiary basement rocks occur. These rocks are not known to host clay deposits in the Western US (Tingley and others, 1998).

Tingley and others (1998) noted an area of unknown clay potential in the Groom Range, where intermediate, rhyolitic, and tuffaceous Tertiary volcanic rocks occur. These areas were considered under-evaluated with respect to the potential for clay deposits, and were classified as having unknown potential for clay deposits.

10.11.2 Alternative 3A – the EC South Area

The EC South area has a moderate potential, certainty level B, for clay deposits based on the presence of altered Tertiary volcanic rocks and Tertiary and Quaternary alluvial deposits derived from the weathering and erosion of altered volcanic rocks.

10.11.3 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Area

The Alternative 3B area is underlain primarily by pre-Tertiary basement rocks that are not known to host clay deposits. Alternative 3B is considered to have a low potential, certainty level C, for clay deposits.

10.11.4 Alternative 3C – the Alamo Area

The majority of the Alamo area is underlain by less favorable pre-Tertiary rocks, which have low potential, certainty level C, for clay deposits. The exception is in the northern portion of Alamo area, where Tertiary tuffaceous rocks and sediments occur. This area was classified as having unknown potential for clay deposits in the 2014 Assessment.

10.12 Fluorspar

Nevada was a relatively consistent producer of fluorspar from 1976 through 1991 from four mines. Production records (Davis, 2014) indicate producing mines are located in Pershing, Nye, Lander and Mineral counties. The Mammoth deposit in Nye County is located in the Quinn Canyon District

approximately 50 km north of the study area. Demand for fluorspar and the price of fluorspar have decreased in recent years due to a number of factors (Davis, 2014) that include:

- Inexpensive imports from Mexico and China
- The ban on chlorofluorocarbons
- Changes in steel processing methods

The reduction in fluorspar mining in Nevada is associated with changes in market demand as opposed to depletion of reserves.

Tingley and others (1998) identified two possible fluorspar deposits (Table 10.1) in the 1998 Assessment of the NTTR. Approximately 20 percent fluorite was observed in a hand sample collected from the dump of a small prospect pit near Little Black Peak, and a hand sample of breccia from a dump at the Zabriskie Shaft on Limestone Ridge contained an estimated 60 percent fluorite. In both cases, the exposure of fluorite-bearing material was of limited areal extent.

A sample collected in the East Goldfield Mining District contained minor amounts of fluorine that was associated with trace amounts of fluorite on fractures.

10.12.1 NTTR Update

On the basis of the 1998 Assessment, which included inspection of most of the altered volcanic rocks in the NTTR, NBMG concluded that the potential for fluorspar in the North Range was low, certainty level B.

Much of the fluorspar mined in Nevada was from replacement deposits and breccias in Paleozoic carbonate rocks. As such, potential fluorspar host rocks occur throughout the South Range; however, no fluorspar prospects were identified in the 1998 Assessment of the South Range. NBMG concluded that the potential for fluorspar in the South Range was low, certainty level B.

10.12.2 Alternative 3A – the EC South Area

No indications of fluorspar were observed in the EC South area. The geologic setting and rocks of the EC South area are similar to that of the North Range of the NTTR. The potential for fluorspar deposits in the EC South area is considered low, certainty level B.

10.12.3 Alternative 3B – the 64C/D and 65D and Administrative Incorporation Area

The Paleozoic carbonate rocks in the Alternative 3B area represent potential host rocks for fluorspar replacement and breccia deposits. In the 1993 and 2014 Assessments of the East DNWR, no fluorspar prospects were identified in the 64C/D and 65D area. The potential for fluorspar deposits in the Alternative 3B area is considered to be low, certainty level B.

10.12.4 Alternative 3C – the Alamo Area

The Paleozoic carbonate rocks in the Alamo area also represent potential host rocks for fluorspar replacement and breccia deposits. In the 1993 Assessment and the 2014 Assessment of the East DNWR, no fluorspar prospects were identified in the Alamo area. The potential for fluorspar deposits in the Alamo area is considered to be low, certainty level B.

11.0 CLOSING

This energy and mineral resource assessment has been prepared in support of a Legislative Environmental Impact Statement (LEIS) for the land withdrawal extension and potential expansion at the Nevada Test and Training Range (NTTR), Nellis Air Force Base (NAFB), in Clark, Nye, and Lincoln counties, Nevada. The energy and mineral resources assessment study area includes existing withdrawn NTTR lands that are proposed for extension of withdrawal, and proposed expansion areas that will extend the boundaries of the NTTR into contiguous land areas. This assessment has been prepared in accordance with Bureau of Land Management guidelines for mineral resource assessments. It addresses the new expansion areas and updates the mineral and energy resource assessment of previously withdrawn lands.

While some potential for metallic mineral resources is indicated, primarily inside previously withdrawn lands, no economically viable metallic mineral deposits have been identified in the study area to date. Lands within the NTTR and the Desert National Wildlife Refuge have been closed to mineral location for decades and can be considered underexplored relative to metallic mineral potential. Advancing the understanding of the metallic mineral potential of the NTTR will require on-the-ground geologic investigation that conflicts with military training operations inside the NTTR, and subsurface exploration activities that are outside the scope of an energy and mineral resource assessment.

Carlin-type gold deposits (CTGD) have made the State of Nevada one of the major global gold producers. Recent studies have postulated that the intersection of a number of unique magmatic and tectonic events and structural conditions may be responsible for the concentration of CTGDs in central and north-central Nevada. In the previous and current assessments, study area structural settings and pathfinder metal anomalies suggest the potential for CTDGs but additional exploration will be required to confirm their presence or absence in the study area.

The energy resource potential of the study area is low. The study area is located in the Great Basin where geothermal potential is relatively high compared to the contiguous U.S., but in an area of low heat flow relative to the Great Basin. As such, there is some potential for low temperature direct use geothermal applications such as building heating and spas, but very low potential for high temperature resources capable of generating electricity. The potential for oil and gas resources is also low in the study area because the geologic units that have been the source of petroleum elsewhere in the Great Basin do not occur in the study area.

The highest potential for resources in the study area is associated with industrial minerals and construction materials such as aggregate derived from alluvial and quarry sources, cement limestone, and to a lesser degree, high calcium limestone suitable for lime production and dolomite suitable for dolime manufacture. The value of these resources is limited by lack of access and distance to markets. In addition, there appear to be adequate off-site resources to support industrial mineral and construction material demand in the

vicinity of the study area. At present and for the foreseeable future, limited demand for on-site resources is anticipated.

Lithium is of special interest due to the development and use of lithium-ion batteries. Elevated concentrations of lithium have been detected in study area playa sediments. A comparison of on-site playas to Clayton Valley, where lithium is being recovered from brine, suggests that the conditions responsible for economic lithium concentrations at nearby Clayton Valley do not exist in the study area. Further subsurface exploration including the completion of wells and groundwater sampling will be required to further define the potential for lithium in the study area.

12.0 REFERENCES

Allis, R., J. Moore, B. Blackett, M. Gwynn, S. Kirby, and D. Sprinkel. 2011. The Potential for Basin Centered Geothermal Resources in the Great Basin, Geoscience and Remote Sensing (GRS) Transactions, Vol. 35.

Agency for Nuclear Projects. 1997. Summary of Yucca Mountain Oversight and Impact Assessment Findings. State of Nevada, Office of the Governor, Office of Nuclear Waste. Available online at: http://www.state.nv.us/nucwaste/yucca/ymsum01.htm.

Anna, L.A., L.N.R. Roberts, and C.J. Potter. 2007. Geologic Assessment of Undiscovered Oil and Gas in the Paleozoic-Tertiary Composite Total Petroleum System, of the Eastern Great Basin, Nevada and Utah, US Geological Survey (USGS) Digital Data Series DDS-69-L.

Armstrong, R.L. 1968. Sevier orogenic belt in Nevada and Utah: Geological Society of America Bulletin, v. 79, p. 429-458.

Bagley, W.C. 1996. Descriptive Model of Volcanogenic Uranium, in Mineral Deposit Models, edited by D.P. Cox and D.A. Singer. USGS Bulletin 1693.

Ball, S.H. 1907. A Geologic Reconnaissance in Southwestern Nevada and Eastern California. USGS Bulletin 308. Government Printing Office.

Barker, C.E. 1994. Thermal and petroleum generation history of the Mississippian Eleana Formation and Tertiary source rocks, Yucca Mountain area, southern Nye County, Nevada: USGS Open-File Report 94-161, 42 p.

Barnes, H., E.B. Ekren, C.L. Rodgers, and D.C. Hedlund. 1982. Geologic and tectonic maps of the Mercury quadrangle, Nye and Clark Counties, Nevada: USGS Miscellaneous Investigations Series I-1197, scale 1:24,000.

Bell, J.W. and A.R. Ramelli. 2007. Active Faults and Neotechtonics at Geothermal Sites in the Western Basin and Range: Preliminary Results, GRCTransactions, v. 31, p. 375-378.

Best, M.G., E.H Christiansen, A.L. Deino, C.S. Gromme, E.H. Mckee, and D.C. Noble. 1989. Eocene through Miocene volcanism in the Great Basin of the western United States; New Mexico Bureau of Mines and Mineral Resources Memoir 47, p. 91-133.

Best, M.G. and E.H. Christiansen. 1991. Limited extension during peak Tertiary volcanism, Great Basin of Nevada and Utah: Journal of Geophysical Research, v. 96, p. 13,509-13,528.

Best, M.G., E.H. Christiansen, and S. Gromme. 2013. Introduction: The 36-18 Ma southern Great Basin, USA, ignimbrite province and flareup: Swarm of subduction-related supervolcanoes. Geosphere, April 2013: v. 9; no. 2; p. 260-274.

Bradley, D., L. Munk, H. Jochens, and K. Labay. 2013. A Preliminary Deposit Model for Lithium Brines, USGS Open File Report 2013-1006.

British Geologic Survey. 2005. Mineral Profile, Cement Raw Materials, National Environmental Research Council.

Burchfiel, B.C. 1964. Precambrian and Paleozoic Stratigraphy of Specter Range Quadrangle, Nye County, Nevada: American Association Petroleum Geologists Bull., v. 48, p. 40-56.

Burchfiel, B.C., D.S. Cowan, and G.A. Davis. 1992. Tectonic overview of the Cordilleran orogeny in the western United States, in The Cordilleran orogeny; Conterminous U.S.: Boulder, Colorado, edited by B.C. Burchfiel, P.W. Lipman, and M.L. Zoback. Geological Society of America, The Geology of North America, v. G-3, p. 407-479.

BLM (Bureau of Land Management). 1985. Energy and Mineral Resource Assessment, BLM Manual 3031, Release 3-115, June 19, 1985.

BLM. 1994. Mineral Reports – Preperation and Review, BLM Manual 3060, Release 3-284, April 7, 1994.

BLM. 2016. LR2000 Database, US Department of the Interior (DOI). Available online at: http://www.blm.gov/lr2000/index.htm, accessed June, 2016.

Byers, F.M., Jr., W.J. Carr, P.P. Orkild, W.D. Quinlivan, and K.A. Sargent. 1976. Volcanic suites and related cauldrons of Timber Mountain-Oasis Valley Caldera Complex, southern Nevada: US Geological Survey Professional Paper 919, 70 p.

Carr, M.D. and S.E. Monsen. 1988. A field trip guide to the geology of Bare Mountain, in Thisextended land, edited by D.L. Weide and M.L. Faber. Geological Section Meeting, Las Vegas, p. 50-57.

Carr, M.W. 1990. Styles of extension in the Nevada Test Site region, southern Walker Lane belt: an integration of volcano-tectonic and detachment fault models, in Basin and Range extensional tectonics near the latitude of Las Vegas, edited by B.P. Wernicke. Geological Society of America Memoir 176, p. 283-303.

Carr, W.J. 1974. Late Cenozoic tectonic history of Nevada Test Site region: Geological Society of America Abstracts with Programs, v.b, no. 3 p. 152.

Caskey, S.J. and R.A. Schweickert. 1992. Mesozoic deformation in the Nevada Test Site and vicinity: Implications for the structural framework of the Cordilleran Fold and thrust belt and Tertiary extension north of Las Vegas Valley, Tectonics, 11(6), p. 1314–1331.

Castor, S.B. 2003. Industrial Minerals, in The Nevada Mineral Industry 2003, Special Publication MI-2003, Nevada Bureau of Mines and Geology.

Chinn, E.W. 1991. The role of organic chemistry in petroleum exploration: Basin Research Institute Bulletin, Louisiana State University, Baton Rouge, LA., p. 15-23.

Christiansen R.L., F.G. Poole, H. Barnes, P.P. Orkild, F.M. Byers, W.J. Carr, F.N. McKeown, E.M. Houser, E.M. Shoemaker, and W.L. Emerick. 1969. Guidebook for past field trips to the Nevada Test Site, USGS Open-File Report 69-38.

Christiansen, R.L., P.W. Lipman, W.J. Carr, F.M. Byers, Jr., P.P. Orkild, and K.A. Sargent. 1977. Timber Mountain-Oasis Valley Caldera Complex of Southern Nevada: Geological Society of America Bulletin v. 88, p. 943-959.

Christiansen, R.L. and R.S. Yeats. 1992. Post-Laramide geology of the U.S. cordilleran region, in The Cordilleran orogeny; Conterminous US: Boulder, Colorado, edited by B.C. Burchfiel, P.W. Lipman, and M.L Zoback. Geological Society of America, The Geology of North America, v. G-3, p. 261-406.

Cline, J.S., A.H. Hofstra, J.L Muntean, R.M. Tosdal, and K.A. Hickey. 2005. Carlin-type gold deposits in Nevada: Critical geologic characteristics and viable models. *Economic Geology 100th anniversary volume*, *45*.

Cole, J.C. and P.H. Cashman. 1999. Structural relationships of pre-Tertiary rocks in the Nevada Test Site Region, Southern Nevada: USGS Professional Paper 1607.

Coolbaugh, M. 2003. Regional Geologic Controls, Geochemical Characteristics, and Thermal Infared Signatures of Geothermal Systems of the Great Basin, Geological Society of Nevada, membership meeting abstract. January 17, 2003.

Coolbaugh, M.F., J.V. Taranik, G.L. Raines, L.A. Shevenell, D.L. Sawatzky, R. Bedell, and T.B. Minor. 2002. A Geothermal GIS for Nevada: Defining Regional Controls and Favorable Exploration Terrains for Extensional Geothermal Systems, Geothermal Resources Council Transactions, v. 26, p 485-490.

Coolbaugh, M.F., R. Zehner, C. Kreemer, D. Blackwell, and G. Opplinger. 2005. A Map of Geothermal Potential for the Great Basin, USA: Recognition of Multiple Geothermal Environments, GRC Transactions Vol. 29, 2005.

Coolbaugh, M.F., C. Sladek, C. Kratt, L. Shevenell, and J.E. Faulds. 2006. Surface Indicators of Geothermal Activity at Salt Wells, Nevada, Including Warm Ground, Borate Deposits and Siliceous Alteration, GRC Transactions, Vol. 30, 2006.

Cornwall, H.R. 1972. Geology and mineral deposits of southern Nye County, Nevada: Nevada Bureau of Mines and Geology Bulletin. p. 49.

Cox, D.P. and Singer, D.A., editors. 1992. Mineral Deposit Models, US Geological Survey Bulletin 1693, U.S. Department of the Interior.

Crafford, A.E.J. 2007. Geologic Map of Nevada. USGS Data Series 247, 1 CD, 1 plate, p. 46.

Cramer, T.F. 2014. Using Landsat ETM+ and ASTER Sensors to Aid the Mineral Assessment of the Desert National Wildlife Refuge. Clark and Lincoln Counties, Nevada, University of Nevada, Reno, Master's Thesis.

CWRR (Center for Water Resources Research). 1973. Nevada University of Nevada, Reno, Desert Research Institute: computer data bank.

Davis, D.A. 2014. *Industrial Minerals*, in The Nevada Mineral Industry, Special Publication MI-2014, Nevada Bureau of Mines and Geology.

Davis, T.L. and J. Namson. 2014. Nevada's Chainman Shale shows exploration potential, Oil and Gas Journal, June 2, 2014.

Dickenson, W.R. 1997. Tectonic implications of Cenozoic volcanism in coastal California: Geological Society of America Bulletin, v. 109, p. 936-954.

Dickenson, W.R. 2006. Geotectonic evolution of the Great Basin: Geosphere, v. 2; No. 7; p. 353-368.

Ekren, E.B. 1968. Nevada Test Site and Nellis Air Force Range, Nevada, in Eckel, E.B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 11-19.

Ekren, E.B., C.L. Rogers, R.E. Anderson, and T. Botinelly. 1967. Geologic Map of the Belted Peak Quadrangle, Nye County, Nevada. USGS.

Ekren, E.B., C.L. Rodgers, R.E. Anderson, and P.P. Orkild. 1968. Age of basin and range normal faulting in Nevada Test Site and Nellis Air Force Range, Nevada *in* Nevada Test Site: Geological Society of America Memoir 110, p. 247-250.

Ekren, E.B., R.E. Anderson, C.L. Rogers, and D.C. Noble. 1971. Geology of Northern Nellis Air Force Base Bombing and Gunnery Range, Nye County, Nevada. USGS Professional Paper 651, Prepared on behalf of the US Atomic Energy Commission, Stratigraphy and Structure of 2,400-square-mile area of dominantly Tertiary volcanic rocks in the Great Basin, with brief descriptions of small mines and prospects.

Engebretson, D.C., A. Cox, and R.G. Gordon. 1985. Relative motions between oceanic and continental plates in the Pacific basin: Geological Society of America Special Paper 206, p. 59.

England, M. 2016. Ashburton Acquires Area 51 Lithium Brine Project in Nevada, Ashburton Ventures Inc. February 1, 2016. Available online at: http://www.marketwired.com/press-release/ashburton-acquires-area-51-lithium-brine-project-in-nevada-tsx-venture-abr-2092699.htm.

Epstein, A.G., J.B. Epstein, and L.D. Harris. 1977. Conodont Color Alteration - An Index to Organic Metamorphism, USGS Professional Paper 995.

Faulds, J.E., M.F. Coolbaugh, G. Blewitt, and C.D. Henry. 2004. Why is Nevada in Hot Water? Structural Controls and Tectonic Model of Geothermal Systems in the Characterizing Structural Controls of Geothermal Fields in the Northwestern Great Basin. GRC Transactions, Vol. 28, 2004.

Faulds, J.E., M.F. Coolbaugh, S.V. Garrett, and M.L. Edwards. 2006. Characterizing Structural Controls of Geothermal Fields in the Northwestern Great Basin: A Progress Report. GRC Transactions, Vol. 30.

Faulds, J.E. and C.D. Henry. 2008. Tectonic influences on the spatial and temporal evolution of the Walker Lane: An incipient transform fault along the evolving Pacific – North American plate boundary, in Ores and orogenesis: Circum-Pacific tectonics, geologic evolution, and ore deposits, edited by J.E. Spencer and S.R. Titley. Arizona Geological Society Digest 22, p. 437-470.

Faulds, J.E., M.F. Coolbaugh, P.H. Cashman, C. Kratt, G. Dering, J. Edwards, B. Mayhew, and H. McLachlan. 2011. Assessment of Favorable Structural Settings of Geothermal Systems in the Great Basin, Western USA: Geothermal Resources Council Transactions, v. 35, p. 777-784.

Faulds, J.E., N.H Hinz, and C. Kreemer. 2012. Structural and Tectonic Controls of Geothermal Activity in the Basin and Range Provence, Western, New Zealand Geothermal Workshop, 2012 Preceedings, November 19-21, 2012, Auckland, New Zealand.

Faulds, J.E. and N.H. Hinz. 2015. Favorable Tectonic and Structural Settings of Geothermal Systems in the Great Basin Region, Western USA: Proxies for Discovering Blind Geothermal Systems, Proceedings World Geothermal Congress, Melbourne, Australia, April 2015.

Fleck, R.J. 1970. Tectonic style, magnitude, and age of deformation in the Sevier orogenic belt in southern Nevada and eastern California: Geological Society of America Bulletin, v. 81, p. 1705-1720.

Fossen, H. and A. Rotevatn. 2016. Fault Linkage and Relay Structures in Extensional Settings – A Review, Earth Science Reviews, 154, p. 14-28, Elsevier.

Fournier, R.O. 1981. Application of Water Geochemistry to Geothermal Systems, in Geothermal Systems: Principles and Case Histories, edited by L. Ryback and L.J.P. Muffler. John Wiley and Sons, NY, p. 109-143.

Fridrich, C.J., S.A. Minor, and E.A. Mankinen. 1999. Geologic evaluation of the Oasis Valley basin, Nye County, Nevada. US Geological Survey Open-File Report 99-533-A.

Fridrich, C.J., S.A. Minor, J.L. Slate, and P.L. Ryder. 2007. Geologic map of Oasis Valley spring-discharge area and vicinity. Nye County, Nevada: US Geological Survey Scientific Investigations Map 2957, p.25.

Frizzell, V.A., Jr. and J. Shulters. 1990. Geologic map of the Nevada Test Site, southern Nevada: US Geological Survey Miscellaneous Investigations Series I-2046, scale 1:100,000.

Garside, L.J. 1973. Radioactive mineral occurrences in Nevada, NBMG Bulletin 81.

Garside, L.J. 1994. Nevada Low Temperature Geothermal Resource Assessment, NBMG Open-File Report 94-2, University of Nevada - Reno.

Garside, L.J. and J.H. Schilling. 1979. Thermal Waters of Nevada, NBMG Bulletin 91, Mackay School of Mines, University of Nevada – Reno.

Garside, L.J., K.G. Papke, and J.H. Schilling. 1980. A preliminary First Stage Study of Nevada Coal Resources, NBMG Open-File Report 80-5.

Garside, L.J. and R.H. Hess. 2011. Qualitative Petroleum Potential Map of Nevada, Nevada Bureau of Mines and Geology Open-File Report 11-2.

GeoHeat Center. 2002. Available online at: http://geoheat.oit.edu, accessed October, 2016.

Grauch, V.J.S., 1996. Magnetically Interpreted granitoid plutonic bodies in Nevada, in An Analysis of Nevada's Metal Bearing Mineral Resources, edited by D.A. Singer, NBMG Open-File Report 96-2.

Great Basin Groundwater Geochemical Database. Available online: http://www.nbmg.unr.edu/Geothermal/GeochemDatabase.html, accessed August, 2016.

Guth, P.L.1980. Geology of the Sheep Range, Clark County, Nevada: Ph.D. dissertation, Massachusetts Institue of Technology, Boston, Massachusetts, 189 p.

Guth, P. L. 1981. Tertiary extension north of Las Vegas Valley shear zone, Sheep and Desert ranges, Clark County, Nevada: Geological Society of America Bulletin, v. 92, p. 763-771.

Guth, P.L. 1990. Superimposed Mesozoic and Cenozoic deformation, Indian Springs quadrangle, southern Nevada in Basin and Range tectonics near the latitude of Las Vegas, Nevada, edited by B.P. Wernicke, Geological Society of America Memoir 176, p. 237-249.

Guth, P.L., D.L. Schmidt, J. Deibert, and J.C. Yount. 1988. Tertiary extensional basins of northwestern Clark County, Nevada, in This extended land, geologic journeys in southern Basin and Range, edited by D.L. Weide and M.L. Faber. Geological Society of America, Cordilleran Section, Las Vegas, University of Nevada Printing Services, p. 239-253.

Hall, S. 1981. A Guide to the Ghost Towns and Mining Camps of Nye County, Nevada: Dodd, Mead, and Co., New York.

Hildebrand, T.G., V.E. Langenheim, E.A. Mankinen, and E.H. McKee. 1999. Inversion of gravity data to define the pre-Tertiary surface and regional structures possibly influencing ground-water flow in the Pahute Mesa-Oasis Valley region, Nye County, Nevada (No. 99-49). US Geological Survey.

Hinz, N.H., M.F. Coolbaugh, J.E. Faulds, D.L. Siler, and G. Dering. 2015. Building the Next Generation of Regional Geothermal Potential Maps: Examples from the Great Basin Region, Western USA, Proceedings World Geothermal Congress, 2015, Melborn, Australia, April 2015.

4483 Hittleman, A.M., J.O. Kinsfather, and H. Meyers. 1994. Geophysics of North America: Compact Disk, Third
4484 Printing. National Oceanic and Atmospheric Administration, US Department of Commerce.

4485 Hudson, M.R., J.G. Rosenbaum, C.S. Gromme', R.B. Scott, and P.D. Rowley. 1998. Paleomagnetic
4486 evidence for counterclockwise rotation in a broad sinistral shear zone, Basin and Range province,
4487 southeastern Nevada and southwestern Utah, in Accommodation zones and transfer zones: The
4488 regional segmentation of the Basin and Range Province, edited by J.E. Faulds and J.J Stewart.
4489 Geological Society of America Special Paper 323, p. 149-180.

4490 Jachens, R.C., B.C. Moring, and P.G. Schruben. 1996. Thickness of Cenozoic Deposits and the Isostatic
4491 Residual Gravity Over Basement, in An Analysis of Nevada's Metal Bearing Mineral Resources, edited
4492 by D.A. Singer, NBMG Open-File Report 96-2.

4493 Jackson, M.R., Jr. 1988. The Timber Mountain magmato-thermal event: An intense widespread culmination
4494 of magmatic and hydrothermal activity at the Southwestern Nevada Volcanic Field: Master's Thesis,
4495 University of Nevada, Reno, p. 46.

4496 Kreemer, C. G. Blewitt, and W.C. Hammond. 2010. Evidence for an active shear zone in southern Nevada
4497 linking the Wasatch fault to the Eastern California shear zone, Nevada Bureau of Mines and Geology,
4498 Geological Society of America, Geology, May 2010, no. 5: p. 475-478.

4499 Kreemer, C., W.C. Hammond, G. Blewitt, A.A. Holland, and R.A. Bennett. 2012. A Geodedic Strain Rate
4500 Model for the Pacific-North American Plate Boundary, Western United States, Nevada Bureau of Mines
4501 and Geology Map 178.

4502 Lipman, P.W. 1992. Magmatics in the Cordilleran United States; Progress and Problems, in The Cordilleran
4503 orogeny; Conterminous U.S.: Boulder, Colorado, edited by B.C. Burchfiel, P.W. Lipman, and M.L.
4504 Zoback. Geological Society of America, The Geology of North America, v. G-3, p. 481-514.

4505 Malmberg, G.T. and T.E. Eakin. 1962. Ground-water appraisal of Srcobatus Flat and Oasis Valley, Nye and
4506 Esmeralda Counties, Nevada. Nevada Department of Conservatioon and Natural Resources, Ground-
4507 water Resources-Reconnaisance Service, REPT.10.

4508 Mankinen, E.A, T.G. Hildenbrand, G.L. Dixon, E.H. McKee, C.J. Fridrich, and R.J. Laczniak. 1999. Gravity
4509 and Magenetic Study of the Pahute Mesa and Oasis Valley Region, Nye County, Nevada: US
4510 Geological Survey Open-File Report 99-303.

4511 Marvin, R.F., F.M. Byers, Jr., H.H. Mehnert, P.P. Orkild, and T.W. Stern. 1970. Radiometric ages and
4512 stratigraphic sequence of volcanic of volcanic and plutonic rocks, southern Nye and western Lincoln
4513 Counties, Nevada: Geological Society of America Bulletin, v. 81, p. 2657-2676.

4514 McKee, E.H. and J.R. Bergquist. 1993. New radiometric ages related to alteration and mineralization in the
4515 vicinity of Yucca Mountain, Nye County, Nevada. USGS Open-File Report 93-538.

4516 Minor, S.A., D.A. Sawyer, R.R. Wahl, V.A. Frizzell, S.P. Schilling, R.F. Warren, P.P. Orkild, J.A. Coe, M.R.
4517 Hudson, R.J. Fleck, M.A. Lanphere, W.C. Swadley, and J. Cole. 1993. Preliminary geologic map of the
4518 Pahute Mesa 30'X60' quadrangle, Nevada: USGS Open-File Report 93-299, 1:100,000.

4519 Mueller, P.A., J.L. Wooden, D.W. Mogk, and D.A. Foster. 2011. Paleoproterozoic evolution of the
4520 Farmington zone: Implications for terrane accretion in southwestern Laurentia. Lithosphere; v. 3; no. 6;
4521 p. 401-408; Data Repository Item 2011350.

4522 Muntean, J.L., M.P. Coward, and C.A. Tarnocai. 2007. Reactivated Palaeozoic normal faults: controls on
4523 the formation of Carlin-type gold deposits in north-central Nevada. *Geological Society, London, Special*
4524 *Publications*, *272*(1), p. 571-587.

4525 Muntean, J.L., J.S. Cline, A.C. Simon, and A.A. Longo. 2011. Magmatic-hydrothermal origin of Nevada's
4526 Carlin-type gold deposits. *Nature Geoscience*, *4*(2), pp.122-127.

4527 Muntean, J.L., N. Hinz, T. Cramer, D. Davis, G. Dering, and C. Sladek. 2014. An Updated Energy and
4528 Mineral Resource Assessment of the Desert National Wildlife Range, Clark and Lincoln Counties,
4529 Nevada, Nevada Bureau of Mines and Geology Open-File Report 14-3.

4530 NBMG (Nevada Bureau of Mines and Geology). 2011. Map 161 Interactive Geothermal Map of Nevada.
4531 Available online: http://web2.nbmg.unr.edu/flexviewers/map_161, accessed August, 2016.

4532 NBMG. 2016. Geothermal Energy, Site Descriptions, Univeristy of Nevada, Reno.
4533 http://www.nbmg.unr.edu/geothermal/SiteDescriptions.html, accessed August, 2016.

4534 Noble, D.C., S.I. Weiss, and E.H. McKee. 1991. Magmatic and Hydrothermal Activity, Caldera Geology,
4535 and Regional Extension in the Western part of the Southwestern Nevada Volcanic Field, in Geology
4536 and Ore Deposits of the Great Basin, edited by G.L Raines, R.E. Lisle, R.W. Schafer, and W.H.
4537 Wilkinson. Geological Society of Nevada, Reno, p. 913-934.

4538 Page, W.R., G.L. Dixon, P.D. Rowley, and D.W. Brickey. 2005. Geologic Map of Parts of the Colorado,
4539 White River, and Death Valley Regional Groundwater Flow Systems, Nevada, Utah, and Arizona,
4540 Nevada Bureau of Mines and Geology Map 150, p. 23.

4541 Papke, K.G. 1970. Montmorillonite, bentonite and fuller's earth deposits in Nevada, Nevada Bureau of
4542 Mines and Geology Bulletin 76.

4543 Papke, K.G. and S.B. Castor. 2003. Industrial Mineral Deposits in Nevada, Nevada Bureau of Mines and
4544 Geology Map 142,

4545 Penfield, R., L. Shevenell, L. Garside, and R. Zehner. 2010. Nevada Geothermal Resources, Nevada
4546 Geothermal Resources Map 161, NBMG.

4547 Raines, G. L., K.A. Connors, L.A. Moyer, and R.J. Miller. 2003. Spatial Digital Database for the Geologic
4548 Map of Nevada. Geology compiled by John H. Stewart and John E. Carlson. Map originally published
4549 in 1978. 1:500,000, USGS Open-File Report 03-66, Digital database, version 3.0.

4550 Rasmussen, J.C. and S.B. Keith. 1991. Magma-Metal Series Classification of Mineralization in the Vicinity
4551 of Yucca Mountain, Nevada.

4552 Ross, R.J. and C.R. Longwell. 1964. Paleotectonic significance of Ordovician sections south of the Las
4553 Vegas shear zone, p. C-88 - C-93 in Middle and Lower Ordovician Formation in southernmost Nevada
4554 and adjacent California, edited by R.J. Ross: USGS Bulletin 1180-C, 101.

4555 Rye, R.O. 1993. The evolution of magmatic fluids in the epithermal environment: the stable isotope
4556 perspective: Economic Geology, v. 88, p. 733-753.

4557 Saltus, R.W. 1988a. Bougher Gravity Anomaly Map of Nevada, Nevada Bureau of Mines and Geology Map
4558 94A.

4559 Saltus, R.W. 1988b. Regional, Residual and Derivative Gravity Maps of Nevada, Nevada Bureau of Mines
4560 and Geology, Map 94B.

Sass, J.H., S.S. Priest, A.H. Lachenbruch, S.P. Galanas, T.H. Moses, J.P. Kennelly, R.J. Munroe, E.P. Smith, F.V. Grubb, R.H. Husk, and C.W. Mase. 1999. Summary of Supporting Data for USGS Regional Heat Flow Studies of the Great Basin, 1970-1990, US Department of the Interior, USGS. Available online at: http://pubs.usgs.gov/of/2005/1207/.

Sawyer, D.A., R.J. Fleck, M.A. Lanphere, R.G. Warren, D.E. Broxton, and M.R. Hudson. 1994. Episodic Caldera Volcanism in the Miocene Southwestern Nevada Volcanic Field: Revised Stratigraphic Framework, 40Ar/39Ar Geochronology, and Implications for Magmatism and Extension: Geological Society of America Bulletin, v. 106, p. 1304-1318.

Seedorff, E., J.H. Dilles, J.M. Proffett, M.T. Einaudi, L. Zurcher, W.J.A. Stavast, D.A. Johnson, and M.D. Barton. 2005. Porphyry Deposits: Characteristics and Origin of Hypogene Features, Economic Geology 100th Anniversary Issue, p. 251-298.

Schenkel, C.J., T.G. Hildenbrand, and G.L. Dixon. 1999. Magnetotelluric Study of the Pahute Mesa and Oasis Valley Regions, Nye County, Nevada. US Geological Survey Open-File Report 99-355, In cooperation with the US Department of Energy.

Sherlock, M.G., D.P. Cox, and D.F. Huber. 1996. Known Mineral Deposits and Occurrences in Nevada, in An Analysis of Nevada's Metal-bearing Mineral Resources, edited by D.A. Singer, NBMG Open-File Report 96-2.

Simmons, S.F., N.C. White, and D.A. John. 2005. Geological Characteristics of Epithermal Precious and Base Metal Deposits, Economic Geology 100th Anniversary Issue, p. 485-522.

Sims, P.K., R.W. Saltus, and E.D. Anderson. 2005. Preliminary Precambrian Basement Structure Map of the Continental United States – An Interpretation of Geologic and Aeromagnetic Data. USGS Open-File Report 2005-1029, US Department of the Interior.

Singer, D.A. (editor). 1996. An Analysis of Nevada's Metal-bearing Mineral Resources, NBMG Open-File Report 96-2.

Snow, J.K. 1992. Large magnitude Permian shortening and continental-marginal tectonics in the southern Cordillera: Geological Society of America Bulletin, v. 104, P. 80-105.

Southern Methodist University, 2016. Stewart, J.H. and J.E. Carlson. 1978. Geologic Map of Nevada, USGS and Nevada Bureau of Mines and Geology. Available online at: http://www.smu.edu/geothermal, accessed October, 2016.

Stewart, J.H. 1980. Geology of Nevada, Nevada Bureau of Mines and Geology Special Publication 4.

Stewart, J.H. 1988. Tectonics of the Walker Lane belt, western Great Basin Mesozoic and Cenozoic deformation in a zone of shear, in Ernst, W.G., ed., Metamorphism and crustal evolution of the Western United States (Ruby Volume 7): Geological society of America Bulletin, v. 79, p. 1407-1414.

Stewart, J.H. and J.C. Crowell. 1992. Strike-slip tectonics in the Cordillera region, western United States, in The Cordilleran Orogeny in Conterminous U.S.: Boulder, Colorado, edited by B.C. Burchfiel, P.W. Lipman, and M.L Zoback. Geological Society of America, Geology of North America, v. G-3, p. 609-628.

Taylor, W.J., J.M. Bartley, J.E. Fryxell, J.G. Schmitt, and D.S. Vandervoot. 1993. Tectonic style and regional relations of the central Nevada thrust belt, in Crustal evolution of the Great Basin and Sierra Nevada, edited by M.M. Lahren, J.H. Trexler, Jr., and C. Spinosa. Geological Society of America Fieldtrip guidebook, Department of Geological Sciences, University of Nevada, Reno, p. 57-96.

Tingley, J.V., 1991. Mineral resources of the Timpahute Range 30º by 60º Quadrangle, Neveda Bureau of Mines and Geology Report 46.

Tingley, J.V. 1998. Mining Districts of Nevada, second edition, NBMG Report 47, CD, plate, p. 128.

Tingley, J.V., S.B. Castor, L.J. Garside, H.F. Bonham, Jr., T.P. Lugaski, and P.J. Lechler. 1993. Energy and Mineral Resource Assessment of the Desert National Wildlife Range, Eastern Section, Clark and Lincoln Counties, Nevada, Nevada Bureau of Mines and Geology Open–File Report 93-2.

Tingley, J.V., S.B. Castor, S.I. Weiss, L.J. Garside, J.G. Price, D.D. LaPointe, H.F. Bonham, Jr., and T.P Lugaski. 1998. Mineral and Energy Resource Assessment of the Nellis Air Force Range U.S. Air Force Air Combat Command, Clark, Lincoln, and Nye Counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 98-1.

Tschanz, C.M. and A.N. Pampeyan. 1970. Geology and Mineral Deposits of Lincoln County, Nevada, NBMG Bulletin 73.

US Energy Information Administration (USEIA). 2016. http://www.eia.gov various web pages, accessed October, 2016.

US Geological Survey. 2005. NWIS Database. Available online at: www.waterdata.usgs.gov/NWIS, accessed August, 2016.

Vandervoort, D.S. and J.G. Schmitt. 1990. Cretaceous to early Tertiary paleogeography in the hinterland of the Sevier thrust belt, east-central Nevada: Geology, v. 18, p. 567-570.

Vikre, P., Browne, Q.J., Fleck, R., Hofstra, A. and Wooden, J., 2011. Ages and sources of components of Zn-Pb, Cu, precious metal, and platinum group element deposits in the goodsprings district, Clark county, Nevada. *Economic Geology*, *106*(3), pp.381-412.

Water Storage and Retrieval System (WATSTORE) Source/Platform Document. Available online at: http://daac.ornl.gov/source_documents/watstore.html, accessed August, 2016.

Wesnousky, S.G. 2005. The San Andreas and Walker Lane fault systems, western North America: transpression, transtension, cumulative slip and the structural evolution of a major transform plate boundary, Center for Neotectonic Studies, University of Nevada, Reno, Journal of Structural Geology 27, p. 1505-1512.

Western Cordillera Inc. 2006. An integrated petroleum evaluation of Northeastern Nevada, http://westerncordillera.com., accessed October, 2016.

White, D.E. and C.E. Roberson. 1962. Sulphur Bank, California, a major hot-spring quicksilver deposit. *Petrologic studies, a volume to honor AF Buddington*, pp. 397-428.

Wohletz, K. and G. Heiken. 1992. Volcanology and Geothermal Energy: University of California Press, p. 432.

Workman, J.B., C.M. Menges, W.R. Page, E.B. Ekren, P.D. Rowley, and G.L. Dixon. 2002. Tectonic map of the Death Valley ground-water model area, Nevada and California. Pamphlet to accompany Miscellaneous Field Studies Map MF-2381-B. US Geological Survey.

Zehner, R., M. Coolbaugh, G. Blewett, and C. Kreemer. 2005. Combined Dilational Strain Rate from Geodesy, http://repository.stategeothermaldata.org/repository/resource/50ec3aefb656b70647f32e38bc2f7b84/.

4641 Zehner, R., M. Coolbaugh, and L. Shevenell. 2009. Preliminary Geothermal Potential and Exploration
4642 Activity in Nevada, NBMG Open-File Report 09-10.

APPENDIX A: PROPOSED WITHDRAWAL AND RENEWAL AREA LEGAL DESCRIPTIONS

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[LLNVS00000 L19200000.ET0000 WBS LRORF1608700]

Notice of Application for Withdrawal Extension; Notice of Application for Withdrawal Expansion; and Opportunity for Public Meeting; Department of the Air Force, Nevada Test and Training Range, Nevada

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice of Withdrawal Applications.

SUMMARY: The Department of the Air Force (DAF) has filed an application with the Department of the Interior to extend the current withdrawal of public lands from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, subject to valid existing rights, for military use of the Nevada Test and Training Range (NTTR), in Clark, Lincoln, and Nye Counties, Nevada. The DAF has also requested the withdrawal of approximately 301,507 additional acres of public lands from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, subject to valid existing rights. This notice temporarily segregates these lands from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, for 2 years; gives the public an opportunity to comment on the extension and withdrawal applications; and announces the date, time, and location of public meetings.

DATES: Comments on the extension and withdrawal applications, including their environmental consequences, should be received on or before December 10, 2016. In addition, the BLM and DAF will hold joint public meetings on the extension and withdrawal applications, and DAF's National Environmental Policy Act (NEPA) evaluation of the withdrawals. The dates and locations of the public meetings are listed in the **SUPPLEMENTARY INFORMATION** section.

ADDRESSES: Comments pertaining to the DAF withdrawal extension proposal and/or the DAF withdrawal expansion proposal should be sent to Nellis Air Force Base 99th Air Base Wing Public Affairs, 4430 Grissom Ave., Suite 107, Nellis AFB, NV 89191. Comments pertaining to this Notice should be submitted by any of the following methods:

- *Email: BLM_NV_SNDO_NTTR_Withdrawal@blm.gov*
- *Fax:* (702) 515–5023
- *Mail:* BLM Southern Nevada District Office, Attn: NTTR Withdrawal, 4701 North Torrey Pines Drive, Las Vegas, NV, 89130–2301.

FOR FURTHER INFORMATION CONTACT: Tom Seley, Project Manager, BLM Southern Nevada District Office, 4701 North Torrey Pines Drive, Las Vegas, NV, 89130–2301; email: *tseley@blm.gov.* Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339 to contact the above individual during normal business hours. The FIRS is available 24 hours a day, seven days a week, to leave a message or question with the above individual. You will receive a reply during normal business hours.

SUPPLEMENTARY INFORMATION: Pursuant to section 3016 of the National Defense Authorization Act for Fiscal Year 2000 (FY 2000 NDAA), Pub. L. 106–65, and section 3092(k) of the Carl Levin and Howard P. ''Buck'' McKeon National Defense Authorization Act of Fiscal Year 2015 (FY 2015 NDAA), the Department of the Air Force (DAF) has filed an application to extend the current withdrawal of public lands from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, subject to valid existing rights, for military use of the Nevada Test and Training Range (NTTR), in Clark, Lincoln, and Nye Counties, Nevada. The lands are currently withdrawn under the Act, which reserves these lands for defense-related purposes for a period of 20 years. Unless Congress extends the withdrawal, it will expire on November 5, 2021.

In addition to the DAF's request that the current withdrawal be extended, the DAF filed an application requesting the withdrawal and reservation of additional public lands for military use as a national security testing and training range at the NTTR, located in Clark, Lincoln, and Nye Counties, Nevada. The application to expand the acreage of lands withdrawn for the Air Force's use at the NTTR seeks the withdrawal of approximately 301,507 additional acres of public lands from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, subject to valid existing rights.

As required by section 204(b)(1) of the Federal Land Policy and Management Act of 1976 (FLPMA), 43 U.S.C. 1714(b)(1), and the BLM regulations at 43 CFR part 2300, the BLM is publishing Notice of the DAF applications. While the BLM and the Department of the Interior (DOI) assist the DAF with the processing of this application, and the Secretary of the Interior makes a recommendation to Congress on the proposed withdrawal, Congress, not the Secretary, will make the decision on the requested extension and expansion of the existing NTTR withdrawal.

Extension Request. This application requests extension of the withdrawal of the following area at the NTTR, Nevada, subject to valid existing rights as described below:

Lands Withdrawn by the FY 2000 NDAA

The DAF lands not withdrawn from the public domain and non-Federal lands are contained within the lands withdrawn boundary. Portions of the lands are unsurveyed and the acres were based upon protraction diagrams.

Mount Diablo Meridian, Nevada

Tps. 1, 2, 3, and 4 S., R. 44 E.
T. 5 S., R. 44 E., partly unsurveyed,
  Secs. 1 and 2;
  Secs. 10 thru 16;
  Secs. 20 thru 36.
T. 6 S., R. 44 E., unsurveyed,
  Secs. 1 thru 6;
  Secs. 8 thru 17;
  Secs. 21 thru 27;
  Secs. 34 thru 36.
T. 7 S., R. 44 E., partly unsurveyed,
  Secs. 1 and 2;
  Secs. 11 thru 13.
Tps. 1, 2, 3, and 4 S., R. 45 E.
Tps. 5 and 6 S., R. 45 E., unsurveyed.
T. 7 S., R 45 E., unsurveyed,
  Secs. 1 thru 30;
  Secs. 32 thru 36.
T. 8 S., R. 45 E., unsurveyed,
  Secs. 1 thru 4;
  Secs. 10 thru 14;
  Secs. 24 and 25.
Tps. 1 and 2 S., R. 46 E.
Tps. 3, 4, 5, 6, 7, and 8 S., R. 46 E., unsurveyed.
T. 9 S., R. 46 E., unsurveyed,
  Secs. 1 thru 5;
  Secs. 9 thru 15;
  Secs. 23 and 24.
Tps. 1 and 2 S., R. 47 E.
Tps. 3, 4, 5, 6, 7, and 8 S., R. 47 E., unsurveyed.
T. 9 S., R. 47 E., unsurveyed,
  Secs. 1 thru 30;
  Secs. 33 thru 36.
T. 10 S., R. 47 E., partly unsurveyed,
  Secs. 1, 2, and 12.
Tps. 1 and 2 S., R. 48 E.
Tps. 3, 4, and 5 S., R. 48 E., unsurveyed.
T. 6 S., R. 48 E., unsurveyed,
  Secs. 1 thru 34;

Sec. 35, N½;
Sec. 36. N½.
T. 7 S., R. 48 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 23;
Sec. 25, W½;
Secs. 26 thru 36.
Tps. 8 and 9 S., R. 48 E., unsurveyed.
T. 10 S., R. 48 E., unsurveyed,
Secs. 1 thru 17;
Secs. 21 thru 26;
Sec. 36.
Tps. 1 and 2 S., R. 49 E.
Tps. 3, 4, and 5 S., R. 49 E., unsurveyed.
T. 6 S., R. 49 E., unsurveyed,
Secs. 1 thru 30;
Sec. 31, N½ and SE¼;
Secs. 32 thru 36.
T. 7 S., R. 49 E., unsurveyed,
Secs. 1 thru 5;
Sec. 6, E½.
T. 8 S., R. 49 E., unsurveyed,
Sec. 6, W½;
Sec. 7;
Sec. 17, W½;
Secs. 18 thru 20;
Secs. 28 thru 33;
Sec. 34, W½.
T. 9 S., R. 49 E., unsurveyed,
Secs. 3 thru 11;
Secs. 14 thru 23;
Secs. 24 and 25, excepting those portions withdrawn by Public Land Order 2568;
Secs. 26 thru 35;
Sec. 36, excepting those portions withdrawn by Public Land Order 2568.
T. 10 S., R. 49 E., unsurveyed,
Sec. 1, excepting those portions withdrawn by Public Land Order 2568;
Secs. 2 thru 11;
Secs. 12 and 13, excepting those portions withdrawn by Public Land Order 2568;
Secs. 14 thru 23;
Secs. 24 and 25, excepting those portions withdrawn by Public Land Order 2568;
Secs. 26 thru 35;
Sec. 36, excepting those portions withdrawn by Public Land Order 2568.
T. 11 S., R. 49 E., unsurveyed,
Sec. 1, excepting those portions withdrawn by Public Land Order 2568;
Secs. 2 thru 11;
Secs. 12 and 13, excepting those portions withdrawn by Public Land Order 2568;
Secs. 14 thru 23;
Secs. 24 and 25, excepting those portions withdrawn by Public Land Order 2568;
Secs. 26 thru 35;
Sec. 36, excepting those portions withdrawn by Public Land Order 2568.
T. 12 S., R. 49 E., unsurveyed,
Sec. 1, excepting those portions withdrawn by Public Land Order 2568;
Secs. 2 thru 11;
Secs. 12 and 13, excepting those portions withdrawn by Public Land Order 2568;
secs 14 thru 23;
Secs. 24 and 25, excepting those portions withdrawn by Public Land Order 2568;
Secs. 26 thru 35;
Sec. 36, excepting those portions withdrawn by Public Land Order 2568.
Tps. 1, 2, 3, 4, and 5 S., R. 50 E., unsurveyed.
T. 6 S., R. 50 E., unsurveyed,
Secs. 1 thru 33.
T. 7 S., R. 50 E., unsurveyed,
Sec. 6.
Tps. 2, 3, 4, and 5 S., R. 51 E., unsurveyed.
T. 6 S., R. 51 E., unsurveyed,
Secs. 1 thru 30;
Secs. 34 thru 36.
T. 7 S., R. 51 E., unsurveyed,
Sec. 1.
Tps. 3 and 4 S., R. 51 ½ E., unsurveyed.
Tps. 3, 4, 5, and 6 S., R. 52 E., unsurveyed.
T. 7 S., R. 52 E., unsurveyed,
Secs. 1 thru 16;
Secs. 21 thru 28;
Secs. 33 thru 36.
T. 8 S., R. 52 E., unsurveyed,
Secs. 1 thru 4;
Secs. 9 thru 12, excepting those portions withdrawn by Public Land Order 805.
Tps. 3 and 4 S., R. 53 E.
Tps. 5, 6, and 7 S., R 53 E., unsurveyed.
T. 8 S., R. 53 E., unsurveyed,
Secs. 1 thru 6;
Secs. 7 thru 12, excepting those portions withdrawn by Public Land Order 805.
T. 3 S., R. 54 E.,
Secs. 4 thru 9;
Secs. 16 thru 21;
Secs. 28 thru 33.
T. 4 S., R. 54 E.,
Secs. 4 thru 9;
Secs. 16 thru 21;
Secs. 28 thru 33.
Tps. 5, 6, and 7 S., R 54 E., unsurveyed.
T. 8 S., R. 54 E., unsurveyed,
Secs. 1 thru 6;
Secs. 7 thru 11, excepting those portions withdrawn by Public Land Order 805;
Secs. 12 and 13;
Secs. 14 and 23, excepting those portions withdrawn by Public Land Order 805;
Secs. 24 and 25;
Secs. 26 and 35, excepting those portions withdrawn by Public Land Order 805;
Sec. 36.
T. 9 S., R. 54 E., unsurveyed,
Sec. 1;
Secs. 2 and 11, excepting those portions withdrawn by Public Land Order 805;
Secs. 12 and 13;
Secs. 14 and 23, excepting those portions withdrawn by Public Land Order 805;
Secs. 24 and 25;
Secs. 26 and 35, excepting those portions withdrawn by Public Land Order 805;
Sec. 36.
T. 10 S., R. 54 E., unsurveyed,
Sec. 1;
Secs. 2 and 11, excepting those portions withdrawn by Public Land Order 805;
Secs. 12 and 13;
Secs. 14 and 23, excepting those portions withdrawn by Public Land Order 805;
Secs. 24 and 25;
Secs. 26 and 35, excepting those portions withdrawn by Public Land Order 805;
Sec. 36.
T. 11 S., R. 54 E., unsurveyed,
Sec. 1;
Secs. 2 and 11, excepting those portions withdrawn by Public Land Order 805;
Secs. 12 and 13;
Secs. 14 and 23, excepting those portions withdrawn by Public Land Order 805;
Secs. 24 and 25;
Secs. 26 and 35, excepting those portions withdrawn by Public Land Order 805;
Sec. 36.
T. 12 S., R. 54 E., unsurveyed,
Sec. 1;
Secs. 2 and 11, excepting those portions withdrawn by Public Land Order 805;
Secs. 12 and 13;
Secs. 14 and 23, excepting those portions withdrawn by Public Land Order 805;
Secs. 24 and 25;
Secs. 26 and 35, excepting those portions withdrawn by Public Land Order 805;
Sec. 36.
T. 13 S., R. 54 E., unsurveyed,
Sec. 9, excepting those portions withdrawn by Public Land Order 805;
Secs. 10 thru 15;
Secs. 16 and 21, excepting those portions withdrawn by Public Land Order 805;
Secs. 22 thru 27;
Secs. 28 and 33, excepting those portions withdrawn by Public Land Order 805;
Secs. 34 thru 36.
T. 14 S., R. 54 E., unsurveyed,
Secs. 1 thru 3;
Secs. 4 and 9, excepting those portions withdrawn by Public Land Order 805;
Secs. 10 thru 15;
Secs. 16 and 21, excepting those portions withdrawn by Public Land Order 805;
Secs. 22 thru 27;
Secs. 28 and 33, excepting those portions withdrawn by Public Land Order 805;
Secs. 34 thru 36.
Tps. 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14 S., R. 55 E., unsurveyed.
T. 5 S., R. 55½ E., unsurveyed,
Secs. 6 thru 8;
Secs. 16 thru 21;
Secs. 28 thru 33.
Tps. 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 S., R. 55½ E., unsurveyed.
T. 16 S., R. 55½ E.,
Sec. 1, N½;
Sec. 2, lots 1 and 2; NE¼.
T. 5 S., R. 56 E., unsurveyed,
Secs. 19 and 20;
Secs. 27 thru 35.
T. 6 S., R. 56 E., partly unsurveyed,
Secs. 2 thru 11;
Secs. 14 thru 23;
Secs. 25 thru 36.
T. 7 S., R. 56 E., partly unsurveyed,
Secs. 1 thru 11;
Sec. 13, W½;
Secs. 14 thru 23;
Sec. 24, NW¼;
Secs. 26 thru 35.
Tps. 8, 9, 10, 11, 12, 13, and 14 S., R. 56 E., unsurveyed.
T. 15 S., R. 56 E.
T. 16 S., R. 56 E.,
Secs. 1 thru 6;
Sec. 8, lot 1;
Sec. 9, lot 1;
Tracts 38, 39, 40, 41;
Tract 42, lots A, B and C.
T. 6 S., R. 57 E.,
Sec. 30, lots 1 thru 4, E½NW¼, E½SW¼;
Sec. 31.
T. 7 S., R. 57 E.,
Sec. 6.
Tps. 8, 9, 10, 11, 12, 13, 14, and 15 S., R. 57 E., unsurveyed.
T. 16 S., R. 57 E., partly unsurveyed,
Secs. 1 thru 6;
Sec. 7, NE¼;
Secs. 8 thru 16;

Sec. 17, NE¼;
Sec. 20, SE¼SW¼, S½SE¼;
Secs. 21 thru 26;
Sec. 27, NE¼;
Sec. 28, NW¼NW¼;
Sec. 29, N½NE¼, NE¼NW¼;
Sec. 35, NE¼;
Sec. 36.
Tps. 8, 9, 10, 11, 12, 13, 14, and 15 S., R. 58 E., unsurveyed.
T. 16 S., R. 58 E., unsurveyed,
Secs. 1 thru 10;
Secs. 15 thru 22;
Secs. 27 thru 34.
T. 17 S., R. 58 E.,
Secs. 1 thru 4;
Sec. 5, NE¼;
Sec. 9, NE¼;
Sec. 10, N½, N½SW¼, SE¼SW¼, SE¼;
Secs. 11 and 12;
Sec. 13, NW¼;
Sec. 14, N½, NE¼SW¼, SE¼;
Sec.15, NE¼NE¼.
Tps. 8, 9, 10, 11, 12, 13, and 14 S., R. 59 E., unsurveyed.

The area described aggregates 361,558 acres in Clark County, 778,681 acres in Lincoln County, and 1,808,244 acres in Nye County.

DAF Lands Not Withdrawn From the Public Domain

Mount Diablo Meridian, Nevada

General Land Office Patent #1660

T. 7 S., R. 55½ E.,
Sec. 5.

General Land Office Patent #1661

T. 7 S., R. 55½ E.,
Secs. 5 and 8.

Patent #1034979

T. 7 S., R. 55½ E.,
Sec. 8.

Patent #1055957

T. 7 S., R. 55½ E.,
Sec. 17.

The area described aggregates 87.49 acres in Lincoln County.

Non-Federally Owned Land

Mount Diablo Meridian, Nevada

Patent #284077

T. 2 S., R. 44 E.,
Secs. 18 and 19.

Patent #1001726

T. 1 S., R. 49 E.,
Sec. 2.

Patent #861377

T. 1 S., R. 49 E.,
Sec. 9, SW¼NW¼ and NW¼SW¼.

Patent #83152

T. 3 S., R. 44 E.,
Secs. 1 and 12.

Patent #572555

T. 4 S., R. 46 E.,
Sec. 27.

Patent #31381

T. 5 S., R. 45 E.,
Secs. 1 and 12.
T. 5 S., R. 46 E.,
Secs. 6 and 7.

Patent #296554

T. 5 S., R. 46 E.,
Secs. 1 and 2.

Patent #285880

T. 5 S., R. 46 E.,
Sec. 1.

The area described aggregates 365 acres in Nye County.

Lands Withdrawn by the FY 2015 NDAA

Mount Diablo Meridian, Nevada

T. 19 S., R. 62 E.,
Sec. 13, lots 2, 4 and 5, excepting those portions lying within the right-of-way of the Union Pacific Railroad;
Sec. 14, lots 1, 2, 5, 6, and 8, N½NE¼, NW¼, excepting those portions lying within the right-of-way of the Union Pacific Railroad;
Sec. 24, SE¼, excepting those portions lying within the right-of-way of Nevada State Route 604 (Las Vegas Blvd.);
Sec. 25, lot 2.
T. 19 S., R. 63 E.;
Sec. 19, lot 4, S½SW¼, SW¼SE¼, excepting those portions lying within the right-of-way of Nevada State Route 604 (Las Vegas Blvd.);
Sec. 27, S½NW¼ and SE¼SE¼;
Sec. 28, S½NE¼ and SE¼NW¼;
Sec. 30, lots 1 and 2, W½NE¼ and NW¼.

The area described aggregates 1,120 acres in Clark County.

The total area aggregates 2,949,603 acres.

Expansion Request. In addition, in accordance with the Engle Act, (43 U.S.C. 155–158), the DAF has filed an application requesting withdrawal and reservation of additional public lands for military use as a national security testing and training range at the NTTR, in Clark, Lincoln, and Nye Counties, Nevada (the ''expansion area''). The DAF requests that the lands be withdrawn from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws, subject to valid existing rights, and reserved for use by the DAF for training for aerial gunnery, rocketry, electronic warfare, and tactical maneuvering and air support; as an armament and high-hazard testing area; for equipment and tactics development and testing; as well as for other defense-related purposes. The expansion area consists of the lands and interests in lands described below and adjacent to the exterior boundaries of the NTTR, located in Clark, Lincoln, and Nye Counties, Nevada. Portions of the lands are unsurveyed and the acres were based upon protraction diagrams.

Mount Diablo Meridian, Nevada

EC South/Range 77

T. 9 S., R. 46 E., unsurveyed,
Secs. 16, 22, 25, 26, and 36.
T. 9 S., R. 47 E., unsurveyed,
Secs. 31 and 32.
T. 10 S., R. 47 E., partly unsurveyed,
Secs. 3 thru 11.
T. 10 S., R. 48 E., unsurveyed,
Secs. 18 thru 20;
Secs. 27 thru 35.

The area described aggregates 17,960 acres in Nye County.

Mount Diablo Meridian, Nevada

Range 65D

T. 15 S., R. 54 E., unsurveyed,
Secs. 1 thru 3;
Sec. 4, excepting those portions withdrawn by Public Land Order 805;
Secs. 9 thru 16;
Secs. 21 thru 28;
Secs. 33 thru 36.
T. 16 S., R. 54 E.,
Secs. 1 and 2;
Sec. 3, lots 1 thru 4, S½NE¼, S½NW¼, N½SW¼, and SE¼;
Sec. 4, lots 1 thru 4, and S½NE¼.
T. 15 S., R. 55 E., unsurveyed.
T. 16 S., R. 55 E.,
Secs. 1 thru 6.
T. 16 S., R. 55½ E.,
Sec. 1, lot 1, E½SW¼, NW¼SW¼, and SE¼;
Sec. 2, lots 3 thru 5, NE¼SE¼, and W½SE¼.

The area described aggregates 39,119 acres in Clark County and 9,780 acres in Nye County.

Mount Diablo Meridian, Nevada

Ranges 63/64

T. 16 S., R. 56 E.,
Sec. 7, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Sec. 9, lot 2, that portion lying northerly of the northerly right-of-way line of U.S. Highway 95;
Secs. 10 and 11, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Sec. 12;
Secs. 13 and 14, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Tract 37.
T. 16 S., R. 57 E., partly unsurveyed,
Sec. 7, W½ and SE¼;
Sec. 17, W½ and SE¼;
Secs. 18 and 19, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Sec. 20, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65;
Sec. 27, W½ and SE¼;
Sec. 28, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65;
Secs. 33 and 34, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Sec. 35, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65.
T. 17 S., R. 58 E.,
Sec. 5, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65;
Sec. 6, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;

Sec. 8, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95;
Secs. 9 and 10, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65;
Sec. 13, NE¼ and S½;
Secs. 14 and 15, those portions lying northerly of the northerly right-of-way line of U.S. Highway 95, excepting those portions withdrawn by Public Law 106–65;

The area described aggregates 7,621 acres in Clark County.

Mount Diablo Meridian, Nevada

Alamos

T. 16 S., R. 58 E., unsurveyed,
Sec. 11;
Sec. 12, W½;
Sec. 13, NW¼, that portion lying westerly of the westerly boundary of Alamo Road;
Sec. 14;
Sec. 23, NE¼ and W½;
Sec. 26, W½.
T. 15 S., R. 59 E., unsurveyed,
Secs. 2 thru 11;
Secs. 14 thru 19;
Sec. 20, W½, that portion lying westerly of the westerly boundary of Alamo Road;
Sec. 30, that portion lying westerly of the westerly boundary of Alamo Road;
Sec. 31, NW¼.
Tps. 9, 10, 11, 12, 12½, and 13 S., R. 60 E., unsurveyed.
T. 14 S., R 60 E., unsurveyed,
Secs. 1 thru 11;
Sec. 12, NE¼ and W½;
Sec. 14, NE¼ and W½;
Secs. 15 thru 22;
Sec. 23, NW¼;
Sec. 27, NW¼;
Secs. 28 thru 32;
Sec. 33, NW¼.
T. 15 S., R. 60 E., unsurveyed,
Sec. 5, NW¼;
Sec. 6;
Sec. 7, NE¼ and W½.
T. 9 S., R. 61 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 22;
Secs. 27 thru 34.
T. 10 S., R. 61 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 22;
Secs. 27 thru 34.
T. 11 S., R. 61 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 22;
Secs. 27 thru 34.
T. 12 S., R. 61 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 22;
Secs. 27 thru 34.
T. 12½ S., R. 61 E., unsurveyed,
Secs. 31 thru 34.
T. 13 S., R 61 E., unsurveyed,
Secs. 3 thru 10;
Secs. 15 thru 21;
Sec. 22, NE¼ and W½;
Sec. 28, NE¼ and W½;
Secs. 29 thru 31;
Sec. 32, NE¼ and W½.
T. 14 S., R. 61 E., unsurveyed,
Sec. 6, NE¼ and W½.

The area described aggregates 72,649 acres in Clark County, and 154,378 acres in Lincoln County.

The Total Area Aggregates 301,507 Acres

In the event any non-Federally owned lands within these areas described above return or pass to Federal ownership in the future, they would be subject to the terms and conditions described.

The purpose of the requested extension and expansion of the withdrawals at NTTR is to withdraw and reserve the lands for use by the DAF for training for aerial gunnery, rocketry, electronic warfare, and tactical maneuvering and air support; as an armament and high-hazard testing area; for equipment and tactics development and testing; as well as other defense-related purposes. National defense requirements are rapidly evolving in response to changing world conditions, modern conflicts, developing technologies, and new emerging threats. The NTTR is a Major Range and Test Facility Base national asset and is used to accommodate two major national defense necessities: Test and Evaluation (T&E) and large-scale training. It is sized, operated, and maintained to provide T&E information to Department of Defense (DoD) component users in support of DoD research, development, and acquisition. The NTTR must provide a broad base of T&E capabilities that is sufficient to support the full spectrum of DoD T&E requirements. The NTTR also contributes to combat readiness training, providing a venue for major training events, 5th-generation aircraft training, and training for other Federal agencies, state and local governments, allied foreign governments, and commercial entities. The NTTR is the Air Combat Command's premier range for Tactics Development and Evaluations due to its focus on high-end combat training and operationally relevant testing. The DAF indicates that the requested withdrawals are essential to enhance large-scale training at the NTTR to support advanced weapons systems and large-scale combat training exercises while providing for public safety.

Copies of the legal descriptions and the maps depicting the lands that are the subject of the DAF's applications are available for public inspection at the following offices: State Director, BLM Nevada State Office, 1430 Financial Blvd., Reno, Nevada 89502 District Manager, BLM Southern Nevada District Office, 4701 North Torrey Pines Drive, Las Vegas, NV, 89130–2301.

For a period until December 1, 2016 all persons who wish to submit comments, suggestions, or objections in connection with the withdrawal applications may present their comments in writing to the persons and offices listed in the **ADDRESSES** section above. All comments received will be considered before the Secretary of the Interior makes any recommendation for withdrawal to Congress.

Notice is hereby given that public meetings addressing the withdrawal applications will be held concurrently with the DAF's public meetings associated with NEPA evaluation of the proposed withdrawals. Public meetings will be held at the following locations:

- Beatty Community Center, Beatty, NV, October 12, 2016, 5–9 p.m.;
- Tonopah Convention Center, Tonopah, NV, October 13, 2016, 5–9 p.m.;
- Caliente Elementary School, Caliente, NV, October 18, 2016, 5–9 p.m.;
- Pahranagat Valley High School, Alamo, NV, October 19, 2016, 5–9 p.m.;
- Aliante Hotel, North Las Vegas, October 20, 2016, 5–9 p.m.

The DAF will be the lead agency for evaluation of the proposed withdrawal extension and expansion pursuant to NEPA and other applicable environmental and cultural resources authorities, and will be publishing its own scoping and other notices.

Comments, including names and street addresses of respondents, will be available for public review at the DAF and BLM addresses noted above, during regular business hours Monday through Friday, except Federal holidays. Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment, including your personal identifying information, may be publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. Subject to valid existing rights, the public lands that are the subject of the DAF application for expansion of the withdrawal, and that are described in this Notice, will be segregated from all forms of appropriation under the public land laws, including the mining laws, the mineral leasing laws, and the geothermal leasing laws. The segregation will be effective for a period until [two years from date of publication in FR], unless the expansion application is denied or canceled or the requested withdrawal is approved prior to that date. Licenses, permits, cooperative agreements, or discretionary land use authorizations may be allowed during the period of segregation, but only with the approval of the authorized officer and, as appropriate, with the concurrence of DAF.

The applications for withdrawal and reservation will be processed in accordance with the regulations at 43 CFR part 2300.

Authority: 43 U.S.C. 1714(b)(1) and 43CFR 2300.

John F. Ruhs,

State Director, Nevada.

[FR Doc. 2016–21214 Filed 9–1–16; 8:45 am]

BILLING CODE 4310–HC–P

APPENDIX B: ACTIVE MINING CLAIMS

Appendix B: Active Mining Claims

Serial #	County	Withdrawal Area	Meridian	Township	Range	Section	Quadrant	Claim Name/Number	Claimant(s)	Lead File	Case Type	Status	Location Date	Last Assessment
NMC635691	NYE	EC SOUTH	21	0100S	0470E	3	NW	TANK #15	YOUNGHANS GEORGE E	NMC635677	LODE	ACTIVE	10/27/1991	2017
									YOUNGHANS LARENE M					
						4	NE		YOUNGHANS GEORGE E					
									YOUNGHANS LARENE M					

Notes:

Source: BLM Land & Mineral Legacy Rehost 2000 System-LR2000 https://www.blm.gov/lr2000/ Accessed on February 23, 2017

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APPENDIX C: GEOCHEMICAL ANALYTICAL RESULTS

- Appendix C.1: Laboratory Assay Data (ALS)
  - Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses
  - Appendix C.1b: Stream Sediment Sample Analyses
  - Appendix C.1c: Carbon Analyses
  - Appendix C.1d: Laboratory Results First Sample Delivery Group (ALS)
  - Appendix C.1e: Laboratory Results Second Sample Delivery Group (ALS)
- Appendix C.2: X-Ray Diffraction Test Results
  - Appendix C.2a: X-ray Diffraction Analysis
  - Appendix C.2b: Laboratory Results (DCM)
- Appendix C.3: Laboratory QA/QC Data (ALS)
  - Appendix C.3a: Laboratory Results First Sample Delivery Group (ALS)
  - Appendix C.3b: Laboratory Results Second Sample Delivery Group (ALS)
  - Appendix C.3c: USGS Quartz Latite Standard (QL0-1a) Reference Material Evaluation
  - Appendix C.3d: USGS Disseminated Gold Ore (DGPM-1) Reference Material Evaluation

Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	Sample Type	Locality	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																
			Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
			ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	Limit of Reporting		0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01	0.05	0.05	0.1
1213016	GSC	Indian Springs - Niavi Wash	0.02	0.08	0.8	<10	0.05	0.01	20.3	<0.02	1.63	0.4	2	0.07	1.6	0.05	0.19	0.09	0.1
1213017	GSC	Indian Springs - Niavi Wash	0.02	0.05	0.7	<10	0.05	0.01	20.1	<0.02	1.47	0.3	1	0.05	1.1	0.04	0.12	0.08	<0.1
1213018	GSC	Indian Springs - Silica Quarry	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213019	GSC	Indian Springs - Silica Quarry	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213020	GSC	Indian Springs - Timpi Wash	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213021	GSC	Indian Springs - Timpi Wash	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213022	GSC	Indian Springs - Timpi Wash	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1424933	GSC	West of Transvaal Hills	0.06	6.34	9.4	190	10.65	0.03	0.44	0.25	177.5	1.3	4	5.08	2.6	1.7	28	0.28	12.8
1424934	GSC	West of Transvaal Hills	0.11	6.72	6.2	260	5.34	0.27	1.26	0.07	67.4	3	11	7.26	6	1.16	19.15	0.18	3.9
1424937	GSC	West of Transvaal Hills	0.02	6.08	17.7	50	5.97	0.04	0.79	0.1	54.5	1	9	6.49	2	0.55	19.5	0.17	3
1213006	Mineralized Area	Transvaal Hills	0.15	5.28	3.7	720	1.89	0.09	1.56	0.06	95.1	1	22	9.3	1.8	0.94	13.55	0.2	2.3
1213009	Mineralized Area	Transvaal Hills	0.08	5.36	6.7	580	2.43	0.14	0.35	0.04	108	1.2	14	10.7	2.6	1.41	14.65	0.19	2.5
1213023	Mineralized Area	Don Dale Mine	281*	0.58	603	70	1.16	5.88	0.21	7.33	11.5	3.3	21	0.53	1445	3.35	8.51	0.06	0.1
1213024	Mineralized Area	Don Dale Mine	183*	1.53	276	120	0.81	9.84	0.06	3.52	29.8	2.9	30	1.46	2600	4.83	17.15	0.22	0.3
1213025	Mineralized Area	Don Dale Mine	11.3	5.95	20.6	670	2.09	0.82	0.22	0.53	77.2	5.7	18	5.36	367	2.42	16.05	0.16	1.6
1213026	Mineralized Area	Don Dale District	17.1	1.33	200	640	0.56	0.13	0.14	1.37	19.65	1.7	31	0.89	78.6	5.24	3.35	0.07	0.4
1213027	Mineralized Area	Don Dale District	1.51	3.42	32.5	520	4.56	0.23	0.38	0.27	50	30.9	52	4.53	22.8	6.79	9.06	0.1	0.8
1213028	Mineralized Area	Don Dale District	14.6	3.54	87.6	750	3.14	0.85	0.2	1.61	42.9	24.2	25	4.44	271	4.13	11.5	0.09	1
1213029	Mineralized Area	Limestone Ridge	0.15	5.14	6	280	2.17	0.13	0.68	0.04	73.9	18.9	44	3.21	19.2	5.68	13.75	0.16	1.2
1213030	Mineralized Area	Limestone Ridge	0.11	4.41	2.9	380	4.52	0.1	1.12	0.02	99.8	8.8	48	2.35	4.4	8.39	13	0.19	2
1213031	Mineralized Area	Limestone Ridge	0.08	1.28	3.6	140	0.89	0.04	3.27	0.09	16.65	8	32	0.8	4.3	2.94	3.83	0.07	0.5
1213032	Mineralized Area	Limestone Ridge	0.05	4.39	6.6	150	1.22	0.11	0.76	0.02	60.4	13.1	35	2.73	5.4	5.42	11.25	0.13	1.2
1213033	Mineralized Area	Limestone Ridge	0.07	0.44	11	50	0.35	0.03	12.4	0.07	7.34	1.1	11	0.59	3.6	0.68	1.19	0.08	0.4
1213034	Mineralized Area	Limestone Ridge	0.1	0.94	25.1	90	0.71	0.05	7.03	0.09	14.35	2.4	19	0.98	8.1	1.23	2.33	<0.05	0.8
1213035	Mineralized Area	Cliff Spring Mine - LS Ridge	0.1	7.49	7.7	930	3.52	0.06	0.63	0.1	144	2.3	4	6.47	3.9	2.21	18.95	0.27	3.5
1213036	Mineralized Area	Limestone Ridge	27.8	0.29	4.1	20	0.3	0.17	0.15	0.27	3.98	3.9	36	0.34	60100*	5.49	1.06	0.05	0.2
1213037	Mineralized Area	Limestone Ridge	0.1	2.06	179	40	9.01	0.09	0.44	0.03	31	19.9	33	1.36	148.5	37.8	7.03	0.22	1.4
1213038	Mineralized Area	Limestone Ridge	0.09	0.76	10.8	40	0.38	0.05	1.52	0.02	16	1.6	28	0.43	15	1.55	2.03	<0.05	0.4
1213039	Mineralized Area	Limestone Ridge	0.04	2.41	16	90	1.18	0.1	7.31	0.04	51.5	5.1	31	2.24	7.1	2.44	5.9	0.09	1.7
1213040	Mineralized Area	Limestone Ridge	0.08	0.64	57.6	280	0.42	0.05	0.14	0.1	11.7	4.9	49	0.62	7.6	3.06	1.85	<0.05	0.5
1424901	Mineralized Area	Transvaal Hills	0.14	6.47	9.2	1140	3.1	8.69	0.62	0.11	141	1	4	4.92	4.6	1.59	16.25	0.21	4.1
1424902	Mineralized Area	Transvaal Hills	0.03	6.26	11	280	1.55	0.85	0.28	0.03	92.2	0.4	11	0.71	1.5	1.55	14.55	0.19	2.7
1424903	Mineralized Area	Transvaal Hills	0.06	5.4	10.9	380	2.75	0.27	0.96	0.11	78.4	0.7	16	2.87	2.4	0.72	12.55	0.17	2.4
1424906	Mineralized Area	Transvaal Hills	0.04	4.1	6.7	230	0.95	2.31	1.23	0.22	44.1	1.1	59	0.7	2.8	1.37	9.92	0.14	2.1
1424907	Mineralized Area	Transvaal Hills	0.03	3.75	19.5	360	1.09	1.26	0.42	0.07	81.2	0.4	11	2.32	2.6	0.82	12.25	0.18	3.2
1424908	Mineralized Area	Transvaal Hills	0.04	6.55	11.8	260	2.47	0.12	0.65	0.06	94.9	0.4	12	3.35	1	0.78	14.8	0.18	2.6
1424909	Mineralized Area	Transvaal Hills	0.02	5.25	11.2	230	2.83	0.09	3.34	0.05	70	0.7	6	2.23	1.8	0.84	13.05	0.17	1.8
1424910	Mineralized Area	Transvaal Hills	0.04	6	2.7	310	1.91	0.05	0.45	0.11	88.7	1.1	18	1.7	2.4	0.98	12.35	0.19	2.2
1424911	Mineralized Area	Transvaal Hills	0.03	5.18	14.5	100	0.17	3.27	1.36	0.06	62.3	0.5	69	0.66	1.7	0.96	13.6	0.14	2.5
1424914	Mineralized Area	Oasis Hills	0.09	6.55	25.2	870	2.78	0.07	0.19	0.11	108	1	14	2.13	4.8	2.91	17.55	0.21	3.8

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	CV/AAS ALS Code Hg-CV41	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																			
	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta
	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	0.005	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05
1213016	0.008	<0.005	0.04	0.9	0.7	12.65	42	0.25	0.02	0.2	1	30	0.9	1.3	<0.002	<0.01	0.11	0.2	<1	<0.2	50.6	<0.05
1213017	0.006	<0.005	0.02	0.6	0.5	12.55	50	0.44	0.03	0.1	0.9	30	0.8	0.8	<0.002	<0.01	0.09	0.3	<1	<0.2	44.7	<0.05
1213018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213020	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213021	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213022	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1424933	0.02	0.152	3.81	91	78.2	0.15	627	3.14	3.15	100	2	390	41.5	270	<0.002	0.03	1.01	2.1	2	8.5	53.7	5.4
1424934	0.038	0.048	2.96	34.3	62.5	0.68	666	2.23	2.01	46.2	5.4	200	30	184.5	<0.002	0.01	1.03	5	1	3.2	596	3.78
1424937	0.009	0.031	4.04	25.3	74.1	0.07	679	3.6	2.55	53	1.2	430	32.9	330	<0.002	0.18	1.54	3.6	1	2.3	31.6	4.38
1213006	0.47	0.029	3.98	47.5	39.9	0.16	344	1.58	1.39	16.3	1.3	180	20.4	138	<0.002	0.02	1.07	1.6	1	1.5	219	0.93
1213009	0.204	0.033	3.11	58	19.9	0.15	151	1.06	0.17	16.7	2.1	180	29.7	145	<0.002	0.01	1.51	2.2	1	1.7	84	1
1213023	8	50.6	0.22	5.4	9.2	0.03	212	4.39	0.01	0.5	4.8	170	40400*	10.8	<0.002	0.08	1465	0.5	3	24.9	8.9	<0.05
1213024	2.4	116	0.65	14.7	17.6	0.07	384	8.07	0.01	1.1	6.5	240	5530	34.8	<0.002	0.06	1190	1.5	2	77.2	7.6	0.07
1213025	0.36	2.63	2.63	39.8	23.2	0.22	1400	3.07	0.03	12	4.2	670	1000	144	<0.002	0.02	29	5.5	1	2.8	35.4	0.82
1213026	0.37	0.497	0.45	10.5	15.7	0.05	136	5.13	0.01	1.2	12.1	400	581	18.6	<0.002	0.06	24.3	1.3	3	0.7	33.1	0.1
1213027	0.06	0.256	1.69	25.4	24.7	0.24	2400	8.86	0.02	7.9	42.8	370	614	71.7	<0.002	0.03	12.2	4.7	2	2.9	22.2	0.55
1213028	2.2	7.75	1.54	20.3	29.7	0.17	3000	12.05	0.02	6	27.3	500	5030	87	<0.002	0.15	15	3.9	2	6.3	37.6	0.39
1213029	0.04	0.111	1.99	30	21.1	0.53	538	1.41	0.15	6.5	22.4	1130	33.1	75.3	<0.002	0.01	1.45	12.3	1	1.4	26.5	0.47
1213030	0.06	0.115	1.89	33.3	15.4	0.44	1060	0.99	0.99	11.5	8.8	2750	27.1	72.5	<0.002	0.01	1.26	9.8	2	1.4	79.8	0.81
1213031	0.02	0.061	0.55	6.7	13.6	0.2	1650	5.48	0.04	3.3	11.6	410	13	17.3	<0.002	0.01	1.64	5.5	2	0.5	38.7	0.19
1213032	0.03	0.052	1.27	22.8	28.2	0.4	262	1.16	0.1	5.9	20	1000	7.8	47.6	<0.002	0.01	1.11	9.2	1	1.1	20	0.44
1213033	0.03	0.019	0.18	3.2	19.9	7.2	267	2.31	0.02	0.9	2.6	160	10.8	6.7	<0.002	0.01	2.88	0.6	2	0.2	57.9	0.05
1213034	0.04	0.03	0.39	4.9	15.6	3.62	478	3.02	0.04	2.1	8.4	350	9.9	14.2	<0.002	0.01	3.11	1.6	2	0.4	51.3	0.13
1213035	<0.01	0.045	6.76	71.9	20.9	0.07	2090	1.26	1.37	17.9	2.9	120	41.5	190	<0.002	<0.01	1.79	5.4	1	2.4	186.5	1.16
1213036	0.1	0.304	0.14	1.7	4.4	0.03	95	3.91	0.01	0.8	8	90	19.2	4.7	<0.002	1.81	2.4	1.2	7	0.8	7.7	<0.05
1213037	0.1	0.038	0.83	18.2	6.8	0.21	742	3.16	0.01	7.7	67.1	2130	7.6	23.7	<0.002	0.19	2.87	6.1	2	0.7	54.3	0.46
1213038	0.03	0.017	0.37	7.8	6.2	0.84	157	2.13	0.01	1.8	7.7	130	13.4	9.5	<0.002	0.02	1.84	2.7	2	0.3	11.1	0.1
1213039	0.07	0.032	1.03	23.9	13.2	4.03	319	1.29	0.04	5.6	16.4	550	16.8	31.2	<0.002	0.02	3.7	5.7	2	0.7	61.4	0.36
1213040	0.05	0.011	0.27	5.8	11	0.07	2320	3.79	0.01	1.5	7.2	400	10.5	7.7	<0.002	0.04	3.34	2	2	0.2	31.3	0.07
1424901	0.271	0.053	3.95	77.6	31	0.3	867	1.1	0.83	20.1	3.9	230	113.5	122.5	<0.002	0.03	2.31	2.9	1	2	85.6	1.17
1424902	0.118	0.051	2.06	52	17.4	0.04	54	1.09	0.23	18.1	0.9	130	28.9	71.7	<0.002	0.03	1.06	2	<1	1.6	68.7	1.14
1424903	1.655	0.03	3.77	42.9	19.6	0.17	1410	1.01	0.55	18.3	1.1	260	24.3	131.5	<0.002	0.02	1.19	2	1	1.6	506	1.14
1424906	3.09	0.021	4.22	25.9	28.8	0.08	227	18.55	0.37	10.5	2.5	3870	15.8	144	<0.002	0.04	1.63	1	<1	2.8	46.5	0.76
1424907	1.25	0.02	2.58	48.9	22.1	0.12	363	15.6	0.81	23	0.9	140	23.8	112	<0.002	0.01	0.95	1	1	2.2	127	1.16
1424908	0.219	0.024	4.18	51.5	36.2	0.16	214	1.35	1.14	19.2	0.6	130	22.7	139	<0.002	<0.01	0.52	2.2	<1	1.5	80.2	1.25
1424909	0.519	0.023	3.47	35.8	36.8	0.2	386	1.53	0.9	17.7	1	220	24.1	119.5	<0.002	0.05	0.6	1.9	1	1.5	207	1.18
1424910	0.26	0.021	4.59	50.9	23.5	0.13	242	1.33	0.86	17.3	1.8	360	23.8	155.5	<0.002	0.04	0.9	2	<1	1.2	66	1.08
1424911	0.341	0.015	0.09	37.4	26.9	0.09	61	7.61	0.06	16.3	1.5	210	15.6	5.9	<0.002	0.01	0.75	1	<1	1.2	103	1
1424914	0.082	0.049	3.96	59.6	17.6	0.11	395	4.74	1.24	22.9	1.7	550	35.3	161.5	<0.002	0.16	0.92	2.6	1	1.8	181.5	1.29

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61										Rare Earth ICP MS - ALS Code ME-MS61r											
	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Dy	Er	Eu	Gd	Ho	Lu	Nd	Pr	Sm	Tb	Tm	Yb
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.05	0.03	0.03	0.05	0.01	0.01	0.1	0.03	0.03	0.01	0.01	0.03
1213016	<0.05	0.19	0.005	<0.02	0.8	2	<0.1	0.9	2	2.3	0.13	0.08	<0.03	0.13	0.03	0.01	0.8	0.2	0.16	0.02	0.01	0.07
1213017	<0.05	0.27	<0.005	<0.02	0.8	3	0.1	0.6	<2	1	0.11	0.06	<0.03	0.12	0.02	0.01	0.7	0.18	0.14	0.02	0.01	0.06
1213018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213020	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213021	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1213022	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1424933	<0.05	34.7	0.116	0.98	7	20	5.2	68.2	139	364	11.35	6.58	0.28	11.05	2.29	0.87	71.9	21	13.5	1.89	0.97	5.97
1424934	<0.05	24.5	0.145	1.28	5.6	19	2.4	37.5	43	99.7	6.5	4.09	0.45	5.79	1.36	0.62	29.1	8.26	6.39	1.04	0.64	4.22
1424937	<0.05	24.7	0.055	1.55	9.2	7	3.9	41.6	32	58.9	6.74	4.44	0.13	5.42	1.43	0.64	21.5	6.15	5.32	1.04	0.7	4.52
1213006	<0.05	17.5	0.09	0.89	2.7	7	1.5	15.8	35	64.6	3	1.72	0.58	3.35	0.58	0.28	33.1	9.84	5.25	0.5	0.28	1.7
1213009	<0.05	17.9	0.111	0.93	3.9	17	1.6	21.8	42	65.4	3.66	2.02	0.67	4.22	0.73	0.32	38.2	11.15	6.42	0.63	0.31	1.97
1213023	83.5	1.14	0.019	0.19	0.7	4	2.3	1.9	1060	2.9	0.59	0.26	0.24	0.99	0.1	0.03	4.9	1.26	1.14	0.14	0.03	0.18
1213024	52	2.01	0.044	0.42	1.6	11	3.9	3.1	1700	9.5	0.85	0.32	0.37	1.56	0.14	0.04	11.4	3.13	2.18	0.19	0.07	0.25
1213025	3.38	14.15	0.223	1.52	2.8	42	2.1	11	305	47.4	2.24	1.1	0.98	3.36	0.42	0.17	31	9.02	5.18	0.44	0.17	1.04
1213026	1.32	3.26	0.04	0.25	1	9	2	2.5	290	9.5	0.53	0.25	0.31	1.08	0.11	0.05	8	2.15	1.96	0.12	0.06	0.24
1213027	0.55	9.07	0.15	0.82	1.8	30	2	6.7	221	33.6	1.51	0.7	0.63	2.31	0.27	0.1	19.9	5.52	3.58	0.31	0.1	0.66
1213028	5.12	9.05	0.126	0.95	2.4	29	5	8.1	990	28.8	1.79	0.87	0.76	2.71	0.33	0.13	18.3	4.82	3.58	0.36	0.14	0.85
1213029	0.07	6.16	0.328	0.28	1.1	78	0.9	14.5	68	38.9	3.25	1.55	1.45	5.02	0.57	0.27	34.6	8.83	7.39	0.69	0.22	1.47
1213030	0.05	9.82	0.469	0.26	1.8	69	1.2	25.2	36	60.4	5.57	2.88	1.84	7.89	1	0.33	42.2	10.55	9.62	1.11	0.49	2.2
1213031	<0.05	1.6	0.176	0.07	0.9	29	1.9	6.1	40	13.9	1.3	0.72	0.51	1.63	0.27	0.12	7.7	1.86	1.93	0.24	0.11	0.7
1213032	<0.05	5.34	0.265	0.18	1.2	57	1.3	14.2	37	48.3	4.52	1.65	1.34	5.43	0.61	0.24	29.5	7.12	6.84	0.65	0.24	1.66
1213033	<0.05	1	0.018	0.19	1.2	6	0.8	4.6	20	16.1	0.56	0.38	0.11	0.5	0.13	0.05	2.8	0.73	0.57	0.08	0.06	0.36
1213034	<0.05	2.18	0.041	0.54	1.8	13	2	5.7	16	26.5	0.91	0.52	0.21	0.95	0.19	0.07	4.8	1.24	1.06	0.14	0.08	0.5
1213035	<0.05	22.8	0.094	2.37	5.3	17	3.8	28.3	57	82.3	4.91	2.85	1.01	5.74	1.04	0.46	50	15.1	7.82	0.86	0.45	2.86
1213036	<0.05	0.42	0.027	0.02	3.8	8	0.8	1.2	76	5.2	0.27	0.15	0.1	0.36	0.04	0.02	1.8	0.45	0.41	0.05	0.02	0.16
1213037	<0.05	5.51	0.149	0.12	3.2	27	1.5	11.1	242	49.2	1.66	0.96	0.36	1.55	0.36	0.13	11.3	3.3	1.89	0.27	0.14	0.81
1213038	<0.05	2.19	0.042	0.17	0.4	11	0.9	3.6	7	14.9	0.76	0.39	0.27	1.04	0.15	0.06	6.8	1.83	1.32	0.14	0.06	0.32
1213039	<0.05	9.81	0.138	0.31	2.5	32	1	13.2	22	63.4	2.38	1.23	0.86	3.26	0.46	0.17	23.4	6.03	4.6	0.46	0.19	1.08
1213040	<0.05	3.16	0.036	0.55	1.2	20	0.7	2.4	18	15.1	0.4	0.28	0.14	0.47	0.08	0.04	4.6	1.26	0.75	0.07	0.04	0.26
1424901	<0.05	19.4	0.147	1.14	2.6	13	1.4	21.2	148	152	4.21	2.24	1.45	5.17	0.8	0.32	54	16.15	7.9	0.76	0.34	2.16
1424902	<0.05	27.7	0.119	0.36	2.7	11	1.7	13.4	11	79.6	2.59	1.42	0.62	3.79	0.49	0.22	30.9	9.55	5.07	0.52	0.23	1.52
1424903	<0.05	21.4	0.097	1.06	2.9	8	0.8	17.4	25	72	3.11	1.74	0.44	3.31	0.6	0.26	26.9	7.99	4.33	0.53	0.27	1.78
1424906	0.13	18.35	0.08	1.24	19.5	16	3.1	8.7	16	63.9	1.51	0.91	0.27	1.6	0.3	0.15	13.5	4.21	2.08	0.25	0.15	0.92
1424907	0.06	27.1	0.15	0.96	3.4	9	3	14.5	14	91	2.64	1.58	0.34	2.83	0.55	0.25	28.2	8.65	4.31	0.45	0.26	1.69
1424908	<0.05	27.7	0.108	0.75	2.9	7	1.2	15.2	21	71.8	2.86	1.64	0.53	3.36	0.55	0.23	32.9	10.05	4.99	0.5	0.24	1.58
1424909	<0.05	22.6	0.093	0.79	3	18	5.3	10.6	15	50.9	2.24	1.22	0.37	2.44	0.41	0.18	24.7	7.43	3.87	0.39	0.18	1.18
1424910	<0.05	25.6	0.114	1.17	4.2	12	0.9	14.6	28	63.2	2.87	1.58	0.56	3.41	0.54	0.22	31.5	9.53	4.82	0.5	0.23	1.47
1424911	<0.05	22.3	0.104	0.18	1.3	12	2.5	12.3	5	78.8	2.18	1.37	0.31	2.45	0.45	0.21	21.4	6.62	3.26	0.38	0.21	1.42
1424914	<0.05	20.1	0.168	0.92	4.5	34	1.8	22.3	72	132	3.99	2.21	0.71	4.48	0.78	0.29	38.1	11.65	6.39	0.71	0.33	2

FOR OFFICIAL USE ONLY

Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	AAS - ALS Code Au-AA23	CV-AAS - ALS Code Hg-CV41	Whole Rock - XRF - ALS Code ME-XRF26															
	Au	Hg	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	P2O5	SO3	SiO2	SrO	TiO2	Total	LOI 1000
	ppm	ppm	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1213016	<0.005	<0.01	0.16	<0.01	31.5	<0.01	0.08	0.05	21.9	0.01	0.06	0.01	0.01	0.4	<0.01	0.01	100.1	45.89
1213017	<0.005	<0.01	0.09	<0.01	31.2	<0.01	0.06	0.03	21.8	0.01	0.06	0.01	0.01	0.22	<0.01	<0.01	99.52	46.01
1213018	---	---	0.12	<0.01	32.4	<0.01	0.1	0.04	19.95	0.02	0.04	0.3	0.04	0.67	<0.01	<0.01	99.24	45.54
1213019	---	---	0.19	0.02	54.1	<0.01	0.11	0.06	0.26	0.01	0.01	0.01	0.04	3.7	0.03	0.01	100.5	41.93
1213020	---	---	0.08	<0.01	53.7	<0.01	0.05	0.02	0.54	0.01	0.01	0.01	0.03	2.62	0.06	0.01	99.51	42.33
1213021	---	---	0.04	<0.01	30.8	<0.01	0.02	0.01	21.6	0.01	0.05	0.01	0.01	0.41	<0.01	<0.01	99.16	46.18
1213022	---	---	0.08	<0.01	55.7	<0.01	0.03	0.02	0.26	0.01	0.01	<0.01	0.04	1.4	0.02	<0.01	100.25	42.67
1424933	<0.005	0.02	12.64	0.03	0.61	<0.01	2.57	4.71	0.29	0.09	4.41	0.09	0.08	73.1	0.01	0.2	100.1	1.14
1424934	<0.005	0.05	13.18	0.03	1.73	<0.01	1.74	3.61	1.28	0.09	2.78	0.04	0.02	69.76	0.06	0.25	99.55	4.93
1424937	<0.005	0.01	12.36	0.01	1.1	<0.01	0.85	4.95	0.14	0.09	3.55	0.09	0.44	75.44	<0.01	0.09	100	0.87
1213006	0.071	0.53	11.13	0.09	2.2	<0.01	1.45	4.93	0.31	0.05	1.96	0.04	0.05	74.48	0.02	0.16	99.16	2.26
1213009	0.005	0.23	11	0.07	0.5	<0.01	2.2	3.9	0.29	0.02	0.24	0.04	0.02	78.21	0.01	0.2	99.34	2.6
1213023	0.103													---	---	---	---	---
1213024	0.13													---	---	---	---	---
1213025	0.007													---	---	---	---	---
1213026	0.043													---	---	---	---	---
1213027	<0.005													---	---	---	---	---
1213028	0.047													---	---	---	---	---
1213029	<0.005													---	---	---	---	---
1213030	<0.005													---	---	---	---	---
1213031	<0.005													---	---	---	---	---
1213032	<0.005													---	---	---	---	---
1213033	<0.005		0.83	0.02	17.85	<0.01	0.98	0.22	11.6	0.04	0.04	0.03	0.03	41.61	0.01	0.03	100	26.72
1213034	<0.005		1.77	0.05	9.68	<0.01	1.8	0.45	5.96	0.06	0.06	0.07	0.03	65.72	0.01	0.08	100.1	14.32
1213035	<0.005													---	---	---	---	---
1213036	0.006													---	---	---	---	---
1213037	<0.005													---	---	---	---	---
1213038	<0.005													---	---	---	---	---
1213039	<0.005		4.57	0.07	10.3	<0.01	3.58	1.24	6.73	0.04	0.05	0.12	0.06	57.33	0.01	0.25	100.3	15.93
1213040	<0.005													---	---	---	---	---
1424901	<0.005	0.29	12.8	0.12	0.85	<0.01	2.36	4.78	0.64	0.12	1.14	0.05	0.06	73.65	0.01	0.25	99.41	2.5
1424902	<0.005	0.13	12.29	0.03	0.39	<0.01	2.32	2.52	0.13	0.01	0.31	0.03	0.09	77.56	0.01	0.2	99.81	3.89
1424903	<0.005	1.84	10.66	0.04	1.3	<0.01	1.06	4.45	0.37	0.19	0.75	0.06	0.03	77.14	0.05	0.16	99.61	3.32
1424906	<0.005	3.26	8.09	0.03	1.7	0.01	2.07	5.17	0.17	0.03	0.51	0.87	0.09	79.74	0.01	0.14	100.2	1.52
1424907	<0.005	1.31	7.63	0.04	0.59	<0.01	1.27	3.31	0.24	0.05	1.16	0.03	0.03	82.3	0.01	0.26	99.66	2.7
1424908	<0.005	0.23	13.5	0.03	0.92	<0.01	1.2	5.27	0.39	0.03	1.62	0.03	0.01	74.17	0.01	0.19	99.7	2.31
1424909	<0.005	0.49	11.63	0.02	4.61	<0.01	1.28	4.24	0.46	0.05	1.22	0.05	0.13	69.1	0.02	0.16	98.87	5.88
1424910	<0.005	0.27	11.34	0.03	0.59	<0.01	1.41	5.5	0.28	0.03	1.14	0.08	0.09	77.13	0.01	0.19	99.71	1.87
1424911	<0.005	0.35	10.22	0.01	1.8	0.01	1.4	0.11	0.21	0.01	0.08	0.04	0.03	79.77	0.01	0.17	99.59	5.71
1424914	<0.005	0.09	12.94	0.09	0.27	<0.01	4.38	4.9	0.26	0.05	1.74	0.12	0.41	72.33	0.02	0.29	100.2	2.32

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	NAA - Platinum Group Metals - ALS Code PGM-NAA26						
	Au	Ir	Os	Pd	Pt	Rh	Ru
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.001	0.001	0.01	0.02	0.02	0.005	0.05
1213016	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213017	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213018	---	---	---	---	---	---	---
1213019	---	---	---	---	---	---	---
1213020	---	---	---	---	---	---	---
1213021	---	---	---	---	---	---	---
1213022	---	---	---	---	---	---	---
1424933	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424934	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424937	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213006	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213009	0.003	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213023	0.1	<0.001	<0.01	<0.07	<0.2	0.013	<0.05
1213024	0.12	<0.001	<0.01	<0.05	<0.1	<0.005	<0.05
1213025	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213026	0.047	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213027	0.005	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213028	0.035	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213029	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213030	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213031	0.003	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213032	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213033	0.003	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213034	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213035	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213036	0.005	<0.001	<0.01	<0.4	<0.1	<0.005	<0.05
1213037	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213038	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213039	0.004	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213040	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424901	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424902	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424903	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424906	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424907	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424908	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424909	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424910	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424911	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424914	0.003	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05

Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	Sample Type	Locality	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																
			Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
			ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	Limit of Reporting		0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01	0.05	0.05	0.1
1424918	Mineralized Area	Oasis Hills	0.17	5.2	22.8	410	1.59	0.09	0.24	0.02	89.1	0.5	16	1.21	2.8	1.79	12.3	0.17	3.5
1424919	Mineralized Area	Oasis Hills	0.16	6.81	47.9	770	5.92	0.07	0.49	0.11	94.9	1.1	9	3.04	4.3	6.97	18.2	0.2	3.1
1424921	Mineralized Area	Oasis Hills	0.06	6.49	4.6	1160	2.13	0.03	2.14	0.04	96.7	2.7	5	2.38	5.1	1.6	15.6	0.19	2.4
1424932	Mineralized Area	Colson Pond Area	0.03	5.61	4.1	550	2.51	0.11	1.64	0.07	66.4	1.1	23	2.69	1.9	1.58	16.2	0.17	2.1
1424938	Mineralized Area	West of Transvaal Hills	0.03	6.28	8.7	20	6.13	0.25	1.11	0.03	49.6	0.3	8	13.8	1.2	0.56	19.65	0.17	3.3
1424947	Mineralized Area	South Spotted Range	0.04	0.71	5.4	140	0.18	0.02	17.3	0.07	18.05	1.6	19	0.27	3	0.44	1.54	0.12	0.6
1424953	Mineralized Area	Spotted Range	0.12	0.32	6.5	290	0.24	0.03	2.9	0.22	21.8	5.4	64	0.42	5.3	0.4	0.9	0.13	0.1
1424954	Mineralized Area	Spotted Range	0.04	0.32	5.1	30	0.13	0.01	28.5	0.14	3.55	0.7	22	1.81	2.3	0.24	0.8	0.09	0.2
1424959	Mineralized Area	E of Indian Springs	0.04	3.18	45	80	1.06	0.14	18.6	0.3	40.8	11.7	19	5.35	17.8	1.77	8.39	0.14	1.9
1424982	Mineralized Area	Transvaal Hills	0.07	7.66	6.5	300	1.25	0.24	0.31	<0.02	117.5	0.3	12	0.89	1.5	1.7	19.65	0.19	4.4
1424983	Mineralized Area	Transvaal Hills	0.05	6.07	6.5	130	3.7	0.1	0.28	0.02	99.1	0.6	20	1.14	3.6	1.08	14.45	0.18	2.4
1213001	Stream Float	Transvaal Hills	0.06	6.82	4.6	760	4.6	0.16	2.19	0.1	199.5	8.8	40	2.63	7.7	3.15	22.6	0.27	13.4
1213003	Stream Float	Colson Pond Area	0.07	7.23	10.7	810	4.39	0.05	2.65	0.14	170	8.6	40	2.02	12.9	3.74	23.9	0.28	9.2
1213005	Stream Float	Colson Pond Area	0.08	5.71	3.3	490	3.29	0.14	0.92	0.14	120.5	2.1	14	3.56	3.8	1.11	18.95	0.21	4.5
1213008	Stream Float	Transvaal Hills	0.07	5.72	3	330	4.2	0.11	0.84	0.11	74.9	1	23	4.93	3.8	0.86	14.55	0.18	4.8
1213011	Stream Float	Transvaal Hills	0.06	5.02	3.3	700	2.3	0.32	0.8	0.09	94.8	1.3	45	2.01	1.8	1.04	13.4	0.18	3.1
1213013	Stream Float	Transvaal Hills	0.04	1.99	2.8	210	2.65	0.17	1.08	0.06	36.6	0.6	100	0.72	1.7	0.62	6.33	0.12	1.1
1213015	Stream Float	Niavi Wash Indian Springs	0.05	0.25	81	40	0.24	0.01	12.2	0.12	5.09	1.7	43	0.35	2.5	0.66	0.57	0.1	0.2
1424905	Stream Float	Transvaal Hills	0.04	4.52	4.6	300	1.46	0.88	0.55	0.06	81.9	0.6	51	1.29	1.6	0.71	10.7	0.17	1.9
1424913	Stream Float	Transvaal Hills	0.06	5.02	4.7	400	2.49	0.42	1.73	0.09	71.3	1.2	34	2.09	2.8	0.78	13.5	0.19	2.3
1424931	Stream Float	North of Oasis Hills	0.05	3.27	4.9	250	5.3	0.08	1.53	0.11	190.5	2	86	2.1	3.5	1.78	16.9	0.26	19.1
1424936	Stream Float	West of Transvaal Hills	0.04	4.41	2.9	170	2.58	0.47	1.09	0.11	62.2	0.8	30	1.49	2	0.77	11.65	0.15	2.2
1424940	Stream Float	Spotted Range	0.02	0.24	1150	240	1.62	0.02	23.7	0.07	5.24	6.2	10	0.42	11.8	2.35	0.78	0.11	0.3
1424942	Stream Float	Spotted Range	0.04	0.25	9.5	20	0.16	0.01	14.95	0.03	3.9	0.6	11	0.21	1.6	0.29	0.61	0.09	0.3
1424944	Stream Float	W Sandy drainage	0.04	1.09	57.9	130	0.58	0.05	21.1	0.12	17.5	4.1	11	0.78	4.8	1.82	2.84	0.12	0.9
1424946	Stream Float	South Spotted Range	0.02	0.25	63.2	40	0.29	0.01	11.25	0.04	6.25	2.7	47	0.21	1.8	0.81	0.79	0.1	0.2
1424949	Stream Float	South Spotted Range	0.02	0.91	16.4	90	0.45	0.05	20	0.03	23	2	13	0.4	3.2	0.75	2.31	0.12	0.5
1424951	Stream Float	South Spotted Range	0.02	0.35	8.6	160	0.21	0.01	26.1	0.02	8.17	1.1	4	0.16	1.6	0.37	0.92	0.1	0.2
1424952	Stream Float	South Spotted Range	0.03	0.45	18.2	120	0.28	0.02	9.55	0.05	10.15	1.2	40	0.28	2.7	0.66	1.4	0.11	0.3
1424956	Stream Float	Spotted Range	0.02	0.63	68.2	20	0.82	0.02	17.6	0.62	13.95	2.2	45	4.83	4.9	1.13	2	0.11	0.6
1424958	Stream Float	Spotted Range	0.03	0.3	3.8	60	0.12	0.01	3.79	0.05	9.17	0.8	95	0.93	1.8	0.39	0.76	0.11	0.3
1424961	Stream Float	E of Indian Springs	0.05	0.39	4	70	0.17	0.04	8.1	0.06	8.75	0.7	33	0.3	5.5	0.34	0.93	0.11	0.5
1424963	Stream Float	East Sandy Wash	0.02	0.24	6.8	20	0.19	0.03	3.1	0.05	7.53	1.3	21	0.31	3.4	0.49	0.72	0.1	0.4
1424965	Stream Float	East Sandy Wash	0.45	2.37	15.3	180	0.89	0.08	9.21	0.2	32	2.8	96	2.17	19	3.12	5.69	0.15	1.7
1424967	Stream Float	Upper West Sandy Wash	0.15	0.61	11.1	60	0.3	0.06	9.86	0.06	10.65	1.2	163	0.72	3.7	2.75	1.92	0.1	0.6
1424969	Stream Float	Winding Wash	0.03	1.85	129	270	0.64	0.07	19.45	0.08	26.3	3.2	15	0.91	6.1	1.33	3.82	0.14	1.6
1424971	Stream Float	Winding Wash	0.02	0.86	5.2	160	0.3	0.05	14	0.09	13.8	1.6	13	0.48	3	0.53	1.99	0.11	0.6
1424973	Stream Float	East Sandy Wash	0.03	1.4	11.2	170	0.5	0.06	13.5	0.06	21.9	2.5	27	0.76	4	1.11	3.21	0.12	1
1424975	Stream Float	Crossgrain Valley	0.03	2.05	15.6	260	0.46	0.08	14.4	<0.02	38.1	2.1	28	0.76	3.8	1.17	4.02	0.13	1.6
1424977	Stream Float	Crossgrain Valley	0.02	1.4	10.1	50	0.28	0.05	21.7	0.03	11.95	0.8	11	0.77	2.5	0.52	2.15	0.11	1.1

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	CV/AAS ALS Code Hg-CV41	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																			
	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta
	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	0.005	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05
1424918	0.008	0.035	2.26	48.9	17.2	0.13	154	14.95	0.05	19.4	1.5	260	35.3	87.1	<0.002	0.56	1.39	1.8	<1	1.6	88.1	1.14
1424919	0.04	0.046	4.2	53.8	11.9	0.15	160	7.33	0.55	21.4	1.8	670	28.7	175.5	<0.002	0.04	1	2.5	1	1.6	159.5	1.31
1424921	0.059	0.042	3.11	54.1	41.5	0.57	415	0.32	1.66	16.2	3.4	480	20.5	110	<0.002	0.01	0.5	3	1	0.8	314	0.91
1424932	0.022	0.03	4.64	39.5	14.6	0.15	441	4.83	1.6	20.4	1.4	380	25.1	184.5	<0.002	0.03	1.19	1.2	1	1.6	129.5	1.16
1424938	0.014	0.035	3.02	23.8	37.1	0.28	640	2.4	1.87	50.9	0.7	80	32.7	231	<0.002	0.02	1.02	3.8	2	3.6	696	4.22
1424947	0.041	0.005	0.74	7.9	2.6	1.65	227	1.42	0.02	1	3.2	350	4.9	13.1	<0.002	0.02	0.17	0.9	1	<0.2	143.5	0.06
1424953	0.091	<0.005	0.27	13.4	5.9	0.08	1400	8.27	0.02	0.6	18.3	2410	7.8	8.1	0.005	0.02	1.36	0.6	1	<0.2	43.7	<0.05
1424954	0.011	<0.005	0.07	3.3	2.7	0.21	55	1.2	0.01	0.9	3.6	60	1.3	4.9	<0.002	<0.01	0.26	0.7	1	0.2	400	0.05
1424959	0.047	0.033	0.61	23.4	24.4	3.24	217	3.81	0.28	6.8	38.4	260	16	46.7	0.003	0.09	1.17	4.9	1	1.1	56.2	0.48
1424982	0.036	0.039	2.66	57.4	16.2	0.06	65	0.85	0.45	25.4	1	140	19.4	82.1	<0.002	0.02	0.44	3.1	1	2.2	64.2	1.56
1424983	0.057	0.026	1.38	52.1	25.9	0.07	63	1.34	0.23	20.2	3.6	100	17.8	47.7	<0.002	0.01	0.89	2.4	1	1.7	32.1	1.33
1213001	0.027	0.089	3.54	99.9	34.2	0.79	652	1.12	2.43	57.2	20.4	1370	23.2	172	<0.002	0.01	0.66	6.4	2	4.8	352	3.32
1213003	0.138	0.088	3.26	97.9	27.7	0.6	936	1.22	2.72	34.9	26.6	2350	18.6	112	<0.002	0.01	0.81	9.2	2	2.7	429	1.99
1213005	0.169	0.051	3.78	67.7	34.3	0.19	441	1.45	2.05	31.4	3.9	1310	27.1	147	<0.002	0.01	0.77	1.5	1	2.6	109.5	1.78
1213008	0.099	0.047	4.76	42	16.2	0.11	333	1.38	0.98	24.1	2.5	730	22.5	202	<0.002	0.01	0.46	1.7	1	2.1	94.3	1.35
1213011	0.219	0.027	3.66	55.6	21.8	0.18	357	3.71	1.48	21.4	2.2	610	19.4	140	<0.002	0.01	0.99	1.9	1	2	95.4	1.24
1213013	0.072	0.008	1.51	20.8	11	0.1	116	5.64	0.15	6.4	2.5	270	9.1	49.1	<0.002	0.01	0.44	1	<1	0.6	130	0.45
1213015	0.013	<0.005	0.11	2.6	2.6	0.77	224	2.74	0.03	0.5	5	110	2.8	3.8	<0.002	0.01	3.33	0.4	<1	<0.2	58.8	<0.05
1424905	1.315	0.026	3.63	50.7	18.1	0.13	173	3.36	0.79	14.1	1.5	290	19.6	122.5	<0.002	0.01	1.05	1.5	<1	1.6	72.1	0.85
1424913	0.097	0.036	4	39.8	13.6	0.21	281	2.43	1.2	21.4	2.3	510	47.7	144	<0.002	0.02	0.7	1.6	1	1.8	147.5	1.22
1424931	0.012	0.097	2.07	103.5	40	0.22	664	3.81	1.65	69.8	3.6	1010	23.6	157	<0.002	0.01	1.25	2.3	2	5.9	65.9	4.14
1424936	0.279	0.075	2.67	34	17.3	0.19	262	2.29	0.77	19.2	1.6	260	25.7	112.5	<0.002	0.01	0.73	1.8	<1	1.7	71.2	1.31
1424940	0.031	<0.005	0.07	2.9	2.2	8.03	864	3.01	0.02	0.9	7.5	310	8.2	3.1	<0.002	<0.01	6.09	0.5	1	<0.2	68.8	<0.05
1424942	0.005	<0.005	0.13	2.7	3	5.6	55	0.94	0.02	0.8	3.2	50	2	4.1	<0.002	<0.01	0.4	0.3	<1	<0.2	54.4	0.05
1424944	0.015	0.017	0.95	8.7	6	1.85	255	1.51	0.04	3.4	8.9	140	26.5	24.4	<0.002	0.01	0.86	2	1	0.4	197.5	0.23
1424946	0.006	<0.005	0.23	3	2.4	4.23	142	3.75	0.02	1	2.7	800	2.9	4.8	<0.002	0.01	0.51	0.5	<1	<0.2	48.5	<0.05
1424949	0.015	0.012	0.81	10.4	4.9	5.6	785	1.04	0.04	1.7	7.2	910	6.3	14.3	<0.002	<0.01	0.24	1.4	1	0.2	169	0.1
1424951	0.014	<0.005	0.33	3.9	2.3	3.98	3080	0.7	0.02	0.9	1.1	1830	3	6.1	<0.002	<0.01	0.12	0.6	1	<0.2	307	0.06
1424952	0.023	0.006	0.35	5.3	7.3	1.82	316	2.93	0.02	1.1	3	520	7.5	8.4	<0.002	0.02	0.31	0.7	<1	0.2	94.3	0.05
1424956	0.021	0.006	0.13	7.9	6.7	0.76	138	1.58	0.02	1.4	14.4	110	11.5	13.3	<0.002	<0.01	2.1	1.5	1	0.2	37.2	0.09
1424958	0.011	<0.005	0.19	4.4	6.4	0.62	100	4.86	0.01	1.1	3.3	380	2.2	6.5	<0.002	0.01	0.42	0.4	<1	<0.2	47.4	<0.05
1424961	0.023	0.005	0.32	7.3	2.5	4.79	105	3.19	0.02	1.5	7	90	5.5	9.3	0.002	0.01	0.23	0.7	<1	0.2	33.9	0.08
1424963	0.016	<0.005	0.09	3.5	3.1	0.13	80	1.41	0.02	0.7	4	100	2.5	4	<0.002	0.01	0.43	0.5	<1	<0.2	35.8	<0.05
1424965	0.07	0.026	0.75	21.5	14.6	0.95	137	3.2	0.17	5.5	34.7	980	8.1	36.4	<0.002	0.01	0.8	4.8	3	0.8	199.5	0.37
1424967	0.034	0.019	0.19	6.2	8.5	1.49	163	3.44	0.03	1.8	14.6	560	5.1	8.4	<0.002	0.01	0.74	2.4	1	0.2	98.2	0.11
1424969	0.012	0.018	2.13	10.6	3.9	1.82	287	1.63	0.07	5.4	7.1	260	20.9	47.8	<0.002	0.01	2.01	2.9	1	0.6	137	0.38
1424971	0.01	0.008	0.9	5.3	13.7	4.92	157	0.94	0.07	2.8	2.4	120	5.8	22.1	<0.002	0.02	0.2	1.3	<1	0.3	121	0.19
1424973	0.016	0.018	1.37	9.6	5.4	1.57	219	1.67	0.07	4.1	6	230	6.1	32.2	<0.002	0.02	0.36	2.4	1	0.5	124.5	0.28
1424975	0.009	0.024	2.12	15.9	2.9	1.6	327	1.52	0.09	6.3	5.4	220	5.8	46	<0.002	0.01	0.3	3.2	1	0.6	127	0.47
1424977	0.015	0.007	1.86	5.1	40.2	1.76	30	0.89	0.02	3.4	2.5	140	4.3	13	<0.002	0.02	0.25	2.1	1	0.4	282	0.24

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61										Rare Earth ICP MS - ALS Code ME-MS61r											
	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Dy	Er	Eu	Gd	Ho	Lu	Nd	Pr	Sm	Tb	Tm	Yb
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.05	0.03	0.03	0.05	0.01	0.01	0.1	0.03	0.03	0.01	0.01	0.03
1424918	<0.05	17.45	0.134	0.71	2.9	14	2.8	17.3	15	116.5	3.2	1.88	0.53	3.48	0.65	0.26	31.5	9.32	4.99	0.56	0.28	1.82
1424919	<0.05	19.85	0.173	1.23	3.6	49	2.2	19.5	81	102	3.91	2.21	0.74	4.33	0.76	0.3	35.9	10.5	5.83	0.71	0.33	2.03
1424921	<0.05	11.65	0.208	0.49	2.8	16	1.1	12.6	50	83.3	2.54	1.29	1.05	3.41	0.46	0.18	38	10.95	5.56	0.47	0.19	1.16
1424932	<0.05	19.45	0.109	0.98	3.6	12	8.8	16.7	36	53.3	2.6	1.64	0.45	2.65	0.54	0.29	21.3	6.43	3.43	0.43	0.27	1.81
1424938	<0.05	24.4	0.057	1.64	7.3	5	2.4	40.1	33	65	6.57	4.15	0.11	5.21	1.36	0.63	20.7	5.92	5.33	1	0.66	4.28
1424947	<0.05	1.61	0.026	0.12	1	6	0.3	5.4	6	23.2	0.84	0.49	0.26	1	0.17	0.06	6.8	1.73	1.21	0.16	0.07	0.42
1424953	<0.05	1.42	0.013	1.39	2.8	26	2.5	16.5	22	1.4	2.35	1.15	0.62	2.82	0.45	0.11	12.4	2.78	2.61	0.43	0.14	0.76
1424954	<0.05	0.57	0.023	0.04	0.5	8	0.3	6.3	21	7.1	0.5	0.35	0.11	0.53	0.12	0.04	2.4	0.59	0.46	0.08	0.05	0.28
1424959	0.08	5.63	0.166	0.72	3.9	45	2.3	16.9	56	73.9	2.98	1.71	0.78	3.4	0.6	0.22	21.3	5.32	3.91	0.52	0.23	1.49
1424982	<0.05	50.6	0.187	0.59	2.6	21	1.2	20.6	13	141	3.98	2.48	0.62	3.72	0.82	0.42	36.5	11.5	5.37	0.63	0.4	2.76
1424983	<0.05	23.8	0.106	0.3	3	7	1	25.3	15	69.3	5.21	3	0.73	5.22	1.04	0.41	40.8	11.65	7.38	0.87	0.46	2.83
1213001	<0.05	27.3	0.365	0.86	3.7	42	1.9	60.5	115	>500	10.65	6.92	1.3	10.35	2.23	1.12	79.3	22.3	13.55	1.71	1.12	7.3
1213003	<0.05	13.3	0.484	0.64	3.2	57	2.1	46.5	104	373	8.08	4.48	1.67	9.56	1.6	0.63	82.3	21.7	13.3	1.41	0.67	4.21
1213005	<0.05	18.2	0.108	1.09	3.4	9	2.1	34.1	57	134.5	5.64	3.37	0.68	6.06	1.13	0.49	44.7	13.2	8.07	0.94	0.52	3.25
1213008	<0.05	21.4	0.088	1.1	3	4	0.9	25.9	32	130	4.48	2.68	0.51	4.55	0.92	0.39	28.9	8.48	5.73	0.74	0.41	2.6
1213011	0.05	15.8	0.14	1.08	6.4	11	1.2	19	30	101.5	3.4	1.92	0.81	3.98	0.67	0.27	36.3	10.45	5.97	0.58	0.29	1.85
1213013	<0.05	6.79	0.049	0.47	5.3	6	0.4	8.2	10	34.3	1.38	0.85	0.25	1.59	0.29	0.14	13	3.81	2.35	0.23	0.14	0.87
1213015	<0.05	0.54	0.011	0.05	0.4	9	2.2	2.4	17	7.2	0.33	0.21	0.08	0.37	0.08	0.03	2.4	0.6	0.45	0.06	0.03	0.2
1424905	0.06	19.35	0.096	1.06	3.2	5	1.2	12.3	27	60.1	2.2	1.23	0.56	2.76	0.42	0.18	29.5	8.96	4.21	0.4	0.19	1.2
1424913	0.06	18.5	0.121	1.1	3	8	1	28	31	72.1	4.21	2.64	0.51	3.79	0.93	0.36	24.2	7.12	4.17	0.65	0.41	2.43
1424931	<0.05	30.4	0.101	0.44	6.9	12	1.5	69.1	124	>500	11.45	7.6	0.63	10.75	2.46	1.26	84.5	24.1	14.65	1.81	1.24	8.21
1424936	<0.05	19.25	0.081	4.27	4.1	5	1	17.5	34	65.4	3.07	1.87	0.31	3.09	0.63	0.26	23.6	7.05	4.05	0.53	0.28	1.83
1424940	<0.05	0.51	0.01	0.56	2.2	119	8.2	2.9	39	16.7	0.41	0.26	0.09	0.45	0.09	0.04	2.6	0.62	0.48	0.07	0.04	0.24
1424942	<0.05	0.65	0.015	0.04	0.8	5	0.2	2.5	8	11.8	0.37	0.22	0.08	0.38	0.08	0.03	2.4	0.58	0.42	0.06	0.03	0.22
1424944	<0.05	2.31	0.066	0.12	1.9	24	1.1	10	65	33.5	1.71	1.04	0.4	1.85	0.35	0.14	9	2.18	1.9	0.29	0.14	0.94
1424946	<0.05	0.7	0.017	0.03	2.5	28	1	2.8	14	7.4	0.44	0.28	0.11	0.49	0.09	0.04	2.9	0.7	0.52	0.08	0.04	0.25
1424949	<0.05	2.15	0.038	0.12	1.2	16	0.5	6.2	11	19.6	1.07	0.55	0.34	1.35	0.2	0.07	9.3	2.33	1.65	0.19	0.08	0.44
1424951	<0.05	0.95	0.023	0.15	0.6	6	0.2	3.7	8	8.9	0.66	0.39	0.14	0.65	0.13	0.05	3.9	0.97	0.68	0.11	0.06	0.34
1424952	<0.05	1.05	0.025	0.11	2.6	22	0.6	3.6	7	11.3	0.56	0.36	0.16	0.72	0.12	0.05	4.5	1.14	0.81	0.11	0.05	0.33
1424956	<0.05	1.31	0.044	0.42	0.6	17	0.7	9.4	108	23.3	1.31	0.82	0.27	1.29	0.29	0.11	7.6	1.9	1.36	0.21	0.12	0.74
1424958	<0.05	1.03	0.015	0.05	0.7	6	0.4	3.7	7	10.9	0.62	0.29	0.18	0.81	0.11	0.04	4.3	1	0.86	0.12	0.04	0.27
1424961	<0.05	1.04	0.026	0.07	0.9	6	0.3	6.1	10	19.4	0.77	0.46	0.18	0.88	0.16	0.06	5.5	1.39	0.98	0.13	0.07	0.42
1424963	<0.05	0.98	0.014	0.04	0.7	6	0.3	2.7	8	13.1	0.49	0.3	0.09	0.49	0.1	0.05	3.1	0.82	0.62	0.08	0.05	0.31
1424965	0.08	4.21	0.157	0.18	2.3	80	0.9	21	88	61.4	2.96	1.74	0.81	3.57	0.59	0.26	20.9	5.1	4.28	0.5	0.26	1.62
1424967	0.21	1.59	0.048	0.06	1.4	95	0.3	4.3	16	21.5	0.73	0.44	0.2	0.84	0.15	0.08	5.3	1.47	1	0.12	0.07	0.48
1424969	<0.05	3.83	0.105	0.21	1.5	32	1.9	13.5	74	57	2.4	1.5	0.53	2.45	0.5	0.24	13	3.13	2.79	0.4	0.23	1.57
1424971	<0.05	2.01	0.051	0.1	1.2	9	0.4	5.5	35	21.9	1.11	0.65	0.27	1.2	0.22	0.1	6.6	1.58	1.51	0.19	0.1	0.63
1424973	<0.05	3	0.082	0.15	1.2	18	0.7	11.3	28	36.7	2.03	1.18	0.46	2.11	0.41	0.17	11.1	2.72	2.4	0.34	0.18	1.15
1424975	<0.05	4.72	0.128	0.18	1.4	15	0.7	19.4	14	55.2	3.66	2.13	0.78	3.8	0.75	0.32	21.2	4.97	4.59	0.61	0.33	2.15
1424977	<0.05	2.96	0.056	0.07	1.7	11	0.4	4.9	14	41.3	0.92	0.55	0.16	0.92	0.19	0.08	5.7	1.48	1.22	0.15	0.09	0.56

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	AAS - ALS Code Au-AA23	CV-AAS - ALS Code Hg-CV41	Whole Rock - XRF - ALS Code ME-XRF26															
	Au	Hg	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	P2O5	SO3	SiO2	SrO	TiO2	Total	LOI 1000
	ppm	ppm	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1424918	0.016	0.01	10.08	0.04	0.32	<0.01	2.65	2.74	0.28	0.02	0.07	0.06	1.37	78.57	0.02	0.23	100.6	4.14
1424919	0.514	0.05	13.1	0.08	0.67	<0.01	10.36	5.05	0.33	0.02	0.76	0.15	0.09	65.8	0.02	0.3	99.98	3.16
1424921	0.006	0.06	13.16	0.12	2.97	<0.01	2.42	3.82	1.14	0.06	2.29	0.11	0.03	68.85	0.03	0.35	98.87	3.48
1424932	<0.005	0.03	11.04	0.06	2.18	<0.01	2.29	5.42	0.31	0.06	2.12	0.08	0.06	74.27	0.02	0.18	99.86	1.75
1424938	<0.005	0.02	12.3	<0.01	1.5	<0.01	0.84	3.58	0.54	0.09	2.51	0.01	0.04	73.25	0.07	0.09	98.91	4.07
1424947	<0.005	0.04	1.37	0.01	26.1	<0.01	0.67	0.91	3.01	0.03	0.01	0.08	0.06	44.38	0.01	0.05	100.35	23.62
1424953	<0.005	0.09	0.6	0.03	3.8	0.01	0.58	0.32	0.08	0.18	0.01	0.52	0.04	91.16	0.01	0.02	99.96	2.59
1424954	<0.005	0.01	0.61	<0.01	42.1	<0.01	0.35	0.08	0.26	0.01	<0.01	0.01	0.01	22.62	0.04	0.04	99.41	33.26
1424959	<0.005	0.04	6.22	<0.01	28.4	<0.01	2.68	0.76	6.03	0.03	0.36	0.06	0.24	24.42	0.01	0.3	99.27	29.7
1424982	<0.005	0.04	15.6	0.04	0.45	<0.01	2.61	3.35	0.16	0.01	0.63	0.03	0.04	72.24	0.01	0.34	100	4.45
1424983	<0.005	0.06	12.44	0.01	0.39	<0.01	1.68	1.74	0.16	0.01	0.32	0.02	0.03	78.12	<0.01	0.19	99.29	4.17
1213001	<0.005	0.02	13.68	0.08	3.1	0.01	4.66	4.32	1.48	0.09	3.38	0.31	0.01	65.76	0.04	0.63	99.05	1.38
1213003	<0.005	0.15	14.69	0.09	3.78	0.01	5.57	3.96	1.14	0.13	3.71	0.53	0.01	63.13	0.05	0.84	99.39	1.65
1213005	<0.005	0.19	11.36	0.06	1.28	0.01	1.68	4.65	0.34	0.06	2.87	0.3	0.01	75.41	0.01	0.19	99.22	0.94
1213008	0.144	0.1	11.32	0.04	1.15	<0.01	1.29	6.89	0.21	0.05	1.36	0.16	0.02	75.31	0.01	0.15	99.53	1.54
1213011	<0.005	0.23	10.24	0.08	1.13	0.01	1.61	4.6	0.32	0.05	2.12	0.14	0.01	77.71	0.01	0.24	99.45	1.15
1213013	<0.005	0.07	3.95	0.02	1.52	0.01	0.91	1.88	0.14	0.02	0.2	0.06	0.02	88.25	0.01	0.08	99.19	2.12
1213015	<0.005	0.01	0.48	<0.01	17.85	0.01	0.99	0.13	1.34	0.03	0.03	0.02	0.03	62.38	0.01	0.02	99.08	15.74
1424905	<0.005	1.43	8.87	0.04	0.74	0.01	1.07	4.36	0.27	0.02	1.1	0.06	0.01	81.09	0.01	0.17	99.16	1.32
1424913	<0.005	0.1	10.06	0.05	2.37	<0.01	1.14	4.88	0.43	0.04	1.64	0.11	0.04	75.93	0.02	0.2	99.64	2.69
1424931	<0.005	0.01	6.33	0.03	2.07	0.01	2.6	2.51	0.33	0.09	2.27	0.22	0.02	81.29	0.01	0.17	99.87	1.81
1424936	<0.005	0.3	8.82	0.02	1.52	<0.01	1.15	3.26	0.36	0.04	1.05	0.06	0.02	80.78	0.01	0.14	99.81	2.56
1424940	<0.005	0.02	0.44	0.02	34.8	0.01	3.44	0.08	13.7	0.12	0.02	0.07	0.02	5.56	0.01	0.02	99.96	41.42
1424942	<0.005	0.01	0.46	<0.01	21.6	<0.01	0.42	0.15	9.4	0.01	0.02	0.01	0.02	40.6	<0.01	0.03	99.71	26.97
1424944	<0.005	0.01	2.08	0.01	32	0.01	2.75	1.16	3.39	0.04	0.03	0.03	0.05	29.38	0.02	0.13	100.25	29.12
1424946	<0.005	0.01	0.47	<0.01	16.45	<0.01	1.19	0.28	7.24	0.02	0.03	0.17	0.02	53.06	<0.01	0.03	99.84	20.86
1424949	<0.005	0.01	1.78	0.01	30.4	<0.01	1.15	0.97	9.92	0.12	0.05	0.21	0.02	21.79	0.02	0.07	100.45	33.93
1424951	<0.005	0.01	0.67	0.01	39.5	<0.01	0.54	0.4	6.9	0.43	0.01	0.4	0.03	13.72	0.03	0.04	100.2	37.48
1424952	0.007	0.02	0.85	0.01	13.25	0.01	0.97	0.42	3.17	0.04	0.02	0.11	0.04	67.68	0.01	0.05	100.4	13.75
1424956	<0.005	0.02	1.22	<0.01	26.7	0.01	1.73	0.16	1.36	0.02	0.01	0.02	0.01	45	<0.01	0.09	99.18	22.8
1424958	<0.005	0.01	0.56	<0.01	5.2	0.01	0.56	0.24	1.07	0.01	0.01	0.08	0.02	86.52	<0.01	0.02	99.44	5.14
1424961	<0.005	0.02	0.75	<0.01	11.95	<0.01	0.51	0.4	8.39	0.02	0.04	0.02	0.03	59.4	<0.01	0.05	99.81	18.24
1424963	<0.005	0.01	0.46	<0.01	4.3	<0.01	0.74	0.11	0.18	0.01	0.02	0.02	0.01	90.33	<0.01	0.03	99.87	3.66
1424965	<0.005	0.07	4.54	0.02	13.5	0.02	4.67	0.92	1.76	0.02	0.23	0.22	0.04	60	0.02	0.32	99.66	13.31
1424967	<0.005	0.03	1.15	<0.01	14.35	0.03	4.02	0.22	2.65	0.02	0.03	0.12	0.03	62.56	0.01	0.09	99.97	14.66
1424969	<0.005	0.01	3.56	0.03	29.3	<0.01	2	2.58	3.38	0.04	0.08	0.06	0.04	32.22	0.01	0.2	100.35	26.77
1424971	<0.005	0.01	1.68	0.02	21.3	<0.01	0.81	1.09	8.48	0.03	0.1	0.03	0.05	40.53	0.01	0.09	100.05	25.79
1424973	<0.005	0.01	2.8	0.02	21.2	0.01	1.72	1.71	2.95	0.03	0.09	0.05	0.03	49.98	0.02	0.16	100.4	19.61
1424975	<0.005	<0.01	3.99	0.03	21.9	0.01	1.79	2.62	3	0.05	0.1	0.05	0.03	45.7	0.01	0.24	100	20.45
1424977	<0.005	0.01	2.66	0.01	32.3	<0.01	0.77	2.15	3.13	0.01	0.02	0.03	0.06	30.35	0.03	0.09	100	28.37

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	NAA - Platinum Group Metals - ALS Code PGM-NAA26						
	Au	Ir	Os	Pd	Pt	Rh	Ru
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.001	0.001	0.01	0.02	0.02	0.005	0.05
1424918	0.008	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424919	0.66	<0.001	<0.01	<0.02	<0.05	<0.005	<0.05
1424921	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424932	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424938	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424947	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424953	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424954	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424959	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424982	0.003	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424983	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213001	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213003	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213005	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213008	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213011	0.006	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213013	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1213015	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424905	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424913	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424931	---	---	---	---	---	---	---
1424936	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424940	0.003	<0.001	<0.01	<0.04	<0.05	<0.005	<0.05
1424942	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424944	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424946	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424949	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424951	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424952	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424956	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424958	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424961	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424963	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424965	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424967	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424969	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424971	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424973	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424975	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424977	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05

Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	Sample Type	Locality	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																
			Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
			ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	Limit of Reporting		0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01	0.05	0.05	0.1
1424979	Stream Float	East Sandy Wash	0.15	2.17	22.3	130	1.21	0.08	9.29	0.64	37.7	7.1	32	1.22	5.4	11.8	5.09	0.17	1.6
1424981	Stream Float	Transvaal Hills	0.04	3.76	4.3	460	2.39	0.07	0.66	0.05	87.3	1.1	60	2.3	2	1.03	12.45	0.17	2.7
1424985	Stream Float	Transvaal Hills	0.04	4.41	4.7	220	2.22	0.1	0.17	0.03	79.9	0.4	70	1.42	1.4	1.09	13.75	0.17	2.1
1424987	Stream Float	Transvaal Hills	0.08	6.07	5.3	520	1.14	0.24	0.24	0.02	137	0.6	9	1.21	1.1	1.71	14.75	0.18	3.9
1424989	Stream Float	Transvaal Hills	0.06	6.13	4.4	400	2.12	0.48	0.46	0.05	99.8	0.6	26	1.7	1.7	0.93	14.45	0.18	3.2
1424991	Stream Float	Transvaal Hills	0.04	4.66	4.8	100	4.32	0.17	0.46	0.08	52.9	0.8	48	11.5	2.4	0.58	16.1	0.17	2.6
1424993	Stream Float	Transvaal Hills	0.02	4.44	6.9	90	3.98	0.16	0.55	0.07	47	0.6	40	3.8	1.6	0.58	14.25	0.15	2.3
1424995	Stream Float	Transvaal Hills	0.04	4.65	12.2	130	4.21	0.13	0.46	0.07	56.4	0.9	28	4.79	1.4	0.71	16.9	0.17	2.7
1424997	Stream Float	Transvaal Hills	0.07	5.2	3.6	390	1.82	0.4	1.35	0.08	111	2.3	19	1.77	3.4	1.06	12.5	0.2	3
1424999	Stream Float	Transvaal Hills	0.04	5.12	6.1	1030	1.77	0.03	2.76	0.08	113	11.4	119	0.92	5.8	3.16	14.45	0.19	3.5

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	CV/AAS ALS Code Hg-CV41	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61																			
	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta
	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	0.005	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05
1424979	0.032	0.05	1.06	16.9	16.6	0.58	315	3.12	0.07	4.8	21.2	>10000	8.3	12.4	<0.002	0.02	0.56	8.6	9	0.7	270	0.32
1424981	0.022	0.023	2.3	51	15.8	0.19	309	4.05	1.31	14.6	2.7	470	13.5	78.7	<0.002	0.01	0.44	2.1	1	1.1	111	0.85
1424985	0.135	0.023	1.74	41.7	21.2	0.04	170	4.43	0.28	16	1.7	240	16.2	62.5	<0.002	0.08	0.85	1.9	<1	1.5	56.4	1.02
1424987	0.545	0.031	1.19	74.9	10.2	0.04	68	1.64	0.29	19.1	0.8	210	27.2	35.6	<0.002	0.28	0.68	2.8	1	1.7	85.2	1.23
1424989	0.259	0.033	4.3	53.1	21.3	0.09	165	1.66	0.75	19.5	1.5	410	23.2	121	<0.002	0.02	0.77	1.8	1	1.9	74.2	1.17
1424991	0.045	0.027	3.89	27.3	69.8	0.08	510	4.05	1.44	40.4	2.5	380	25.2	280	<0.002	0.01	1.97	2.8	1	2.5	26	3.25
1424993	0.021	0.02	3.4	24.2	47.6	0.09	438	3.63	1.38	35.6	1.8	340	23.4	229	<0.002	<0.01	1.65	2.4	1	2.2	55.8	2.86
1424995	0.014	0.05	3.56	32.7	104	0.07	527	3.6	1.58	39.4	1.5	560	24.6	272	<0.002	<0.01	3.96	3	1	3	45.2	3.11
1424997	0.214	0.033	4.88	46.2	20.7	0.26	343	1.34	0.93	17.5	4.4	730	21.6	149.5	<0.002	0.01	0.73	2.3	1	1.6	166	1.14
1424999	0.021	0.044	1.61	66.9	21.9	0.91	559	3.85	1.55	15.6	40.1	1760	9.6	41.8	<0.002	<0.01	0.52	7.9	1	1.1	388	1.06

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	48 Element-Four Acid-ICP MS/AES - ALS Code ME-MS61										Rare Earth ICP MS - ALS Code ME-MS61r											
	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Dy	Er	Eu	Gd	Ho	Lu	Nd	Pr	Sm	Tb	Tm	Yb
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.05	0.03	0.03	0.05	0.01	0.01	0.1	0.03	0.03	0.01	0.01	0.03
1424979	<0.05	3.74	0.107	0.11	2.5	51	1.1	66.4	57	67.1	12	4.16	5.75	19.05	1.89	0.33	24.6	4.89	9.73	2.66	0.49	2.49
1424981	<0.05	12.45	0.107	0.75	3.3	12	1.9	14.3	30	104	2.45	1.35	0.59	2.99	0.48	0.19	29.8	8.98	4.44	0.43	0.21	1.33
1424985	<0.05	20	0.081	0.44	2.9	6	1.2	11.7	12	56.1	2.07	1.21	0.4	2.36	0.41	0.19	28.2	8.35	4.57	0.35	0.2	1.32
1424987	<0.05	26	0.128	0.3	2.8	8	1.1	23.1	10	126	4.38	2.58	1.07	4.69	0.86	0.39	46.7	14.9	7.2	0.74	0.4	2.57
1424989	<0.05	21.5	0.11	0.83	3	7	1	19.5	22	91.9	3.73	2.11	0.64	4.26	0.73	0.31	37.4	11.25	6.24	0.65	0.32	2.09
1424991	<0.05	19.95	0.043	1.51	9.3	3	3.1	37.3	24	51.9	5.41	3.51	0.19	4.67	1.14	0.55	21.4	6.1	5.28	0.85	0.56	3.74
1424993	<0.05	17.2	0.045	1.22	9.1	3	1.8	32.5	22	46.3	5.1	3.31	0.18	4.34	1.1	0.51	19.3	5.53	4.63	0.79	0.54	3.61
1424995	<0.05	19.35	0.077	1.34	10.3	5	2.5	42.8	28	63	6.15	3.88	0.29	5.39	1.3	0.57	25	7.09	5.84	0.95	0.6	3.9
1424997	<0.05	21.4	0.139	3.11	3.5	13	1.1	18.3	32	96.7	3.23	1.97	0.64	3.65	0.67	0.34	33.7	9.65	5.33	0.56	0.32	2.18
1424999	<0.05	8.5	0.444	0.3	2.4	79	1	21	46	160	3.87	2.04	1.52	4.87	0.76	0.29	47.6	13.35	7.36	0.68	0.3	1.86

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Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	AAS - ALS Code Au-AA23	CV-AAS - ALS Code Hg-CV41	Whole Rock - XRF - ALS Code ME-XRF26															
	Au	Hg	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	P2O5	SO3	SiO2	SrO	TiO2	Total	LOI 1000
	ppm	ppm	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1424979	<0.005	0.03	4.23	0.01	14.4	<0.01	17.96	1.3	1.1	0.05	0.08	2.86	0.04	44.75	0.03	0.21	99.13	12.07
1424981	<0.005	0.02	7.57	0.06	0.92	0.01	1.51	2.88	0.35	0.04	1.88	0.1	0.01	83.11	0.02	0.19	99.78	1.1
1424985	<0.005	0.14	8.36	0.02	0.22	0.01	1.58	2.06	0.06	0.02	0.37	0.05	0.17	83.66	<0.01	0.13	99.08	2.36
1424987	<0.005	0.59	12.4	0.06	0.34	<0.01	2.62	1.5	0.1	0.01	0.41	0.05	0.71	76.45	0.01	0.22	100.1	5.18
1424989	<0.005	0.27	12.2	0.05	0.63	<0.01	1.41	5.2	0.18	0.02	1.04	0.09	0.04	76.49	0.01	0.19	99.68	2.1
1424991	<0.005	0.05	9.25	0.02	0.62	0.01	0.87	4.77	0.13	0.07	2.01	0.08	0.01	81.04	<0.01	0.07	99.97	1
1424993	<0.005	0.02	9.01	0.02	0.78	0.01	0.89	4.26	0.16	0.06	1.98	0.08	<0.01	81.02	0.01	0.08	99.22	0.85
1424995	<0.005	0.01	9.44	0.02	0.64	0.01	1.09	4.43	0.12	0.07	2.23	0.13	<0.01	80.38	<0.01	0.14	99.34	0.61
1424997	<0.005	0.23	10.34	0.05	1.86	<0.01	1.56	5.96	0.5	0.05	1.29	0.16	0.03	75.3	0.02	0.23	99.33	1.95
1424999	<0.005	0.02	9.6	0.11	3.75	0.02	4.53	1.85	1.6	0.08	2.03	0.38	0.01	73.04	0.04	0.74	99.03	1.17

Appendix C.1a: GSC, Mineralized Area and Stream Float Chip Analyses

Sample #	NAA - Platinum Group Metals - ALS Code PGM-NAA26						
	Au	Ir	Os	Pd	Pt	Rh	Ru
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	0.001	0.001	0.01	0.02	0.02	0.005	0.05
1424979	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424981	0.001	<0.001	<0.01	0.03	<0.02	<0.005	<0.05
1424985	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424987	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424989	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424991	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424993	0.002	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424995	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424997	0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05
1424999	<0.001	<0.001	<0.01	<0.02	<0.02	<0.005	<0.05

Notes:

ICP MS = Inductively Coupled Plasma Mass Spectrometry

CV/AAS = Cold Vapor Atomic Absorption Spectroscopy

AAS = Atomic Absorption Spectroscopy

XRF = X-ray Fluorocensce

LOI = Lost on Ignition

% = percent

NAA = Neutron Activation Analysis

* = Four Acid Ore Grade Analysis

AES = Atomic Emission Spectrometry

Appendix C.1b: Stream Sediment Sample Analyses

Sample #	Locality	Aqua Regia - ICP MS - ALS Code ME-MS41L																
		Au	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga
		ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
	Limit of Reporting	**0.0002**	**0.001**	**0.01**	**0.01**	**10**	**0.5**	**0.01**	**0.001**	**0.01**	**0.001**	**0.003**	**0.001**	**0.01**	**0.005**	**0.01**	**0.001**	**0.004**
1213002	Colson Pond Area	0.0021	0.038	1.46	7.12	10	133	1.87	0.158	1.42	0.157	63.7	9.63	15.8	3.07	13.25	2.55	6.07
1213004	Colson Pond Area	0.0008	0.02	0.88	3.67	10	167.5	0.63	0.158	1.09	0.11	52.3	5.79	11.8	1.115	7.38	2.83	4.29
1213007	Transvaal Hills	0.0009	0.031	0.94	4.2	10	110	0.69	0.194	0.48	0.128	52.6	4.33	7.82	2.94	7.66	1.71	3.49
1213010	Transvaal Hills	0.0006	0.027	0.9	3.7	10	103.5	0.77	0.263	0.61	0.109	52.5	4.35	9.12	6.04	6.68	1.96	3.75
1213012	Transvaal Hills	0.0008	0.023	1.04	4.32	10	124.5	0.7	0.169	1.64	0.1	40.1	3.99	7.95	2.11	7.67	1.44	3.5
1213014	Niavi Wash Indian Springs	0.0009	0.024	0.89	10.1	10	102	0.47	0.118	11.95	0.122	23.5	4.18	9.71	1.705	8.97	1.18	2.95
1424904	Transvaal Hills	0.001	0.037	1.15	3.68	10	115.5	0.98	0.223	0.95	0.133	42.6	4.41	8.71	2.26	9.98	1.31	3.85
1424912	Transvaal Hills	0.0004	0.019	0.78	3.13	10	113	0.64	0.179	0.83	0.088	47.1	3.88	8.12	1.35	5.89	1.83	3.44
1424935	West of Transvaal Hills	0.0011	0.026	0.97	3.39	10	134.5	1.11	0.185	1.44	0.102	42.4	3.73	6.95	2.41	6.75	1.45	3.93
1424939	Spotted Range	0.0002	0.022	0.92	6.27	10	88.7	0.51	0.095	11.3	0.093	21.4	3.82	8.24	1.6	8.52	1.04	2.86
1424941	Spotted Range	<0.0002	0.01	0.44	6.27	10	54	0.29	0.065	12.95	0.071	13.15	2.26	5.72	0.82	4.89	0.68	1.46
1424943	W Sandy drainage	<0.0002	0.018	0.71	5.6	10	94.8	0.51	0.113	11.15	0.124	23.1	4.1	7.85	1.29	7.67	1.07	2.45
1424945	South Spotted Range	<0.0002	0.017	0.54	3.77	10	54.9	0.36	0.075	12.85	0.094	15.15	2.54	5.75	0.895	5.66	0.71	1.685
1424948	South Spotted Range	<0.0002	0.011	0.49	3.4	10	47.2	0.3	0.07	12.4	0.082	14.45	2.29	5.66	0.752	4.98	0.73	1.565
1424950	South Spotted Range	<0.0002	0.019	0.63	3.36	10	60.9	0.34	0.084	10.85	0.111	17.6	2.86	6.43	0.972	6.14	0.81	1.945
1424955	Spotted Range	0.0005	0.016	0.44	7.81	10	60.4	0.33	0.075	>25.0	0.249	16.7	2.34	4.16	0.948	5.01	0.5	1.375
1424957	Spotted Range	0.0003	0.019	0.67	8.26	10	62.4	0.48	0.093	19.15	0.148	27.5	3.82	7.7	1.37	6.93	0.88	2.15
1424960	E of Indian Springs	<0.0002	0.02	0.58	4.83	10	60.5	0.34	0.1	11	0.153	16.45	2.52	7.24	0.951	6.36	0.79	1.78
1424962	East Sandy Wash	0.0004	0.025	0.9	7.12	10	119.5	0.53	0.134	8.45	0.125	26.3	4.86	9.81	1.555	9.43	1.3	2.98
1424964	East Sandy Wash	0.0004	0.033	0.93	7.44	10	133.5	0.54	0.144	7.65	0.13	26.7	5.52	10.7	1.86	13.05	1.42	3.01
1424966	Upper West Sandy Wash	<0.0002	0.014	0.57	8.73	<10	77	0.41	0.086	14.95	0.116	20.6	3.95	7.42	1.19	7.02	0.93	1.905
1424968	Winding Wash	<0.0002	0.015	0.69	4.88	10	101	0.45	0.125	10.95	0.107	24.6	4.34	7.35	1.325	7.35	1.04	2.4
1424970	Winding Wash	0.0002	0.018	0.76	4.93	10	106.5	0.48	0.114	10.65	0.114	23.5	3.99	7.88	1.25	7.53	1.12	2.51
1424972	East Sandy Wash	0.0004	0.02	0.8	6.42	10	101.5	0.49	0.128	10.45	0.128	25.9	4.49	9.12	1.53	8.9	1.22	2.68
1424974	Crossgrain Valley	<0.0002	0.016	0.8	4.69	10	122	0.47	0.114	12.6	0.123	22.3	4.28	7.79	1.485	7.71	1.07	2.66
1424976	Crossgrain Valley	0.0003	0.024	0.82	4.19	10	155	0.45	0.119	12.95	0.154	20.8	3.35	7.99	1.51	8.84	1.04	2.6
1424978	East Sandy Wash	0.0005	0.024	0.97	6.54	10	126.5	0.52	0.133	8.61	0.122	26.1	5.05	10.1	1.755	10.15	1.31	3.03
1424980	Transvaal Hills	0.0003	0.024	1.07	3.71	10	127	0.75	0.188	0.9	0.113	47.6	4.2	8.85	1.385	7.4	1.56	3.66
1424984	Transvaal Hills	0.0002	0.028	0.93	3.96	10	121.5	0.71	0.152	0.58	0.106	40.6	4.41	8.84	1.525	8.03	1.61	3.45
1424986	Transvaal Hills	0.0005	0.024	0.78	3.32	10	125.5	0.57	0.142	0.63	0.099	40.7	3.96	7.28	1.315	6.38	1.43	2.92
1424988	Transvaal Hills	0.0006	0.031	1.13	4.05	10	116.5	0.85	0.208	0.53	0.123	52.9	4.34	7.8	3.33	7.91	1.53	3.77
1424990	Transvaal Hills	0.0006	0.031	1.39	3.86	10	79.7	1.72	0.249	0.98	0.11	46	4.22	8.41	3.6	7.87	1.77	4.97
1424992	Transvaal Hills	0.0009	0.029	1.23	4.39	10	71	2.23	0.251	0.86	0.103	44.8	3.96	7.79	2.21	6.25	1.66	4.62
1424994	Transvaal Hills	0.0012	0.036	1.14	4.77	10	101.5	1.24	0.204	0.77	0.103	42.2	4.67	8.81	3.47	7.72	1.96	4.6
1424996	Transvaal Hills	0.0006	0.04	1.07	4.06	10	148.5	0.74	0.184	1.21	0.136	41	4.61	9.2	1.965	10.25	1.57	3.82
1424998	Transvaal Hills	0.0008	0.031	1.14	4.57	10	135	0.83	0.141	1.25	0.11	45.2	8	14.45	2.77	11.05	1.9	4.69
1425000	Transvaal Hills	0.0007	0.032	1.67	5.13	10	209	0.84	0.132	2.06	0.129	52.9	12.1	16.75	1.81	14.15	2.71	5.5

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Appendix C.1b: Stream Sediment Sample Analyses

Sample #	Locality	Aqua Regia - ICP MS - ALS Code ME-MS41L						Aqua Regia - ICP MS - ALS Code ME-MS41L												
		Ge	Hf	Hg*	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Pd	Pt	Rb	Re
		ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	Limit of Reporting	**0.005**	**0.002**	**0.004**	**0.005**	**0.01**	**0.002**	**0.1**	**0.01**	**0.1**	**0.01**	**0.001**	**0.002**	**0.04**	**0.001**	**0.005**	**0.001**	**0.002**	**0.005**	**0.001**
1213002	Colson Pond Area	0.146	0.968	0.095	0.029	0.4	33.5	36.9	0.84	569	0.73	0.028	0.616	19.4	0.079	13.25	<0.001	0.003	31.4	<0.001
1213004	Colson Pond Area	0.094	0.403	0.022	0.024	0.28	29.6	16.9	0.5	576	0.86	0.018	0.603	8.74	0.047	11.5	0.001	0.002	15.35	<0.001
1213007	Transvaal Hills	0.075	0.231	0.156	0.02	0.28	31.5	16	0.39	487	0.52	0.019	0.662	6.5	0.028	16.25	0.001	<0.002	22.1	<0.001
1213010	Transvaal Hills	0.079	0.305	0.145	0.018	0.23	30.8	17.8	0.43	473	1.1	0.015	0.38	6.14	0.036	14.8	0.001	<0.002	17.75	<0.001
1213012	Transvaal Hills	0.079	0.239	0.047	0.023	0.31	24	21.5	0.52	370	0.48	0.017	0.832	6.79	0.039	12.15	0.005	<0.002	22	<0.001
1213014	Niavi Wash Indian Springs	0.057	0.085	0.045	0.018	0.24	12.2	15.1	3.04	281	0.6	0.02	0.917	9.01	0.039	8.86	0.004	<0.002	19.25	<0.001
1424904	Transvaal Hills	0.059	0.216	0.079	0.017	0.36	23.2	23.4	0.57	433	0.56	0.015	1.015	8.23	0.034	12.3	0.001	<0.002	28	<0.001
1424912	Transvaal Hills	0.075	0.301	0.08	0.022	0.24	25.6	16.6	0.37	479	0.6	0.014	0.582	5.68	0.028	10.7	0.003	0.002	15.5	<0.001
1424935	West of Transvaal Hills	0.079	0.346	0.143	0.018	0.29	22.7	26.5	0.46	405	0.46	0.015	1.035	5.69	0.026	10.75	0.002	<0.002	26.6	<0.001
1424939	Spotted Range	0.049	0.082	0.019	0.007	0.22	11.3	16	5.77	267	0.45	0.021	0.81	7.55	0.035	7.05	0.003	<0.002	18.8	<0.001
1424941	Spotted Range	0.037	0.045	0.02	0.006	0.1	7.37	8	6.68	162	0.55	0.018	0.499	5.41	0.025	5.32	0.001	<0.002	8.41	<0.001
1424943	W Sandy drainage	0.054	0.089	0.018	0.008	0.19	11.75	15.3	2.19	266	0.52	0.014	0.75	7.45	0.034	9.59	0.001	<0.002	14.7	<0.001
1424945	South Spotted Range	0.039	0.084	0.019	<0.005	0.11	7.83	9.8	6.42	200	0.33	0.018	0.325	5.24	0.034	6.6	0.003	<0.002	9.23	<0.001
1424948	South Spotted Range	0.038	0.071	0.013	<0.005	0.1	7.43	8.6	6.2	190	0.34	0.017	0.397	4.71	0.032	5.46	0.002	<0.002	8.03	<0.001
1424950	South Spotted Range	0.037	0.108	0.016	0.008	0.14	9.11	11	5.41	216	0.39	0.027	0.348	5.66	0.036	7.05	0.001	<0.002	10.85	<0.001
1424955	Spotted Range	0.035	0.056	0.023	<0.005	0.11	8.62	7.4	0.64	192.5	0.68	0.012	0.59	5.25	0.041	8.67	0.002	<0.002	8.13	<0.001
1424957	Spotted Range	0.051	0.078	0.03	0.01	0.17	14.7	12.7	2.5	326	0.36	0.016	0.58	8.56	0.043	8.27	0.006	<0.002	11.65	<0.001
1424960	E of Indian Springs	0.038	0.112	0.02	0.007	0.13	9.16	10.6	5.11	193.5	0.62	0.019	0.339	6.18	0.033	9.54	0.002	<0.002	10.35	0.001
1424962	East Sandy Wash	0.05	0.096	0.022	0.01	0.26	13.95	15.6	1.09	339	0.57	0.012	0.813	9.84	0.039	9.54	0.003	<0.002	17.7	<0.001
1424964	East Sandy Wash	0.052	0.119	0.031	0.012	0.26	14	15.8	1.03	324	0.62	0.013	0.68	15.1	0.054	10.85	0.003	<0.002	19.15	<0.001
1424966	Upper West Sandy Wash	0.035	0.076	0.018	0.009	0.13	11.45	10.6	1.31	262	0.56	0.013	0.507	8.34	0.033	7.01	0.004	<0.002	11	<0.001
1424968	Winding Wash	0.053	0.075	0.019	0.008	0.18	12	16.9	2.69	282	0.53	0.015	0.852	6.89	0.029	10.3	0.004	<0.002	13.8	<0.001
1424970	Winding Wash	0.054	0.073	0.025	0.012	0.19	11.35	23.2	3.03	266	0.48	0.015	0.813	6.81	0.027	10.75	0.003	<0.002	14.3	<0.001
1424972	East Sandy Wash	0.053	0.087	0.021	0.011	0.2	13.15	16.9	3.01	300	0.69	0.016	0.716	8.63	0.034	12.5	0.001	<0.002	15.9	<0.001
1424974	Crossgrain Valley	0.057	0.077	0.026	0.011	0.23	11.25	25.7	3.73	241	0.59	0.015	0.943	7	0.032	9.72	0.003	<0.002	16.65	<0.001
1424976	Crossgrain Valley	0.047	0.116	0.028	0.009	0.22	10.85	33.1	3.3	272	0.63	0.016	0.978	7.21	0.059	11.15	0.003	<0.002	17.2	<0.001
1424978	East Sandy Wash	0.056	0.101	0.023	0.016	0.27	13.6	17.1	1.58	310	0.57	0.014	0.921	10.05	0.043	10.35	0.002	<0.002	20.3	<0.001
1424980	Transvaal Hills	0.074	0.325	0.033	0.015	0.36	25.5	20.5	0.54	405	0.54	0.02	1.29	11.1	0.032	10.65	0.004	<0.002	24	<0.001
1424984	Transvaal Hills	0.06	0.196	0.044	0.016	0.29	21.9	18.7	0.43	435	0.7	0.014	1.24	7.25	0.035	11.3	0.001	<0.002	20	<0.001
1424986	Transvaal Hills	0.062	0.247	0.031	0.015	0.23	22.2	15.2	0.34	382	0.57	0.013	0.73	6.09	0.028	10.4	0.002	<0.002	16.4	<0.001
1424988	Transvaal Hills	0.066	0.228	0.07	0.015	0.35	29.2	18.3	0.43	488	0.47	0.025	1.155	6.5	0.033	15.55	<0.001	<0.002	26.5	<0.001
1424990	Transvaal Hills	0.065	0.306	0.053	0.015	0.38	22.8	24.5	0.54	541	0.5	0.026	1.25	6.77	0.029	16.55	<0.001	0.002	42	<0.001
1424992	Transvaal Hills	0.069	0.362	0.071	0.017	0.25	22.3	32.9	0.49	482	0.46	0.021	1.105	5.48	0.022	15.6	0.001	0.002	29.2	<0.001
1424994	Transvaal Hills	0.077	0.372	0.092	0.019	0.31	21.9	27.4	0.51	488	0.67	0.018	1.095	6.84	0.028	13.65	0.001	0.002	37.5	<0.001
1424996	Transvaal Hills	0.077	0.316	0.032	0.017	0.31	23.4	22.5	0.58	376	0.6	0.019	0.6	8.26	0.044	12.15	0.002	0.002	23.8	<0.001
1424998	Transvaal Hills	0.111	0.441	0.032	0.018	0.32	24	36.1	0.85	453	0.54	0.027	0.762	23.5	0.054	9.99	0.003	0.002	23.3	<0.001
1425000	Transvaal Hills	0.122	0.434	0.036	0.023	0.46	27.2	29.1	1.24	581	0.52	0.036	0.488	23	0.112	10.4	0.004	0.002	27.7	<0.001

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Appendix C.1b: Stream Sediment Sample Analyses

Sample #	Locality	Aqua Regia - ICP MS - ALS Code ME-MS41L											Aqua Regia - ICP MS - ALS Code ME-MS41L					
		S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
		%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	Limit of Reporting	**0.01**	**0.005**	**0.005**	**0.1**	**0.01**	**0.01**	**0.005**	**0.01**	**0.002**	**0.001**	**0.002**	**0.005**	**0.1**	**0.001**	**0.003**	**0.1**	**0.01**
1213002	Colson Pond Area	0.01	0.506	4.66	0.5	1.23	114.5	<0.005	<0.01	9.19	0.117	0.257	0.929	41.6	0.538	13	65.4	50.4
1213004	Colson Pond Area	0.01	0.354	2.59	0.5	1.01	69.5	<0.005	0.01	7.25	0.147	0.115	0.745	45.7	0.765	10.15	72.7	17.9
1213007	Transvaal Hills	0.01	0.389	1.91	0.4	0.77	79.3	<0.005	<0.01	8.31	0.057	0.163	0.627	26.1	0.323	8.3	43.8	8.95
1213010	Transvaal Hills	0.01	0.371	1.895	0.4	0.93	62.9	<0.005	<0.01	8.88	0.054	0.133	0.687	34.8	0.315	10.2	44.2	9.75
1213012	Transvaal Hills	0.01	0.317	1.875	0.4	0.74	172.5	<0.005	0.02	8.98	0.057	0.17	0.66	27.1	0.304	8.41	41.9	9.14
1213014	Niavi Wash Indian Springs	0.01	0.364	2.19	0.4	0.41	146	<0.005	0.03	4.26	0.038	0.138	0.627	21.5	0.278	6.54	34.4	3.52
1424904	Transvaal Hills	0.01	0.383	2.24	0.4	0.75	81.1	<0.005	0.02	7.89	0.035	0.221	0.635	19.6	0.315	8.08	41.6	7.68
1424912	Transvaal Hills	0.01	0.318	1.84	0.4	0.83	93.9	<0.005	<0.01	7.98	0.078	0.148	0.549	33	0.342	7.44	45.9	10.75
1424935	West of Transvaal Hills	0.01	0.279	1.935	0.5	0.84	104	<0.005	<0.01	7.57	0.058	0.219	0.57	27	0.238	9.62	40.1	13.05
1424939	Spotted Range	<0.01	0.325	1.915	0.5	0.41	122.5	<0.005	0.01	3.22	0.035	0.153	0.72	18.6	0.276	5.65	30.6	3.51
1424941	Spotted Range	<0.01	0.239	1.29	0.3	0.24	73	<0.005	0.01	1.82	0.019	0.075	0.666	12	0.162	4.06	18.7	1.69
1424943	W Sandy drainage	0.01	0.287	2.11	0.5	0.42	120	<0.005	<0.01	3.22	0.031	0.107	0.542	17.4	0.213	6.59	35.8	3.67
1424945	South Spotted Range	<0.01	0.199	1.47	0.3	0.29	93	<0.005	<0.01	2.15	0.02	0.072	0.448	12	0.204	4.63	20.5	3.51
1424948	South Spotted Range	<0.01	0.19	1.285	0.2	0.26	84.2	<0.005	<0.01	3.39	0.019	0.065	0.481	13.3	0.162	4.08	19	2.7
1424950	South Spotted Range	<0.01	0.202	1.565	0.3	0.31	96.3	<0.005	<0.01	2.62	0.023	0.075	0.482	13.8	0.193	4.94	23.7	4.35
1424955	Spotted Range	0.03	0.387	1.35	0.4	0.25	137.5	<0.005	0.01	1.4	0.014	0.102	0.481	8.3	0.341	6.29	24.6	2.03
1424957	Spotted Range	0.03	0.304	2.3	0.5	0.36	223	<0.005	0.01	2.62	0.017	0.094	0.559	11.4	0.254	9.25	24.1	2.55
1424960	E of Indian Springs	<0.01	0.257	1.515	0.4	0.34	118.5	<0.005	0.02	2.42	0.023	0.078	0.649	14.8	0.202	5.03	25.7	4.36
1424962	East Sandy Wash	0.01	0.329	2.18	0.5	0.48	153.5	<0.005	0.02	4.06	0.038	0.127	0.543	21.5	0.281	7.16	38	3.81
1424964	East Sandy Wash	0.01	0.439	2.4	0.7	0.51	150.5	<0.005	0.03	4.39	0.04	0.148	0.605	22.8	0.259	8.97	50.4	5.21
1424966	Upper West Sandy Wash	0.01	0.317	1.92	0.4	0.29	174	<0.005	0.01	3.45	0.022	0.095	0.615	15.2	0.216	7.77	27.9	3.19
1424968	Winding Wash	0.01	0.257	2.01	0.4	0.4	111.5	<0.005	0.02	3.26	0.03	0.097	0.552	16.8	0.23	6.44	30.1	3.02
1424970	Winding Wash	0.01	0.266	1.94	0.5	0.43	111	<0.005	0.01	3.37	0.034	0.108	0.645	19.6	0.259	5.81	32.3	2.71
1424972	East Sandy Wash	0.01	0.313	2.22	0.4	0.5	111.5	<0.005	0.01	3.31	0.035	0.121	0.553	20.3	0.234	6.49	38.8	3.79
1424974	Crossgrain Valley	0.01	0.268	1.92	0.4	0.44	131.5	<0.005	0.01	2.67	0.035	0.112	0.695	19.2	0.256	5.81	39.6	2.98
1424976	Crossgrain Valley	0.02	0.288	1.98	0.4	0.45	165	<0.005	0.01	2.83	0.034	0.122	0.646	18	0.239	5.23	39.4	3.38
1424978	East Sandy Wash	0.01	0.36	2.32	0.5	0.51	145.5	<0.005	0.01	3.86	0.04	0.14	0.539	21.6	0.263	7.15	41.2	3.9
1424980	Transvaal Hills	0.01	0.331	2.08	0.4	0.94	111	<0.005	0.01	7.69	0.069	0.191	0.496	25.7	0.292	8.39	44.8	13.65
1424984	Transvaal Hills	0.01	0.365	2.06	0.4	0.76	63.5	<0.005	0.01	5.64	0.056	0.174	0.534	24.5	0.317	6.88	43.7	6.6
1424986	Transvaal Hills	0.01	0.317	1.75	0.3	0.68	58.8	<0.005	0.01	5.9	0.054	0.144	0.502	21.5	0.359	7.28	36.5	9.1
1424988	Transvaal Hills	0.01	0.353	2.09	0.4	0.96	76.4	<0.005	0.01	8.13	0.047	0.231	0.825	23	0.285	8.72	42	8.42
1424990	Transvaal Hills	0.01	0.336	2.42	0.5	1.09	78.8	<0.005	0.01	9.89	0.057	0.333	0.698	31.2	0.33	14.45	46.7	10.45
1424992	Transvaal Hills	0.01	0.311	1.97	0.5	1.01	73.2	<0.005	0.01	10.5	0.054	0.285	0.579	36.7	0.302	13.85	42	12.9
1424994	Transvaal Hills	0.01	0.363	2.16	0.5	0.98	86.7	<0.005	0.01	8.14	0.079	0.283	0.651	38.5	0.25	10.75	50.9	14.3
1424996	Transvaal Hills	0.01	0.378	2.37	0.4	0.79	74	<0.005	0.01	7.34	0.06	0.192	0.556	26	0.268	8.17	45.4	11.4
1424998	Transvaal Hills	0.01	0.364	2.84	0.4	0.82	133	<0.005	0.01	5.84	0.09	0.197	0.569	31.7	0.331	8.42	46.7	22
1425000	Transvaal Hills	0.01	0.355	5.03	0.5	0.83	163	<0.005	0.01	6.23	0.132	0.161	0.713	43.2	0.295	12.15	53.2	26.9

Notes:

ICP MS = Inductively Coupled Plasma Mass Spectrometry

* = Trace Hg by ICP MS - ALS Code Hg-MS42

% = percent

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Appendix C.1c: Carbon Analyses

Sample #	Sample Type	Locality	CO_2 Coulometer - ALS Code C-GAS05		LECO Analyzer - ALS Code C-1R17
			C	CO_2	C organic
			%	%	%
	Limit of Reporting		0.05	0.2	0.02
1424933	GSC	West of Transvaal Hills	---	---	0.03
1424934	GSC	West of Transvaal Hills	---	---	0.05
1424937	GSC	West of Transvaal Hills	---	---	0.03
1213016	GSC	Indian Springs - Niavi Wash	12.35	45.3	0.02
1213017	GSC	Indian Springs - Niavi Wash	12.35	45.3	<0.02
1213018	GSC	Indian Springs - near Silica Quarry	12.35	45.2	0.04
1213019	GSC	Indian Springs - near Silica Quarry	11.15	40.8	0.03
1213020	GSC	Timpi Wash	11.35	41.7	0.03
1213021	GSC	Timpi Wash	12.45	45.6	0.02
1213022	GSC	Timpi Wash	11.45	42	0.02

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 9- JUN- 2016
Account: GOLINC

CERTIFICATE RE16070617

Project: Geochemistry

This report is for 66 Pulp samples submitted to our lab in Reno, NV, USA on 5- MAY- 2016.

The following have access to data associated with this certificate:

EMILY CLARK	GENE MULLER	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
FND- 02	Find Sample for Addn Analysis
SND- 01	Send samples to external laboratory

ANALYTICAL PROCEDURES

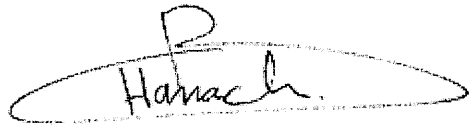
ALS CODE	DESCRIPTION
PGM- NAA26	PGM NiS collection NAA finish

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: GOLDER ASSOCIATES INC.
ATTN: GENE MULLER
4730 N. ORACLE
STE 210
TUCSON AZ 85705

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature: 

Hanachi Bouhenchir, Lab Manager

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 9- JUN- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16070617

Sample Description	Method	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26
	Analyte	Pt	Pd	Au	Os	Ru	Ir	Rh
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	LOR	0.02	0.02	0.001	0.01	0.05	0.001	0.005
1424901		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424902		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424903		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424905		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424906		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
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1424908		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424909		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424910		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424911		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424913		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424914		<0.02	<0.02	0.003	<0.01	<0.05	<0.001	<0.005
1424918		<0.02	<0.02	0.008	<0.01	<0.05	<0.001	<0.005
1424919		<0.05	<0.02	0.660	<0.01	<0.05	<0.001	<0.005
1424921		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424932		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424933		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424934		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424936		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424937		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424938		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424940		<0.05	<0.04	0.003	<0.01	<0.05	<0.001	<0.005
1424942		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424944		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424946		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424947		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424949		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
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1424952		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424953		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424954		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424956		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
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1424959		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424961		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424963		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424965		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424967		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424969		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424971		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 9- JUN- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16070617

Sample Description	Method	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26
	Analyte	Pt	Pd	Au	Os	Ru	Ir	Rh
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	LOR	0.02	0.02	0.001	0.01	0.05	0.001	0.005
1424973		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424975		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005
1424977		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424979		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424981		<0.02	0.03	0.001	<0.01	<0.05	<0.001	<0.005
1424982		<0.02	<0.02	0.003	<0.01	<0.05	<0.001	<0.005
1424983		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424985		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
1424987		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1424989		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
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1213006		<0.02	<0.02	0.001	<0.01	<0.05	<0.001	<0.005
1213008		<0.02	<0.02	<0.001	<0.01	<0.05	<0.001	<0.005
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1213011		<0.02	<0.02	0.006	<0.01	<0.05	<0.001	<0.005
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1213017		<0.02	<0.02	0.002	<0.01	<0.05	<0.001	<0.005

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 9- JUN- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16070617

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
FND- 02 SND- 01

Applies to Method: Processed at Becquerel Laboratories Inc., Mississauga, Ontario, Canada
PGM- NAA26

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 16- JUN- 2016
Account: GOLINC

CERTIFICATE RE16092806

Project: Geochemistry

This report is for 37 Pulp samples submitted to our lab in Reno, NV, USA on 12- JUN- 2016.

The following have access to data associated with this certificate:

EMILY CLARK	GENE MULLER	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
FND- 02	Find Sample for Addn Analysis

ANALYTICAL PROCEDURES

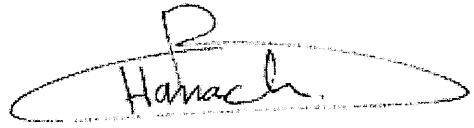
ALS CODE	DESCRIPTION	INSTRUMENT
Au- AA23	Au 30g FA- AA finish	AAS

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: GOLDER ASSOCIATES INC.
ATTN: GENE MULLER
4730 N. ORACLE
STE 210
TUCSON AZ 85705

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature: 

Hanachi Bouhenchir, Lab Manager

ALS USA Inc.
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 16- JUN- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16092806

Sample Description	Method Analyte Units LOR	Au- AA23 Au ppm 0.005
1424904		<0.005
1424912		<0.005
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1424941		<0.005
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1424945		<0.005
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1424950		<0.005
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1424957		<0.005
1424960		<0.005
1424962		<0.005
1424964		<0.005
1424966		<0.005
1424968		<0.005
1424970		0.020
1424972		<0.005
1424974		<0.005
1424976		<0.005
1424978		<0.005
1424980		<0.005
1424984		<0.005
1424986		<0.005
1424988		<0.005
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1424994		<0.005
1424996		<0.005
1424998		<0.005
1425000		<0.005
1213002		<0.005
1213004		<0.005
1213007		<0.005
1213010		<0.005
1213012		<0.005
1213014		<0.005

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
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Page: Appendix 1
Total # Appendix Pages: 1
Finalized Date: 16- JUN- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16092806

	CERTIFICATE COMMENTS
Applies to Method:	LABORATORY ADDRESSES Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA. Au- AA23 FND- 02

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

CERTIFICATE RE16069808

Project: Geochemistry

P.O. No.: Golder Project No 1538787

This report is for 109 Pulp samples submitted to our lab in Reno, NV, USA on 5- MAY- 2016.

The following have access to data associated with this certificate:

EMILY CLARK	GENE MULLER	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
FND- 02	Find Sample for Addn Analysis
SPLIT- Z	Pulp split for send out
LOG- 24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

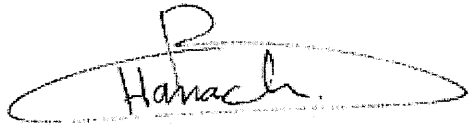
ALS CODE	DESCRIPTION	
ME- MS61r	4A multi- element ICP- MS + REE	
ME- MS61	48 element four acid ICP- MS	
Au- AA23	Au 30g FA- AA finish	AAS
Hg- CV41	Trace Hg - cold vapor/AAS	FIMS
ME- XRF26	Whole Rock By Fusion/XRF	XRF
OA- GRA05x	LOI for XRF	WST- SEQ
C- GAS05	Inorganic Carbon (CO2)	
C- IR17	Organic carbon by LECO	LECO
ME- MS41L	Super Trace Lowest DL AR by ICP- MS	
Hg- MS42	Trace Hg by ICPMS	ICP- MS

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

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ATTN: GENE MULLER
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This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature: 

Hanachi Bouhenchir, Lab Manager

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	WEI- 21 Recvd Wt. kg 0.02	ME- MS61 Ag ppm 0.01	ME- MS61 Al % 0.01	ME- MS61 As ppm 0.2	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.05	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01
1424901			0.14	6.47	9.2	1140	3.10	8.69	0.62	0.11	141.0	1.0	4	4.92	4.6	1.59
1424902			0.03	6.26	11.0	280	1.55	0.85	0.28	0.03	92.2	0.4	11	0.71	1.5	1.55
1424903			0.06	5.40	10.9	380	2.75	0.27	0.96	0.11	78.4	0.7	16	2.87	2.4	0.72
1424904																
1424905			0.04	4.52	4.6	300	1.46	0.88	0.55	0.06	81.9	0.6	51	1.29	1.6	0.71
1424906			0.04	4.10	6.7	230	0.95	2.31	1.23	0.22	44.1	1.1	59	0.70	2.8	1.37
1424907			0.03	3.75	19.5	360	1.09	1.26	0.42	0.07	81.2	0.4	11	2.32	2.6	0.82
1424908			0.04	6.55	11.8	260	2.47	0.12	0.65	0.06	94.9	0.4	12	3.35	1.0	0.78
1424909			0.02	5.25	11.2	230	2.83	0.09	3.34	0.05	70.0	0.7	6	2.23	1.8	0.84
1424910			0.04	6.00	2.7	310	1.91	0.05	0.45	0.11	88.7	1.1	18	1.70	2.4	0.98
1424910a		0.04	0.75	5.18	196.5	1420	2.10	0.10	0.15	0.29	101.5	1.4	120	9.22	14.2	1.41
1424910b		0.04	0.07	7.89	1.5	1420	1.77	0.06	2.23	0.06	45.9	6.6	2	1.60	31.1	2.89
1424911			0.03	5.18	14.5	100	0.17	3.27	1.36	0.06	62.3	0.5	69	0.66	1.7	0.96
1424912																
1424913			0.06	5.02	4.7	400	2.49	0.42	1.73	0.09	71.3	1.2	34	2.09	2.8	0.78
1424914			0.09	6.55	25.2	870	2.78	0.07	0.19	0.11	108.0	1.0	14	2.13	4.8	2.91
1424918			0.17	5.20	22.8	410	1.59	0.09	0.24	0.02	89.1	0.5	16	1.21	2.8	1.79
1424918a		0.04	0.73	5.05	193.5	1390	2.28	0.10	0.15	0.30	97.7	1.3	117	8.89	12.8	1.38
1424919			0.16	6.81	47.9	770	5.92	0.07	0.49	0.11	94.9	1.1	9	3.04	4.3	6.97
1424921			0.06	6.49	4.6	1160	2.13	0.03	2.14	0.04	96.7	2.7	5	2.38	5.1	1.60
1424932			0.03	5.61	4.1	550	2.51	0.11	1.64	0.07	66.4	1.1	23	2.69	1.9	1.58
1424933			0.06	6.34	9.4	190	10.65	0.03	0.44	0.25	177.5	1.3	4	5.08	2.6	1.70
1424934			0.11	6.72	6.2	260	5.34	0.27	1.26	0.07	67.4	3.0	11	7.26	6.0	1.16
1424935																
1424936			0.04	4.41	2.9	170	2.58	0.47	1.09	0.11	62.2	0.8	30	1.49	2.0	0.77
1424937			0.02	6.08	17.7	50	5.97	0.04	0.79	0.10	54.5	1.0	9	6.49	2.0	0.55
1424938			0.03	6.28	8.7	20	6.13	0.25	1.11	0.03	49.6	0.3	8	13.80	1.2	0.56
1424939																
1424940			0.02	0.24	1150	240	1.62	0.02	23.7	0.07	5.24	6.2	10	0.42	11.8	2.35
1424941																
1424942			0.04	0.25	9.5	20	0.16	0.01	14.95	0.03	3.90	0.6	11	0.21	1.6	0.29
1424943																
1424944			0.04	1.09	57.9	130	0.58	0.05	21.1	0.12	17.50	4.1	11	0.78	4.8	1.82
1424945																
1424946			0.02	0.25	63.2	40	0.29	0.01	11.25	0.04	6.25	2.7	47	0.21	1.8	0.81
1424947			0.04	0.71	5.4	140	0.18	0.02	17.30	0.07	18.05	1.6	19	0.27	3.0	0.44
1424948																
1424949			0.02	0.91	16.4	90	0.45	0.05	20.0	0.03	23.0	2.0	13	0.40	3.2	0.75
1424950																
1424951			0.02	0.35	8.6	160	0.21	0.01	26.1	0.02	8.17	1.1	4	0.16	1.6	0.37

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CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	Hg- MS42 Hg ppm 0.005	ME- MS61 In ppm 0.005	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10
1424901		16.25	0.21	4.1	0.271	0.053	3.95	77.6	31.0	0.30	867	1.10	0.83	20.1	3.9	230
1424902		14.55	0.19	2.7	0.118	0.051	2.06	52.0	17.4	0.04	54	1.09	0.23	18.1	0.9	130
1424903		12.55	0.17	2.4	1.655	0.030	3.77	42.9	19.6	0.17	1410	1.01	0.55	18.3	1.1	260
1424904																
1424905		10.70	0.17	1.9	1.315	0.026	3.63	50.7	18.1	0.13	173	3.36	0.79	14.1	1.5	290
1424906		9.92	0.14	2.1	3.09	0.021	4.22	25.9	28.8	0.08	227	18.55	0.37	10.5	2.5	3870
1424907		12.25	0.18	3.2	1.250	0.020	2.58	48.9	22.1	0.12	363	15.60	0.81	23.0	0.9	140
1424908		14.80	0.18	2.6	0.219	0.024	4.18	51.5	36.2	0.16	214	1.35	1.14	19.2	0.6	130
1424909		13.05	0.17	1.8	0.519	0.023	3.47	35.8	36.8	0.20	386	1.53	0.90	17.7	1.0	220
1424910		12.35	0.19	2.2	0.260	0.021	4.59	50.9	23.5	0.13	242	1.33	0.86	17.3	1.8	360
1424910a		12.70	0.14	1.5	1.035	0.012	2.38	57.0	38.9	0.31	25	14.00	0.06	10.6	11.0	430
1424910b		17.00	0.17	4.5	0.007	0.033	2.96	25.3	23.0	0.54	666	2.39	3.06	9.9	2.2	1160
1424911		13.60	0.14	2.5	0.341	0.015	0.09	37.4	26.9	0.09	61	7.61	0.06	16.3	1.5	210
1424912																
1424913		13.50	0.19	2.3	0.097	0.036	4.00	39.8	13.6	0.21	281	2.43	1.20	21.4	2.3	510
1424914		17.55	0.21	3.8	0.082	0.049	3.96	59.6	17.6	0.11	395	4.74	1.24	22.9	1.7	550
1424918		12.30	0.17	3.5	0.008	0.035	2.26	48.9	17.2	0.13	154	14.95	0.05	19.4	1.5	260
1424918a		12.30	0.15	1.4	1.055	0.016	2.34	55.9	39.0	0.30	25	13.45	0.06	10.4	10.9	410
1424919		18.20	0.20	3.1	0.040	0.046	4.20	53.8	11.9	0.15	160	7.33	0.55	21.4	1.8	670
1424921		15.60	0.19	2.4	0.059	0.042	3.11	54.1	41.5	0.57	415	0.32	1.66	16.2	3.4	480
1424932		16.20	0.17	2.1	0.022	0.030	4.64	39.5	14.6	0.15	441	4.83	1.60	20.4	1.4	380
1424933		28.0	0.28	12.8	0.020	0.152	3.81	91.0	78.2	0.15	627	3.14	3.15	100.0	2.0	390
1424934		19.15	0.18	3.9	0.038	0.048	2.96	34.3	62.5	0.68	666	2.23	2.01	46.2	5.4	200
1424935																
1424936		11.65	0.15	2.2	0.279	0.075	2.67	34.0	17.3	0.19	262	2.29	0.77	19.2	1.6	260
1424937		19.50	0.17	3.0	0.009	0.031	4.04	25.3	74.1	0.07	679	3.60	2.55	53.0	1.2	430
1424938		19.65	0.17	3.3	0.014	0.035	3.02	23.8	37.1	0.28	640	2.40	1.87	50.9	0.7	80
1424939																
1424940		0.78	0.11	0.3	0.031	<0.005	0.07	2.9	2.2	8.03	864	3.01	0.02	0.9	7.5	310
1424941																
1424942		0.61	0.09	0.3	0.005	<0.005	0.13	2.7	3.0	5.60	55	0.94	0.02	0.8	3.2	50
1424943																
1424944		2.84	0.12	0.9	0.015	0.017	0.95	8.7	6.0	1.85	255	1.51	0.04	3.4	8.9	140
1424945																
1424946		0.79	0.10	0.2	0.006	<0.005	0.23	3.0	2.4	4.23	142	3.75	0.02	1.0	2.7	800
1424947		1.54	0.12	0.6	0.041	0.005	0.74	7.9	2.6	1.65	227	1.42	0.02	1.0	3.2	350
1424948																
1424949		2.31	0.12	0.5	0.015	0.012	0.81	10.4	4.9	5.60	785	1.04	0.04	1.7	7.2	910
1424950																
1424951		0.92	0.10	0.2	0.014	<0.005	0.33	3.9	2.3	3.98	3080	0.70	0.02	0.9	1.1	1830

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CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Pb ppm 0.5	ME- MS61 Rb ppm 0.1	ME- MS61 Re ppm 0.002	ME- MS61 S % 0.01	ME- MS61 Sb ppm 0.05	ME- MS61 Sc ppm 0.1	ME- MS61 Se ppm 1	ME- MS61 Sn ppm 0.2	ME- MS61 Sr ppm 0.2	ME- MS61 Ta ppm 0.05	ME- MS61 Te ppm 0.05	ME- MS61 Th ppm 0.01	ME- MS61 Ti % 0.005	ME- MS61 Tl ppm 0.02	ME- MS61 U ppm 0.1
1424901		113.5	122.5	<0.002	0.03	2.31	2.9	1	2.0	85.6	1.17	<0.05	19.40	0.147	1.14	2.6
1424902		28.9	71.7	<0.002	0.03	1.06	2.0	<1	1.6	68.7	1.14	<0.05	27.7	0.119	0.36	2.7
1424903		24.3	131.5	<0.002	0.02	1.19	2.0	1	1.6	506	1.14	<0.05	21.4	0.097	1.06	2.9
1424904																
1424905		19.6	122.5	<0.002	0.01	1.05	1.5	<1	1.6	72.1	0.85	0.06	19.35	0.096	1.06	3.2
1424906		15.8	144.0	<0.002	0.04	1.63	1.0	<1	2.8	46.5	0.76	0.13	18.35	0.080	1.24	19.5
1424907		23.8	112.0	<0.002	0.01	0.95	1.0	1	2.2	127.0	1.16	0.06	27.1	0.150	0.96	3.4
1424908		22.7	139.0	<0.002	<0.01	0.52	2.2	<1	1.5	80.2	1.25	<0.05	27.7	0.108	0.75	2.9
1424909		24.1	119.5	<0.002	0.05	0.60	1.9	1	1.5	207	1.18	<0.05	22.6	0.093	0.79	3.0
1424910		23.8	155.5	<0.002	0.04	0.90	2.0	<1	1.2	66.0	1.08	<0.05	25.6	0.114	1.17	4.2
1424910a		9.1	100.5	0.002	0.38	13.90	9.7	2	1.9	99.4	0.74	0.05	10.55	0.354	8.99	2.8
1424910b		12.9	69.2	<0.002	<0.01	0.68	7.9	1	1.9	337	0.80	<0.05	4.83	0.348	0.18	1.9
1424911		15.6	5.9	<0.002	0.01	0.75	1.0	<1	1.2	103.0	1.00	<0.05	22.3	0.104	0.18	1.3
1424912																
1424913		47.7	144.0	<0.002	0.02	0.70	1.6	1	1.8	147.5	1.22	0.06	18.50	0.121	1.10	3.0
1424914		35.3	161.5	<0.002	0.16	0.92	2.6	1	1.8	181.5	1.29	<0.05	20.1	0.168	0.92	4.5
1424918		35.3	87.1	<0.002	0.56	1.39	1.8	<1	1.6	88.1	1.14	<0.05	17.45	0.134	0.71	2.9
1424918a		9.0	98.7	<0.002	0.37	13.45	9.6	2	1.9	94.7	0.86	<0.05	10.45	0.350	8.64	2.8
1424919		28.7	175.5	<0.002	0.04	1.00	2.5	1	1.6	159.5	1.31	<0.05	19.85	0.173	1.23	3.6
1424921		20.5	110.0	<0.002	0.01	0.50	3.0	1	0.8	314	0.91	<0.05	11.65	0.208	0.49	2.8
1424932		25.1	184.5	<0.002	0.03	1.19	1.2	1	1.6	129.5	1.16	<0.05	19.45	0.109	0.98	3.6
1424933		41.5	270	<0.002	0.03	1.01	2.1	2	8.5	53.7	5.40	<0.05	34.7	0.116	0.98	7.0
1424934		30.0	184.5	<0.002	0.01	1.03	5.0	1	3.2	596	3.78	<0.05	24.5	0.145	1.28	5.6
1424935																
1424936		25.7	112.5	<0.002	0.01	0.73	1.8	<1	1.7	71.2	1.31	<0.05	19.25	0.081	4.27	4.1
1424937		32.9	330	<0.002	0.18	1.54	3.6	1	2.3	31.6	4.38	<0.05	24.7	0.055	1.55	9.2
1424938		32.7	231	<0.002	0.02	1.02	3.8	2	3.6	696	4.22	<0.05	24.4	0.057	1.64	7.3
1424939																
1424940		8.2	3.1	<0.002	<0.01	6.09	0.5	1	<0.2	68.8	<0.05	<0.05	0.51	0.010	0.56	2.2
1424941																
1424942		2.0	4.1	<0.002	<0.01	0.40	0.3	<1	<0.2	54.4	0.05	<0.05	0.65	0.015	0.04	0.8
1424943																
1424944		26.5	24.4	<0.002	0.01	0.86	2.0	1	0.4	197.5	0.23	<0.05	2.31	0.066	0.12	1.9
1424945																
1424946		2.9	4.8	<0.002	0.01	0.51	0.5	<1	<0.2	48.5	<0.05	<0.05	0.70	0.017	0.03	2.5
1424947		4.9	13.1	<0.002	0.02	0.17	0.9	1	<0.2	143.5	0.06	<0.05	1.61	0.026	0.12	1.0
1424948																
1424949		6.3	14.3	<0.002	<0.01	0.24	1.4	1	0.2	169.0	0.10	<0.05	2.15	0.038	0.12	1.2
1424950																
1424951		3.0	6.1	<0.002	<0.01	0.12	0.6	1	<0.2	307	0.06	<0.05	0.95	0.023	0.15	0.6

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Sample Description	Method Analyte Units LOR	ME- MS61 V ppm 1	ME- MS61 W ppm 0.1	ME- MS61 Y ppm 0.1	ME- MS61 Zn ppm 2	ME- MS61 Zr ppm 0.5	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1
1424901		13	1.4	21.2	148	152.0	0.14	6.47	10.0	1140	2.92	9.23	0.62	0.14	151.0	1.1
1424902		11	1.7	13.4	11	79.6	0.02	6.26	11.6	280	1.53	0.92	0.28	0.03	97.2	0.4
1424903		8	0.8	17.4	25	72.0	0.05	5.40	11.2	380	2.66	0.28	0.96	0.11	78.5	0.8
1424904																
1424905		5	1.2	12.3	27	60.1	0.02	4.52	4.9	300	1.45	0.95	0.55	0.06	84.7	0.6
1424906		16	3.1	8.7	16	63.9	0.03	4.10	7.0	230	0.81	2.42	1.23	0.16	45.7	1.1
1424907		9	3.0	14.5	14	91.0	0.02	3.75	20.9	360	1.09	1.40	0.42	0.05	88.0	0.4
1424908		7	1.2	15.2	21	71.8	0.04	6.55	12.3	260	2.40	0.12	0.65	0.05	98.1	0.4
1424909		18	5.3	10.6	15	50.9	0.02	5.25	11.7	230	3.09	0.10	3.34	0.05	73.7	0.7
1424910		12	0.9	14.6	28	63.2	0.03	6.00	3.3	310	1.84	0.07	0.45	0.12	97.6	1.1
1424910a		106	86.2	19.8	23	47.1										
1424910b		47	0.5	21.7	61	184.5	0.06	7.89	1.6	1420	1.91	0.06	2.23	0.04	48.0	6.8
1424911		12	2.5	12.3	5	78.8	<0.01	5.18	15.3	100	0.15	3.51	1.36	0.05	65.8	0.5
1424912																
1424913		8	1.0	28.0	31	72.1	0.05	5.02	4.7	400	2.28	0.42	1.73	0.10	72.4	1.2
1424914		34	1.8	22.3	72	132.0	0.08	6.55	24.0	870	2.59	0.08	0.19	0.11	105.5	1.0
1424918		14	2.8	17.3	15	116.5	0.17	5.20	23.1	410	1.53	0.10	0.24	<0.02	90.6	0.5
1424918a		103	85.7	19.0	22	45.5										
1424919		49	2.2	19.5	81	102.0	0.16	6.81	50.8	770	6.11	0.08	0.49	0.11	103.5	1.1
1424921		16	1.1	12.6	50	83.3	0.06	6.49	4.8	1160	2.17	0.04	2.14	0.05	105.5	2.9
1424932		12	8.8	16.7	36	53.3	0.02	5.61	3.9	550	2.33	0.12	1.64	0.06	66.1	1.1
1424933		20	5.2	68.2	139	364	0.07	6.34	9.2	190	10.10	0.04	0.44	0.22	180.0	1.2
1424934		19	2.4	37.5	43	99.7	0.12	6.72	6.5	260	5.51	0.32	1.26	0.07	74.6	3.2
1424935																
1424936		5	1.0	17.5	34	65.4	0.03	4.41	3.5	170	2.61	0.53	1.09	0.11	68.4	0.9
1424937		7	3.9	41.6	32	58.9	0.03	6.08	18.0	50	5.64	0.07	0.79	0.09	55.7	0.9
1424938		5	2.4	40.1	33	65.0	0.03	6.28	8.6	20	5.99	0.29	1.11	0.03	50.7	0.3
1424939																
1424940		119	8.2	2.9	39	16.7	0.01	0.24	1150	240	1.52	0.02	23.7	0.08	5.67	6.4
1424941																
1424942		5	0.2	2.5	8	11.8	0.03	0.25	10.3	20	0.12	0.02	14.95	0.02	4.13	0.6
1424943																
1424944		24	1.1	10.0	65	33.5	0.02	1.09	59.2	130	0.65	0.06	21.1	0.10	18.30	4.1
1424945																
1424946		28	1.0	2.8	14	7.4	0.01	0.25	67.5	40	0.25	0.03	11.25	0.02	6.77	2.8
1424947		6	0.3	5.4	6	23.2	0.03	0.71	5.6	140	0.18	0.03	17.30	0.07	18.20	1.6
1424948																
1424949		16	0.5	6.2	11	19.6	0.02	0.91	16.2	90	0.38	0.05	20.0	0.03	22.7	2.0
1424950																
1424951		6	0.2	3.7	8	8.9	0.01	0.35	9.5	160	0.19	0.03	26.1	0.02	9.37	1.1

***** See Appendix Page for comments regarding this certificate *****

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01
1424901		4	5.30	5.0	1.59	17.50	0.23	4.5	0.056	3.95	78.1	31.3	0.30	867	1.10	0.83
1424902		11	0.77	1.5	1.55	15.15	0.17	2.8	0.050	2.06	52.0	17.5	0.04	54	1.04	0.23
1424903		16	2.89	2.3	0.72	12.20	0.16	2.6	0.028	3.77	40.9	19.2	0.17	1410	1.00	0.55
1424904																
1424905		51	1.34	1.5	0.71	11.05	0.16	2.0	0.022	3.63	48.7	18.3	0.13	173	3.25	0.79
1424906		59	0.74	2.9	1.37	10.00	0.14	2.1	0.022	4.22	25.0	29.3	0.08	227	18.05	0.37
1424907		11	2.51	2.6	0.82	12.85	0.17	3.6	0.020	2.58	49.6	23.1	0.12	363	16.30	0.81
1424908		12	3.44	0.9	0.78	14.50	0.18	2.7	0.025	4.18	51.5	36.3	0.16	214	1.22	1.14
1424909		6	2.31	1.8	0.84	13.20	0.14	2.0	0.030	3.47	36.8	36.8	0.20	386	1.45	0.90
1424910		18	1.86	2.5	0.98	12.90	0.17	2.5	0.023	4.59	52.4	24.5	0.13	242	1.36	0.86
1424910a																
1424910b		2	1.71	30.4	2.89	17.10	0.14	4.8	0.035	2.96	24.6	24.4	0.54	666	2.49	3.06
1424911		69	0.71	1.7	0.96	13.75	0.13	2.7	0.012	0.09	36.7	28.0	0.09	61	7.45	0.06
1424912																
1424913		34	2.16	2.7	0.78	13.00	0.16	2.5	0.038	4.00	37.7	13.4	0.21	281	2.33	1.20
1424914		14	2.08	4.4	2.91	16.15	0.18	3.8	0.050	3.96	55.1	16.9	0.11	395	4.38	1.24
1424918		16	1.30	2.6	1.79	12.10	0.13	3.7	0.038	2.26	48.1	17.3	0.13	154	14.85	0.05
1424918a																
1424919		9	3.27	4.3	6.97	18.25	0.19	3.3	0.045	4.20	55.0	12.7	0.15	160	7.47	0.55
1424921		5	2.61	5.2	1.60	16.20	0.18	2.6	0.047	3.11	56.0	44.2	0.57	415	0.33	1.66
1424932		23	2.58	1.8	1.58	14.80	0.14	2.1	0.025	4.64	36.5	13.8	0.15	441	4.51	1.60
1424933		4	5.24	2.5	1.70	27.2	0.24	13.4	0.134	3.81	87.2	79.4	0.15	627	3.01	3.15
1424934		11	7.83	6.1	1.16	19.75	0.15	4.2	0.045	2.96	35.3	62.2	0.68	666	2.23	2.01
1424935																
1424936		30	1.62	2.0	0.77	12.20	0.15	2.5	0.073	2.67	35.6	18.7	0.19	262	2.35	0.77
1424937		9	6.66	1.8	0.55	18.85	0.15	3.1	0.026	4.04	24.6	73.5	0.07	679	3.36	2.55
1424938		8	13.75	1.1	0.56	18.70	0.14	3.4	0.035	3.02	23.3	37.0	0.28	640	2.37	1.87
1424939																
1424940		10	0.44	11.9	2.35	0.79	0.09	0.3	<0.005	0.07	2.9	2.5	8.03	864	2.92	0.02
1424941																
1424942		11	0.22	1.6	0.29	0.61	0.09	0.3	<0.005	0.13	2.7	3.0	5.60	55	0.93	0.02
1424943																
1424944		11	0.83	4.8	1.82	2.91	0.10	0.9	0.017	0.95	8.6	6.2	1.85	255	1.47	0.04
1424945																
1424946		47	0.23	1.8	0.81	0.77	0.07	0.2	<0.005	0.23	3.1	2.7	4.23	142	3.83	0.02
1424947		19	0.27	2.9	0.44	1.44	0.10	0.6	0.005	0.74	7.4	2.6	1.65	227	1.37	0.02
1424948																
1424949		13	0.41	3.1	0.75	2.25	0.09	0.5	0.012	0.81	10.0	4.9	5.60	785	1.01	0.04
1424950																
1424951		4	0.18	1.7	0.37	0.99	0.08	0.3	<0.005	0.33	4.2	2.9	3.98	3080	0.76	0.02

***** See Appendix Page for comments regarding this certificate *****

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01
1424901		19.1	4.1	230	114.0	127.0	<0.002	0.03	2.28	3.2	1	2.1	89.2	1.19	<0.05	19.00
1424902		17.4	0.9	130	29.2	71.5	<0.002	0.03	1.09	2.2	<1	1.6	71.1	1.17	<0.05	27.0
1424903		16.6	1.2	260	23.0	127.5	<0.002	0.02	1.11	2.0	1	1.5	506	1.15	<0.05	21.2
1424904																
1424905		12.9	1.5	290	19.1	122.5	<0.002	0.01	1.01	1.5	1	1.6	72.3	0.84	0.05	18.30
1424906		9.8	2.3	3870	15.4	142.5	<0.002	0.04	1.62	1.1	<1	2.8	47.1	0.78	0.15	17.85
1424907		22.1	0.9	140	24.6	116.0	<0.002	0.01	0.98	1.2	1	2.2	131.0	1.26	0.06	28.0
1424908		17.2	0.5	130	21.8	137.5	<0.002	<0.01	0.49	2.2	1	1.5	80.6	1.18	<0.05	26.3
1424909		16.5	1.0	220	22.9	120.0	<0.002	0.05	0.59	1.9	1	1.5	208	1.20	<0.05	21.3
1424910		16.7	1.8	360	24.3	160.5	<0.002	0.04	0.88	2.3	1	1.2	69.8	1.13	<0.05	26.6
1424910a																
1424910b		9.2	2.3	1160	12.9	70.2	<0.002	<0.01	0.69	8.4	1	1.9	337	0.81	<0.05	4.86
1424911		14.8	1.4	210	15.5	5.9	<0.002	0.01	0.74	1.1	1	1.2	106.0	1.02	0.05	21.9
1424912																
1424913		19.0	2.1	510	44.8	138.5	<0.002	0.02	0.68	1.6	1	1.8	146.5	1.23	0.08	17.85
1424914		20.0	1.5	550	33.2	153.0	<0.002	0.16	0.86	2.6	1	1.7	180.0	1.28	<0.05	18.55
1424918		17.7	1.5	260	34.4	85.5	<0.002	0.56	1.37	1.8	<1	1.6	89.3	1.15	<0.05	16.75
1424918a																
1424919		20.5	1.7	670	28.7	176.5	<0.002	0.04	0.97	2.7	1	1.6	163.0	1.33	<0.05	20.0
1424921		15.5	3.6	480	21.1	113.5	<0.002	0.01	0.53	3.3	1	0.9	314	0.95	<0.05	12.15
1424932		17.7	1.4	380	23.5	173.0	<0.002	0.03	1.11	1.1	1	1.5	126.0	1.10	<0.05	18.00
1424933		89.8	1.9	390	40.5	265	<0.002	0.03	1.00	2.1	2	8.3	54.1	5.40	<0.05	35.2
1424934		44.6	5.4	200	30.9	187.5	<0.002	0.01	1.10	5.5	1	3.4	596	3.90	<0.05	25.7
1424935																
1424936		18.8	1.7	260	27.0	116.0	<0.002	0.01	0.74	2.0	1	1.8	76.2	1.35	<0.05	20.1
1424937		47.4	1.1	430	33.8	326	<0.002	0.18	1.50	3.7	2	2.2	32.3	4.31	<0.05	24.9
1424938		46.3	0.8	80	32.2	225	<0.002	0.02	0.99	3.8	1	3.5	696	4.29	<0.05	24.7
1424939																
1424940		0.8	7.6	310	8.2	3.2	<0.002	<0.01	6.03	0.5	1	<0.2	71.5	<0.05	<0.05	0.53
1424941																
1424942		0.7	3.2	50	1.9	4.1	0.002	<0.01	0.38	0.4	1	<0.2	55.6	0.05	<0.05	0.65
1424943																
1424944		3.1	9.1	140	25.7	24.1	<0.002	0.01	0.84	2.1	1	0.4	198.5	0.24	<0.05	2.23
1424945																
1424946		0.9	2.9	800	2.9	4.8	<0.002	0.01	0.52	0.5	<1	<0.2	50.6	<0.05	<0.05	0.74
1424947		0.9	3.2	350	4.5	12.4	<0.002	0.02	0.18	0.9	<1	<0.2	141.5	0.05	<0.05	1.47
1424948																
1424949		1.5	7.1	910	5.8	13.5	<0.002	<0.01	0.23	1.4	<1	0.2	167.5	0.10	<0.05	1.96
1424950																
1424951		1.0	1.5	1830	3.1	6.6	<0.002	<0.01	0.12	0.6	1	<0.2	307	0.06	<0.05	1.03

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Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1
1424901		0.147	1.15	2.6	13	1.4	21.9	148	155.5	4.21	2.24	1.45	5.17	0.80	0.32	54.0
1424902		0.119	0.38	2.8	11	1.8	13.5	11	81.4	2.59	1.42	0.62	3.79	0.49	0.22	30.9
1424903		0.097	0.98	3.0	8	0.8	16.9	25	69.5	3.11	1.74	0.44	3.31	0.60	0.26	26.9
1424904																
1424905		0.096	1.07	3.3	5	1.2	12.1	27	59.0	2.20	1.23	0.56	2.76	0.42	0.18	29.5
1424906		0.080	1.28	19.9	16	3.0	8.5	16	63.8	1.51	0.91	0.27	1.60	0.30	0.15	13.5
1424907		0.150	1.06	3.7	9	3.1	14.7	14	93.6	2.64	1.58	0.34	2.83	0.55	0.25	28.2
1424908		0.108	0.76	2.9	7	1.1	15.1	21	71.9	2.86	1.64	0.53	3.36	0.55	0.23	32.9
1424909		0.093	0.80	3.0	18	5.2	10.5	15	52.3	2.24	1.22	0.37	2.44	0.41	0.18	24.7
1424910		0.114	1.24	4.3	12	0.9	15.3	28	65.8	2.87	1.58	0.56	3.41	0.54	0.22	31.5
1424910a																
1424910b		0.348	0.18	2.0	47	0.5	21.3	61	185.5	3.90	2.33	1.25	4.07	0.79	0.37	22.9
1424911		0.104	0.20	1.4	12	2.6	11.9	5	78.6	2.18	1.37	0.31	2.45	0.45	0.21	21.4
1424912																
1424913		0.121	1.03	3.0	8	1.0	26.6	31	69.0	4.21	2.64	0.51	3.79	0.93	0.36	24.2
1424914		0.168	0.94	4.5	34	1.7	20.7	72	125.0	3.99	2.21	0.71	4.48	0.78	0.29	38.1
1424918		0.134	0.74	3.0	14	2.8	17.4	15	115.5	3.20	1.88	0.53	3.48	0.65	0.26	31.5
1424918a																
1424919		0.173	1.26	3.7	49	2.2	20.1	81	105.5	3.91	2.21	0.74	4.33	0.76	0.30	35.9
1424921		0.208	0.51	3.0	16	1.1	12.9	50	87.4	2.54	1.29	1.05	3.41	0.46	0.18	38.0
1424932		0.109	0.95	3.5	12	8.3	15.7	36	49.8	2.60	1.64	0.45	2.65	0.54	0.29	21.3
1424933		0.116	0.99	7.2	20	5.2	65.4	139	362	11.35	6.58	0.28	11.05	2.29	0.87	71.9
1424934		0.145	1.36	6.2	19	2.6	38.5	43	103.0	6.50	4.09	0.45	5.79	1.36	0.62	29.1
1424935																
1424936		0.081	4.52	4.5	5	1.0	18.6	34	69.1	3.07	1.87	0.31	3.09	0.63	0.26	23.6
1424937		0.055	1.66	9.5	7	3.9	40.9	32	58.6	6.74	4.44	0.13	5.42	1.43	0.64	21.5
1424938		0.057	1.63	7.7	5	2.5	38.6	33	63.5	6.57	4.15	0.11	5.21	1.36	0.63	20.7
1424939																
1424940		0.010	0.55	2.3	119	8.1	2.9	39	17.2	0.41	0.26	0.09	0.45	0.09	0.04	2.6
1424941																
1424942		0.015	0.04	0.8	5	0.2	2.5	8	11.7	0.37	0.22	0.08	0.38	0.08	0.03	2.4
1424943																
1424944		0.066	0.12	2.0	24	1.1	9.8	65	33.8	1.71	1.04	0.40	1.85	0.35	0.14	9.0
1424945																
1424946		0.017	0.04	2.6	28	1.1	2.9	14	8.2	0.44	0.28	0.11	0.49	0.09	0.04	2.9
1424947		0.026	0.11	1.0	6	0.3	5.1	6	21.6	0.84	0.49	0.26	1.00	0.17	0.06	6.8
1424948																
1424949		0.038	0.12	1.1	16	0.5	5.9	11	18.0	1.07	0.55	0.34	1.35	0.20	0.07	9.3
1424950																
1424951		0.023	0.17	0.6	6	0.2	4.0	8	9.8	0.66	0.39	0.14	0.65	0.13	0.05	3.9

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01
1424901		16.15	7.90	0.76	0.34	2.16	<0.005	0.29	12.80	0.12	0.85	<0.01	2.36	4.78	0.64	0.12
1424902		9.55	5.07	0.52	0.23	1.52	<0.005	0.13	12.29	0.03	0.39	<0.01	2.32	2.52	0.13	0.01
1424903		7.99	4.33	0.53	0.27	1.78	<0.005	1.84	10.66	0.04	1.30	<0.01	1.06	4.45	0.37	0.19
1424904																
1424905		8.96	4.21	0.40	0.19	1.20	<0.005	1.43	8.87	0.04	0.74	0.01	1.07	4.36	0.27	0.02
1424906		4.21	2.08	0.25	0.15	0.92	<0.005	3.26	8.09	0.03	1.70	0.01	2.07	5.17	0.17	0.03
1424907		8.65	4.31	0.45	0.26	1.69	<0.005	1.31	7.63	0.04	0.59	<0.01	1.27	3.31	0.24	0.05
1424908		10.05	4.99	0.50	0.24	1.58	<0.005	0.23	13.50	0.03	0.92	<0.01	1.20	5.27	0.39	0.03
1424909		7.43	3.87	0.39	0.18	1.18	<0.005	0.49	11.63	0.02	4.61	<0.01	1.28	4.24	0.46	0.05
1424910		9.53	4.82	0.50	0.23	1.47	<0.005	0.27	11.34	0.03	0.59	<0.01	1.41	5.50	0.28	0.03
1424910a							0.707									
1424910b		5.54	4.48	0.65	0.36	2.32	<0.005									
1424911		6.62	3.26	0.38	0.21	1.42	<0.005	0.35	10.22	0.01	1.80	0.01	1.40	0.11	0.21	0.01
1424912																
1424913		7.12	4.17	0.65	0.41	2.43	<0.005	0.10	10.06	0.05	2.37	<0.01	1.14	4.88	0.43	0.04
1424914		11.65	6.39	0.71	0.33	2.00	<0.005	0.09	12.94	0.09	0.27	<0.01	4.38	4.90	0.26	0.05
1424918		9.32	4.99	0.56	0.28	1.82	0.016	0.01	10.08	0.04	0.32	<0.01	2.65	2.74	0.28	0.02
1424918a							0.733									
1424919		10.50	5.83	0.71	0.33	2.03	0.514	0.05	13.10	0.08	0.67	<0.01	10.36	5.05	0.33	0.02
1424921		10.95	5.56	0.47	0.19	1.16	0.006	0.06	13.16	0.12	2.97	<0.01	2.42	3.82	1.14	0.06
1424932		6.43	3.43	0.43	0.27	1.81	<0.005	0.03	11.04	0.06	2.18	<0.01	2.29	5.42	0.31	0.06
1424933		21.0	13.50	1.89	0.97	5.97	<0.005	0.02	12.64	0.03	0.61	<0.01	2.57	4.71	0.29	0.09
1424934		8.26	6.39	1.04	0.64	4.22	<0.005	0.05	13.18	0.03	1.73	<0.01	1.74	3.61	1.28	0.09
1424935																
1424936		7.05	4.05	0.53	0.28	1.83	<0.005	0.30	8.82	0.02	1.52	<0.01	1.15	3.26	0.36	0.04
1424937		6.15	5.32	1.04	0.70	4.52	<0.005	0.01	12.36	0.01	1.10	<0.01	0.85	4.95	0.14	0.09
1424938		5.92	5.33	1.00	0.66	4.28	<0.005	0.02	12.30	<0.01	1.50	<0.01	0.84	3.58	0.54	0.09
1424939																
1424940		0.62	0.48	0.07	0.04	0.24	<0.005	0.02	0.44	0.02	34.8	0.01	3.44	0.08	13.70	0.12
1424941																
1424942		0.58	0.42	0.06	0.03	0.22	<0.005	0.01	0.46	<0.01	21.6	<0.01	0.42	0.15	9.40	0.01
1424943																
1424944		2.18	1.90	0.29	0.14	0.94	<0.005	0.01	2.08	0.01	32.0	0.01	2.75	1.16	3.39	0.04
1424945																
1424946		0.70	0.52	0.08	0.04	0.25	<0.005	0.01	0.47	<0.01	16.45	<0.01	1.19	0.28	7.24	0.02
1424947		1.73	1.21	0.16	0.07	0.42	<0.005	0.04	1.37	0.01	26.1	<0.01	0.67	0.91	3.01	0.03
1424948																
1424949		2.33	1.65	0.19	0.08	0.44	<0.005	0.01	1.78	0.01	30.4	<0.01	1.15	0.97	9.92	0.12
1424950																
1424951		0.97	0.68	0.11	0.06	0.34	<0.005	0.01	0.67	0.01	39.5	<0.01	0.54	0.40	6.90	0.43

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method / Analyte / Units / LOR	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02	ME- MS41L Au ppm 0.0002	ME- MS41L Ag ppm 0.001	ME- MS41L Al % 0.01	ME- MS41L As ppm 0.01
1424901		1.14	0.05	0.06	73.65	0.01	0.25	99.41	2.50							
1424902		0.31	0.03	0.09	77.56	0.01	0.20	99.81	3.89							
1424903		0.75	0.06	0.03	77.14	0.05	0.16	99.61	3.32							
1424904													0.0010	0.037	1.15	3.68
1424905		1.10	0.06	0.01	81.09	0.01	0.17	99.16	1.32							
1424906		0.51	0.87	0.09	79.74	0.01	0.14	100.20	1.52							
1424907		1.16	0.03	0.03	82.30	0.01	0.26	99.66	2.70							
1424908		1.62	0.03	0.01	74.17	0.01	0.19	99.70	2.31							
1424909		1.22	0.05	0.13	69.10	0.02	0.16	98.87	5.88							
1424910		1.14	0.08	0.09	77.13	0.01	0.19	99.71	1.87							
1424910a													0.579	0.313	0.25	176.5
1424910b													0.0007	0.014	0.24	0.18
1424911		0.08	0.04	0.03	79.77	0.01	0.17	99.59	5.71							
1424912													0.0004	0.019	0.78	3.13
1424913		1.64	0.11	0.04	75.93	0.02	0.20	99.64	2.69							
1424914		1.74	0.12	0.41	72.33	0.02	0.29	100.20	2.32							
1424918		0.07	0.06	1.37	78.57	0.02	0.23	100.60	4.14							
1424918a													0.587	0.303	0.25	173.5
1424919		0.76	0.15	0.09	65.80	0.02	0.30	99.98	3.16							
1424921		2.29	0.11	0.03	68.85	0.03	0.35	98.87	3.48							
1424932		2.12	0.08	0.06	74.27	0.02	0.18	99.86	1.75							
1424933		4.41	0.09	0.08	73.10	0.01	0.20	100.10	1.14			0.03				
1424934		2.78	0.04	0.02	69.76	0.06	0.25	99.55	4.93			0.05				
1424935													0.0011	0.026	0.97	3.39
1424936		1.05	0.06	0.02	80.78	0.01	0.14	99.81	2.56							
1424937		3.55	0.09	0.44	75.44	<0.01	0.09	100.00	0.87			0.03				
1424938		2.51	0.01	0.04	73.25	0.07	0.09	98.91	4.07							
1424939													0.0002	0.022	0.92	6.27
1424940		0.02	0.07	0.02	5.56	0.01	0.02	99.96	41.42							
1424941													<0.0002	0.010	0.44	6.27
1424942		0.02	0.01	0.02	40.60	<0.01	0.03	99.71	26.97							
1424943													<0.0002	0.018	0.71	5.60
1424944		0.03	0.03	0.05	29.38	0.02	0.13	100.25	29.12							
1424945													<0.0002	0.017	0.54	3.77
1424946		0.03	0.17	0.02	53.06	<0.01	0.03	99.84	20.86							
1424947		0.01	0.08	0.06	44.38	0.01	0.05	100.35	23.62							
1424948													<0.0002	0.011	0.49	3.40
1424949		0.05	0.21	0.02	21.79	0.02	0.07	100.45	33.93							
1424950													<0.0002	0.019	0.63	3.36
1424951		0.01	0.40	0.03	13.72	0.03	0.04	100.20	37.48							

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L B ppm 10	ME- MS41L Ba ppm 0.5	ME- MS41L Be ppm 0.01	ME- MS41L Bi ppm 0.001	ME- MS41L Ca % 0.01	ME- MS41L Cd ppm 0.001	ME- MS41L Ce ppm 0.003	ME- MS41L Co ppm 0.001	ME- MS41L Cr ppm 0.01	ME- MS41L Cs ppm 0.005	ME- MS41L Cu ppm 0.01	ME- MS41L Fe % 0.001	ME- MS41L Ga ppm 0.004	ME- MS41L Ge ppm 0.005	ME- MS41L Hf ppm 0.002
1424901																
1424902																
1424903																
1424904		10	115.5	0.98	0.223	0.95	0.133	42.6	4.41	8.71	2.26	9.98	1.310	3.85	0.059	0.216
1424905																
1424906																
1424907																
1424908																
1424909																
1424910																
1424910a		<10	197.5	0.13	0.104	0.11	0.416	73.8	0.978	35.1	0.911	9.53	1.200	1.125	0.080	0.047
1424910b		<10	39.8	0.05	0.004	0.20	0.009	9.31	1.540	2.64	0.020	19.40	0.680	0.995	0.033	0.069
1424911																
1424912		10	113.0	0.64	0.179	0.83	0.088	47.1	3.88	8.12	1.350	5.89	1.830	3.44	0.075	0.301
1424913																
1424914																
1424918																
1424918a		<10	200	0.11	0.083	0.11	0.878	73.9	0.972	34.6	0.915	9.13	1.190	1.075	0.070	0.052
1424919																
1424921																
1424932																
1424933																
1424934																
1424935		10	134.5	1.11	0.185	1.44	0.102	42.4	3.73	6.95	2.41	6.75	1.450	3.93	0.079	0.346
1424936																
1424937																
1424938																
1424939		10	88.7	0.51	0.095	11.30	0.093	21.4	3.82	8.24	1.600	8.52	1.040	2.86	0.049	0.082
1424940																
1424941		10	54.0	0.29	0.065	12.95	0.071	13.15	2.26	5.72	0.820	4.89	0.680	1.460	0.037	0.045
1424942																
1424943		10	94.8	0.51	0.113	11.15	0.124	23.1	4.10	7.85	1.290	7.67	1.070	2.45	0.054	0.089
1424944																
1424945		10	54.9	0.36	0.075	12.85	0.094	15.15	2.54	5.75	0.895	5.66	0.710	1.685	0.039	0.084
1424946																
1424947																
1424948		10	47.2	0.30	0.070	12.40	0.082	14.45	2.29	5.66	0.752	4.98	0.730	1.565	0.038	0.071
1424949																
1424950		10	60.9	0.34	0.084	10.85	0.111	17.60	2.86	6.43	0.972	6.14	0.810	1.945	0.037	0.108
1424951																

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Hg ppm 0.004	ME- MS41L In ppm 0.005	ME- MS41L K % 0.01	ME- MS41L La ppm 0.002	ME- MS41L Li ppm 0.1	ME- MS41L Mg % 0.01	ME- MS41L Mn ppm 0.1	ME- MS41L Mo ppm 0.01	ME- MS41L Na % 0.001	ME- MS41L Nb ppm 0.002	ME- MS41L Ni ppm 0.04	ME- MS41L P % 0.001	ME- MS41L Pb ppm 0.005	ME- MS41L Pd ppm 0.001	ME- MS41L Pt ppm 0.002
1424901																
1424902																
1424903																
1424904		0.079	0.017	0.36	23.2	23.4	0.57	433	0.56	0.015	1.015	8.23	0.034	12.30	0.001	<0.002
1424905																
1424906																
1424907																
1424908																
1424909																
1424910																
1424910a		0.982	0.012	0.22	41.7	5.8	0.04	16.4	12.45	0.035	0.031	7.32	0.038	7.97	0.012	0.004
1424910b		0.010	<0.005	0.06	3.90	1.9	0.02	90.6	0.41	0.144	0.209	1.92	0.046	1.730	<0.001	<0.002
1424911																
1424912		0.080	0.022	0.24	25.6	16.6	0.37	479	0.60	0.014	0.582	5.68	0.028	10.70	0.003	0.002
1424913																
1424914																
1424918																
1424918a		0.971	0.009	0.22	42.0	5.6	0.04	15.8	12.50	0.036	0.032	7.27	0.038	7.69	0.013	0.004
1424919																
1424921																
1424932																
1424933																
1424934																
1424935		0.143	0.018	0.29	22.7	26.5	0.46	405	0.46	0.015	1.035	5.69	0.026	10.75	0.002	<0.002
1424936																
1424937																
1424938																
1424939		0.019	0.007	0.22	11.30	16.0	5.77	267	0.45	0.021	0.810	7.55	0.035	7.05	0.003	<0.002
1424940																
1424941		0.020	0.006	0.10	7.37	8.0	6.68	162.0	0.55	0.018	0.499	5.41	0.025	5.32	0.001	<0.002
1424942																
1424943		0.018	0.008	0.19	11.75	15.3	2.19	266	0.52	0.014	0.750	7.45	0.034	9.59	0.001	<0.002
1424944																
1424945		0.019	<0.005	0.11	7.83	9.8	6.42	200	0.33	0.018	0.325	5.24	0.034	6.60	0.003	<0.002
1424946																
1424947																
1424948		0.013	<0.005	0.10	7.43	8.6	6.20	190.0	0.34	0.017	0.397	4.71	0.032	5.46	0.002	<0.002
1424949																
1424950		0.016	0.008	0.14	9.11	11.0	5.41	216	0.39	0.027	0.348	5.66	0.036	7.05	0.001	<0.002
1424951																

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Rb ppm 0.005	ME- MS41L Re ppm 0.001	ME- MS41L S % 0.01	ME- MS41L Sb ppm 0.005	ME- MS41L Sc ppm 0.005	ME- MS41L Se ppm 0.1	ME- MS41L Sn ppm 0.01	ME- MS41L Sr ppm 0.01	ME- MS41L Ta ppm 0.005	ME- MS41L Te ppm 0.01	ME- MS41L Th ppm 0.002	ME- MS41L Ti % 0.001	ME- MS41L Tl ppm 0.002	ME- MS41L U ppm 0.005	ME- MS41L V ppm 0.1
1424901																
1424902																
1424903																
1424904		28.0	<0.001	0.01	0.383	2.24	0.4	0.75	81.1	<0.005	0.02	7.89	0.035	0.221	0.635	19.6
1424905																
1424906																
1424907																
1424908																
1424909																
1424910																
1424910a		5.63	0.001	0.34	5.47	4.34	1.8	0.75	48.6	<0.005	0.04	8.18	0.001	6.93	1.305	30.1
1424910b		0.844	<0.001	0.01	0.378	0.523	0.2	0.95	13.95	<0.005	<0.01	0.192	0.097	0.006	0.069	24.4
1424911																
1424912		15.50	<0.001	0.01	0.318	1.840	0.4	0.83	93.9	<0.005	<0.01	7.98	0.078	0.148	0.549	33.0
1424913																
1424914																
1424918																
1424918a		5.51	0.001	0.34	5.61	3.97	1.7	0.75	48.2	<0.005	0.04	8.29	0.001	6.88	1.310	27.5
1424919																
1424921																
1424932																
1424933																
1424934																
1424935		26.6	<0.001	0.01	0.279	1.935	0.5	0.84	104.0	<0.005	<0.01	7.57	0.058	0.219	0.570	27.0
1424936																
1424937																
1424938																
1424939		18.80	<0.001	<0.01	0.325	1.915	0.5	0.41	122.5	<0.005	0.01	3.22	0.035	0.153	0.720	18.6
1424940																
1424941		8.41	<0.001	<0.01	0.239	1.290	0.3	0.24	73.0	<0.005	0.01	1.820	0.019	0.075	0.666	12.0
1424942																
1424943		14.70	<0.001	0.01	0.287	2.11	0.5	0.42	120.0	<0.005	<0.01	3.22	0.031	0.107	0.542	17.4
1424944																
1424945		9.23	<0.001	<0.01	0.199	1.470	0.3	0.29	93.0	<0.005	<0.01	2.15	0.020	0.072	0.448	12.0
1424946																
1424947																
1424948		8.03	<0.001	<0.01	0.190	1.285	0.2	0.26	84.2	<0.005	<0.01	3.39	0.019	0.065	0.481	13.3
1424949																
1424950		10.85	<0.001	<0.01	0.202	1.565	0.3	0.31	96.3	<0.005	<0.01	2.62	0.023	0.075	0.482	13.8
1424951																

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L W ppm 0.001	ME- MS41L Y ppm 0.003	ME- MS41L Zn ppm 0.1	ME- MS41L Zr ppm 0.01
1424901					
1424902					
1424903					
1424904		0.315	8.08	41.6	7.68
1424905					
1424906					
1424907					
1424908					
1424909					
1424910					
1424910a		7.92	13.50	14.6	1.79
1424910b		0.046	3.44	11.3	2.86
1424911					
1424912		0.342	7.44	45.9	10.75
1424913					
1424914					
1424918					
1424918a		8.13	13.25	14.1	1.84
1424919					
1424921					
1424932					
1424933					
1424934					
1424935		0.238	9.62	40.1	13.05
1424936					
1424937					
1424938					
1424939		0.276	5.65	30.6	3.51
1424940					
1424941		0.162	4.06	18.7	1.69
1424942					
1424943		0.213	6.59	35.8	3.67
1424944					
1424945		0.204	4.63	20.5	3.51
1424946					
1424947					
1424948		0.162	4.08	19.0	2.70
1424949					
1424950		0.193	4.94	23.7	4.35
1424951					

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CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method	WEI- 21	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	Recvd Wt.	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe
	Units	kg	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%
	LOR	0.02	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01
1424952			0.03	0.45	18.2	120	0.28	0.02	9.55	0.05	10.15	1.2	40	0.28	2.7	0.66
1424953			0.12	0.32	6.5	290	0.24	0.03	2.90	0.22	21.8	5.4	64	0.42	5.3	0.40
1424954			0.04	0.32	5.1	30	0.13	0.01	28.5	0.14	3.55	0.7	22	1.81	2.3	0.24
1424955																
1424956			0.02	0.63	68.2	20	0.82	0.02	17.60	0.62	13.95	2.2	45	4.83	4.9	1.13
1424957																
1424958			0.03	0.30	3.8	60	0.12	0.01	3.79	0.05	9.17	0.8	95	0.93	1.8	0.39
1424959			0.04	3.18	45.0	80	1.06	0.14	18.60	0.30	40.8	11.7	19	5.35	17.8	1.77
1424960																
1424961			0.05	0.39	4.0	70	0.17	0.04	8.10	0.06	8.75	0.7	33	0.30	5.5	0.34
1424962																
1424963			0.02	0.24	6.8	20	0.19	0.03	3.10	0.05	7.53	1.3	21	0.31	3.4	0.49
1424964																
1424964a		0.04	0.74	5.07	194.5	1400	2.15	0.10	0.15	0.32	98.9	1.3	116	9.03	12.7	1.39
1424965			0.45	2.37	15.3	180	0.89	0.08	9.21	0.20	32.0	2.8	96	2.17	19.0	3.12
1424966																
1424967			0.15	0.61	11.1	60	0.30	0.06	9.86	0.06	10.65	1.2	163	0.72	3.7	2.75
1424968																
1424969			0.03	1.85	129.0	270	0.64	0.07	19.45	0.08	26.3	3.2	15	0.91	6.1	1.33
1424970																
1424971			0.02	0.86	5.2	160	0.30	0.05	14.00	0.09	13.80	1.6	13	0.48	3.0	0.53
1424972																
1424973			0.03	1.40	11.2	170	0.50	0.06	13.50	0.06	21.9	2.5	27	0.76	4.0	1.11
1424974																
1424975			0.03	2.05	15.6	260	0.46	0.08	14.40	<0.02	38.1	2.1	28	0.76	3.8	1.17
1424976																
1424977			0.02	1.40	10.1	50	0.28	0.05	21.7	0.03	11.95	0.8	11	0.77	2.5	0.52
1424978																
1424979			0.15	2.17	22.3	130	1.21	0.08	9.29	0.64	37.7	7.1	32	1.22	5.4	11.80
1424980																
1424981			0.04	3.76	4.3	460	2.39	0.07	0.66	0.05	87.3	1.1	60	2.30	2.0	1.03
1424982			0.07	7.66	6.5	300	1.25	0.24	0.31	<0.02	117.5	0.3	12	0.89	1.5	1.70
1424983			0.05	6.07	6.5	130	3.70	0.10	0.28	0.02	99.1	0.6	20	1.14	3.6	1.08
1424984																
1424985			0.04	4.41	4.7	220	2.22	0.10	0.17	0.03	79.9	0.4	70	1.42	1.4	1.09
1424986																
1424987			0.08	6.07	5.3	520	1.14	0.24	0.24	0.02	137.0	0.6	9	1.21	1.1	1.71
1424988																
1424989			0.06	6.13	4.4	400	2.12	0.48	0.46	0.05	99.8	0.6	26	1.70	1.7	0.93
1424990																

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	Hg- MS42 Hg ppm 0.005	ME- MS61 In ppm 0.005	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10
1424952		1.40	0.11	0.3	0.023	0.006	0.35	5.3	7.3	1.82	316	2.93	0.02	1.1	3.0	520
1424953		0.90	0.13	0.1	0.091	<0.005	0.27	13.4	5.9	0.08	1400	8.27	0.02	0.6	18.3	2410
1424954		0.80	0.09	0.2	0.011	<0.005	0.07	3.3	2.7	0.21	55	1.20	0.01	0.9	3.6	60
1424955																
1424956		2.00	0.11	0.6	0.021	0.006	0.13	7.9	6.7	0.76	138	1.58	0.02	1.4	14.4	110
1424957																
1424958		0.76	0.11	0.3	0.011	<0.005	0.19	4.4	6.4	0.62	100	4.86	0.01	1.1	3.3	380
1424959		8.39	0.14	1.9	0.047	0.033	0.61	23.4	24.4	3.24	217	3.81	0.28	6.8	38.4	260
1424960																
1424961		0.93	0.11	0.5	0.023	0.005	0.32	7.3	2.5	4.79	105	3.19	0.02	1.5	7.0	90
1424962																
1424963		0.72	0.10	0.4	0.016	<0.005	0.09	3.5	3.1	0.13	80	1.41	0.02	0.7	4.0	100
1424964																
1424964a		12.20	0.13	1.4	1.125	0.013	2.32	56.1	38.3	0.31	25	13.50	0.06	10.3	10.7	420
1424965		5.69	0.15	1.7	0.070	0.026	0.75	21.5	14.6	0.95	137	3.20	0.17	5.5	34.7	980
1424966																
1424967		1.92	0.10	0.6	0.034	0.019	0.19	6.2	8.5	1.49	163	3.44	0.03	1.8	14.6	560
1424968																
1424969		3.82	0.14	1.6	0.012	0.018	2.13	10.6	3.9	1.82	287	1.63	0.07	5.4	7.1	260
1424970																
1424971		1.99	0.11	0.6	0.010	0.008	0.90	5.3	13.7	4.92	157	0.94	0.07	2.8	2.4	120
1424972																
1424973		3.21	0.12	1.0	0.016	0.018	1.37	9.6	5.4	1.57	219	1.67	0.07	4.1	6.0	230
1424974																
1424975		4.02	0.13	1.6	0.009	0.024	2.12	15.9	2.9	1.60	327	1.52	0.09	6.3	5.4	220
1424976																
1424977		2.15	0.11	1.1	0.015	0.007	1.86	5.1	40.2	1.76	30	0.89	0.02	3.4	2.5	140
1424978																
1424979		5.09	0.17	1.6	0.032	0.050	1.06	16.9	16.6	0.58	315	3.12	0.07	4.8	21.2	>10000
1424980																
1424981		12.45	0.17	2.7	0.022	0.023	2.30	51.0	15.8	0.19	309	4.05	1.31	14.6	2.7	470
1424982		19.65	0.19	4.4	0.036	0.039	2.66	57.4	16.2	0.06	65	0.85	0.45	25.4	1.0	140
1424983		14.45	0.18	2.4	0.057	0.026	1.38	52.1	25.9	0.07	63	1.34	0.23	20.2	3.6	100
1424984																
1424985		13.75	0.17	2.1	0.135	0.023	1.74	41.7	21.2	0.04	170	4.43	0.28	16.0	1.7	240
1424986																
1424987		14.75	0.18	3.9	0.545	0.031	1.19	74.9	10.2	0.04	68	1.64	0.29	19.1	0.8	210
1424988																
1424989		14.45	0.18	3.2	0.259	0.033	4.30	53.1	21.3	0.09	165	1.66	0.75	19.5	1.5	410
1424990																

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Pb ppm 0.5	ME- MS61 Rb ppm 0.1	ME- MS61 Re ppm 0.002	ME- MS61 S % 0.01	ME- MS61 Sb ppm 0.05	ME- MS61 Sc ppm 0.1	ME- MS61 Se ppm 1	ME- MS61 Sn ppm 0.2	ME- MS61 Sr ppm 0.2	ME- MS61 Ta ppm 0.05	ME- MS61 Te ppm 0.05	ME- MS61 Th ppm 0.01	ME- MS61 Ti % 0.005	ME- MS61 Tl ppm 0.02	ME- MS61 U ppm 0.1
1424952		7.5	8.4	<0.002	0.02	0.31	0.7	<1	0.2	94.3	0.05	<0.05	1.05	0.025	0.11	2.6
1424953		7.8	8.1	0.005	0.02	1.36	0.6	1	<0.2	43.7	<0.05	<0.05	1.42	0.013	1.39	2.8
1424954		1.3	4.9	<0.002	<0.01	0.26	0.7	1	0.2	400	0.05	<0.05	0.57	0.023	0.04	0.5
1424955																
1424956		11.5	13.3	<0.002	<0.01	2.10	1.5	1	0.2	37.2	0.09	<0.05	1.31	0.044	0.42	0.6
1424957																
1424958		2.2	6.5	<0.002	0.01	0.42	0.4	<1	<0.2	47.4	<0.05	<0.05	1.03	0.015	0.05	0.7
1424959		16.0	46.7	0.003	0.09	1.17	4.9	1	1.1	56.2	0.48	0.08	5.63	0.166	0.72	3.9
1424960																
1424961		5.5	9.3	0.002	0.01	0.23	0.7	<1	0.2	33.9	0.08	<0.05	1.04	0.026	0.07	0.9
1424962																
1424963		2.5	4.0	<0.002	0.01	0.43	0.5	<1	<0.2	35.8	<0.05	<0.05	0.98	0.014	0.04	0.7
1424964																
1424964a		9.1	98.3	0.002	0.37	13.45	9.5	2	1.9	95.5	0.72	<0.05	10.45	0.347	8.64	2.8
1424965		8.1	36.4	<0.002	0.01	0.80	4.8	3	0.8	199.5	0.37	0.08	4.21	0.157	0.18	2.3
1424966																
1424967		5.1	8.4	<0.002	0.01	0.74	2.4	1	0.2	98.2	0.11	0.21	1.59	0.048	0.06	1.4
1424968																
1424969		20.9	47.8	<0.002	0.01	2.01	2.9	1	0.6	137.0	0.38	<0.05	3.83	0.105	0.21	1.5
1424970																
1424971		5.8	22.1	<0.002	0.02	0.20	1.3	<1	0.3	121.0	0.19	<0.05	2.01	0.051	0.10	1.2
1424972																
1424973		6.1	32.2	<0.002	0.02	0.36	2.4	1	0.5	124.5	0.28	<0.05	3.00	0.082	0.15	1.2
1424974																
1424975		5.8	46.0	<0.002	0.01	0.30	3.2	1	0.6	127.0	0.47	<0.05	4.72	0.128	0.18	1.4
1424976																
1424977		4.3	13.0	<0.002	0.02	0.25	2.1	1	0.4	282	0.24	<0.05	2.96	0.056	0.07	1.7
1424978																
1424979		8.3	12.4	<0.002	0.02	0.56	8.6	9	0.7	270	0.32	<0.05	3.74	0.107	0.11	2.5
1424980																
1424981		13.5	78.7	<0.002	0.01	0.44	2.1	1	1.1	111.0	0.85	<0.05	12.45	0.107	0.75	3.3
1424982		19.4	82.1	<0.002	0.02	0.44	3.1	1	2.2	64.2	1.56	<0.05	50.6	0.187	0.59	2.6
1424983		17.8	47.7	<0.002	0.01	0.89	2.4	1	1.7	32.1	1.33	<0.05	23.8	0.106	0.30	3.0
1424984																
1424985		16.2	62.5	<0.002	0.08	0.85	1.9	<1	1.5	56.4	1.02	<0.05	20.0	0.081	0.44	2.9
1424986																
1424987		27.2	35.6	<0.002	0.28	0.68	2.8	1	1.7	85.2	1.23	<0.05	26.0	0.128	0.30	2.8
1424988																
1424989		23.2	121.0	<0.002	0.02	0.77	1.8	1	1.9	74.2	1.17	<0.05	21.5	0.110	0.83	3.0
1424990																

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CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 V ppm 1	ME- MS61 W ppm 0.1	ME- MS61 Y ppm 0.1	ME- MS61 Zn ppm 2	ME- MS61 Zr ppm 0.5	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1
1424952		22	0.6	3.6	7	11.3	0.02	0.45	18.6	120	0.23	0.04	9.55	0.05	10.45	1.1
1424953		26	2.5	16.5	22	1.4	0.12	0.32	6.7	290	0.24	0.04	2.90	0.21	23.3	5.5
1424954		8	0.3	6.3	21	7.1	0.03	0.32	5.0	30	0.10	0.02	28.5	0.13	3.56	0.7
1424955																
1424956		17	0.7	9.4	108	23.3	0.01	0.63	72.5	20	0.88	0.03	17.60	0.63	15.70	2.3
1424957																
1424958		6	0.4	3.7	7	10.9	0.02	0.30	3.8	60	0.09	0.02	3.79	0.06	9.23	0.7
1424959		45	2.3	16.9	56	73.9	0.03	3.18	47.1	80	1.00	0.16	18.60	0.29	43.5	11.8
1424960																
1424961		6	0.3	6.1	10	19.4	0.03	0.39	3.5	70	0.16	0.03	8.10	0.07	8.29	0.7
1424962																
1424963		6	0.3	2.7	8	13.1	0.01	0.24	6.8	20	0.16	0.03	3.10	0.04	7.84	1.4
1424964																
1424964a		103	85.4	19.0	22	44.7										
1424965		80	0.9	21.0	88	61.4	0.43	2.37	14.5	180	0.96	0.08	9.21	0.20	32.6	2.8
1424966																
1424967		95	0.3	4.3	16	21.5	0.14	0.61	11.2	60	0.34	0.06	9.86	0.07	10.45	1.1
1424968																
1424969		32	1.9	13.5	74	57.0	0.02	1.85	129.5	270	0.72	0.08	19.45	0.10	27.2	3.4
1424970																
1424971		9	0.4	5.5	35	21.9	0.02	0.86	5.1	160	0.27	0.05	14.00	0.09	13.90	1.6
1424972																
1424973		18	0.7	11.3	28	36.7	0.03	1.40	11.1	170	0.53	0.07	13.50	0.07	22.8	2.6
1424974																
1424975		15	0.7	19.4	14	55.2	0.02	2.05	16.8	260	0.56	0.09	14.40	<0.02	42.1	2.4
1424976																
1424977		11	0.4	4.9	14	41.3	0.01	1.40	9.6	50	0.25	0.06	21.7	0.04	11.60	0.8
1424978																
1424979		51	1.1	66.4	57	67.1	0.16	2.17	20.9	130	1.26	0.07	9.29	0.62	36.6	6.9
1424980																
1424981		12	1.9	14.3	30	104.0	0.02	3.76	4.1	460	2.59	0.08	0.66	0.05	82.9	1.1
1424982		21	1.2	20.6	13	141.0	0.06	7.66	6.6	300	1.32	0.26	0.31	0.03	123.0	0.3
1424983		7	1.0	25.3	15	69.3	0.04	6.07	6.2	130	4.09	0.11	0.28	<0.02	101.0	0.6
1424984																
1424985		6	1.2	11.7	12	56.1	0.03	4.41	4.6	220	2.35	0.10	0.17	0.03	78.6	0.4
1424986																
1424987		8	1.1	23.1	10	126.0	0.07	6.07	5.4	520	1.20	0.26	0.24	0.02	139.0	0.6
1424988																
1424989		7	1.0	19.5	22	91.9	0.06	6.13	5.0	400	2.73	0.55	0.46	0.07	108.5	0.7
1424990																

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01
1424952		40	0.28	2.7	0.66	1.31	0.08	0.3	0.007	0.35	5.2	7.6	1.82	316	2.87	0.02
1424953		64	0.45	5.1	0.40	0.86	0.10	<0.1	0.005	0.27	13.1	6.2	0.08	1400	8.28	0.02
1424954		22	1.83	2.1	0.24	0.78	0.08	0.2	<0.005	0.07	3.1	2.7	0.21	55	1.15	0.01
1424955																
1424956		45	5.37	5.0	1.13	2.09	0.09	0.7	0.007	0.13	8.3	7.2	0.76	138	1.63	0.02
1424957																
1424958		95	0.95	1.6	0.39	0.71	0.08	0.4	<0.005	0.19	4.1	6.2	0.62	100	4.55	0.01
1424959		19	5.64	17.0	1.77	8.32	0.11	2.0	0.030	0.61	23.2	24.6	3.24	217	3.69	0.28
1424960																
1424961		33	0.28	5.2	0.34	0.90	0.08	0.5	<0.005	0.32	6.8	2.5	4.79	105	3.18	0.02
1424962																
1424963		21	0.32	3.5	0.49	0.80	0.08	0.4	<0.005	0.09	3.6	3.4	0.13	80	1.59	0.02
1424964																
1424964a																
1424965		96	2.15	18.7	3.12	5.90	0.12	1.8	0.032	0.75	20.9	16.4	0.95	137	3.32	0.17
1424966																
1424967		163	0.71	3.8	2.75	2.03	0.08	0.6	0.023	0.19	5.9	9.3	1.49	163	3.54	0.03
1424968																
1424969		15	0.93	6.4	1.33	4.28	0.11	1.8	0.021	2.13	10.9	4.4	1.82	287	1.75	0.07
1424970																
1424971		13	0.49	3.1	0.53	2.09	0.09	0.6	0.011	0.90	5.3	15.7	4.92	157	0.99	0.07
1424972																
1424973		27	0.78	4.1	1.11	3.47	0.11	1.1	0.015	1.37	10.1	6.1	1.57	219	1.80	0.07
1424974																
1424975		28	0.88	4.4	1.17	4.69	0.11	1.8	0.032	2.12	16.0	3.6	1.60	327	1.83	0.09
1424976																
1424977		11	0.75	2.3	0.52	2.10	0.10	1.1	0.010	1.86	4.8	44.7	1.76	30	0.94	0.02
1424978																
1424979		32	1.19	5.2	11.80	5.18	0.15	1.7	0.054	1.06	16.3	18.7	0.58	315	3.24	0.07
1424980																
1424981		60	2.16	1.9	1.03	12.30	0.12	2.9	0.024	2.30	47.4	17.0	0.19	309	3.99	1.31
1424982		12	0.93	1.6	1.70	21.7	0.16	4.8	0.042	2.66	59.0	19.4	0.06	65	0.93	0.45
1424983		20	1.16	3.7	1.08	15.50	0.14	2.6	0.026	1.38	52.3	31.4	0.07	63	1.49	0.23
1424984																
1424985		70	1.36	1.3	1.09	14.00	0.15	2.0	0.021	1.74	39.8	23.7	0.04	170	4.50	0.28
1424986																
1424987		9	1.24	1.1	1.71	15.75	0.15	4.2	0.033	1.19	74.8	11.7	0.04	68	1.76	0.29
1424988																
1424989		26	1.85	1.9	0.93	16.20	0.17	3.5	0.034	4.30	56.3	26.6	0.09	165	1.90	0.75
1424990																

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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01
1424952		1.0	3.0	520	7.3	8.1	<0.002	0.02	0.30	0.7	<1	0.2	94.8	0.05	<0.05	1.03
1424953		0.4	18.5	2410	7.5	7.9	0.005	0.02	1.29	0.7	1	<0.2	44.7	<0.05	<0.05	1.42
1424954		0.8	3.7	60	1.2	4.6	<0.002	<0.01	0.25	0.7	1	<0.2	400	0.05	<0.05	0.53
1424955																
1424956		1.4	15.4	110	11.7	13.6	<0.002	<0.01	2.09	1.6	1	0.2	40.2	0.09	<0.05	1.35
1424957																
1424958		0.9	3.2	380	2.0	6.1	<0.002	0.01	0.41	0.4	<1	<0.2	46.6	<0.05	<0.05	0.96
1424959		6.3	38.2	260	16.2	45.4	0.004	0.09	1.13	5.1	1	1.1	57.2	0.47	0.05	5.71
1424960																
1424961		1.3	6.8	90	5.4	8.7	0.002	0.01	0.22	0.6	1	0.2	33.2	0.08	<0.05	1.02
1424962																
1424963		0.7	4.2	100	2.6	4.0	<0.002	0.01	0.43	0.6	<1	<0.2	37.6	<0.05	<0.05	1.00
1424964																
1424964a																
1424965		5.3	35.4	980	8.2	34.2	<0.002	0.01	0.77	4.9	3	0.8	200	0.36	0.06	4.22
1424966																
1424967		1.8	14.7	560	5.2	8.0	<0.002	0.01	0.72	2.3	1	0.2	99.4	0.10	0.21	1.57
1424968																
1424969		5.5	7.8	260	22.6	49.2	<0.002	0.01	2.09	3.1	1	0.6	141.5	0.39	<0.05	4.12
1424970																
1424971		2.8	2.7	120	6.1	22.1	<0.002	0.02	0.21	1.4	1	0.3	123.5	0.19	<0.05	2.04
1424972																
1424973		4.2	6.4	230	6.7	33.6	<0.002	0.02	0.35	2.4	1	0.5	128.5	0.27	<0.05	3.24
1424974																
1424975		6.9	6.4	220	6.4	50.4	<0.002	0.01	0.33	3.6	1	0.8	135.0	0.49	<0.05	5.18
1424976																
1424977		3.2	2.4	140	4.3	12.2	<0.002	0.02	0.24	2.0	1	0.4	282	0.22	<0.05	2.86
1424978																
1424979		4.6	21.6	>10000	8.7	11.8	0.002	0.02	0.57	8.3	7	0.6	270	0.30	<0.05	3.81
1424980																
1424981		13.5	2.6	470	13.3	74.0	<0.002	0.01	0.43	2.0	1	1.0	108.5	0.78	<0.05	11.55
1424982		25.7	1.1	140	20.7	83.7	<0.002	0.02	0.44	3.3	1	2.3	68.2	1.53	<0.05	54.0
1424983		20.2	3.8	100	19.3	49.0	<0.002	0.01	0.90	2.5	1	1.7	34.4	1.28	<0.05	25.6
1424984																
1424985		14.8	1.7	240	16.5	59.5	<0.002	0.08	0.82	1.8	1	1.5	56.1	0.99	<0.05	19.60
1424986																
1424987		19.3	0.8	210	27.8	34.6	<0.002	0.28	0.69	2.8	1	1.8	87.9	1.20	<0.05	26.4
1424988																
1424989		20.4	1.6	410	26.0	125.5	<0.002	0.02	0.79	2.0	1	2.0	78.9	1.19	<0.05	24.4
1424990																

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method / Analyte / Units / LOR	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1
1424952		0.025	0.11	2.7	22	0.6	3.4	7	10.8	0.56	0.36	0.16	0.72	0.12	0.05	4.5
1424953		0.013	1.37	2.9	26	2.5	16.7	22	2.2	2.35	1.15	0.62	2.82	0.45	0.11	12.4
1424954		0.023	0.04	0.5	8	0.3	5.9	21	6.5	0.50	0.35	0.11	0.53	0.12	0.04	2.4
1424955																
1424956		0.044	0.44	0.6	17	0.8	9.9	108	24.1	1.31	0.82	0.27	1.29	0.29	0.11	7.6
1424957																
1424958		0.015	0.05	0.7	6	0.3	3.4	7	10.6	0.62	0.29	0.18	0.81	0.11	0.04	4.3
1424959		0.166	0.78	4.1	45	2.4	16.6	56	72.9	2.98	1.71	0.78	3.40	0.60	0.22	21.3
1424960																
1424961		0.026	0.08	0.9	6	0.2	5.9	10	18.0	0.77	0.46	0.18	0.88	0.16	0.06	5.5
1424962																
1424963		0.014	0.05	0.7	6	0.3	2.9	8	13.5	0.49	0.30	0.09	0.49	0.10	0.05	3.1
1424964																
1424964a																
1424965		0.157	0.19	2.4	80	0.9	21.0	88	61.3	2.96	1.74	0.81	3.57	0.59	0.26	20.9
1424966																
1424967		0.048	0.07	1.5	95	0.3	4.4	16	21.0	0.73	0.44	0.20	0.84	0.15	0.08	5.3
1424968																
1424969		0.105	0.24	1.7	32	2.0	14.3	74	61.0	2.40	1.50	0.53	2.45	0.50	0.24	13.0
1424970																
1424971		0.051	0.10	1.3	9	0.4	5.7	35	21.0	1.11	0.65	0.27	1.20	0.22	0.10	6.6
1424972																
1424973		0.082	0.17	1.3	18	0.7	12.0	28	38.2	2.03	1.18	0.46	2.11	0.41	0.17	11.1
1424974																
1424975		0.128	0.22	1.6	15	0.8	20.7	14	59.3	3.66	2.13	0.78	3.80	0.75	0.32	21.2
1424976																
1424977		0.056	0.06	1.7	11	0.3	4.8	14	39.5	0.92	0.55	0.16	0.92	0.19	0.08	5.7
1424978																
1424979		0.107	0.12	2.6	51	1.0	65.7	57	65.3	12.00	4.16	5.75	19.05	1.89	0.33	24.6
1424980																
1424981		0.107	0.77	3.3	12	1.7	13.9	30	97.3	2.45	1.35	0.59	2.99	0.48	0.19	29.8
1424982		0.187	0.68	2.8	21	1.3	21.9	13	145.0	3.98	2.48	0.62	3.72	0.82	0.42	36.5
1424983		0.106	0.35	3.2	7	1.0	26.9	15	66.0	5.21	3.00	0.73	5.22	1.04	0.41	40.8
1424984																
1424985		0.081	0.49	2.8	6	1.1	11.4	12	52.0	2.07	1.21	0.40	2.36	0.41	0.19	28.2
1424986																
1424987		0.128	0.32	3.0	8	1.1	24.4	10	129.0	4.38	2.58	1.07	4.69	0.86	0.39	46.7
1424988																
1424989		0.110	0.95	3.4	7	1.1	21.5	22	98.8	3.73	2.11	0.64	4.26	0.73	0.31	37.4
1424990																

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TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01
1424952		1.14	0.81	0.11	0.05	0.33	0.007	0.02	0.85	0.01	13.25	0.01	0.97	0.42	3.17	0.04
1424953		2.78	2.61	0.43	0.14	0.76	<0.005	0.09	0.60	0.03	3.80	0.01	0.58	0.32	0.08	0.18
1424954		0.59	0.46	0.08	0.05	0.28	<0.005	0.01	0.61	<0.01	42.1	<0.01	0.35	0.08	0.26	0.01
1424955																
1424956		1.90	1.36	0.21	0.12	0.74	<0.005	0.02	1.22	<0.01	26.7	0.01	1.73	0.16	1.36	0.02
1424957																
1424958		1.00	0.86	0.12	0.04	0.27	<0.005	0.01	0.56	<0.01	5.20	0.01	0.56	0.24	1.07	0.01
1424959		5.32	3.91	0.52	0.23	1.49	<0.005	0.04	6.22	<0.01	28.4	<0.01	2.68	0.76	6.03	0.03
1424960																
1424961		1.39	0.98	0.13	0.07	0.42	<0.005	0.02	0.75	<0.01	11.95	<0.01	0.51	0.40	8.39	0.02
1424962																
1424963		0.82	0.62	0.08	0.05	0.31	<0.005	0.01	0.46	<0.01	4.30	<0.01	0.74	0.11	0.18	0.01
1424964																
1424964a							0.740									
1424965		5.10	4.28	0.50	0.26	1.62	<0.005	0.07	4.54	0.02	13.50	0.02	4.67	0.92	1.76	0.02
1424966																
1424967		1.47	1.00	0.12	0.07	0.48	<0.005	0.03	1.15	<0.01	14.35	0.03	4.02	0.22	2.65	0.02
1424968																
1424969		3.13	2.79	0.40	0.23	1.57	<0.005	0.01	3.56	0.03	29.3	<0.01	2.00	2.58	3.38	0.04
1424970																
1424971		1.58	1.51	0.19	0.10	0.63	<0.005	0.01	1.68	0.02	21.3	<0.01	0.81	1.09	8.48	0.03
1424972																
1424973		2.72	2.40	0.34	0.18	1.15	<0.005	0.01	2.80	0.02	21.2	0.01	1.72	1.71	2.95	0.03
1424974																
1424975		4.97	4.59	0.61	0.33	2.15	<0.005	<0.01	3.99	0.03	21.9	0.01	1.79	2.62	3.00	0.05
1424976																
1424977		1.48	1.22	0.15	0.09	0.56	<0.005	0.01	2.66	0.01	32.3	<0.01	0.77	2.15	3.13	0.01
1424978																
1424979		4.89	9.73	2.66	0.49	2.49	<0.005	0.03	4.23	0.01	14.40	<0.01	17.96	1.30	1.10	0.05
1424980																
1424981		8.98	4.44	0.43	0.21	1.33	<0.005	0.02	7.57	0.06	0.92	0.01	1.51	2.88	0.35	0.04
1424982		11.50	5.37	0.63	0.40	2.76	<0.005	0.04	15.60	0.04	0.45	<0.01	2.61	3.35	0.16	0.01
1424983		11.65	7.38	0.87	0.46	2.83	<0.005	0.06	12.44	0.01	0.39	<0.01	1.68	1.74	0.16	0.01
1424984																
1424985		8.35	4.57	0.35	0.20	1.32	<0.005	0.14	8.36	0.02	0.22	0.01	1.58	2.06	0.06	0.02
1424986																
1424987		14.90	7.20	0.74	0.40	2.57	<0.005	0.59	12.40	0.06	0.34	<0.01	2.62	1.50	0.10	0.01
1424988																
1424989		11.25	6.24	0.65	0.32	2.09	<0.005	0.27	12.20	0.05	0.63	<0.01	1.41	5.20	0.18	0.02
1424990																

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Finalized Date: 23- MAY- 2016
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CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02	ME- MS41L Au ppm 0.0002	ME- MS41L Ag ppm 0.001	ME- MS41L Al % 0.01	ME- MS41L As ppm 0.01
1424952		0.02	0.11	0.04	67.68	0.01	0.05	100.40	13.75							
1424953		0.01	0.52	0.04	91.16	0.01	0.02	99.96	2.59							
1424954		<0.01	0.01	0.01	22.62	0.04	0.04	99.41	33.26							
1424955													0.0005	0.016	0.44	7.81
1424956		0.01	0.02	0.01	45.00	<0.01	0.09	99.18	22.80							
1424957													0.0003	0.019	0.67	8.26
1424958		0.01	0.08	0.02	86.52	<0.01	0.02	99.44	5.14							
1424959		0.36	0.06	0.24	24.42	0.01	0.30	99.27	29.70							
1424960													<0.0002	0.020	0.58	4.83
1424961		0.04	0.02	0.03	59.40	<0.01	0.05	99.81	18.24							
1424962													0.0004	0.025	0.90	7.12
1424963		0.02	0.02	0.01	90.33	<0.01	0.03	99.87	3.66							
1424964													0.0004	0.033	0.93	7.44
1424964a																
1424965		0.23	0.22	0.04	60.00	0.02	0.32	99.66	13.31							
1424966													<0.0002	0.014	0.57	8.73
1424967		0.03	0.12	0.03	62.56	0.01	0.09	99.97	14.66							
1424968													<0.0002	0.015	0.69	4.88
1424969		0.08	0.06	0.04	32.22	0.01	0.20	100.35	26.77							
1424970													0.0002	0.018	0.76	4.93
1424971		0.10	0.03	0.05	40.53	0.01	0.09	100.05	25.79							
1424972													0.0004	0.020	0.80	6.42
1424973		0.09	0.05	0.03	49.98	0.02	0.16	100.40	19.61							
1424974													<0.0002	0.016	0.80	4.69
1424975		0.10	0.05	0.03	45.70	0.01	0.24	100.00	20.45							
1424976													0.0003	0.024	0.82	4.19
1424977		0.02	0.03	0.06	30.35	0.03	0.09	100.00	28.37							
1424978													0.0005	0.024	0.97	6.54
1424979		0.08	2.86	0.04	44.75	0.03	0.21	99.13	12.07							
1424980													0.0003	0.024	1.07	3.71
1424981		1.88	0.10	0.01	83.11	0.02	0.19	99.78	1.10							
1424982		0.63	0.03	0.04	72.24	0.01	0.34	100.00	4.45							
1424983		0.32	0.02	0.03	78.12	<0.01	0.19	99.29	4.17							
1424984													0.0002	0.028	0.93	3.96
1424985		0.37	0.05	0.17	83.66	<0.01	0.13	99.08	2.36							
1424986													0.0005	0.024	0.78	3.32
1424987		0.41	0.05	0.71	76.45	0.01	0.22	100.10	5.18							
1424988													0.0006	0.031	1.13	4.05
1424989		1.04	0.09	0.04	76.49	0.01	0.19	99.68	2.10							
1424990													0.0006	0.031	1.39	3.86

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L B ppm 10	ME- MS41L Ba ppm 0.5	ME- MS41L Be ppm 0.01	ME- MS41L Bi ppm 0.001	ME- MS41L Ca % 0.01	ME- MS41L Cd ppm 0.001	ME- MS41L Ce ppm 0.003	ME- MS41L Co ppm 0.001	ME- MS41L Cr ppm 0.01	ME- MS41L Cs ppm 0.005	ME- MS41L Cu ppm 0.01	ME- MS41L Fe % 0.001	ME- MS41L Ga ppm 0.004	ME- MS41L Ge ppm 0.005	ME- MS41L Hf ppm 0.002
1424952																
1424953																
1424954																
1424955		10	60.4	0.33	0.075	>25.0	0.249	16.70	2.34	4.16	0.948	5.01	0.500	1.375	0.035	0.056
1424956																
1424957		10	62.4	0.48	0.093	19.15	0.148	27.5	3.82	7.70	1.370	6.93	0.880	2.15	0.051	0.078
1424958																
1424959																
1424960		10	60.5	0.34	0.100	11.00	0.153	16.45	2.52	7.24	0.951	6.36	0.790	1.780	0.038	0.112
1424961																
1424962		10	119.5	0.53	0.134	8.45	0.125	26.3	4.86	9.81	1.555	9.43	1.300	2.98	0.050	0.096
1424963																
1424964		10	133.5	0.54	0.144	7.65	0.130	26.7	5.52	10.70	1.860	13.05	1.420	3.01	0.052	0.119
1424964a																
1424965																
1424966		<10	77.0	0.41	0.086	14.95	0.116	20.6	3.95	7.42	1.190	7.02	0.930	1.905	0.035	0.076
1424967																
1424968		10	101.0	0.45	0.125	10.95	0.107	24.6	4.34	7.35	1.325	7.35	1.040	2.40	0.053	0.075
1424969																
1424970		10	106.5	0.48	0.114	10.65	0.114	23.5	3.99	7.88	1.250	7.53	1.120	2.51	0.054	0.073
1424971																
1424972		10	101.5	0.49	0.128	10.45	0.128	25.9	4.49	9.12	1.530	8.90	1.220	2.68	0.053	0.087
1424973																
1424974		10	122.0	0.47	0.114	12.60	0.123	22.3	4.28	7.79	1.485	7.71	1.070	2.66	0.057	0.077
1424975																
1424976		10	155.0	0.45	0.119	12.95	0.154	20.8	3.35	7.99	1.510	8.84	1.040	2.60	0.047	0.116
1424977																
1424978		10	126.5	0.52	0.133	8.61	0.122	26.1	5.05	10.10	1.755	10.15	1.310	3.03	0.056	0.101
1424979																
1424980		10	127.0	0.75	0.188	0.90	0.113	47.6	4.20	8.85	1.385	7.40	1.560	3.66	0.074	0.325
1424981																
1424982																
1424983																
1424984		10	121.5	0.71	0.152	0.58	0.106	40.6	4.41	8.84	1.525	8.03	1.610	3.45	0.060	0.196
1424985																
1424986		10	125.5	0.57	0.142	0.63	0.099	40.7	3.96	7.28	1.315	6.38	1.430	2.92	0.062	0.247
1424987																
1424988		10	116.5	0.85	0.208	0.53	0.123	52.9	4.34	7.80	3.33	7.91	1.530	3.77	0.066	0.228
1424989																
1424990		10	79.7	1.72	0.249	0.98	0.110	46.0	4.22	8.41	3.60	7.87	1.770	4.97	0.065	0.306

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Hg ppm 0.004	ME- MS41L In ppm 0.005	ME- MS41L K % 0.01	ME- MS41L La ppm 0.002	ME- MS41L Li ppm 0.1	ME- MS41L Mg % 0.01	ME- MS41L Mn ppm 0.1	ME- MS41L Mo ppm 0.01	ME- MS41L Na % 0.001	ME- MS41L Nb ppm 0.002	ME- MS41L Ni ppm 0.04	ME- MS41L P % 0.001	ME- MS41L Pb ppm 0.005	ME- MS41L Pd ppm 0.001	ME- MS41L Pt ppm 0.002
1424952																
1424953																
1424954																
1424955		0.023	<0.005	0.11	8.62	7.4	0.64	192.5	0.68	0.012	0.590	5.25	0.041	8.67	0.002	<0.002
1424956																
1424957		0.030	0.010	0.17	14.70	12.7	2.50	326	0.36	0.016	0.580	8.56	0.043	8.27	0.006	<0.002
1424958																
1424959																
1424960		0.020	0.007	0.13	9.16	10.6	5.11	193.5	0.62	0.019	0.339	6.18	0.033	9.54	0.002	<0.002
1424961																
1424962		0.022	0.010	0.26	13.95	15.6	1.09	339	0.57	0.012	0.813	9.84	0.039	9.54	0.003	<0.002
1424963																
1424964		0.031	0.012	0.26	14.00	15.8	1.03	324	0.62	0.013	0.680	15.10	0.054	10.85	0.003	<0.002
1424964a																
1424965																
1424966		0.018	0.009	0.13	11.45	10.6	1.31	262	0.56	0.013	0.507	8.34	0.033	7.01	0.004	<0.002
1424967																
1424968		0.019	0.008	0.18	12.00	16.9	2.69	282	0.53	0.015	0.852	6.89	0.029	10.30	0.004	<0.002
1424969																
1424970		0.025	0.012	0.19	11.35	23.2	3.03	266	0.48	0.015	0.813	6.81	0.027	10.75	0.003	<0.002
1424971																
1424972		0.021	0.011	0.20	13.15	16.9	3.01	300	0.69	0.016	0.716	8.63	0.034	12.50	0.001	<0.002
1424973																
1424974		0.026	0.011	0.23	11.25	25.7	3.73	241	0.59	0.015	0.943	7.00	0.032	9.72	0.003	<0.002
1424975																
1424976		0.028	0.009	0.22	10.85	33.1	3.30	272	0.63	0.016	0.978	7.21	0.059	11.15	0.003	<0.002
1424977																
1424978		0.023	0.016	0.27	13.60	17.1	1.58	310	0.57	0.014	0.921	10.05	0.043	10.35	0.002	<0.002
1424979																
1424980		0.033	0.015	0.36	25.5	20.5	0.54	405	0.54	0.020	1.290	11.10	0.032	10.65	0.004	<0.002
1424981																
1424982																
1424983																
1424984		0.044	0.016	0.29	21.9	18.7	0.43	435	0.70	0.014	1.240	7.25	0.035	11.30	0.001	<0.002
1424985																
1424986		0.031	0.015	0.23	22.2	15.2	0.34	382	0.57	0.013	0.730	6.09	0.028	10.40	0.002	<0.002
1424987																
1424988		0.070	0.015	0.35	29.2	18.3	0.43	488	0.47	0.025	1.155	6.50	0.033	15.55	<0.001	<0.002
1424989																
1424990		0.053	0.015	0.38	22.8	24.5	0.54	541	0.50	0.026	1.250	6.77	0.029	16.55	<0.001	0.002

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Rb ppm 0.005	ME- MS41L Re ppm 0.001	ME- MS41L S % 0.01	ME- MS41L Sb ppm 0.005	ME- MS41L Sc ppm 0.005	ME- MS41L Se ppm 0.1	ME- MS41L Sn ppm 0.01	ME- MS41L Sr ppm 0.01	ME- MS41L Ta ppm 0.005	ME- MS41L Te ppm 0.01	ME- MS41L Th ppm 0.002	ME- MS41L Ti % 0.001	ME- MS41L Tl ppm 0.002	ME- MS41L U ppm 0.005	ME- MS41L V ppm 0.1
1424952																
1424953																
1424954																
1424955		8.13	<0.001	0.03	0.387	1.350	0.4	0.25	137.5	<0.005	0.01	1.400	0.014	0.102	0.481	8.3
1424956																
1424957		11.65	<0.001	0.03	0.304	2.30	0.5	0.36	223	<0.005	0.01	2.62	0.017	0.094	0.559	11.4
1424958																
1424959																
1424960		10.35	0.001	<0.01	0.257	1.515	0.4	0.34	118.5	<0.005	0.02	2.42	0.023	0.078	0.649	14.8
1424961																
1424962		17.70	<0.001	0.01	0.329	2.18	0.5	0.48	153.5	<0.005	0.02	4.06	0.038	0.127	0.543	21.5
1424963																
1424964		19.15	<0.001	0.01	0.439	2.40	0.7	0.51	150.5	<0.005	0.03	4.39	0.040	0.148	0.605	22.8
1424964a																
1424965																
1424966		11.00	<0.001	0.01	0.317	1.920	0.4	0.29	174.0	<0.005	0.01	3.45	0.022	0.095	0.615	15.2
1424967																
1424968		13.80	<0.001	0.01	0.257	2.01	0.4	0.40	111.5	<0.005	0.02	3.26	0.030	0.097	0.552	16.8
1424969																
1424970		14.30	<0.001	0.01	0.266	1.940	0.5	0.43	111.0	<0.005	0.01	3.37	0.034	0.108	0.645	19.6
1424971																
1424972		15.90	<0.001	0.01	0.313	2.22	0.4	0.50	111.5	<0.005	0.01	3.31	0.035	0.121	0.553	20.3
1424973																
1424974		16.65	<0.001	0.01	0.268	1.920	0.4	0.44	131.5	<0.005	0.01	2.67	0.035	0.112	0.695	19.2
1424975																
1424976		17.20	<0.001	0.02	0.288	1.980	0.4	0.45	165.0	<0.005	0.01	2.83	0.034	0.122	0.646	18.0
1424977																
1424978		20.3	<0.001	0.01	0.360	2.32	0.5	0.51	145.5	<0.005	0.01	3.86	0.040	0.140	0.539	21.6
1424979																
1424980		24.0	<0.001	0.01	0.331	2.08	0.4	0.94	111.0	<0.005	0.01	7.69	0.069	0.191	0.496	25.7
1424981																
1424982																
1424983																
1424984		20.0	<0.001	0.01	0.365	2.06	0.4	0.76	63.5	<0.005	0.01	5.64	0.056	0.174	0.534	24.5
1424985																
1424986		16.40	<0.001	0.01	0.317	1.750	0.3	0.68	58.8	<0.005	0.01	5.90	0.054	0.144	0.502	21.5
1424987																
1424988		26.5	<0.001	0.01	0.353	2.09	0.4	0.96	76.4	<0.005	0.01	8.13	0.047	0.231	0.825	23.0
1424989																
1424990		42.0	<0.001	0.01	0.336	2.42	0.5	1.09	78.8	<0.005	0.01	9.89	0.057	0.333	0.698	31.2

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L W ppm 0.001	ME- MS41L Y ppm 0.003	ME- MS41L Zn ppm 0.1	ME- MS41L Zr ppm 0.01
1424952					
1424953					
1424954					
1424955		0.341	6.29	24.6	2.03
1424956					
1424957		0.254	9.25	24.1	2.55
1424958					
1424959					
1424960		0.202	5.03	25.7	4.36
1424961					
1424962		0.281	7.16	38.0	3.81
1424963					
1424964		0.259	8.97	50.4	5.21
1424964a					
1424965					
1424966		0.216	7.77	27.9	3.19
1424967					
1424968		0.230	6.44	30.1	3.02
1424969					
1424970		0.259	5.81	32.3	2.71
1424971					
1424972		0.234	6.49	38.8	3.79
1424973					
1424974		0.256	5.81	39.6	2.98
1424975					
1424976		0.239	5.23	39.4	3.38
1424977					
1424978		0.263	7.15	41.2	3.90
1424979					
1424980		0.292	8.39	44.8	13.65
1424981					
1424982					
1424983					
1424984		0.317	6.88	43.7	6.60
1424985					
1424986		0.359	7.28	36.5	9.10
1424987					
1424988		0.285	8.72	42.0	8.42
1424989					
1424990		0.330	14.45	46.7	10.45

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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	WEI- 21 Recvd Wt. kg 0.02	ME- MS61 Ag ppm 0.01	ME- MS61 Al % 0.01	ME- MS61 As ppm 0.2	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.05	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01
1424991			0.04	4.66	4.8	100	4.32	0.17	0.46	0.08	52.9	0.8	48	11.50	2.4	0.58
1424992																
1424993			0.02	4.44	6.9	90	3.98	0.16	0.55	0.07	47.0	0.6	40	3.80	1.6	0.58
1424994																
1424995			0.04	4.65	12.2	130	4.21	0.13	0.46	0.07	56.4	0.9	28	4.79	1.4	0.71
1424996																
1424997			0.07	5.20	3.6	390	1.82	0.40	1.35	0.08	111.0	2.3	19	1.77	3.4	1.06
1424998																
1424999			0.04	5.12	6.1	1030	1.77	0.03	2.76	0.08	113.0	11.4	119	0.92	5.8	3.16
1425000																
1213001			0.06	6.82	4.6	760	4.60	0.16	2.19	0.10	199.5	8.8	40	2.63	7.7	3.15
1213002																
1213003			0.07	7.23	10.7	810	4.39	0.05	2.65	0.14	170.0	8.6	40	2.02	12.9	3.74
1213004																
1213005			0.08	5.71	3.3	490	3.29	0.14	0.92	0.14	120.5	2.1	14	3.56	3.8	1.11
1213006			0.15	5.28	3.7	720	1.89	0.09	1.56	0.06	95.1	1.0	22	9.30	1.8	0.94
1213007																
1213008			0.07	5.72	3.0	330	4.20	0.11	0.84	0.11	74.9	1.0	23	4.93	3.8	0.86
1213009			0.08	5.36	6.7	580	2.43	0.14	0.35	0.04	108.0	1.2	14	10.70	2.6	1.41
1213009a		0.04	0.71	4.95	191.0	1360	2.08	0.09	0.14	1.00	95.4	1.3	115	8.64	12.5	1.36
1213010																
1213011			0.06	5.02	3.3	700	2.30	0.32	0.80	0.09	94.8	1.3	45	2.01	1.8	1.04
1213012																
1213013			0.04	1.99	2.8	210	2.65	0.17	1.08	0.06	36.6	0.6	100	0.72	1.7	0.62
1213014																
1213015			0.05	0.25	81.0	40	0.24	0.01	12.20	0.12	5.09	1.7	43	0.35	2.5	0.66
1213016			0.02	0.08	0.8	<10	0.05	0.01	20.3	<0.02	1.63	0.4	2	0.07	1.6	0.05
1213017			0.02	0.05	0.7	<10	0.05	0.01	20.1	<0.02	1.47	0.3	1	0.05	1.1	0.04
1424931			0.05	3.27	4.9	250	5.30	0.08	1.53	0.11	190.5	2.0	86	2.10	3.5	1.78

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	Hg- MS42 Hg ppm 0.005	ME- MS61 In ppm 0.005	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10
1424991		16.10	0.17	2.6	0.045	0.027	3.89	27.3	69.8	0.08	510	4.05	1.44	40.4	2.5	380
1424992																
1424993		14.25	0.15	2.3	0.021	0.020	3.40	24.2	47.6	0.09	438	3.63	1.38	35.6	1.8	340
1424994																
1424995		16.90	0.17	2.7	0.014	0.050	3.56	32.7	104.0	0.07	527	3.60	1.58	39.4	1.5	560
1424996																
1424997		12.50	0.20	3.0	0.214	0.033	4.88	46.2	20.7	0.26	343	1.34	0.93	17.5	4.4	730
1424998																
1424999		14.45	0.19	3.5	0.021	0.044	1.61	66.9	21.9	0.91	559	3.85	1.55	15.6	40.1	1760
1425000																
1213001		22.6	0.27	13.4	0.027	0.089	3.54	99.9	34.2	0.79	652	1.12	2.43	57.2	20.4	1370
1213002																
1213003		23.9	0.28	9.2	0.138	0.088	3.26	97.9	27.7	0.60	936	1.22	2.72	34.9	26.6	2350
1213004																
1213005		18.95	0.21	4.5	0.169	0.051	3.78	67.7	34.3	0.19	441	1.45	2.05	31.4	3.9	1310
1213006		13.55	0.20	2.3	0.470	0.029	3.98	47.5	39.9	0.16	344	1.58	1.39	16.3	1.3	180
1213007																
1213008		14.55	0.18	4.8	0.099	0.047	4.76	42.0	16.2	0.11	333	1.38	0.98	24.1	2.5	730
1213009		14.65	0.19	2.5	0.204	0.033	3.11	58.0	19.9	0.15	151	1.06	0.17	16.7	2.1	180
1213009a		11.75	0.14	1.4	1.115	0.016	2.25	53.6	37.6	0.30	23	13.25	0.06	10.1	10.5	410
1213010																
1213011		13.40	0.18	3.1	0.219	0.027	3.66	55.6	21.8	0.18	357	3.71	1.48	21.4	2.2	610
1213012																
1213013		6.33	0.12	1.1	0.072	0.008	1.51	20.8	11.0	0.10	116	5.64	0.15	6.4	2.5	270
1213014																
1213015		0.57	0.10	0.2	0.013	<0.005	0.11	2.6	2.6	0.77	224	2.74	0.03	0.5	5.0	110
1213016		0.19	0.09	0.1	0.008	<0.005	0.04	0.9	0.7	12.65	42	0.25	0.02	0.2	1.0	30
1213017		0.12	0.08	<0.1	0.006	<0.005	0.02	0.6	0.5	12.55	50	0.44	0.03	0.1	0.9	30
1424931		16.90	0.26	19.1	0.012	0.097	2.07	103.5	40.0	0.22	664	3.81	1.65	69.8	3.6	1010

***** See Appendix Page for comments regarding this certificate *****

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STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61 Pb ppm 0.5	ME- MS61 Rb ppm 0.1	ME- MS61 Re ppm 0.002	ME- MS61 S % 0.01	ME- MS61 Sb ppm 0.05	ME- MS61 Sc ppm 0.1	ME- MS61 Se ppm 1	ME- MS61 Sn ppm 0.2	ME- MS61 Sr ppm 0.2	ME- MS61 Ta ppm 0.05	ME- MS61 Te ppm 0.05	ME- MS61 Th ppm 0.01	ME- MS61 Ti % 0.005	ME- MS61 Tl ppm 0.02	ME- MS61 U ppm 0.1
1424991		25.2	280	<0.002	0.01	1.97	2.8	1	2.5	26.0	3.25	<0.05	19.95	0.043	1.51	9.3
1424992																
1424993		23.4	229	<0.002	<0.01	1.65	2.4	1	2.2	55.8	2.86	<0.05	17.20	0.045	1.22	9.1
1424994																
1424995		24.6	272	<0.002	<0.01	3.96	3.0	1	3.0	45.2	3.11	<0.05	19.35	0.077	1.34	10.3
1424996																
1424997		21.6	149.5	<0.002	0.01	0.73	2.3	1	1.6	166.0	1.14	<0.05	21.4	0.139	3.11	3.5
1424998																
1424999		9.6	41.8	<0.002	<0.01	0.52	7.9	1	1.1	388	1.06	<0.05	8.50	0.444	0.30	2.4
1425000																
1213001		23.2	172.0	<0.002	0.01	0.66	6.4	2	4.8	352	3.32	<0.05	27.3	0.365	0.86	3.7
1213002																
1213003		18.6	112.0	<0.002	0.01	0.81	9.2	2	2.7	429	1.99	<0.05	13.30	0.484	0.64	3.2
1213004																
1213005		27.1	147.0	<0.002	0.01	0.77	1.5	1	2.6	109.5	1.78	<0.05	18.20	0.108	1.09	3.4
1213006		20.4	138.0	<0.002	0.02	1.07	1.6	1	1.5	219	0.93	<0.05	17.50	0.090	0.89	2.7
1213007																
1213008		22.5	202	<0.002	0.01	0.46	1.7	1	2.1	94.3	1.35	<0.05	21.4	0.088	1.10	3.0
1213009		29.7	145.0	<0.002	0.01	1.51	2.2	1	1.7	84.0	1.00	<0.05	17.90	0.111	0.93	3.9
1213009a		9.0	94.8	0.002	0.37	13.25	9.2	2	1.9	92.7	0.72	<0.05	10.30	0.337	8.45	2.8
1213010																
1213011		19.4	140.0	<0.002	0.01	0.99	1.9	1	2.0	95.4	1.24	0.05	15.80	0.140	1.08	6.4
1213012																
1213013		9.1	49.1	<0.002	0.01	0.44	1.0	<1	0.6	130.0	0.45	<0.05	6.79	0.049	0.47	5.3
1213014																
1213015		2.8	3.8	<0.002	0.01	3.33	0.4	<1	<0.2	58.8	<0.05	<0.05	0.54	0.011	0.05	0.4
1213016		0.9	1.3	<0.002	<0.01	0.11	0.2	<1	<0.2	50.6	<0.05	<0.05	0.19	0.005	<0.02	0.8
1213017		0.8	0.8	<0.002	<0.01	0.09	0.3	<1	<0.2	44.7	<0.05	<0.05	0.27	<0.005	<0.02	0.8
1424931		23.6	157.0	<0.002	0.01	1.25	2.3	2	5.9	65.9	4.14	<0.05	30.4	0.101	0.44	6.9

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TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r
	Analyte	V	W	Y	Zn	Zr	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co
	Units	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	1	0.1	0.1	2	0.5	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1
1424991		3	3.1	37.3	24	51.9	0.03	4.66	4.7	100	4.66	0.18	0.46	0.06	51.4	0.8
1424992																
1424993		3	1.8	32.5	22	46.3	0.03	4.44	6.6	90	4.55	0.18	0.55	0.07	47.3	0.6
1424994																
1424995		5	2.5	42.8	28	63.0	0.03	4.65	11.7	130	4.81	0.14	0.46	0.07	55.6	0.9
1424996																
1424997		13	1.1	18.3	32	96.7	0.04	5.20	3.9	390	2.13	0.45	1.35	0.11	113.0	2.3
1424998																
1424999		79	1.0	21.0	46	160.0	0.03	5.12	6.4	1030	2.16	0.05	2.76	0.11	120.5	11.9
1425000																
1213001		42	1.9	60.5	115	>500	0.04	6.82	4.9	760	5.29	0.17	2.19	0.09	200	8.7
1213002																
1213003		57	2.1	46.5	104	373	0.07	7.23	10.3	810	5.01	0.05	2.65	0.16	166.5	8.4
1213004																
1213005		9	2.1	34.1	57	134.5	0.09	5.71	3.4	490	3.61	0.15	0.92	0.11	114.5	2.1
1213006		7	1.5	15.8	35	64.6	0.15	5.28	3.3	720	2.09	0.10	1.56	0.06	96.0	1.0
1213007																
1213008		4	0.9	25.9	32	130.0	0.07	5.72	2.7	330	4.65	0.13	0.84	0.12	75.8	1.1
1213009		17	1.6	21.8	42	65.4	0.06	5.36	6.9	580	2.78	0.14	0.35	0.05	104.5	1.2
1213009a		102	85.5	18.6	21	44.6										
1213010																
1213011		11	1.2	19.0	30	101.5	0.05	5.02	3.1	700	2.55	0.32	0.80	0.10	93.9	1.3
1213012																
1213013		6	0.4	8.2	10	34.3	0.03	1.99	2.7	210	3.05	0.17	1.08	0.05	36.5	0.6
1213014																
1213015		9	2.2	2.4	17	7.2	0.03	0.25	80.0	40	0.25	0.02	12.20	0.13	5.20	1.7
1213016		2	<0.1	0.9	2	2.3	<0.01	0.08	1.0	<10	<0.05	0.01	20.3	0.02	1.65	0.4
1213017		3	0.1	0.6	<2	1.0	<0.01	0.05	0.3	<10	0.05	0.01	20.1	<0.02	1.53	0.3
1424931		12	1.5	69.1	124	>500	0.05	3.27	5.0	250	6.19	0.08	1.53	0.11	198.0	2.0

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01
1424991		48	11.00	2.3	0.58	16.30	0.15	2.6	0.027	3.89	26.3	76.4	0.08	510	4.13	1.44
1424992																
1424993		40	3.85	1.6	0.58	15.25	0.14	2.4	0.022	3.40	24.1	55.6	0.09	438	3.89	1.38
1424994																
1424995		28	4.77	1.4	0.71	17.40	0.17	2.7	0.049	3.56	31.8	118.0	0.07	527	3.75	1.58
1424996																
1424997		19	1.79	3.5	1.06	13.25	0.18	3.0	0.035	4.88	45.9	24.2	0.26	343	1.35	0.93
1424998																
1424999		119	0.97	6.0	3.16	15.90	0.20	3.9	0.048	1.61	69.7	25.9	0.91	559	4.25	1.55
1425000																
1213001		40	2.66	7.7	3.15	23.7	0.23	14.6	0.087	3.54	98.3	39.6	0.79	652	1.14	2.43
1213002																
1213003		40	2.00	12.6	3.74	24.1	0.24	9.3	0.090	3.26	95.9	30.9	0.60	936	1.27	2.72
1213004																
1213005		14	3.48	3.5	1.11	18.85	0.19	4.7	0.051	3.78	63.5	37.8	0.19	441	1.47	2.05
1213006		22	9.38	1.7	0.94	14.35	0.16	2.5	0.031	3.98	47.2	45.8	0.16	344	1.74	1.39
1213007																
1213008		23	5.01	3.7	0.86	15.20	0.16	5.2	0.051	4.76	41.6	18.2	0.11	333	1.42	0.98
1213009		14	10.50	2.5	1.41	14.80	0.16	2.5	0.034	3.11	55.6	22.4	0.15	151	1.08	0.17
1213009a																
1213010																
1213011		45	2.01	1.8	1.04	13.95	0.16	3.3	0.028	3.66	54.2	25.0	0.18	357	3.92	1.48
1213012																
1213013		100	0.72	1.7	0.62	6.45	0.10	1.1	0.009	1.51	20.2	12.6	0.10	116	5.91	0.15
1213014																
1213015		43	0.34	2.4	0.66	0.63	0.08	0.2	<0.005	0.11	2.7	2.8	0.77	224	2.94	0.03
1213016		2	0.08	1.7	0.05	0.22	0.08	0.1	<0.005	0.04	0.9	0.6	12.65	42	0.24	0.02
1213017		1	0.05	1.2	0.04	0.11	0.08	<0.1	<0.005	0.02	0.6	0.4	12.55	50	0.46	0.03
1424931		86	2.21	3.5	1.78	18.30	0.24	20.7	0.097	2.07	106.0	47.3	0.22	664	4.13	1.65

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Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01
1424991		38.9	2.4	380	25.2	274	<0.002	0.01	1.88	2.7	1	2.5	26.0	2.99	<0.05	19.95
1424992																
1424993		34.7	1.9	340	25.1	228	<0.002	<0.01	1.63	2.4	1	2.3	57.4	2.80	<0.05	18.00
1424994																
1424995		38.8	1.6	560	24.9	267	<0.002	<0.01	3.79	2.9	1	3.0	46.7	2.99	<0.05	18.85
1424996																
1424997		17.6	4.7	730	23.2	150.0	<0.002	0.01	0.73	2.4	1	1.6	168.0	1.11	<0.05	22.5
1424998																
1424999		15.3	43.5	1760	10.5	42.6	<0.002	<0.01	0.52	8.5	1	1.2	388	1.10	<0.05	9.21
1425000																
1213001		56.1	21.3	1370	25.0	171.0	<0.002	0.01	0.63	6.5	2	4.8	352	3.33	<0.05	28.8
1213002																
1213003		33.6	26.8	2350	19.2	107.0	<0.002	0.01	0.78	9.0	2	2.6	429	1.87	<0.05	13.20
1213004																
1213005		29.2	3.9	1310	27.1	140.5	<0.002	0.01	0.73	1.5	1	2.5	107.5	1.66	<0.05	17.50
1213006		15.7	1.4	180	21.2	136.0	<0.002	0.02	1.10	1.6	1	1.5	219	0.93	<0.05	17.85
1213007																
1213008		23.5	2.7	730	24.1	201	<0.002	0.01	0.44	1.8	1	2.2	97.1	1.31	<0.05	22.7
1213009		16.1	2.2	180	30.2	140.5	<0.002	0.01	1.43	2.2	1	1.6	83.8	0.97	<0.05	18.05
1213009a																
1213010																
1213011		20.6	2.3	610	20.3	138.0	<0.002	0.01	0.93	1.9	1	2.1	96.8	1.20	<0.05	16.00
1213012																
1213013		6.2	2.6	270	9.5	48.5	<0.002	0.01	0.43	1.0	1	0.6	130.5	0.43	<0.05	6.92
1213014																
1213015		0.5	5.5	110	2.9	3.8	<0.002	0.01	3.33	0.4	1	<0.2	60.9	<0.05	<0.05	0.56
1213016		0.2	1.2	30	1.0	1.3	<0.002	<0.01	0.13	0.2	<1	<0.2	52.6	<0.05	<0.05	0.20
1213017		0.1	1.1	30	0.7	0.8	<0.002	<0.01	0.09	0.3	1	<0.2	46.7	<0.05	<0.05	0.29
1424931		69.6	3.9	1010	24.3	160.0	<0.002	0.01	1.24	2.4	3	6.1	67.9	4.11	<0.05	30.4

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1
1424991		0.043	1.57	9.4	3	2.8	37.0	24	50.3	5.41	3.51	0.19	4.67	1.14	0.55	21.4
1424992																
1424993		0.045	1.33	9.8	3	1.8	34.2	22	46.4	5.10	3.31	0.18	4.34	1.10	0.51	19.3
1424994																
1424995		0.077	1.49	10.3	5	2.3	43.6	28	62.7	6.15	3.88	0.29	5.39	1.30	0.57	25.0
1424996																
1424997		0.139	3.41	3.7	13	1.1	19.0	32	98.6	3.23	1.97	0.64	3.65	0.67	0.34	33.7
1424998																
1424999		0.444	0.36	2.6	79	1.0	22.9	46	164.5	3.87	2.04	1.52	4.87	0.76	0.29	47.6
1425000																
1213001		0.365	0.96	4.1	42	1.9	62.6	115	>500	10.65	6.92	1.30	10.35	2.23	1.12	79.3
1213002																
1213003		0.484	0.69	3.3	57	2.0	46.1	104	372	8.08	4.48	1.67	9.56	1.60	0.63	82.3
1213004																
1213005		0.108	1.12	3.5	9	1.9	33.3	57	128.5	5.64	3.37	0.68	6.06	1.13	0.49	44.7
1213006		0.090	0.96	2.8	7	1.4	16.5	35	65.2	3.00	1.72	0.58	3.35	0.58	0.28	33.1
1213007																
1213008		0.088	1.22	3.2	4	0.9	26.6	32	128.5	4.48	2.68	0.51	4.55	0.92	0.39	28.9
1213009		0.111	1.01	3.9	17	1.5	22.1	42	64.4	3.66	2.02	0.67	4.22	0.73	0.32	38.2
1213009a																
1213010																
1213011		0.140	1.18	6.7	11	1.2	19.3	30	103.0	3.40	1.92	0.81	3.98	0.67	0.27	36.3
1213012																
1213013		0.049	0.50	5.5	6	0.4	8.3	10	34.6	1.38	0.85	0.25	1.59	0.29	0.14	13.0
1213014																
1213015		0.011	0.07	0.5	9	2.2	2.5	17	7.3	0.33	0.21	0.08	0.37	0.08	0.03	2.4
1213016		0.005	<0.02	0.9	2	<0.1	0.9	2	2.2	0.13	0.08	<0.03	0.13	0.03	0.01	0.8
1213017		<0.005	<0.02	0.9	3	0.1	0.6	<2	1.1	0.11	0.06	<0.03	0.12	0.02	0.01	0.7
1424931		0.101	0.48	7.1	12	1.4	73.3	124	>500	11.45	7.60	0.63	10.75	2.46	1.26	84.5

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01
1424991		6.10	5.28	0.85	0.56	3.74	<0.005	0.05	9.25	0.02	0.62	0.01	0.87	4.77	0.13	0.07
1424992																
1424993		5.53	4.63	0.79	0.54	3.61	<0.005	0.02	9.01	0.02	0.78	0.01	0.89	4.26	0.16	0.06
1424994																
1424995		7.09	5.84	0.95	0.60	3.90	<0.005	0.01	9.44	0.02	0.64	0.01	1.09	4.43	0.12	0.07
1424996																
1424997		9.65	5.33	0.56	0.32	2.18	<0.005	0.23	10.34	0.05	1.86	<0.01	1.56	5.96	0.50	0.05
1424998																
1424999		13.35	7.36	0.68	0.30	1.86	<0.005	0.02	9.60	0.11	3.75	0.02	4.53	1.85	1.60	0.08
1425000																
1213001		22.3	13.55	1.71	1.12	7.30	<0.005	0.02	13.68	0.08	3.10	0.01	4.66	4.32	1.48	0.09
1213002																
1213003		21.7	13.30	1.41	0.67	4.21	<0.005	0.15	14.69	0.09	3.78	0.01	5.57	3.96	1.14	0.13
1213004																
1213005		13.20	8.07	0.94	0.52	3.25	<0.005	0.19	11.36	0.06	1.28	0.01	1.68	4.65	0.34	0.06
1213006		9.84	5.25	0.50	0.28	1.70	0.071	0.53	11.13	0.09	2.20	<0.01	1.45	4.93	0.31	0.05
1213007																
1213008		8.48	5.73	0.74	0.41	2.60	0.144	0.10	11.32	0.04	1.15	<0.01	1.29	6.89	0.21	0.05
1213009		11.15	6.42	0.63	0.31	1.97	0.005	0.23	11.00	0.07	0.50	<0.01	2.20	3.90	0.29	0.02
1213009a							0.742									
1213010																
1213011		10.45	5.97	0.58	0.29	1.85	<0.005	0.23	10.24	0.08	1.13	0.01	1.61	4.60	0.32	0.05
1213012																
1213013		3.81	2.35	0.23	0.14	0.87	<0.005	0.07	3.95	0.02	1.52	0.01	0.91	1.88	0.14	0.02
1213014																
1213015		0.60	0.45	0.06	0.03	0.20	<0.005	0.01	0.48	<0.01	17.85	0.01	0.99	0.13	1.34	0.03
1213016		0.20	0.16	0.02	0.01	0.07	<0.005	<0.01	0.16	<0.01	31.5	<0.01	0.08	0.05	21.9	0.01
1213017		0.18	0.14	0.02	0.01	0.06	<0.005	<0.01	0.09	<0.01	31.2	<0.01	0.06	0.03	21.8	0.01
1424931		24.1	14.65	1.81	1.24	8.21	<0.005	0.01	6.33	0.03	2.07	0.01	2.60	2.51	0.33	0.09

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02	ME- MS41L Au ppm 0.0002	ME- MS41L Ag ppm 0.001	ME- MS41L Al % 0.01	ME- MS41L As ppm 0.01
1424991		2.01	0.08	0.01	81.04	<0.01	0.07	99.97	1.00							
1424992													0.0009	0.029	1.23	4.39
1424993		1.98	0.08	<0.01	81.02	0.01	0.08	99.22	0.85							
1424994													0.0012	0.036	1.14	4.77
1424995		2.23	0.13	<0.01	80.38	<0.01	0.14	99.34	0.61							
1424996													0.0006	0.040	1.07	4.06
1424997		1.29	0.16	0.03	75.30	0.02	0.23	99.33	1.95							
1424998													0.0008	0.031	1.14	4.57
1424999		2.03	0.38	0.01	73.04	0.04	0.74	99.03	1.17							
1425000													0.0007	0.032	1.67	5.13
1213001		3.38	0.31	0.01	65.76	0.04	0.63	99.05	1.38							
1213002													0.0021	0.038	1.46	7.12
1213003		3.71	0.53	0.01	63.13	0.05	0.84	99.39	1.65							
1213004													0.0008	0.020	0.88	3.67
1213005		2.87	0.30	0.01	75.41	0.01	0.19	99.22	0.94							
1213006		1.96	0.04	0.05	74.48	0.02	0.16	99.16	2.26							
1213007													0.0009	0.031	0.94	4.20
1213008		1.36	0.16	0.02	75.31	0.01	0.15	99.53	1.54							
1213009		0.24	0.04	0.02	78.21	0.01	0.20	99.34	2.60							
1213009a																
1213010													0.0006	0.027	0.90	3.70
1213011		2.12	0.14	0.01	77.71	0.01	0.24	99.45	1.15							
1213012													0.0008	0.023	1.04	4.32
1213013		0.20	0.06	0.02	88.25	0.01	0.08	99.19	2.12							
1213014													0.0009	0.024	0.89	10.10
1213015		0.03	0.02	0.03	62.38	0.01	0.02	99.08	15.74							
1213016		0.06	0.01	0.01	0.40	<0.01	0.01	100.10	45.89	12.35	45.3	0.02				
1213017		0.06	0.01	0.01	0.22	<0.01	<0.01	99.52	46.01	12.35	45.3	<0.02				
1424931		2.27	0.22	0.02	81.29	0.01	0.17	99.87	1.81							

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L B ppm 10	ME- MS41L Ba ppm 0.5	ME- MS41L Be ppm 0.01	ME- MS41L Bi ppm 0.001	ME- MS41L Ca % 0.01	ME- MS41L Cd ppm 0.001	ME- MS41L Ce ppm 0.003	ME- MS41L Co ppm 0.001	ME- MS41L Cr ppm 0.01	ME- MS41L Cs ppm 0.005	ME- MS41L Cu ppm 0.01	ME- MS41L Fe % 0.001	ME- MS41L Ga ppm 0.004	ME- MS41L Ge ppm 0.005	ME- MS41L Hf ppm 0.002
1424991																
1424992		10	71.0	2.23	0.251	0.86	0.103	44.8	3.96	7.79	2.21	6.25	1.660	4.62	0.069	0.362
1424993																
1424994		10	101.5	1.24	0.204	0.77	0.103	42.2	4.67	8.81	3.47	7.72	1.960	4.60	0.077	0.372
1424995																
1424996		10	148.5	0.74	0.184	1.21	0.136	41.0	4.61	9.20	1.965	10.25	1.570	3.82	0.077	0.316
1424997																
1424998		10	135.0	0.83	0.141	1.25	0.110	45.2	8.00	14.45	2.77	11.05	1.900	4.69	0.111	0.441
1424999																
1425000		10	209	0.84	0.132	2.06	0.129	52.9	12.10	16.75	1.810	14.15	2.71	5.50	0.122	0.434
1213001																
1213002		10	133.0	1.87	0.158	1.42	0.157	63.7	9.63	15.80	3.07	13.25	2.55	6.07	0.146	0.968
1213003																
1213004		10	167.5	0.63	0.158	1.09	0.110	52.3	5.79	11.80	1.115	7.38	2.83	4.29	0.094	0.403
1213005																
1213006																
1213007		10	110.0	0.69	0.194	0.48	0.128	52.6	4.33	7.82	2.94	7.66	1.710	3.49	0.075	0.231
1213008																
1213009																
1213009a																
1213010		10	103.5	0.77	0.263	0.61	0.109	52.5	4.35	9.12	6.04	6.68	1.960	3.75	0.079	0.305
1213011																
1213012		10	124.5	0.70	0.169	1.64	0.100	40.1	3.99	7.95	2.11	7.67	1.440	3.50	0.079	0.239
1213013																
1213014		10	102.0	0.47	0.118	11.95	0.122	23.5	4.18	9.71	1.705	8.97	1.180	2.95	0.057	0.085
1213015																
1213016																
1213017																
1424931																

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TUCSON AZ 85705

Finalized Date: 23- MAY- 2016
Account: GOLINC

Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Hg ppm 0.004	ME- MS41L In ppm 0.005	ME- MS41L K % 0.01	ME- MS41L La ppm 0.002	ME- MS41L Li ppm 0.1	ME- MS41L Mg % 0.01	ME- MS41L Mn ppm 0.1	ME- MS41L Mo ppm 0.01	ME- MS41L Na % 0.001	ME- MS41L Nb ppm 0.002	ME- MS41L Ni ppm 0.04	ME- MS41L P % 0.001	ME- MS41L Pb ppm 0.005	ME- MS41L Pd ppm 0.001	ME- MS41L Pt ppm 0.002
1424991																
1424992		0.071	0.017	0.25	22.3	32.9	0.49	482	0.46	0.021	1.105	5.48	0.022	15.60	0.001	0.002
1424993																
1424994		0.092	0.019	0.31	21.9	27.4	0.51	488	0.67	0.018	1.095	6.84	0.028	13.65	0.001	0.002
1424995																
1424996		0.032	0.017	0.31	23.4	22.5	0.58	376	0.60	0.019	0.600	8.26	0.044	12.15	0.002	0.002
1424997																
1424998		0.032	0.018	0.32	24.0	36.1	0.85	453	0.54	0.027	0.762	23.5	0.054	9.99	0.003	0.002
1424999																
1425000		0.036	0.023	0.46	27.2	29.1	1.24	581	0.52	0.036	0.488	23.0	0.112	10.40	0.004	0.002
1213001																
1213002		0.095	0.029	0.40	33.5	36.9	0.84	569	0.73	0.028	0.616	19.40	0.079	13.25	<0.001	0.003
1213003																
1213004		0.022	0.024	0.28	29.6	16.9	0.50	576	0.86	0.018	0.603	8.74	0.047	11.50	0.001	0.002
1213005																
1213006																
1213007		0.156	0.020	0.28	31.5	16.0	0.39	487	0.52	0.019	0.662	6.50	0.028	16.25	0.001	<0.002
1213008																
1213009																
1213009a																
1213010		0.145	0.018	0.23	30.8	17.8	0.43	473	1.10	0.015	0.380	6.14	0.036	14.80	0.001	<0.002
1213011																
1213012		0.047	0.023	0.31	24.0	21.5	0.52	370	0.48	0.017	0.832	6.79	0.039	12.15	0.005	<0.002
1213013																
1213014		0.045	0.018	0.24	12.20	15.1	3.04	281	0.60	0.020	0.917	9.01	0.039	8.86	0.004	<0.002
1213015																
1213016																
1213017																
1424931																

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STE 210
TUCSON AZ 85705

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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L Rb ppm 0.005	ME- MS41L Re ppm 0.001	ME- MS41L S % 0.01	ME- MS41L Sb ppm 0.005	ME- MS41L Sc ppm 0.005	ME- MS41L Se ppm 0.1	ME- MS41L Sn ppm 0.01	ME- MS41L Sr ppm 0.01	ME- MS41L Ta ppm 0.005	ME- MS41L Te ppm 0.01	ME- MS41L Th ppm 0.002	ME- MS41L Ti % 0.001	ME- MS41L Tl ppm 0.002	ME- MS41L U ppm 0.005	ME- MS41L V ppm 0.1
1424991																
1424992		29.2	<0.001	0.01	0.311	1.970	0.5	1.01	73.2	<0.005	0.01	10.50	0.054	0.285	0.579	36.7
1424993																
1424994		37.5	<0.001	0.01	0.363	2.16	0.5	0.98	86.7	<0.005	0.01	8.14	0.079	0.283	0.651	38.5
1424995																
1424996		23.8	<0.001	0.01	0.378	2.37	0.4	0.79	74.0	<0.005	0.01	7.34	0.060	0.192	0.556	26.0
1424997																
1424998		23.3	<0.001	0.01	0.364	2.84	0.4	0.82	133.0	<0.005	0.01	5.84	0.090	0.197	0.569	31.7
1424999																
1425000		27.7	<0.001	0.01	0.355	5.03	0.5	0.83	163.0	<0.005	0.01	6.23	0.132	0.161	0.713	43.2
1213001																
1213002		31.4	<0.001	0.01	0.506	4.66	0.5	1.23	114.5	<0.005	<0.01	9.19	0.117	0.257	0.929	41.6
1213003																
1213004		15.35	<0.001	0.01	0.354	2.59	0.5	1.01	69.5	<0.005	0.01	7.25	0.147	0.115	0.745	45.7
1213005																
1213006																
1213007		22.1	<0.001	0.01	0.389	1.910	0.4	0.77	79.3	<0.005	<0.01	8.31	0.057	0.163	0.627	26.1
1213008																
1213009																
1213009a																
1213010		17.75	<0.001	0.01	0.371	1.895	0.4	0.93	62.9	<0.005	<0.01	8.88	0.054	0.133	0.687	34.8
1213011																
1213012		22.0	<0.001	0.01	0.317	1.875	0.4	0.74	172.5	<0.005	0.02	8.98	0.057	0.170	0.660	27.1
1213013																
1213014		19.25	<0.001	0.01	0.364	2.19	0.4	0.41	146.0	<0.005	0.03	4.26	0.038	0.138	0.627	21.5
1213015																
1213016																
1213017																
1424931																

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Finalized Date: 23- MAY- 2016
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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

Sample Description	Method Analyte Units LOR	ME- MS41L W ppm 0.001	ME- MS41L Y ppm 0.003	ME- MS41L Zn ppm 0.1	ME- MS41L Zr ppm 0.01
1424991					
1424992		0.302	13.85	42.0	12.90
1424993					
1424994		0.250	10.75	50.9	14.30
1424995					
1424996		0.268	8.17	45.4	11.40
1424997					
1424998		0.331	8.42	46.7	22.0
1424999					
1425000		0.295	12.15	53.2	26.9
1213001					
1213002		0.538	13.00	65.4	50.4
1213003					
1213004		0.765	10.15	72.7	17.90
1213005					
1213006					
1213007		0.323	8.30	43.8	8.95
1213008					
1213009					
1213009a					
1213010		0.315	10.20	44.2	9.75
1213011					
1213012		0.304	8.41	41.9	9.14
1213013					
1213014		0.278	6.54	34.4	3.52
1213015					
1213016					
1213017					
1424931					

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Project: Geochemistry

CERTIFICATE OF ANALYSIS RE16069808

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Applies to Method: Gold determinations by this method are semi- quantitative due to the small sample weight used (0.5g).
ME- MS41L

Applies to Method: REE's may not be totally soluble in this method.
ME- MS61 ME- MS61r

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
Au- AA23 FND- 02 LOG- 24 SPLIT- Z
WEI- 21

Applies to Method: Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
C- GAS05 C- IR17 Hg- CV41 Hg- MS42
ME- MS41L ME- MS61 ME- MS61r ME- XRF26
OA- GRA05x

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE TU16158768

P.O. No.: 153878

This report is for 23 Rock samples submitted to our lab in Tucson, AZ, USA on 20- SEP- 2016.

The following have access to data associated with this certificate:

GENE MULLER

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- 31	Fine crushing - 70% < 2mm
SND- 01	Send samples to external laboratory
SPL- 21d	Split sample - duplicate
SPL- 21	Split sample - riffle splitter
SPLIT- Z	Pulp split for send out
PUL- 31d	Pulverize Split - duplicate
CRU- QC	Crushing QC Test
PUL- 31	Pulverize split to 85% < 75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
Ag- OG62	Ore Grade Ag - Four Acid	ICP- AES
ME- OG62	Ore Grade Elements - Four Acid	ICP- AES
Cu- OG62	Ore Grade Cu - Four Acid	ICP- AES
Pb- OG62	Ore Grade Pb - Four Acid	ICP- AES
Au- AA23	Au 30g FA- AA finish	AAS
Hg- CV41	Trace Hg - cold vapor/AAS	FIMS
ME- XRF26	Whole Rock By Fusion/XRF	XRF
OA- GRA05x	LOI for XRF	WST- SEQ
C- GAS05	Inorganic Carbon (CO2)	
C- IR17	Organic carbon by LECO	LECO
PGM- NAA26	PGM NiS collection NAA finish	
ME- MS61r	4A multi- element ICP- MS + REE	

To: GOLDER ASSOCIATES INC.
ATTN: GENE MULLER
4730 N. ORACLE
STE 210
TUCSON AZ 85705

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Colin Ramshaw, Vancouver Laboratory Manager

ALS USA Inc.
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	WEI- 21 Recvd Wt. kg 0.02	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01
1213018		2.28														
1213019		1.79														
1213020		1.78														
1213021		1.86														
1213022		1.75														
1213023		1.90	>100	0.58	603	70	1.16	5.88	0.21	7.33	11.50	3.3	21	0.53	1445	3.35
1213024		1.46	>100	1.53	276	120	0.81	9.84	0.06	3.52	29.8	2.9	30	1.46	2600	4.83
1213025		2.31	11.30	5.95	20.6	670	2.09	0.82	0.22	0.53	77.2	5.7	18	5.36	367	2.42
1213026		2.20	17.10	1.33	200	640	0.56	0.13	0.14	1.37	19.65	1.7	31	0.89	78.6	5.24
1213027		2.14	1.51	3.42	32.5	520	4.56	0.23	0.38	0.27	50.0	30.9	52	4.53	22.8	6.79
1213028		2.29	14.60	3.54	87.6	750	3.14	0.85	0.20	1.61	42.9	24.2	25	4.44	271	4.13
1213029		1.61	0.15	5.14	6.0	280	2.17	0.13	0.68	0.04	73.9	18.9	44	3.21	19.2	5.68
1213030		1.52	0.11	4.41	2.9	380	4.52	0.10	1.12	0.02	99.8	8.8	48	2.35	4.4	8.39
1213031		1.96	0.08	1.28	3.6	140	0.89	0.04	3.27	0.09	16.65	8.0	32	0.80	4.3	2.94
1213032		2.63	0.05	4.39	6.6	150	1.22	0.11	0.76	0.02	60.4	13.1	35	2.73	5.4	5.42
1213033		1.87	0.07	0.44	11.0	50	0.35	0.03	12.40	0.07	7.34	1.1	11	0.59	3.6	0.68
1213034		2.27	0.10	0.94	25.1	90	0.71	0.05	7.03	0.09	14.35	2.4	19	0.98	8.1	1.23
1213035		1.34	0.10	7.49	7.7	930	3.52	0.06	0.63	0.10	144.0	2.3	4	6.47	3.9	2.21
1213036		2.05	27.8	0.29	4.1	20	0.30	0.17	0.15	0.27	3.98	3.9	36	0.34	>10000	5.49
1213037		1.88	0.10	2.06	179.0	40	9.01	0.09	0.44	0.03	31.0	19.9	33	1.36	148.5	37.8
1213038		1.61	0.09	0.76	10.8	40	0.38	0.05	1.52	0.02	16.00	1.6	28	0.43	15.0	1.55
1213039		1.90	0.04	2.41	16.0	90	1.18	0.10	7.31	0.04	51.5	5.1	31	2.24	7.1	2.44
1213040		2.03	0.08	0.64	57.6	280	0.42	0.05	0.14	0.10	11.70	4.9	49	0.62	7.6	3.06

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r
	Analyte	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5
1213018																
1213019																
1213020																
1213021																
1213022																
1213023		8.51	0.06	0.1	50.6	0.22	5.4	9.2	0.03	212	4.39	0.01	0.5	4.8	170	>10000
1213024		17.15	0.22	0.3	116.0	0.65	14.7	17.6	0.07	384	8.07	0.01	1.1	6.5	240	5530
1213025		16.05	0.16	1.6	2.63	2.63	39.8	23.2	0.22	1400	3.07	0.03	12.0	4.2	670	1000
1213026		3.35	0.07	0.4	0.497	0.45	10.5	15.7	0.05	136	5.13	0.01	1.2	12.1	400	581
1213027		9.06	0.10	0.8	0.256	1.69	25.4	24.7	0.24	2400	8.86	0.02	7.9	42.8	370	614
1213028		11.50	0.09	1.0	7.75	1.54	20.3	29.7	0.17	3000	12.05	0.02	6.0	27.3	500	5030
1213029		13.75	0.16	1.2	0.111	1.99	30.0	21.1	0.53	538	1.41	0.15	6.5	22.4	1130	33.1
1213030		13.00	0.19	2.0	0.115	1.89	33.3	15.4	0.44	1060	0.99	0.99	11.5	8.8	2750	27.1
1213031		3.83	0.07	0.5	0.061	0.55	6.7	13.6	0.20	1650	5.48	0.04	3.3	11.6	410	13.0
1213032		11.25	0.13	1.2	0.052	1.27	22.8	28.2	0.40	262	1.16	0.10	5.9	20.0	1000	7.8
1213033		1.19	0.08	0.4	0.019	0.18	3.2	19.9	7.20	267	2.31	0.02	0.9	2.6	160	10.8
1213034		2.33	<0.05	0.8	0.030	0.39	4.9	15.6	3.62	478	3.02	0.04	2.1	8.4	350	9.9
1213035		18.95	0.27	3.5	0.045	6.76	71.9	20.9	0.07	2090	1.26	1.37	17.9	2.9	120	41.5
1213036		1.06	0.05	0.2	0.304	0.14	1.7	4.4	0.03	95	3.91	0.01	0.8	8.0	90	19.2
1213037		7.03	0.22	1.4	0.038	0.83	18.2	6.8	0.21	742	3.16	0.01	7.7	67.1	2130	7.6
1213038		2.03	<0.05	0.4	0.017	0.37	7.8	6.2	0.84	157	2.13	0.01	1.8	7.7	130	13.4
1213039		5.90	0.09	1.7	0.032	1.03	23.9	13.2	4.03	319	1.29	0.04	5.6	16.4	550	16.8
1213040		1.85	<0.05	0.5	0.011	0.27	5.8	11.0	0.07	2320	3.79	0.01	1.5	7.2	400	10.5

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Rb ppm 0.1	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1
1213018																
1213019																
1213020																
1213021																
1213022																
1213023		10.8	<0.002	0.08	1465	0.5	3	24.9	8.9	<0.05	83.5	1.14	0.019	0.19	0.7	4
1213024		34.8	<0.002	0.06	1190	1.5	2	77.2	7.6	0.07	52.0	2.01	0.044	0.42	1.6	11
1213025		144.0	<0.002	0.02	29.0	5.5	1	2.8	35.4	0.82	3.38	14.15	0.223	1.52	2.8	42
1213026		18.6	<0.002	0.06	24.3	1.3	3	0.7	33.1	0.10	1.32	3.26	0.040	0.25	1.0	9
1213027		71.7	<0.002	0.03	12.20	4.7	2	2.9	22.2	0.55	0.55	9.07	0.150	0.82	1.8	30
1213028		87.0	<0.002	0.15	15.00	3.9	2	6.3	37.6	0.39	5.12	9.05	0.126	0.95	2.4	29
1213029		75.3	<0.002	0.01	1.45	12.3	1	1.4	26.5	0.47	0.07	6.16	0.328	0.28	1.1	78
1213030		72.5	<0.002	0.01	1.26	9.8	2	1.4	79.8	0.81	0.05	9.82	0.469	0.26	1.8	69
1213031		17.3	<0.002	0.01	1.64	5.5	2	0.5	38.7	0.19	<0.05	1.60	0.176	0.07	0.9	29
1213032		47.6	<0.002	0.01	1.11	9.2	1	1.1	20.0	0.44	<0.05	5.34	0.265	0.18	1.2	57
1213033		6.7	<0.002	0.01	2.88	0.6	2	0.2	57.9	0.05	<0.05	1.00	0.018	0.19	1.2	6
1213034		14.2	<0.002	0.01	3.11	1.6	2	0.4	51.3	0.13	<0.05	2.18	0.041	0.54	1.8	13
1213035		190.0	<0.002	<0.01	1.79	5.4	1	2.4	186.5	1.16	<0.05	22.8	0.094	2.37	5.3	17
1213036		4.7	<0.002	1.81	2.40	1.2	7	0.8	7.7	<0.05	<0.05	0.42	0.027	0.02	3.8	8
1213037		23.7	<0.002	0.19	2.87	6.1	2	0.7	54.3	0.46	<0.05	5.51	0.149	0.12	3.2	27
1213038		9.5	<0.002	0.02	1.84	2.7	2	0.3	11.1	0.10	<0.05	2.19	0.042	0.17	0.4	11
1213039		31.2	<0.002	0.02	3.70	5.7	2	0.7	61.4	0.36	<0.05	9.81	0.138	0.31	2.5	32
1213040		7.7	<0.002	0.04	3.34	2.0	2	0.2	31.3	0.07	<0.05	3.16	0.036	0.55	1.2	20

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r W ppm 0.1	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01
1213018																
1213019																
1213020																
1213021																
1213022																
1213023		2.3	1.9	1060	2.9	0.59	0.26	0.24	0.99	0.10	0.03	4.9	1.26	1.14	0.14	0.03
1213024		3.9	3.1	1700	9.5	0.85	0.32	0.37	1.56	0.14	0.04	11.4	3.13	2.18	0.19	0.07
1213025		2.1	11.0	305	47.4	2.24	1.10	0.98	3.36	0.42	0.17	31.0	9.02	5.18	0.44	0.17
1213026		2.0	2.5	290	9.5	0.53	0.25	0.31	1.08	0.11	0.05	8.0	2.15	1.96	0.12	0.06
1213027		2.0	6.7	221	33.6	1.51	0.70	0.63	2.31	0.27	0.10	19.9	5.52	3.58	0.31	0.10
1213028		5.0	8.1	990	28.8	1.79	0.87	0.76	2.71	0.33	0.13	18.3	4.82	3.58	0.36	0.14
1213029		0.9	14.5	68	38.9	3.25	1.55	1.45	5.02	0.57	0.27	34.6	8.83	7.39	0.69	0.22
1213030		1.2	25.2	36	60.4	5.57	2.88	1.84	7.89	1.00	0.33	42.2	10.55	9.62	1.11	0.49
1213031		1.9	6.1	40	13.9	1.30	0.72	0.51	1.63	0.27	0.12	7.7	1.86	1.93	0.24	0.11
1213032		1.3	14.2	37	48.3	4.52	1.65	1.34	5.43	0.61	0.24	29.5	7.12	6.84	0.65	0.24
1213033		0.8	4.6	20	16.1	0.56	0.38	0.11	0.50	0.13	0.05	2.8	0.73	0.57	0.08	0.06
1213034		2.0	5.7	16	26.5	0.91	0.52	0.21	0.95	0.19	0.07	4.8	1.24	1.06	0.14	0.08
1213035		3.8	28.3	57	82.3	4.91	2.85	1.01	5.74	1.04	0.46	50.0	15.10	7.82	0.86	0.45
1213036		0.8	1.2	76	5.2	0.27	0.15	0.10	0.36	0.04	0.02	1.8	0.45	0.41	0.05	0.02
1213037		1.5	11.1	242	49.2	1.66	0.96	0.36	1.55	0.36	0.13	11.3	3.30	1.89	0.27	0.14
1213038		0.9	3.6	7	14.9	0.76	0.39	0.27	1.04	0.15	0.06	6.8	1.83	1.32	0.14	0.06
1213039		1.0	13.2	22	63.4	2.38	1.23	0.86	3.26	0.46	0.17	23.4	6.03	4.60	0.46	0.19
1213040		0.7	2.4	18	15.1	0.40	0.28	0.14	0.47	0.08	0.04	4.6	1.26	0.75	0.07	0.04

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4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	ME- MS61r	Ag- OG62	Cu- OG62	Pb- OG62	Au- AA23	Hg- CV41	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26
	Analyte	Yb	Ag	Cu	Pb	Au	Hg	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O
	Units	ppm	ppm	%	%	ppm	ppm	%	%	%	%	%	%	%	%	%
	LOR	0.03	1	0.001	0.001	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1213018								0.12	<0.01	32.4	<0.01	0.10	0.04	19.95	0.02	0.04
1213019								0.19	0.02	54.1	<0.01	0.11	0.06	0.26	0.01	0.01
1213020								0.08	<0.01	53.7	<0.01	0.05	0.02	0.54	0.01	0.01
1213021								0.04	<0.01	30.8	<0.01	0.02	0.01	21.6	0.01	0.05
1213022								0.08	<0.01	55.7	<0.01	0.03	0.02	0.26	0.01	0.01
1213023		0.18	281		4.04	0.103	8									
1213024		0.25	183			0.130	2.4									
1213025		1.04				0.007	0.36									
1213026		0.24				0.043	0.37									
1213027		0.66				<0.005	0.06									
1213028		0.85				0.047	2.2									
1213029		1.47				<0.005	0.04									
1213030		2.20				<0.005	0.06									
1213031		0.70				<0.005	0.02									
1213032		1.66				<0.005	0.03									
1213033		0.36				<0.005	0.03	0.83	0.02	17.85	<0.01	0.98	0.22	11.60	0.04	0.04
1213034		0.50				<0.005	0.04	1.77	0.05	9.68	<0.01	1.80	0.45	5.96	0.06	0.06
1213035		2.86				<0.005	<0.01									
1213036		0.16		6.01		0.006	0.1									
1213037		0.81				<0.005	0.10									
1213038		0.32				<0.005	0.03									
1213039		1.08				<0.005	0.07	4.57	0.07	10.30	<0.01	3.58	1.24	6.73	0.04	0.05
1213040		0.26				<0.005	0.05									

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STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	OA- GRA05x	C- GAS05	C- GAS05	C- IR17	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26	PGM- NAA26
	Analyte	P2O5	SO3	SiO2	SrO	TiO2	Total	LOI 1000	C	CO2	C organi	Pt	Pd	Au	Os	Ru
	Units	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.02	0.02	0.02	0.001	0.01	0.05
1213018		0.30	0.04	0.67	<0.01	<0.01	99.24	45.54	12.35	45.2	0.04					
1213019		0.01	0.04	3.70	0.03	0.01	100.50	41.93	11.15	40.8	0.03					
1213020		0.01	0.03	2.62	0.06	0.01	99.51	42.33	11.35	41.7	0.03					
1213021		0.01	0.01	0.41	<0.01	<0.01	99.16	46.18	12.45	45.6	0.02					
1213022		<0.01	0.04	1.40	0.02	<0.01	100.25	42.67	11.45	42.0	0.02					
1213023												<0.2	<0.07	0.100	<0.01	<0.05
1213024												<0.1	<0.05	0.120	<0.01	<0.05
1213025												<0.02	<0.02	0.002	<0.01	<0.05
1213026												<0.02	<0.02	0.047	<0.01	<0.05
1213027												<0.02	<0.02	0.005	<0.01	<0.05
1213028												<0.02	<0.02	0.035	<0.01	<0.05
1213029												<0.02	<0.02	<0.001	<0.01	<0.05
1213030												<0.02	<0.02	0.001	<0.01	<0.05
1213031												<0.02	<0.02	0.003	<0.01	<0.05
1213032												<0.02	<0.02	0.001	<0.01	<0.05
1213033		0.03	0.03	41.61	0.01	0.03	100.00	26.72				<0.02	<0.02	0.003	<0.01	<0.05
1213034		0.07	0.03	65.72	0.01	0.08	100.10	14.32				<0.02	<0.02	0.002	<0.01	<0.05
1213035												<0.02	<0.02	0.002	<0.01	<0.05
1213036												<0.1	<0.4	0.005	<0.01	<0.05
1213037												<0.02	<0.02	0.002	<0.01	<0.05
1213038												<0.02	<0.02	0.001	<0.01	<0.05
1213039		0.12	0.06	57.33	0.01	0.25	100.30	15.93				<0.02	<0.02	0.004	<0.01	<0.05
1213040												<0.02	<0.02	0.001	<0.01	<0.05

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	PGM- NAA26 Ir ppm 0.001	PGM- NAA26 Rh ppm 0.005
1213018			
1213019			
1213020			
1213021			
1213022			
1213023		<0.001	0.013
1213024		<0.001	<0.005
1213025		<0.001	<0.005
1213026		<0.001	<0.005
1213027		<0.001	<0.005
1213028		<0.001	<0.005
1213029		<0.001	<0.005
1213030		<0.001	<0.005
1213031		<0.001	<0.005
1213032		<0.001	<0.005
1213033		<0.001	<0.005
1213034		<0.001	<0.005
1213035		<0.001	<0.005
1213036		<0.001	<0.005
1213037		<0.001	<0.005
1213038		<0.001	<0.005
1213039		<0.001	<0.005
1213040		<0.001	<0.005

***** See Appendix Page for comments regarding this certificate *****

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CERTIFICATE OF ANALYSIS TU16158768

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Applies to Method: REE's may not be totally soluble in this method.
ME- MS61r

Applies to Method: Detection limits on samples requiring dilutions due to interferences or high concentration levels have been increased according to the dilution factor.
Hg- CV41

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Ag- OG62	Au- AA23	C- GAS05	C- IR17
Cu- OG62	Hg- CV41	ME- MS61r	ME- OG62
ME- XRF26	OA- GRA05x	Pb- OG62	

Applies to Method: Processed at ALS Tucson, Arizona, USA

CRU- 31	CRU- QC	LOG- 22	PUL- 31
PUL- 31d	SND- 01	SPL- 21	SPL- 21d
SPLIT- Z	WEI- 21		

Applies to Method: Processed at Becquerel Laboratories Inc., Mississauga, Ontario, Canada
PGM- NAA26

Appendix C.2a: X-ray Diffraction Analysis

Sample #	Sample Type	Locality	XRD Results														Notes
			Quartz	K-Feldspar	Plagioclase	Calcite	Dolomite	Mica	Kaolin	Smectite	Heulandite	Goethite	Hematite	Jarosite	Pyrite	Cerussite	Unaccounted	
1213016	GSC	Indian Springs - Niavi Wash	---	---	---	---	>99	---	---	---	---	---	---	---	---	---	<5	Fine grained, micritic limestone, slightly dolomitized, 15cm beds, brecciated, clastic dikes
1213017	GSC	Indian Springs - Niavi Wash	---	---	---	<2	>98	---	---	---	---	---	---	---	---	---	<5	Very competent, medium grained, perhaps some re-crystallization, slightly sparry, brecciated with inclusions of black fetid limestone
1213018	GSC	Indian Springs - Silica Quarry	---	---	---	3	95	---	---	---	---	---	---	---	---	---	<5	Dark dolomite fine grained mildly fetid
1213019	GSC	Indian Springs - Silica Quarry	---	---	---	>98	<2	---	---	---	---	---	---	---	---	---	<5	Light grey not fetid, fossils, chert lenses
1213020	GSC	Indian Springs - Timpi Wash	2	---	---	97		---	---	---	---	---	---	---	---	---	<5	Very dark grey, fine grained moderately fetid, minor chert
1213021	GSC	Indian Springs - Timpi Wash	---	---	---	<2	>98	---	---	---	---	---	---	---	---	---	<5	Light to dark grey brecciated, bioturbated fossiliferous, worm holes, fetid
1213022	GSC	Indian Springs - Timpi Wash	---	---	---	>98	<2	---	---	---	---	---	---	---	---	---	<5	Limestone fine, variably fossiliferous
1424933	GSC	West of Transvaal Hills	20	38	34	---	---	---	---	---	---	4	---	---	---	---	<5	Crystal and lithic rich tuff, weak eutaxitic texture
1424934	GSC	West of Transvaal Hills	7	---	24	---	---	---	---	<2	66	---	---	---	---	---	<5	Debris flow with matrix supported, monolithic clasts which are vitreous crystal-lithic tuff, matrix is ashy, poorly cemented, no clear grading, very poorly sorted, weak bedding, clasts to .5m
1424937	GSC	West of Transvaal Hills	41	22	36	---	---	---	---	---	---	---	---	---	---	---	<5	Rhyolite with flow banding and silicification
1213006	Mineralized Area	Transvaal Hills	50	20	21	5	---	---	---	---	---	---	---	---	---	---	<5	Sampled test pit adjacent to rhyolite dike, country rock unwelded tuff, intensely bleached, dike is crystal rich and locally brecciated
1213009	Mineralized Area	Transvaal Hills	60	17	12	---	---	---	9	---	---	---	---	---	---	---	<5	Test pit through fault contact btwn Tma/Tmr, strong oxidation and gouge, dip slip lineations on fault surface
1213023	Mineralized Area	Don Dale Mine	90	---	---	---	---	---	---	---	---	<2	---	---	---	5	<5	Dump pile below Don Dale adit, fractured qtzite with heavy feox and minor chrysacolla on fracture surfaces
1213024	Mineralized Area	Don Dale Mine	92	---	---	---	---	4	---	---	---	2	---	---	---	---	<5	Brecciated qtzite vn cutting across mouth of adit, vry fractured chrysocolla on fxs, feox pervasive
1213025	Mineralized Area	Don Dale Mine	75	---	---	2	---	17	3	---	---	---	---	---	---	---	<5	Heavily altered porhyritic intrusion, qtz phenos, primary cubic pyrite, feox & chrysocolla
1213026	Mineralized Area	Don Dale District	92	---	---	---	---	4	---	---	---	2	---	---	---	---	<5	Major fault ~ 20m wide, fault breccia, silicified and oxidized
1213027	Mineralized Area	Don Dale District	82	---	---	2	---	11	---	---	---	2	---	---	---	---	<5	Fault btwn quartzite and shale, both units brecciated and oxidized stockwork MnOx in shale
1213028	Mineralized Area	Don Dale District	90	---	---	---	---	8	---	---	---	2	---	---	---	---	<5	Porphyry near fault quartzite and shale abundant feox
1213029	Mineralized Area	Limestone Ridge	68	5	---	---	---	9	6	---	---	<2	---	---	---	---	<5	Dike cross-cutting a quartzite interbedded with shale, sediments strongly oxidized Fe & Mn
1213030	Mineralized Area	Limestone Ridge	48	10	23	<2	---	7	4	---	---	--	6	---	---	---	<5	Oxidation following bedding, could be primary sedimentary feature, btwn two dikes/sills
1213031	Mineralized Area	Limestone Ridge	85	---	---	10	---	4	---	---	---	<2	---	---	---	---	<5	Low angle qtz vn cutting across folded qtzite bedding, vn has fe&mn ox
1213032	Mineralized Area	Limestone Ridge	69	11	---	2	---	6	9	---	---	3	---	---	---	---	<5	Shaley members prederentially deformed and oxidized
1213033	Mineralized Area	Limestone Ridge	37	---	---	2	59	---	---	---	---	<2	---	---	---	---	<5	Silica cemented fault breccia and stockwork vning in limestone unit
1213034	Mineralized Area	Limestone Ridge	64	---	---	3	30	---	---	---	---	<2	---	---	---	---	<5	Intense silica stockwork vning and oxidation, near contact with dike
1213035	Mineralized Area	Cliff Spring Mine - LS Ridge	18	21	54	---	---	6	---	---	---	---	---	---	<2	---	<5	Intersection of two orthogonal faults in tuff unit, gouge and feox, also a small spring
1213036	Mineralized Area	Limestone Ridge	89	---	---	8	---	---	---	---	---	<2	<2	---	---	---	<5	Two intersecting qtz vns in silltstone, chalcopyrite, malachite present in vns
1213037	Mineralized Area	Limestone Ridge	38	---	---	---	---	---	---	---	---	39	21	---	---	---	<5	0.5m wide bed of total fe replacement, botryodial geothite?, hematite? Oxide penetrates into neighboring qtzite
1213038	Mineralized Area	Limestone Ridge	92	---	---	---	6	---	---	---	---	---	---	---	---	---	<5	Gossan and oxide stockwork
1213039	Mineralized Area	Limestone Ridge	53	---	---	2	39	2	---	---	---	<2	---	---	---	---	<5	Calcerous siltstone feox and limonite, possible faulting along jns
1213040	Mineralized Area	Limestone Ridge	>98	---	---	---	---	---	---	---	---	<2	---	---	---	---	<5	Oxidized, brecciated quartzite Mnox along fracture planes
1424901	Mineralized Area	Transvaal Hills	28	26	24	---	---	4	<2	15	---	---	---	---	---	---	<5	Crystal-rich, moderately welded Tuff with sanidine, biotite and quartz phenocrysts. Sub-vertical fractures ~ 3/ft, striking 025, 90 with strong Fe and Mn oxides and pervasive argillization

FOR OFFICIAL USE ONLY

Appendix C.2a: X-ray Diffraction Analysis

Sample #	Sample Type	Locality	XRD Results														Notes
			Quartz	K-Feldspar	Plagioclase	Calcite	Dolomite	Mica	Kaolin	Smectite	Heulandite	Goethite	Hematite	Jarosite	Pyrite	Cerussite	Unaccounted	
1424902	Mineralized Area	Transvaal Hills	55	16	<2	---	---	---	27	---	---	---	---	---	---	---	<5	Crystal-rich Rhyolite, subhedral sanidine, aphenitic groundmass. Sub-vertical fractures and chalcedony viens strike 055 and are strongly oxidized. Pervasive hydothermal clay alteration in surround rock.
1424903	Mineralized Area	Transvaal Hills	33	31	17	2	---	---	3	---	11	---	---	---	---	---	<5	Sampled float ~10 m along a shallow test trench in heavily oxidized and bleached (argillite or kaolinite) lithic tuff, poorly welded, abundant pumice
1424906	Mineralized Area	Transvaal Hills	39	35	23	<2	---	---	<2	---		<2	---	---	---	---	<5	Silicified breccia with Fe&Mn Ox staining, angular clasts 1-20 cm, silicified clasts and matrix, competent
1424907	Mineralized Area	Transvaal Hills	41	9	9	---	---	---	---	---	40	---	---	---	---	---	<5	Argillic and bleached, oxidized, however no widespread silicification, localized silica
1424908	Mineralized Area	Transvaal Hills	12	37	41	---	---	4	3	<2	---	---	---	---	---	---	<5	Crystal and lithic rich welded tuff weak hydrothermal clay alteration, weak fracture controlled Feox, fractures very planar, sub-parallel ~4/1.5m 330, 80SW
1424909	Mineralized Area	Transvaal Hills	30	21	25	10	---	---	11	---	---	---	---	---	---	---	<5	Crystal and lithic rich, welded tuff, heavily fractured and brecciated. Strongly oxidized fractures. Gouge and minor hydrothermal clay alteration. No measureable structures, very chaotic fracturing.
1424910	Mineralized Area	Transvaal Hills	35	22	31	---	---	3	4	---	---	---	---	---	---	---	<5	Major fault ~ 10m wide, fault breccia with angular clasts up to 1m, silicified and oxidized, very little chalcedony
1424911	Mineralized Area	Transvaal Hills	59	---	---	4	---	---	33	---	---	---	---	---	---	---	<5	Fine, crystal poor tuff, bleached and clay altered with strong feox on fracture surfaces
1424914	Mineralized Area	Oasis Hills	52	20	21	---	---	5	---	---	---	<2	---	<2	---	---	<5	Tuff with eutaxitic texture, small vugs with quartz and Feox, some yellow alteration possibly limonite. Shaft seated in a fault ~330, 80SW
1424918	Mineralized Area	Oasis Hills	71	9	<2	---	---	---	14	---	---	---	---	5	---	---	<5	Adit following 6m thick fault zone, brecciated, sub-parallel fractures @ 040, 75NW, intense hydrothermal clay alteration, few oxides or silica. Tuff has eutaxitic texture which is sub-parallel to fault zone (tilting?)
1424919	Mineralized Area	Oasis Hills	44	33	13	---	---	---	7	---	---	---	---	---	---	---	<5	Adit following 10m thick fault zone, brecciated, sub-parallel fractures @ 025, 65NW, intense hydrothermal clay alteration, few oxides or silica. Tuff has eutaxitic texture which is sub-parallel to fault zone (tilting?)
1424921	Mineralized Area	Oasis Hills	26	19	28	6	---	6	---	8	---	5	---	---	---	---	<5	Flow-banded rhyodacite, fine grained, faulted and brecciated with gouge. Faulted material is strongly argillized with very little oxides
1424932	Mineralized Area	Colson Pond Area	43	18	25	4	---	8	---	---	---	<2	---	---	---	---	<5	Crystal rich, welded tuff, very competent, fracture controlled oxides, minor hydrothermal brecciation present
1424938	Mineralized Area	West of Transvaal Hills	15	16	20	---	---	---	---	---	46	---	---	---	---	---	<5	~2m wide fault zone, breccia with clasts up to 1m, abundant silica, no oxides
1424947	Mineralized Area	South Spotted Range	31	5	---	47	14	---	---	---	---	---	---	---	---	---	<5	Low carbonate unit thin to medium bedding, chert nodules, pervasive feox staining
1424953	Mineralized Area	Indian Springs -Spotted Range	82	---	---	12		---	---	---	---	---	---	---	---	---	<5	Hogback of silicified and oxidized quatrzite breccia, breccia appears to follow bedding planes and fractures, outcrop is roughly 10m long, 2m high, located on the edge of drainage.
1424954	Mineralized Area	Indian Springs -Spotted Range	12	---	---	86	<2	---	---	---	---	---	---	---	---	---	<5	Sampling a fault zone between a dark carbonate w/ horn coral and chert nodes, and a light, soft bleached carbonate. The fault zn is intensely oxidized anf fractured.
1424959	Mineralized Area	East of Indian Springs	7	---	---	51	39	---	---	<2	---	---	---	---	---	---	<5	A claim from the 1920s, massive crystalized calcite vein in heavily fractured fault zone which includes a gouge zone
1424982	Mineralized Area	Transvaal Hills	39	22	11	---	---	---	25	---	---	---	---	---	---	---	<5	Very oxidized, brecciated tuff, matrix is more oxidized than clasts, clasts more welded than matrix, chalcedony around clasts
1424983	Mineralized Area	Transvaal Hills	56	12	8	---	---	---	20	---	---	---	---	---	---	---	<5	Crystall rich tuff, trace lithics, intense oxidation and hydrothermal clay alteration around steep joints which occur between 10cm-2m

FOR OFFICIAL USE ONLY

12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 (303) 463-8270

Semi-Quantitative
X-Ray Diffraction Analysis

Client:
Golder Associates, Inc.
4730 N. Oracle, Ste. 210
Tucson, AZ 85705

Analysis Date: 6-8-16
Reporting Date: 6-9-16
Receipt Date: 6-1-16
Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ10

Client Sample No.:	**1424901**	**1424902**	**1424903**	**142906**	**1424907**
Phase					
Quartz	28	55	33	39	41
Mica	4	-	-	-	-
K-Feldspar	26	16	31	35	9
Plagioclase	24	<2*	17	23	9
Kaolin	<2*	27	3	<2*	-
Smectite	15	-	-	-	-
Heulandite	-	-	11	-	40
Calcite	-	-	2	<2*	-
Goethite	-	-	-	<2*	-
Dolomite	-	-	-	-	-
Jarosite	-	-	-	-	-
Unaccounted	<5	<5	<5	<5	<5

*May be present.

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

DCM SCIENCE LABORATORY, INC #6
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Project Title: Confidential Project
DCMSL Project: GOLDAZ10

Client Sample No.:	**1424908**	**1424909**	**1424910**	**1424911**	**1424914**
Phase					
Quartz	12	30	35	59	52
Mica	4	-	3	-	5
K-Feldspar	37	21	22	-	20
Plagioclase	41	25	31	-	21
Kaolin	3	11	4	33	-
Smectite	<2*	-	-	-	-
Heulandite	-	-	-	-	-
Calcite	-	10	-	4	-
Goethite	-	-	-	-	<2*
Dolomite	-	-	-	-	-
Jarosite	-	-	-	-	<2*
Unaccounted	<5	<5	<5	<5	<5

*May be present.

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

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DCMSL Project: GOLDAZ10

Client Sample No.:	**1424918**	**1424919**	**1424921**	**1424932**	**1424933**
Phase					
Quartz	71	44	26	43	20
Mica	-	-	6	8	-
K-Feldspar	9	33	19	18	38
Plagioclase	<2*	13	28	25	34
Kaolin	14	7	-	-	-
Smectite	-	-	8	-	-
Heulandite	-	-	-	-	-
Calcite	-	-	6	4	-
Goethite	-	-	5	<2*	4
Dolomite	-	-	-	-	-
Jarosite	5	-	-	-	-
Unaccounted	<5	<5	<5	<5	<5

*May be present.

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

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DCMSL Project:	GOLDAZ10

Client Sample No.:	**1424934**	**1424937**	**1424938**	**1424947**	**1424953**
Phase					
Quartz	7	41	15	31	82
Mica	-	<2*	-	-	-
K-Feldspar	-	22	16	5	<2*
Plagioclase	24	36	20	-	-
Kaolin	-	-	-	-	-
Smectite	<2*	-	-	-	-
Heulandite	66	-	46	-	-
Calcite	-	-	-	47	12
Goethite	-	-	-	-	-
Dolomite	-	-	-	14	-
Jarosite	-	-	-	-	-
Unaccounted	<5	<5	<5	<5	<5

*May be present.

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

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Reporting Date: 6-9-16
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Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ10

Client Sample No.:	**1424954**	**1424959**	**1424982**	**1424983**	**1213006**
Phase					
Quartz	12	7	39	56	50
Mica	-	-	-	-	<2*
K-Feldspar	-	-	22	12	20
Plagioclase	-	-	11	8	21
Kaolin	-	-	25	20	-
Smectite	-	<2*	-	-	-
Heulandite	-	0	-	-	<2*
Calcite	86	51	-	-	5
Goethite	-	-	-	-	-
Dolomite	<2*	39	-	-	-
Jarosite	-	-	-	-	-
Unaccounted	<5	<5	<5	<5	<5

*May be present

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

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Client Job No.:	1538787
Project Title:	Confidential Project
DCMSL Project:	GOLDAZ10

Client Sample No.:	**1213009**	**1213016**	**1213017**
Phase			
Quartz	60	-	-
Mica	<2*	-	-
K-Feldspar	17	-	-
Plagioclase	12	-	-
Kaolin	9	-	-
Smectite	-	-	-
Heulandite	-	-	-
Calcite	-	-	<2*
Goethite	-	-	-
Dolomite	-	>99	>98
Jarosite	-	-	-
Unaccounted	<5	<5	<5

*May be present.

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

Jason Barnes, Analyst

DCM SCIENCE LABORATORY, INC.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033

(303) 463-8270/(800) 852-7340
(303) 463-8267 – fax

Date/Time Received 6/1/16 8:55 DCMSL Group No. 1638 DCMSL Log No. GOLDAZ10

Field Data Sheet/Chain of Custody

Samples Submitted By:
Company: Golder Associates Inc
Address: 4730 N. Oracle Ste 210
Tucson, AZ 85705

Contact: Gene Muller
Phone: 520-888-8818
Fax: 520 888 - 8817
Cell/Pager: 520 405 3777

Job/P.O. # 1538787
Project Title Confidential Project

Archive: All samples are archived for 6 months unless other arrangements are made.
E-Mail gmuller@golder.com

Turnaround Time Requested:
[X] Standard (3 to 5 Business Days)
[ ] 24 Hour Rush
[ ] 2 Hour Rush (Asbestos Only)
[ ] Other

Procedure Requested:

ASBESTOS		XRD		OTHER	
Bulk [ ]	Standard EPA	[ ]	Respirable Silica	[ ]	Optical Microscopy
[ ]	Progressive	[ ]	Bulk Silica	[ ]	Gravimetric
[ ]	Point Count	[✓]	Scan & Search	[ ]	SEM
[ ]	Other	[ ]	Other	[ ]	Other

Air [ ] NIOSH 7400
[ ] OSHA ID-160
[ ] Other

ADDITIONAL INFORMATION

Client Sample No.:	Sample Date	Air Volume	Other Information
1 See Attached	sample listing		
2 All samples	are prepared pulps,	30 gram wt.	
3			
4			
5			
6			
7			
8			
9			
10			

Relinquished By:	Date/Time	Received By:	Date/Time
[signature]	5/31/2016, 2:00pm	Nikki Howey	6/1/16 8:55

@LDA210

Sample Transmittal

From

Golder Associates Inc.
4730 N Oracle Suite 210
Tucson, AZ 85705
Contact: Gene Muller gmuller@golder.com 520-888-8818
Project # 1538787

Ship to
DCM Science
12421 W 49th Ave
Wheatridge, CO 80033 303-463-8270

	Sample #	Sample Type	Sample Method	XRD	NOTES
1	1424901	min outcrop	Grab	x	
2	1424902	min outcrop	Grab	x	
3	1424903	min outcrop	Float	x	
4	1424906	min outcrop	Grab	x	
5	1424907	min outcrop	Grab	x	
6	1424908	min outcrop	Grab	x	
7	1424909	min outcrop	Grab	x	
8	1424910	min outcrop	Grab	x	
9	1424911	min outcrop	Grab	x	
10	1424914	min outcrop	Grab	x	
11	1424918	min outcrop	Channel	x	
12	1424919	min outcrop	Grab	x	
13	1424921	min outcrop	Grab	x	
14	1424932	min outcrop	Grab	x	
15	1424933	GSC	Grab	x	XRD Scan/Search, (all)
16	1424934	GSC	Grab	x	
17	1424937	GSC	Grab	x	
18	1424938	min outcrop	Grab	x	
19	1424947	min outcrop	Grab	x	
20	1424953	min outcrop	Grab	x	
21	1424954	min outcrop	Grab	x	
22	1424959	min outcrop	Grab	x	
23	1424982	min outcrop	Grab	x	
24	1424983	min outcrop	Grab	x	
25	1213006	min outcrop	Grab	x	
26	1213009	min outcrop	Grab	x	
27	1213016	GSC	Grab	x	
28	1213017	GSC	Grab	x	

DCM SCIENCE LABORATORY, INC.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 (303) 463-8270

Semi-Quantitative
X-Ray Diffraction Analysis

Client:
Golder Associates, Inc.
4730 N. Oracle, Ste. 210
Tucson, AZ 85705

Analysis Date: 10-11-16
Reporting Date: 10-12-16
Receipt Date: 10-4-16
Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ11

Client Sample No.:	**1213018**	**1213019**	**1213020**	**1213021**	**1213022**
Phase					
Quartz	-	<2*	2	-	<2*
Calcite	3	>98	97	<2*	>98
Dolomite	95	<2*	-	>98	<2*
Unaccounted	<5	<5	<5	<5	<5

*May be present.

Client Sample No.:	**1213023**	**1213024**	**1213025**	**1213026**	**1213027**
Phase					
Quartz	90	92	75	92	82
Cerussite	5	-	-	-	-
Mica	-	4	17	4	11
Kaolin	-	-	3	-	-
Calcite	-	-	2	-	2
Goethite	<2*	2	-	2	2
Unaccounted	<5	<5	<5	<5	<5

*May be present.

12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 (303) 463-8270

Semi-Quantitative
X-Ray Diffraction Analysis

Client:
Golder Associates, Inc.
4730 N. Oracle, Ste. 210
Tucson, AZ 85705

Analysis Date: 10-11-16
Reporting Date: 10-12-16
Receipt Date: 10-4-16
Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ11

Client Sample No.:	**1213028**	**1213029**	**1213030**	**1213031**	**1213032**
Phase					
Quartz	90	68	48	85	69
Mica	8	9	7	4	6
Hematite	-	-	6	-	-
K-Feldspar	-	5	10	-	11
Plagioclase	-	-	23	-	-
Kaolin	-	6	4	-	9
Calcite	-	-	<2*	10	2
Goethite	<2*	<2*	-	<2*	3
Unaccounted	<5	<5	<5	<5	<5

*May be present.

12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 (303) 463-8270

Semi-Quantitative
X-Ray Diffraction Analysis

Client:
Golder Associates, Inc.
4730 N. Oracle, Ste. 210
Tucson, AZ 85705

Analysis Date: 10-11-16
Reporting Date: 10-12-16
Receipt Date: 10-4-16
Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ11

Client Sample No.:	**1213033**	**1213034**	**1213035**	**1213036**	**1213037**
Phase					
Quartz	37	64	18	89	38
K-Feldspar	-	-	21	-	-
Plagioclase	-	-	54	-	-
Pyrite	-	-	<2*	-	-
Calcite	2	3	-	8	-
Hematite	-	-	-	<2*	21
Goethite	<2*	<2*	-	<2*	39
Dolomite	59	30	-	-	-
Mica	-	-	6	-	-
Unaccounted	<5	<5	<5	<5	<5

*May be present.

DCM SCIENCE LABORATORY, INC.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 (303) 463-8270

Semi-Quantitative
X-Ray Diffraction Analysis

Client:
Golder Associates, Inc.
4730 N. Oracle, Ste. 210
Tucson, AZ 85705

Analysis Date: 10-11-16
Reporting Date: 10-12-16
Receipt Date: 10-4-16
Client Job No.: 1538787
Project Title: Confidential Project
DCMSL Project: GOLDAZ11

Client Sample No.:	**1213038**	**1213039**	**1213040**
Phase			
Quartz	92	53	>98
Mica	<2*	2	-
Calcite	-	2	-
Goethite	-	<2*	<2*
Dolomite	6	39	-
Unaccounted	<5	<5	<5

*May be present

The samples were prepared for x-ray diffraction analysis and scanned over a range of 4° to 45° 2Θ Cu Kα radiation, 40kV, 35 mA. Mineral phases were identified with the aid of computer-assisted programs accessing a diffraction database. Estimates of mineral concentrations are based on relative peak heights.

Jason Barnes, Analyst

DCM SCIENCE LABORATORY, INC.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033

(303) 463-8270/(800) 852-7340
(303) 463-8267 – fax

Date/Time Received _____ DCMSL Group No. 3221 DCMSL Log No. Gold AZ 11

Field Data Sheet/Chain of Custody

Samples Submitted By:
Company: Golder Associates Inc.
Address: 4730 N. Oracle Rd STE 210
Tucson, AZ. 85705

Contact: Gene Muller
Phone: 520 - 888-8818
Fax:
Cell/Pager: 520 405 - 3777

Job/P.O. # 1538787
Project Title Confidential Project
Archive: All samples are archived for 6 months unless other arrangements are made.
E-Mail gmuller@golder.com

Turnaround Time Requested:
[X] Standard (3 to 5 Business Days)
[ ] 24 Hour Rush
[ ] 2 Hour Rush (Asbestos Only)
[ ] Other _____

Procedure Requested:

ASBESTOS		XRD		OTHER	
Bulk	[ ] Standard EPA	[ ]	Respirable Silica	[ ]	Optical Microscopy
	[ ] Progressive	[ ]	Bulk Silica	[ ]	Gravimetric
	[ ] Point Count	[X]	Scan & Search	[ ]	SEM
	[ ] Other	[ ]	Other	[ ]	Other
Air	[ ] NIOSH 7400				
	[ ] OSHA ID-160				
	[ ] Other				

ADDITIONAL INFORMATION _____

Client Sample No.:	Sample Date	Air Volume	Other Information
1 See Attached Sample Sheet			$195.00 per
2 All samples are prepared pulps ~50 grams wt.			
3			
4			
5			
6			
7			
8			
9			
10			

Relinquished By:	Date/Time	Received By:	Date/Time
Ryan Muller	10/3/2017 1:11 PM	Shepherd	10-4-16 9:30

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 16-JUN-2016
Account: GOLINC

QC CERTIFICATE RE16092806

Project: Geochemistry

This report is for 37 Pulp samples submitted to our lab in Reno, NV, USA on 12-JUN-2016.

The following have access to data associated with this certificate:

EMILY CLARK	GENE MULLER	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
FND-02	Find Sample for Addn Analysis

ANALYTICAL PROCEDURES

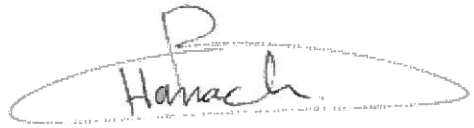
ALS CODE	DESCRIPTION	INSTRUMENT
Au-AA23	Au 30g FA-AA finish	AAS

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: GOLDER ASSOCIATES INC.
ATTN: GENE MULLER
4730 N. ORACLE
STE 210
TUCSON AZ 85705

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature: 

Hanachi Bouhenchir, Lab Manager

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 16- JUN- 2016
Account: GOLINC

Project: Geochemistry

QC CERTIFICATE OF ANALYSIS RE16092806

Sample Description	Method Analyte Units LOR	Au- AA23 Au ppm 0.005
		STANDARDS
BP- 13		0.368
BP- 13		0.371
Target Range - Lower Bound		0.332
Upper Bound		0.384
CDN- GS- 2Q		2.38
CDN- GS- 2Q		2.45
Target Range - Lower Bound		2.22
Upper Bound		2.52
		BLANKS
BLANK		<0.005
BLANK		<0.005
Target Range - Lower Bound		<0.005
Upper Bound		0.010
		DUPLICATES
ORIGINAL		<0.005
DUP		<0.005
Target Range - Lower Bound		<0.005
Upper Bound		0.010
ORIGINAL		0.039
DUP		0.036
Target Range - Lower Bound		0.031
Upper Bound		0.044
ORIGINAL		0.008
DUP		0.008
Target Range - Lower Bound		<0.005
Upper Bound		0.010

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Project: Geochemistry

QC CERTIFICATE OF ANALYSIS RE16092806

Sample Description	Method Analyte Units LOR	Au- AA23 Au ppm 0.005
		DUPLICATES
ORIGINAL		<0.005
DUP		<0.005
Target Range - Lower Bound		<0.005
Upper Bound		0.010
ORIGINAL		<0.005
DUP		<0.005
Target Range - Lower Bound		<0.005
Upper Bound		0.010
1213004		<0.005
DUP		<0.005
Target Range - Lower Bound		<0.005
Upper Bound		0.010

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 16- JUN- 2016
Account: GOLINC

Project: Geochemistry

QC CERTIFICATE OF ANALYSIS RE16092806

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
Au- AA23 FND- 02

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE TU16158768

P.O. No.: 153878

This report is for 23 Rock samples submitted to our lab in Tucson, AZ, USA on 20- SEP- 2016.

The following have access to data associated with this certificate:

GENE MULLER		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- 31	Fine crushing - 70% <2mm
SND- 01	Send samples to external laboratory
SPL- 21d	Split sample - duplicate
SPL- 21	Split sample - riffle splitter
SPLIT- Z	Pulp split for send out
PUL- 31d	Pulverize Split - duplicate
CRU- QC	Crushing QC Test
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
Ag- OG62	Ore Grade Ag - Four Acid	ICP- AES
ME- OG62	Ore Grade Elements - Four Acid	ICP- AES
Cu- OG62	Ore Grade Cu - Four Acid	ICP- AES
Pb- OG62	Ore Grade Pb - Four Acid	ICP- AES
Au- AA23	Au 30g FA- AA finish	AAS
Hg- CV41	Trace Hg - cold vapor/AAS	FIMS
ME- XRF26	Whole Rock By Fusion/XRF	XRF
OA- GRA05x	LOI for XRF	WST- SEQ
C- GAS05	Inorganic Carbon (CO2)	
C- IR17	Organic carbon by LECO	LECO
PGM- NAA26	PGM NiS collection NAA finish	
ME- MS61r	4A multi- element ICP- MS + REE	

To: GOLDER ASSOCIATES INC.
ATTN: GENE MULLER
4730 N. ORACLE
STE 210
TUCSON AZ 85705

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature: 

Colin Ramshaw, Vancouver Laboratory Manager

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05
STANDARDS																
CCU- 1d																
Target Range - Lower Bound																
Upper Bound																
GBM903- 13																
Target Range - Lower Bound																
Upper Bound																
GGC- 10																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		4.59	7.74	32.2	1120	3.31	0.66	2.73	2.32	74.4	19.8	95	13.30	619	3.99	19.40
Target Range - Lower Bound		4.00	6.64	29.5	920	2.98	0.60	2.35	2.00	66.2	17.7	81	11.20	587	3.55	17.50
Upper Bound		4.92	8.14	36.5	1270	3.76	0.76	2.90	2.48	81.0	21.9	102	13.80	675	4.37	21.5
NCS 73317a																
Target Range - Lower Bound																
Upper Bound																
NCSDC73303																
Target Range - Lower Bound																
Upper Bound																
NCSDC73507																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OREAS 503b																
Target Range - Lower Bound																
Upper Bound																
OREAS 604																
OREAS 604																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r
	Analyte	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
	Units	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1
STANDARDS																
CCU- 1d																
Target Range - Lower Bound																
Upper Bound																
GBM903- 13																
Target Range - Lower Bound																
Upper Bound																
GGC- 10																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.18	3.3	0.175	3.18	36.2	33.2	1.36	561	14.80	2.03	21.9	709	1080	1115	199.0
Target Range - Lower Bound		<0.05	2.8	0.155	2.79	31.1	29.5	1.17	497	13.65	1.76	19.0	622	930	971	173.5
Upper Bound		0.27	3.6	0.201	3.43	39.1	36.5	1.45	619	16.75	2.18	23.4	760	1160	1185	212
NCS 73317a																
Target Range - Lower Bound																
Upper Bound																
NCSDC73303																
Target Range - Lower Bound																
Upper Bound																
NCSDC73507																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OREAS 503b																
Target Range - Lower Bound																
Upper Bound																
OREAS 604																
OREAS 604																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r	ME- MS61r
	Analyte	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W
	Units	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1	0.1
STANDARDS																
CCU- 1d																
Target Range - Lower Bound																
Upper Bound																
GBM903- 13																
Target Range - Lower Bound																
Upper Bound																
GGC- 10																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.008	0.31	4.51	12.4	2	4.0	314	1.61	<0.05	20.7	0.508	1.13	5.7	110	4.8
Target Range - Lower Bound		0.005	0.27	3.89	11.1	<1	3.5	277	1.39	<0.05	17.90	0.443	0.89	4.9	97	4.1
Upper Bound		0.013	0.35	5.39	13.7	4	4.7	339	1.81	0.14	21.9	0.553	1.25	6.2	121	5.8
NCS 73317a																
Target Range - Lower Bound																
Upper Bound																
NCSDC73303																
Target Range - Lower Bound																
Upper Bound																
NCSDC73507																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OREAS 503b																
Target Range - Lower Bound																
Upper Bound																
OREAS 604																
OREAS 604																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: +1 775 356 5395 Fax: +1 775 355 0179 www.alsglobal.com

To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03
STANDARDS																
CCU- 1d																
Target Range - Lower Bound																
Upper Bound																
GBM903- 13																
Target Range - Lower Bound																
Upper Bound																
GGC- 10																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		25.2	820	110.5	4.84	2.80	1.33	5.22	0.99	0.41	32.4	9.04	6.46	0.82	0.42	2.63
Target Range - Lower Bound		23.8	722	92.2	3.99	2.25	1.12	4.60	0.79	0.32	26.5	7.02	5.24	0.67	0.32	2.13
Upper Bound		29.3	886	126.0	5.51	3.11	1.59	6.34	1.09	0.46	36.1	9.56	7.16	0.93	0.46	2.95
NCS 73317a																
Target Range - Lower Bound																
Upper Bound																
NCSDC73303																
Target Range - Lower Bound																
Upper Bound																
NCSDC73507																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OREAS 503b																
Target Range - Lower Bound																
Upper Bound																
OREAS 604																
OREAS 604																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	Ag- OG62 Ag ppm 1	Cu- OG62 Cu % 0.001	Pb- OG62 Pb % 0.001	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01
STANDARDS																
CCU- 1d		123	23.9	0.259												
Target Range -	Lower Bound	115	23.1	0.252												
	Upper Bound	126	24.8	0.272												
GBM903- 13		24	2.86	2.13												
Target Range -	Lower Bound	22	2.79	2.07												
	Upper Bound	26	3.00	2.23												
GGC- 10																
Target Range -	Lower Bound															
	Upper Bound															
MA- 3a																
MA- 3a																
Target Range -	Lower Bound															
	Upper Bound															
MRGeo08																
Target Range -	Lower Bound															
	Upper Bound															
NCS 73317a						1.73										
Target Range -	Lower Bound					1.50										
	Upper Bound					1.86										
NCSDC73303							13.82	0.06	8.80	0.02	13.31	2.29	7.77	0.17	3.32	0.96
Target Range -	Lower Bound						13.37	0.03	8.48	<0.01	12.95	2.19	7.47	0.14	3.21	0.88
	Upper Bound						14.29	0.08	9.14	0.04	13.85	2.45	8.07	0.20	3.55	1.02
NCSDC73507						4.34										
Target Range -	Lower Bound					3.59										
	Upper Bound					4.41										
OGGeo08		20	0.845	0.728												
Target Range -	Lower Bound	18	0.809	0.698												
	Upper Bound	22	0.869	0.750												
OREAS 503b					0.704											
Target Range -	Lower Bound				0.648											
	Upper Bound				0.742											
OREAS 604		489	2.15	0.100												
OREAS 604		495	2.18	0.187												
Target Range -	Lower Bound	473														
	Upper Bound	509														

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02
STANDARDS										
CCU- 1d										
Target Range - Lower Bound										
Upper Bound										
GBM903- 13										
Target Range - Lower Bound										
Upper Bound										
GGC- 10										5.43
Target Range - Lower Bound										4.81
Upper Bound										5.20
MA- 3a								2.36	8.7	
MA- 3a								2.44	8.9	
Target Range - Lower Bound								2.31	8.4	
Upper Bound								2.77	10.2	
MRGeo08										
Target Range - Lower Bound										
Upper Bound										
NCS 73317a										
Target Range - Lower Bound										
Upper Bound										
NCSDC73303		0.02	44.31	0.13	2.34	99.69				
Target Range - Lower Bound		<0.01	43.54	0.10	2.24	97.99				
Upper Bound		0.05	45.74	0.16	2.50	102.00				
NCSDC73507										
Target Range - Lower Bound										
Upper Bound										
OGGeo08										
Target Range - Lower Bound										
Upper Bound										
OREAS 503b										
Target Range - Lower Bound										
Upper Bound										
OREAS 604										
OREAS 604										
Target Range - Lower Bound										
Upper Bound										

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05
STANDARDS																
OREAS 621																
Target Range - Lower Bound																
Upper Bound																
OREAS 905		0.55	7.68	34.4	2880	3.00	5.72	0.62	0.35	94.8	16.1	22	7.25	1525	4.14	27.2
Target Range - Lower Bound																
Upper Bound																
OREAS- 106		0.07	7.29	2.7	290	4.66	0.41	1.08	0.08	145.0	6.9	43	1.11	127.0	2.26	28.9
Target Range - Lower Bound		0.03	6.62	1.7	230	4.25	0.38	0.94	0.04	123.5	5.8	37	0.90	121.5	2.02	25.0
Upper Bound		0.07	8.11	2.8	340	5.31	0.49	1.18	0.12	150.5	7.4	48	1.22	140.0	2.49	30.6
OREAS- 45d		0.17	8.35	13.6	190	0.77	0.33	0.19	0.03	39.3	31.5	539	4.09	370	14.40	21.7
Target Range - Lower Bound		0.17	7.33	12.2	140	0.65	0.27	0.16	<0.02	33.5	26.5	493	3.47	345	13.05	19.05
Upper Bound		0.23	8.98	15.4	220	0.93	0.35	0.21	0.09	40.9	32.6	605	4.35	397	16.00	23.4
OxJ111																
Target Range - Lower Bound																
Upper Bound																
SARM- 43																
SARM- 43																
Target Range - Lower Bound																
Upper Bound																
SCH- 1																
SCH- 1																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																

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Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1
STANDARDS																
OREAS 621																
Target Range - Lower Bound																
Upper Bound																
OREAS 905		0.19	7.3	0.670	2.98	48.0	20.4	0.27	375	3.16	2.47	19.3	10.0	290	33.0	145.0
Target Range - Lower Bound																
Upper Bound																
OREAS- 106		0.37	4.5	0.058	1.58	56.6	11.6	0.56	149	8.18	3.98	43.5	13.3	1770	310	94.9
Target Range - Lower Bound		0.16	3.9	0.048	1.40	48.1	10.2	0.48	124	7.29	3.54	37.3	12.2	1520	269	85.6
Upper Bound		0.38	4.9	0.074	1.73	59.9	12.9	0.61	162	9.03	4.35	45.8	15.4	1880	330	105.0
OREAS- 45d		0.12	4.3	0.089	0.42	18.9	21.8	0.23	481	2.45	0.10	14.9	230	430	21.7	43.4
Target Range - Lower Bound		0.09	3.3	0.081	0.36	14.7	19.2	0.21	436	2.20	0.08	13.0	208	370	19.1	37.8
Upper Bound		0.31	4.3	0.111	0.46	19.1	23.9	0.28	544	2.80	0.13	16.1	254	470	24.5	46.4
OxJ111																
Target Range - Lower Bound																
Upper Bound																
SARM- 43																
SARM- 43																
Target Range - Lower Bound																
Upper Bound																
SCH- 1																
SCH- 1																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1
STANDARDS																
OREAS 621																
Target Range - Lower Bound																
Upper Bound																
OREAS 905		<0.002	0.07	1.97	5.6	4	4.0	162.0	1.43	0.09	15.75	0.123	0.73	5.2	10	2.8
Target Range - Lower Bound																
Upper Bound																
OREAS- 106		0.003	0.04	0.38	6.3	2	6.9	82.3	4.88	<0.05	690	0.323	0.29	1175	41	4.9
Target Range - Lower Bound		<0.002	0.02	0.14	5.7	<1	5.7	75.0	3.95	<0.05	580	0.268	0.24	1030	37	4.0
Upper Bound		0.007	0.06	0.39	7.2	6	7.5	92.1	4.93	0.13	708	0.338	0.38	1255	47	5.6
OREAS- 45d		<0.002	0.05	0.89	53.5	4	2.6	32.7	1.13	0.13	16.10	0.766	0.26	2.8	229	1.7
Target Range - Lower Bound		<0.002	0.03	0.64	44.3	<1	2.2	28.0	0.87	<0.05	13.50	0.691	0.20	2.3	211	1.3
Upper Bound		0.007	0.07	1.00	54.3	5	3.2	34.6	1.17	0.23	16.50	0.855	0.34	3.0	260	2.0
OxJ111																
Target Range - Lower Bound																
Upper Bound																
SARM- 43																
SARM- 43																
Target Range - Lower Bound																
Upper Bound																
SCH- 1																
SCH- 1																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																

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TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03
STANDARDS																
OREAS 621																
Target Range - Lower Bound																
Upper Bound																
OREAS 905		16.0	143	255	3.68	1.10	1.42	5.81	0.55	0.11	39.9	11.25	7.70	0.81	0.13	0.71
Target Range - Lower Bound																
Upper Bound																
OREAS- 106		87.8	37	157.5	17.35	10.95	1.94	17.00	3.67	1.72	94.6	21.2	22.6	2.85	1.77	11.20
Target Range - Lower Bound		83.4	30	130.5	16.10	10.35	1.67	15.40	3.31	1.40	71.3	16.70	17.55	2.63	1.59	9.03
Upper Bound		102.0	42	178.0	21.9	14.05	2.33	21.0	4.50	1.92	96.7	22.7	23.8	3.58	2.17	12.30
OREAS- 45d		12.0	44	153.5	2.53	1.38	0.63	2.39	0.48	0.25	15.4	4.16	3.18	0.39	0.22	1.42
Target Range - Lower Bound		8.5	39	119.5												
Upper Bound		10.6	52	162.5												
OxJ111																
Target Range - Lower Bound																
Upper Bound																
SARM- 43																
SARM- 43																
Target Range - Lower Bound																
Upper Bound																
SCH- 1																
SCH- 1																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																
SY- 4																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	Ag- OG62 Ag ppm 1	Cu- OG62 Cu % 0.001	Pb- OG62 Pb % 0.001	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01
						STANDARDS										
OREAS 621		71	0.373	1.360												
Target Range -	Lower Bound	66		1.310												
	Upper Bound	72		1.410												
OREAS 905																
Target Range -	Lower Bound															
	Upper Bound															
OREAS- 106																
Target Range -	Lower Bound															
	Upper Bound															
OREAS- 45d																
Target Range -	Lower Bound															
	Upper Bound															
OxJ111					2.17											
Target Range -	Lower Bound				2.03											
	Upper Bound				2.30											
SARM- 43																
SARM- 43																
Target Range -	Lower Bound															
	Upper Bound															
SCH- 1																
SCH- 1																
Target Range -	Lower Bound															
	Upper Bound															
SY- 4																
SY- 4																
Target Range -	Lower Bound															
	Upper Bound															
SY- 4																
Target Range -	Lower Bound															
	Upper Bound															
SY- 4							20.76	0.04	7.96	<0.01	6.25	1.68	0.54	0.11	7.15	0.12
Target Range -	Lower Bound						20.07	<0.01	7.74	<0.01	5.95	1.56	0.49	0.08	6.81	0.10
	Upper Bound						21.31	0.06	8.36	0.02	6.47	1.76	0.59	0.13	7.39	0.16

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02
STANDARDS										
OREAS 621										
Target Range - Lower Bound										
Upper Bound										
OREAS 905										
Target Range - Lower Bound										
Upper Bound										
OREAS- 106										
Target Range - Lower Bound										
Upper Bound										
OREAS- 45d										
Target Range - Lower Bound										
Upper Bound										
OxJ111										
Target Range - Lower Bound										
Upper Bound										
SARM- 43							47.53			
SARM- 43							47.69			
Target Range - Lower Bound							45.67			
Upper Bound							50.49			
SCH- 1							2.72			
SCH- 1							2.71			
Target Range - Lower Bound							2.56			
Upper Bound							2.85			
SY- 4								1.05	3.9	
SY- 4								0.91	3.3	
Target Range - Lower Bound								0.84	3.0	
Upper Bound								1.08	4.0	
SY- 4										0.12
Target Range - Lower Bound										0.09
Upper Bound										0.17
SY- 4		0.04	50.07	0.14	0.29	99.80				
Target Range - Lower Bound		0.02	48.70	0.11	0.25	97.31				
Upper Bound		0.06	51.10	0.17	0.32	101.30				

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Sample Description	Method Analyte Units LOR	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.01	<0.2	<10	<0.05	0.01	<0.01	<0.02	0.01	<0.1	<1	<0.05	<0.2	<0.01	0.07
Target Range - Lower Bound		<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	<1	<0.05	<0.2	<0.01	<0.05
Upper Bound		0.02	0.02	0.4	20	0.10	0.02	0.02	0.04	0.02	0.2	2	0.10	0.4	0.02	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		0.10	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
Target Range - Lower Bound		<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
Upper Bound		0.10	0.2	0.010	0.02	1.0	0.4	0.02	10	0.10	0.02	0.2	0.4	20	1.0	0.2
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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To: GOLDER ASSOCIATES INC.
4730 N. ORACLE
STE 210
TUCSON AZ 85705

Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1
BLANKS																
BLANK		<0.002	<0.01	0.08	<0.1	1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Target Range - Lower Bound		<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Upper Bound		0.004	0.02	0.10	0.2	5	0.4	0.4	0.10	0.10	0.02	0.010	0.04	0.2	2	0.2
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.1	<2	<0.5	<0.05	<0.03	<0.03	<0.05	<0.01	<0.01	<0.1	<0.03	<0.03	<0.01	<0.01	<0.03
Target Range - Lower Bound		<0.1	<2	<0.5	<0.05	<0.03	<0.03	<0.05	<0.01	<0.01	<0.1	<0.03	<0.03	<0.01	<0.01	<0.03
Upper Bound		0.2	4	1.0	0.10	0.06	0.06	0.10	0.02	0.02	0.2	0.06	0.06	0.02	0.02	0.06
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	Ag- OG62 Ag ppm 1	Cu- OG62 Cu % 0.001	Pb- OG62 Pb % 0.001	Au- AA23 Au ppm 0.005	Hg- CV41 Hg ppm 0.01	ME- XRF26 Al2O3 % 0.01	ME- XRF26 BaO % 0.01	ME- XRF26 CaO % 0.01	ME- XRF26 Cr2O3 % 0.01	ME- XRF26 Fe2O3 % 0.01	ME- XRF26 K2O % 0.01	ME- XRF26 MgO % 0.01	ME- XRF26 MnO % 0.01	ME- XRF26 Na2O % 0.01	ME- XRF26 P2O5 % 0.01
BLANKS																
BLANK					<0.005											
Target Range - Lower Bound					<0.005											
Upper Bound					0.010											
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK						<0.01										
Target Range - Lower Bound						<0.01										
Upper Bound						0.02										
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Target Range - Lower Bound							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Upper Bound							0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<1	<0.001	<0.001												
Target Range - Lower Bound		<1	<0.001	<0.001												
Upper Bound		2	0.002	0.002												
DUPLICATES																
ORIGINAL				>20.0												
DUP		788	0.060	>20.0												
Target Range - Lower Bound		767	0.058	19.50												
Upper Bound		809	0.063	>20.0												

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Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02
BLANKS										
BLANK										
Target Range - Lower Bound										
Upper Bound										
BLANK								<0.05	<0.2	
BLANK								<0.05	<0.2	
Target Range - Lower Bound								<0.05	<0.2	
Upper Bound								0.10	0.4	
BLANK										<0.02
Target Range - Lower Bound										<0.02
Upper Bound										0.04
BLANK										
Target Range - Lower Bound										
Upper Bound										
BLANK										
Target Range - Lower Bound										
Upper Bound										
BLANK		0.01	100.00	<0.01	<0.01	100.00				
Target Range - Lower Bound		<0.01	<0.01	<0.01	<0.01	<0.01				
Upper Bound		0.02	0.02	0.02	0.02	0.02				
BLANK										
BLANK							0.01			
Target Range - Lower Bound							<0.01			
Upper Bound							0.02			
BLANK										
Target Range - Lower Bound										
Upper Bound										
DUPLICATES										
ORIGINAL										
DUP										
Target Range - Lower Bound										
Upper Bound										

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Finalized Date: 13- OCT- 2016
Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	ME- MS61r Ag ppm 0.01	ME- MS61r Al % 0.01	ME- MS61r As ppm 0.2	ME- MS61r Ba ppm 10	ME- MS61r Be ppm 0.05	ME- MS61r Bi ppm 0.01	ME- MS61r Ca % 0.01	ME- MS61r Cd ppm 0.02	ME- MS61r Ce ppm 0.01	ME- MS61r Co ppm 0.1	ME- MS61r Cr ppm 1	ME- MS61r Cs ppm 0.05	ME- MS61r Cu ppm 0.2	ME- MS61r Fe % 0.01	ME- MS61r Ga ppm 0.05
		DUPLICATES														
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213022																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213031																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213032		0.05	4.39	6.6	150	1.22	0.11	0.76	0.02	60.4	13.1	35	2.73	5.4	5.42	11.25
DUP		0.05	4.39	6.9	150	1.14	0.11	0.76	<0.02	56.0	13.2	34	2.70	8.1	5.41	11.35
Target Range - Lower Bound		0.04	4.16	6.2	130	1.07	0.09	0.71	<0.02	55.3	12.4	32	2.53	6.3	5.13	10.70
Upper Bound		0.06	4.62	7.3	170	1.29	0.13	0.81	0.04	61.1	13.9	37	2.90	7.2	5.70	11.90
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	ME- MS61r Ge ppm 0.05	ME- MS61r Hf ppm 0.1	ME- MS61r In ppm 0.005	ME- MS61r K % 0.01	ME- MS61r La ppm 0.5	ME- MS61r Li ppm 0.2	ME- MS61r Mg % 0.01	ME- MS61r Mn ppm 5	ME- MS61r Mo ppm 0.05	ME- MS61r Na % 0.01	ME- MS61r Nb ppm 0.1	ME- MS61r Ni ppm 0.2	ME- MS61r P ppm 10	ME- MS61r Pb ppm 0.5	ME- MS61r Rb ppm 0.1
		DUPLICATES														
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213022																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213031																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213032		0.13	1.2	0.052	1.27	22.8	28.2	0.40	262	1.16	0.10	5.9	20.0	1000	7.8	47.6
DUP		0.11	1.3	0.041	1.27	21.4	24.5	0.40	264	1.18	0.10	5.9	20.2	1010	7.3	48.3
Target Range - Lower Bound		0.06	1.1	0.039	1.20	20.5	24.8	0.37	245	1.06	0.09	5.5	18.9	940	6.7	45.5
Upper Bound		0.18	1.4	0.054	1.34	23.7	27.9	0.43	281	1.28	0.12	6.3	21.3	1070	8.4	50.4
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description / Method / Analyte / Units / LOR	ME- MS61r Re ppm 0.002	ME- MS61r S % 0.01	ME- MS61r Sb ppm 0.05	ME- MS61r Sc ppm 0.1	ME- MS61r Se ppm 1	ME- MS61r Sn ppm 0.2	ME- MS61r Sr ppm 0.2	ME- MS61r Ta ppm 0.05	ME- MS61r Te ppm 0.05	ME- MS61r Th ppm 0.01	ME- MS61r Ti % 0.005	ME- MS61r Tl ppm 0.02	ME- MS61r U ppm 0.1	ME- MS61r V ppm 1	ME- MS61r W ppm 0.1
DUPLICATES															
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															
1213022															
DUP															
Target Range - Lower Bound															
Upper Bound															
1213031															
DUP															
Target Range - Lower Bound															
Upper Bound															
1213032	<0.002	0.01	1.11	9.2	1	1.1	20.0	0.44	<0.05	5.34	0.265	0.18	1.2	57	1.3
DUP	<0.002	0.01	1.05	9.1	2	1.0	20.4	0.43	<0.05	5.24	0.266	0.21	1.1	57	1.3
Target Range - Lower Bound	<0.002	<0.01	0.95	8.6	<1	0.8	19.0	0.36	<0.05	5.02	0.247	0.16	1.0	53	1.1
Upper Bound	0.004	0.02	1.21	9.7	2	1.3	21.4	0.51	0.10	5.56	0.284	0.23	1.3	61	1.5
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method Analyte Units LOR	ME- MS61r Y ppm 0.1	ME- MS61r Zn ppm 2	ME- MS61r Zr ppm 0.5	ME- MS61r Dy ppm 0.05	ME- MS61r Er ppm 0.03	ME- MS61r Eu ppm 0.03	ME- MS61r Gd ppm 0.05	ME- MS61r Ho ppm 0.01	ME- MS61r Lu ppm 0.01	ME- MS61r Nd ppm 0.1	ME- MS61r Pr ppm 0.03	ME- MS61r Sm ppm 0.03	ME- MS61r Tb ppm 0.01	ME- MS61r Tm ppm 0.01	ME- MS61r Yb ppm 0.03
		DUPLICATES														
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213022																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213031																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213032		14.2	37	48.3	4.52	1.65	1.34	5.43	0.61	0.24	29.5	7.12	6.84	0.65	0.24	1.66
DUP		14.6	37	44.0	3.40	2.09	1.35	5.20	0.70	0.24	28.0	6.49	6.44	0.87	0.23	1.53
Target Range - Lower Bound		13.6	33	43.3	3.61	1.70	1.21	4.87	0.60	0.21	26.5	6.26	6.11	0.69	0.21	1.45
Upper Bound		15.2	41	49.0	4.31	2.04	1.48	5.76	0.71	0.27	31.0	7.35	7.17	0.83	0.26	1.74
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method	Ag- OG62	Cu- OG62	Pb- OG62	Au- AA23	Hg- CV41	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26	ME- XRF26
	Analyte	Ag	Cu	Pb	Au	Hg	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	P2O5
	Units	ppm	%	%	ppm	ppm	%	%	%	%	%	%	%	%	%	%
	LOR	1	0.001	0.001	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
1213022							0.08	<0.01	55.7	<0.01	0.03	0.02	0.26	0.01	0.01	<0.01
DUP							0.09	0.01	55.3	<0.01	0.03	0.02	0.24	0.01	0.01	<0.01
Target Range - Lower Bound							0.07	<0.01	54.7	<0.01	0.02	<0.01	0.24	<0.01	<0.01	<0.01
Upper Bound							0.10	0.02	56.3	0.02	0.04	0.03	0.26	0.02	0.02	0.02
1213031					<0.005	0.02										
DUP					<0.005	0.02										
Target Range - Lower Bound					<0.005	<0.01										
Upper Bound					0.010	0.03										
1213032																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL					0.006											
DUP					<0.005											
Target Range - Lower Bound					<0.005											
Upper Bound					0.010											
ORIGINAL					<0.005											
DUP					<0.005											
Target Range - Lower Bound					<0.005											
Upper Bound					0.010											
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS TU16158768

Sample Description	Method / Analyte / Units / LOR	ME- XRF26 SO3 % 0.01	ME- XRF26 SiO2 % 0.01	ME- XRF26 SrO % 0.01	ME- XRF26 TiO2 % 0.01	ME- XRF26 Total % 0.01	OA- GRA05x LOI 1000 % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	C- IR17 C organi % 0.02
					DUPLICATES					
ORIGINAL								3.60	13.2	
DUP								3.53	12.9	
Target Range -	Lower Bound							3.34	12.2	
	Upper Bound							3.79	13.9	
ORIGINAL							1.52			
DUP							1.47			
Target Range -	Lower Bound						1.45			
	Upper Bound						1.54			
1213022		0.04	1.40	0.02	<0.01	100.25		11.45	42.0	0.02
DUP		0.03	1.40	0.02	0.01	99.86		11.30	41.4	0.03
Target Range -	Lower Bound	0.02	1.37	<0.01	<0.01	99.04		10.75	39.4	<0.02
	Upper Bound	0.05	1.43	0.03	0.02	101.05		12.00	44.0	0.04
1213031										
DUP										
Target Range -	Lower Bound									
	Upper Bound									
1213032										
DUP										
Target Range -	Lower Bound									
	Upper Bound									
ORIGINAL										
DUP										
Target Range -	Lower Bound									
	Upper Bound									
ORIGINAL										
DUP										
Target Range -	Lower Bound									
	Upper Bound									
ORIGINAL							12.23			
DUP							12.12			
Target Range -	Lower Bound						11.86			
	Upper Bound						12.49			

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Account: GOLINC

QC CERTIFICATE OF ANALYSIS TU16158768

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Applies to Method: REE's may not be totally soluble in this method.
ME- MS61r

Applies to Method: Detection limits on samples requiring dilutions due to interferences or high concentration levels have been increased according to the dilution factor.
Hg- CV41

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Ag- OG62	Au- AA23	C- GAS05	C- IR17
Cu- OG62	Hg- CV41	ME- MS61r	ME- OG62
ME- XRF26	OA- GRA05x	Pb- OG62	

Applies to Method: Processed at ALS Tucson, Arizona, USA

CRU- 31	CRU- QC	LOG- 22	PUL- 31
PUL- 31d	SND- 01	SPL- 21	SPL- 21d
SPLIT- Z	WEI- 21		

Applies to Method: Processed at Becquerel Laboratories Inc., Mississauga, Ontario, Canada
PGM- NAA26

Appendix C.3c: USGS Quartz Latite Standard (QL0-1a) Reference Material Evaluation

	Four Acid Digestion Analyzed with ICP-MS-AES																						
Constituent	Ag	Ba	Ce	Co	Cr	Cs	Cu	La	Li	Mo	Nb	Pb	Rb	S	Sn	Sr	Ta	Th	U	V	W	Y	Zn	Zr
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Limit of Report																								
	0.01	10	0.01	0.1	1	0.05	0.2	0.5	0.2	0.05	0.1	0.5	0.1	0.01	0.2	0.2	0.05	0.01	0.1	1	0.1	0.1	2	0.5
Quartz Latite Standard - QLO-1a																								
Concentration	0.064	1370	54	7.2	3.2	1.8	29	27	25	2.6	10	20	74	0.003	2.3	340	0.82	4.5	1.9	54	0.58	24	61	185
range (+/-)*	0.005	80	6	0.5	1.7	0.2	3	2	2	0.3	1.3	0.8	3	0	0.09	12	0.1	0.5	0.12	6	0.05	3	3	16
1 Standard Deviation Upper Bound	0.069	1450	60	7.7	4.9	2	32	29	27	2.9	11.3	20.8	77	0.003	2.39	352	0.92	5	2.02	60	0.63	27	64	201
1 Standard Deviation Lower Bound	0.059	1290	48	6.7	1.5	1.6	26	25	23	2.3	8.7	19.2	71	0.003	2.21	328	0.72	4	1.78	48	0.53	21	58	169
2 Standard Deviation Upper Bound	0.074	1530	66	8.2	6.6	2.2	35	31	29	3.2	12.6	21.6	80	0.003	2.48	364	1.02	5.5	2.14	66	0.68	30	67	217
2 Standard Deviation Lower Bound	0.054	1210	42	6.2	-0.2	1.4	23	23	21	2	7.4	18.4	68	0.003	2.12	316	0.62	3.5	1.66	42	0.48	18	55	153
Sample Results for QLO-1a Standard (sample # 1424910b)																								
1424910b	0.07	1420	45.9	6.6	2	1.6	31.1	25.3	23	2.39	9.9	12.9	69.2	<0.01	1.9	337	0.8	4.83	1.9	47	0.5	21.7	61	184.5
Results within 1 Standard Deviation of Upper and Lower Bounds (true of false)																								
1424910b	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE
Results within 2 Standard Deviation of Upper and Lower Bounds (true of false)																								
1424910b	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

Notes:

* = One Standard Deviation

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Table C.3d: USGS Disseminated Gold Ore (DGPM-1) Reference Material Evaluation

	Four Acid Digestion Analyzed with ICP-MS		Atomic Absorption	Aqua Regia Digestion Analyzed with ICP-MS	
Constituent	As	Sb	Au	As	Sb
Units	ppm	ppm	ppm	ppm	ppm
Limit of Reporting					
	0.2	0.05	0.005	0.01	0.005
Disseminated Gold Ore Reference Material (DGPM-1)					
Concentration	180	14	0.73	180	14
range (+/-)*	10	1	0.06	10	1
1 Standard Deviation Upper Bound	190	15	0.79	190	15
1 Standard Deviation Lower Bound	170	13	0.67	170	13
2 Standard Deviation Upper Bound	200	16	0.85	200	16
2 Standard Deviation Lower Bound	160	12	0.61	160	12
Sample Results for DGPM-1 Reference Material					
1424910a	196.5	13.9	0.707	176.5	5.47
1424918a	193.5	13.45	0.733	173.5	5.61
1424964a	194.5	13.45	0.74	---	---
1213009a	191	13.25	0.742	---	---
Results within 1 Standard Deviation of Upper and Lower Bounds (true of false)					
1424910a	FALSE	TRUE	TRUE	TRUE	FALSE
1424918a	FALSE	TRUE	TRUE	TRUE	FALSE
1424964a	FALSE	TRUE	TRUE	---	---
1213009a	FALSE	TRUE	TRUE	---	---
Results within 2 Standard Deviation of Upper and Lower Bounds (true of false)					
1424910a	TRUE	TRUE	TRUE	TRUE	FALSE
1424918a	TRUE	TRUE	TRUE	TRUE	FALSE
1424964a	TRUE	TRUE	TRUE	---	---
1213009a	TRUE	TRUE	TRUE	---	---

Notes:

* = One Standard Deviation

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APPENDIX D: GEOCHEMICAL EVALUATION DATA

- Appendix D.1: Threshold Concentrations for Determination of Geochemical Anomalies
- Appendix D.2a: Single-Element Anomalies and Multi-Element Factor Scores for Mining Districts
- Appendix D.2b:Mining Districts and their Deposit Associations
- Appendix D.3a: Single-Element Anomalies and Multi-element Factor Scores for Mineral Prospects
- Appendix D.3b: MIning Prospects and their Deposit Associations

Appendix D.1: Threshold Concentrations for Determination of Geochemical Anomalies

	Threshold Concentrations Based on GSC Analyses from 1993, 1998, 2014, 2016 Assessments																	
	Paleozoic Zone						Cenozoic Zone						Transition Zone					
	Median	S.D.	Med + 3 S.D.	Med + 2 S.D.	Threshold 2016	Threshold 1998	Median	S.D.	Med + 3 S.D.	Med + 2 S.D.	Threshold 2016	Threshold 1998	Median	S.D.	Med + 3 S.D.	Med + 2 S.D.	Threshold 2016	Notes
Ag	0.016	0.0299	0.1057	0.0758	0.106	0.12	0.02	0.02168	0.085034	0.063356	0.085	0.08	0.0205	0.0701	0.2308	0.1607	0.2308	Detection limit for Ag in 1993 GSC samples was 2 ppm, all values recorded as non-detects were eliminated due to very high detection limit skewing data
As	1.935	6.5158	21.4824	14.9666	21.48	8.6	1.28	4.8247	15.7541	10.9294	15.75	12	1.64	5.8593	19.2179	13.3586	19.2179	
Au	0.0004	0.0006	0.0022	0.0016	0.0022	0.003	0.0008	0.0005	0.0023	0.0018	0.0023	0.003	0.0006	0.0006	0.0024	0.0018	0.0024	
Co	3	6.1658	21.4974	15.3316	21.497	15	2.5	5.9099	20.2297	14.3198	20.23	23	2.5	6.0768	20.7304	14.6536	20.7	
Cu	4	9.3066	31.9198	22.6132	32	32	3.44	6.2775	22.2725	15.995	22.27	25	3.9	8.3605	28.9815	20.621	28.98	
Hg	0.005	0.1116	0.3398	0.2282	0.3398	0.5	0.016	0.098	0.31	0.212	0.31	0.2	0.011	0.1055	0.3275	0.222	0.31	
Mo	0.5	2.5417	8.1251	5.5834	8.125	3	0.634	1.2016	4.2388	3.0372	4.23	5	0.5	2.1076	6.8228	4.7152	4.23	
Pb	1.84	17.1871	53.4013	36.2142	53.401	36	4.48	19.8623	64.0669	44.2046	64.067	79	3.135	18.1013	57.4389	39.3376	57.4389	
Sb	0.2175	0.7876	2.5803	1.7927	2.5	1.5	0.281	4.5606	13.9628	9.4022	2	2	0.2445	2.8698	8.8539	5.9841	2	
Se	2.5	1.1618	5.9854	4.8236	5.98	2	0.175	0.568	1.879	1.311	0.5	0.5	0.2375	1.117	3.5885	2.4715	0.5	
Te	0.131	0.05154	0.285614	0.234076	0.285	0.3	0.152	0.05759	0.324779	0.267186	0.325	0.5	0.146	0.057	0.317	0.26	0.317	Detection limit for Te in 1993 GSC samples was 10 ppm, all values recorded as non-detects were eliminated due to very high detection limit skewing data
Tl	0.2	0.24024	0.92072	0.68048	0.92	0.7	0.345	0.174	0.867	0.693	0.87	0.9	0.2915	0.2221	0.9578	0.7357	0.87	
W	1	0.9786	3.9358	2.9572	4	4	3	3.221	12.663	9.442	10	10	1	2.3954	8.1862	5.7908	8	
Zn	6.29	33.21	105.92	72.71	105	137	27.4	34.2321	130.0963	95.8642	117	117	17.65	35.1245	123.0235	87.899	123	

Notes:

Threshold values for the Transition Zone were calculated using statistics from the entire GSC population

S.D. = standard deviation

Indicates statistical values were used where non-detects were removed from calculations

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Appendix D.2a: Single-Element Anomalies and Multi-Element Factor Scores for Mining Districts

					Anomaly Strength - CENOZOIC							
					Yucca Mtn	Transvaal	Thirsty Canyon-Sleeping Butte	Tolicha	Clarkdale	Scotty's Junction	Wagner	Stonewall
Single Element	**Zone**	**Fig**	**Primary Desposit Association**	**Secondary Deposit Association**	**Tl**	**Hg, Tl**	**Zn**	**Ag, As, Au, Sb**	**Ag, As, Au, Hg**	**Co**	**Ag, Cu, Hg, Te**	
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry				X	X		X	
Arsenic (As)	All	5.3	Epithermal, CTGDs	Porphyry	X			X	X			
Gold (Au)	All	5.4	Porphyry, CTGDs	Epithermal				X	X		X	
Cobalt (Co)	All	5.5		Porphyry						N		
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal							X	
Mercury (Hg)	All	5.7	Epithermal, CTDGs			X			X		X	
Molybdenum (Mo)	All	5.8	Porphyry			N		X	X		X	
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry								
Antimony (Sb)	All	5.10	Epithermal, CTGDs	Porphyry				X	X		X	
Selenium (Se)	All	5.11										
Tellurium (Te)	All	5.12		Epithermal				X			X	
Thallium (Tl)	All	5.13	Epithermal, CTGDs		X	X,N	N					
Tungsten (W)	All	5.14	Porphyry	CTGD								
Zinc (Zn)	All	5.15	Carbonates	Porphyry			X			X		
Multi-element Suite			**Desposit Association**		**Factor Score Strength**							
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGDs	Epithermal, Porphyry			X	X		X	X	X
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry		X	X	X	X		X	X
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGDs	Epithermal, Porphyry								
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGDs								

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

X — Indicates the anomaly was defined in the 1998 Assessment

N — Indicates the anomaly was defined in the current assessment

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Appendix D.2a: Single-Element Anomalies and Multi-Element Factor Scores for Mining Districts

					Anomaly Strength - CENOZOIC							
					Gold Crater	Jamestown	Trappmans	Wilsons	Wellington	Antelope Springs	Eastern Goldfields	South of Mud Lake
Single Element	**Zone**	**Fig**	**Primary Desposit Association**	**Secondary Deposit Association**	**Ag, As, Au, Cu, Hg, Mo, Pb, Sb, Se, Te**	**Ag, As, Au, Hg, Mo, Pb, Sb, Te**	**Ag, As, Au, Hg, Mo, Sb**	**Ag, As, Au, Cu, Mo**	**Ag, As, Au, Mo, Sb**	**Ag, As, Au, Cu, Mo, Sb, Te**		
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry	X	X	X	X	X	X		
Arsenic (As)	All	5.3	Epithermal, CTGDs	Porphyry	X	X	X	X	X	X		
Gold (Au)	All	5.4	Porphyry, CTGDs	Epithermal	X	X	X	X	X	X		
Cobalt (Co)	All	5.5		Porphyry								
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal	X			X		N		
Mercury (Hg)	All	5.7	Epithermal, CTDGs		X	X	X					
Molybdenum (Mo)	All	5.8	Porphyry		X	X	X	X	X	X		
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry	X	X		X		X		
Antimony (Sb)	All	5.10	Epithermal, CTGDs	Porphyry	X	X	X		X	X		
Selenium (Se)	All	5.11			N	N				N		
Tellurium (Te)	All	5.12		Epithermal	X	X		X		X		
Thallium (Tl)	All	5.13	Epithermal, CTGDs									
Tungsten (W)	All	5.14	Porphyry	CTGD								
Zinc (Zn)	All	5.15	Carbonates	Porphyry								
Multi-element Suite			**Desposit Association**		**Factor Score Strength**							
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGDs	Epithermal, Porphyry			X	X		X		
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry	X	X	X	X		X		
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGDs	Epithermal, Porphyry								
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGDs								

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

X — Indicates the anomaly was defined in the 1998 Assessment

N — Indicates the anomaly was defined in the current assessment

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Appendix D.2a: Single-Element Anomalies and Multi-Element Factor Scores for Mining Districts

					Anomaly Strength - CENOZOIC			
					Cactus Springs / West	Mellan Mountain	Silverbow	Cedar Pass
Single Element	**Zone**	**Fig**	**Primary Desposit Association**	**Secondary Deposit Association**	**Ag, As, Cu, Mo, Se**		**Ag, As, Au, Hg, Mo, Sb**	**Ag, As, Au, Hg, MO**
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry	X		X	X
Arsenic (As)	All	5.3	Epithermal, CTGDs	Porphyry	X		X	X
Gold (Au)	All	5.4	Porphyry, CTGDs	Epithermal	X		X	X
Cobalt (Co)	All	5.5		Porphyry				
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal	X,N			
Mercury (Hg)	All	5.7	Epithermal, CTDGs				X	X
Molybdenum (Mo)	All	5.8	Porphyry		X		X	X
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry	X		X	
Antimony (Sb)	All	5.10	Epithermal, CTGDs	Porphyry	X		X	X
Selenium (Se)	All	5.11			N		N	
Tellurium (Te)	All	5.12		Epithermal	X		X	X
Thallium (Tl)	All	5.13	Epithermal, CTGDs		N		X	
Tungsten (W)	All	5.14	Porphyry	CTGD			X	
Zinc (Zn)	All	5.15	Carbonates	Porphyry			X	
Multi-element Suite			**Desposit Association**		**Factor Score Strength**			
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGDs	Epithermal, Porphyry	X		X	
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry	X		X	X
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGDs	Epithermal, Porphyry				
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGDs				

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

X — Indicates the anomaly was defined in the 1998 Assessment

N — Indicates the anomaly was defined in the current assessment

Appendix D.2a: Single-Element Anomalies and Multi-Element Factor Scores for Mining Districts

					Anomaly Strength - TRANSITION					Anomaly Strength - PALEOZOIC			
					Queen City	Gold Range	Oak Spring	Don Dale	Groom	Rainstorm	Papoose	Southeastern	Slate
Single Element	**Zone**	**Fig**	**Primary Desposit Association**	**Secondary Deposit Association**	**Ag, As, Au**	**As, Mo, Sb**			**Sb**	**As, Cu, Sb**	**As, Au, Co, Cu, Pb, Sb, W, Zn**	**Ag, As, Pb, Sb**	**As**
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry	X				X		N	N	
Arsenic (As)	All	5.3	Epithermal, CTGDs	Porphyry	X	X			X	X	X	X	X
Gold (Au)	All	5.4	Porphyry, CTGDs	Epithermal	X	X			X	X	X	X	
Cobalt (Co)	All	5.5		Porphyry					X		X		
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal						X	X,N	X	
Mercury (Hg)	All	5.7	Epithermal, CTDGs			X,N		N	N	X	X	N	
Molybdenum (Mo)	All	5.8	Porphyry			X				X	X	X	
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry					X		X,N	X	
Antimony (Sb)	All	5.10	Epithermal, CTGDs	Porphyry		X		N	X	X	X	X	
Selenium (Se)	All	5.11											
Tellurium (Te)	All	5.12		Epithermal				X	N	N	N	N	
Thallium (Tl)	All	5.13	Epithermal, CTGDs					X	X		X		
Tungsten (W)	All	5.14	Porphyry	CTGD						N	X,N		N
Zinc (Zn)	All	5.15	Carbonates	Porphyry			N		X		X	X	
Multi-element Suite			**Desposit Association**		**Factor Score Strength**								
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGDs	Epithermal, Porphyry	X	X	X	X	X	X	X	X	
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry									
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGDs	Epithermal, Porphyry						X	X	X	
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGDs						X	X		X

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

X — Indicates the anomaly was defined in the 1998 Assessment

N — Indicates the anomaly was defined in the current assessment

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Appendix D.2b: Mining Districts and their Deposit Associations

Lithological Zone	Deposit Association - CENOZOIC															
Mining District	Yucca Mtn	Transvaal	Thirsty Canyon-Sleeping Butte	Tolicha	Clarkdale	Scotty's Junction	Wagner	Stonewall	Gold Crater	Jamestown	Trappmans	Wilsons	Wellington	Antelope Springs	Eastern Goldfields	South of Mud Lake
Primary Deposit Association		Epithermal		Epithermal	Epithermal		Porphyry		Epithermal	Epithermal	Epithermal	Epithermal	Epithermal	Epithermal		
Secondary Deposit Association									Porphyry	Porphyry	Porphyry	Porphyry	Porphyry	Porphyry		
Tertiary Deposit Association																

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

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Appendix D.2b: Mining Districts and their Deposit Associations

Lithological Zone	Deposit Association - CENOZOIC				Deposit Association - TRANSITION					Deposit Association - PALEOZOIC			
Mining District	Cactus Springs / West	Mellan Mountain	Silverbow	Cedar Pass	Queen City	Gold Range	Oak Spring	Don Dale	Groom	Rainstorm	Papoose	Southeastern	Slate
Primary Deposit Association	Epithermal		Epithermal						CTGD		Carbonate	Carbonate	
Secondary Deposit Association	Porphyry		Porphyry						Epithermal		CTGD	CTGD	
Tertiary Deposit Association									Carbonate		Intrusive?	Intrusive?	

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Appendix D.3a: Single-Element Anomalies and Multi-Element Factor Scores for Mineral Prospects

					Anomaly Strength - CENOZOIC								
					Upper Thirsty Canyon	South Belted Range	Cactus Peak	Cactus Flat	Corral Springs	Reveille Valley	Gold Reed	Quartzite Mountain	Mount Helen
Single Element	**Zone**	**Fig**	**Primary Association**	**Secondary Association**	**Cu, Zn**	**As, Cu, Hg, Sb**	**As, Mo**		**Ag, As, Mo**	**As**	**As, Hg, Mo, Sb, Se**	**Ag, As, Hg, Mo, Te**	**Ag, As, Au, Hg, Mo, Pb, Sb, Se, Te**
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry	X		X		X			X	X
Arsenic (As)	All	5.3	Epithermal, Carlin	Porphyry		X	X		X	X	X	X	X
Gold (Au)	All	5.4	Porphyry, Carlin	Epithermal			X				X	X	X
Cobalt (Co)	All	5.5		Porphyry									
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal	X	X						X	
Mercury (Hg)	All	5.7	Epithermal, Carlin			X	X				X	X	X
Molybdenum (Mo)	All	5.8	Porphyry		X	X	X		X		X	X	X
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry							X		X
Antimony (Sb)	All	5.10	Epithermal, Carlin	Porphyry	X	X					X	X	X
Selenium (Se)	All	5.11					N				N		N
Tellurium (Te)	All	5.12		Epithermal			X				X		X
Thallium (Tl)	All	5.13	Epithermal, CTGD		X	X						X	
Tungsten (W)	All	5.14	Porphyry	CTGD									
Zinc (Zn)	All	5.15	Carbonates	Porphyry	X								
Multi-element					**Multi-Element Factor Score Strength**								
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGD	Epithermal, Porphyry									
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry		X	X			X	X	X	X
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGD	Epithermal, Porphyry									
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGD									

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

X — Indicates the anomaly was defined in the 1998 Assessment

N — Indicates the anomaly was defined in the current assessment

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Appendix D.3a: Single-Element Anomalies and Multi-Element Factor Scores for Mineral Prospects

					Anomaly Strength - TRANSITION	Anomaly Strength - PALEOZOIC					
					Limestone Ridge	Prospector Fault	Chert Hill	Fallout Hills	West Pintwater Range	Quartz Peak	Desert Range
Single Element	**Zone**	**Fig**	**Primary Association**	**Secondary Association**	**Sb**	**As**	**As, Cu**	**Zn**	**As, Sb, Zn**		**As**
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry							
Arsenic (As)	All	5.3	Epithermal, Carlin	Porphyry	**X**	X	X		X		X
Gold (Au)	All	5.4	Porphyry, Carlin	Epithermal	X		X	X			
Cobalt (Co)	All	5.5		Porphyry							
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal		N	X	X			
Mercury (Hg)	All	5.7	Epithermal, Carlin								
Molybdenum (Mo)	All	5.8	Porphyry					X			X
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry							
Antimony (Sb)	All	5.10	Epithermal, Carlin	Porphyry	X			X	X		
Selenium (Se)	All	5.11									
Tellurium (Te)	All	5.12		Epithermal							
Thallium (Tl)	All	5.13	Epithermal, CTGD								
Tungsten (W)	All	5.14	Porphyry	CTGD							
Zinc (Zn)	All	5.15	Carbonates	Porphyry				X	X		X
Multi-element					**Multi-Element Factor Score Strength**						
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGD	Epithermal, Porphyry							
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry	X						
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGD	Epithermal, Porphyry							
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGD		X		X	X	X	X

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength

- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength

- Moderate
- High

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Appendix D.3a: Single-Element Anomalies and Multi-Element Factor Scores for Mineral Prospects

					Anomaly Strength - PALEOZOIC							
					Pintwater Cave	Surprise Canyon	Mercury Klippe	Indian Springs	Pahranagat Range	Maynard Lake Fault	North Sheep Range	Cabin Springs
Single Element	**Zone**	**Fig**	**Primary Association**	**Secondary Association**	**As**	**As**	**Ag, As, Mo, Sb**	**As**	**As, Au, Mo, Sb, Sb, W**	**As, Pb, Sb**	**As**	**As**
Silver (Ag)	All	5.2	Carbonates	Epithermal, Porphyry			X		X	X	X	X
Arsenic (As)	All	5.3	Epithermal, Carlin	Porphyry	X	X	X	X	X	X	X	X
Gold (Au)	All	5.4	Porphyry, Carlin	Epithermal					X			
Cobalt (Co)	All	5.5		Porphyry					X			
Copper (Cu)	All	5.6	Porphyry, Carbonates	Epithermal					X			
Mercury (Hg)	All	5.7	Epithermal, Carlin									
Molybdenum (Mo)	All	5.8	Porphyry				X		X			X
Lead (Pb)	All	5.9	Carbonates	Epithermal, Porphyry		X			X	X		
Antimony (Sb)	All	5.10	Epithermal, Carlin	Porphyry	X		X		X	X		
Selenium (Se)	All	5.11										
Tellurium (Te)	All	5.12		Epithermal								
Thallium (Tl)	All	5.13	Epithermal, CTGD									
Tungsten (W)	All	5.14	Porphyry	CTGD					X			
Zinc (Zn)	All	5.15	Carbonates	Porphyry					X			X
Multi-element					**Multi-Element Factor Score Strength**							
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	All	5.18	Carbonates/CTGD	Epithermal, Porphyry								
As/Sb/Pb/Te, Cd, Mo	CZ	5.19	Epithermal	Porphyry								
Ag/Cu/Pb/Zn, As/Sb/Hg, Cd, Mo	PZ	5.20	Carbonates/CTGD	Epithermal, Porphyry								
Ag/Cu/Pb/Zn, Sb	PZ	5.21	Carbonates	Epithermal, CTGD	X	X	X	X			X	

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

Anomaly Strength
- Anomaly defined by only 1 sample
- Anomaly defined by up to 4 samples
- Anomaly defined by up to 11 samples
- Anomaly defined by up to 22 samples

Factor Score Strength
- Moderate
- High

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Appendix D.3b: Mineral Prospects and their Deposit Associations

Lithological Zone	Deposit Association - CENOZOIC									Deposit Association - TRANSITION
Mining Prospect	**Upper Thirsty Canyon**	**South Belted Range**	**Cactus Peak**	**Cactus Flat**	**Corral Springs**	**Reveille Valley**	**Gold Reed**	**Quartzite Mountain**	**Mount Helen**	**Limestone Ridge**
Primary Deposit Association	Epithermal	Epithermal					Epithermal	Epithermal	Epithermal	
Secondary Deposit Association	Porphyry							Porphyry	Porphyry	

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	

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Appendix D.3b: Mineral Prospects and their Deposit Associations

Lithological Zone	Deposit Association - PALEOZOIC													
Mining Prospect	**Chert Hill**	**Fallout Hills**	**West Pintwater Range**	**Quartz Peak**	**Desert Range**	**Pintwater Cave**	**Surprise Canyon**	**Mercury Klippe**	**Indian Springs**	**Pahranagat Range**	**Maynard Lake Fault**	**North Sheep Range**	**Cabin Springs**	**Prospector Fault**
Primary Deposit Association								CTGD		CTGD	CTGD		Carbonates	
Secondary Deposit Association										Carbonates	Carbonates			

Ore Deposit Type	Primary Element Assemblage	Secondary Element Assemblage
Epithermal	As, Sb, Hg, Tl	Cu, Au, Pb, Ag, Te
Porphyry	Cu, Au, Mo, W	Pb, Ag, Zn, As, Sb, Co, Mn, Sb
Carlin-type gold deposit (CTGD)	Au, Sb, As, Hg, Tl	Mo, W
Dolomitized carbonates	Cu, Pb, Ag, Zn	